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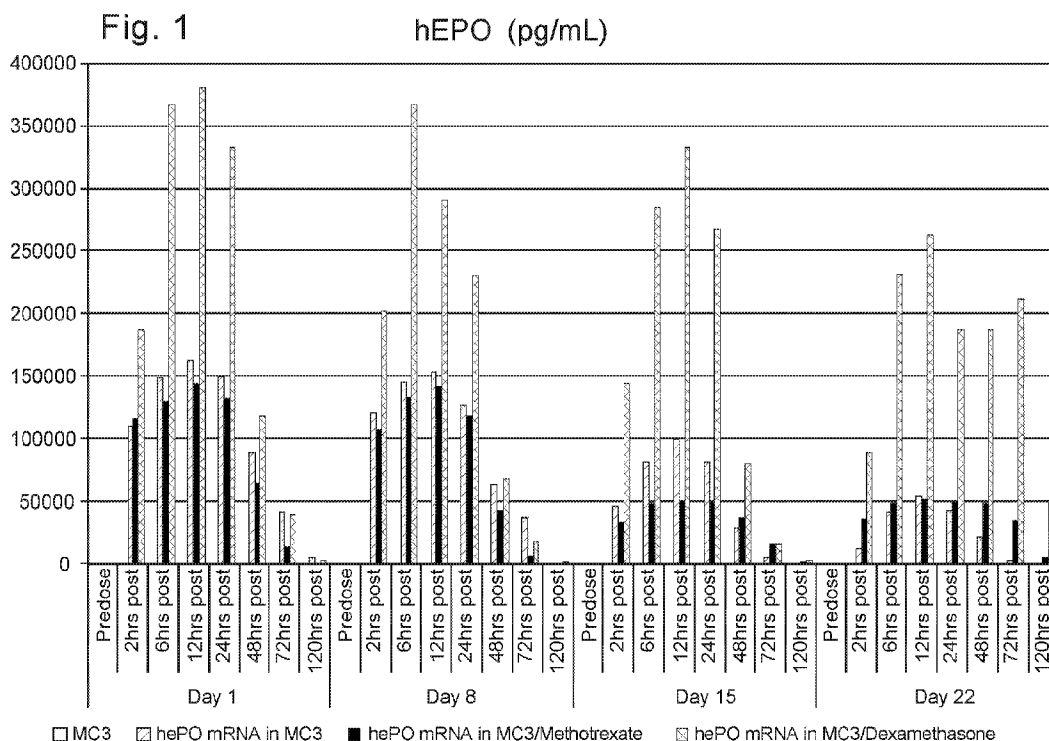
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(54) Titre : COMPOSES ET COMPOSITIONS POUR L'ADMINISTRATION INTRACELLULAIRE D'AGENTS
THERAPEUTIQUES

(54) Title: COMPOUNDS AND COMPOSITIONS FOR INTRACELLULAR DELIVERY OF THERAPEUTIC AGENTS



(57) **Abrégé/Abstract:**

The disclosure features novel lipids and compositions involving the same. Nanoparticle compositions include a novel lipid as well as additional lipids such as phospholipids, structural lipids, and PEG lipids. Nanoparticle compositions further including therapeutic and/or prophylactics such as RNA are useful in the delivery of therapeutic and/or prophylactics to mammalian cells or organs to, for example, regulate polypeptide, protein, or gene expression.

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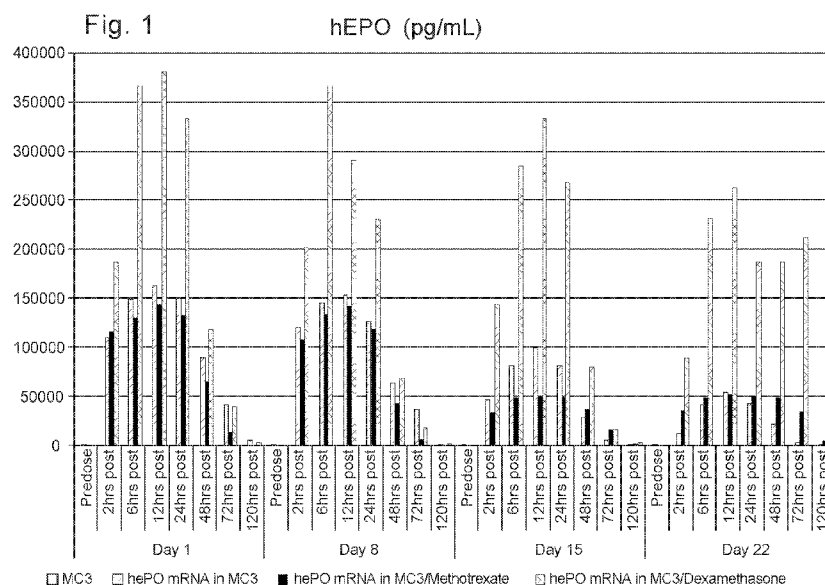
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COMPOUNDS AND COMPOSITIONS FOR INTRACELLULAR DELIVERY OF THERAPEUTIC AGENTS

Related Applications

[0001] This application claims priority to, and the benefit of, U.S. Provisional Application Nos. 62/733,315, filed September 19, 2018, and 62/798,874, filed January 30, 2019, the entire contents of each of which are incorporated herein by reference.

Incorporation-by-Reference of Sequence Listing

[0002] The present application is being filed along with a Sequence Listing in electronic format. The Sequence Listing is provided as a file entitled “MRNA065SequenceListing.txt” created on September 17, 2018, which is 630 bytes in size. The information in the electronic format of the sequence listing is incorporated herein by reference in its entirety.

Field of Disclosure

[0003] The present disclosure provides novel compounds, compositions comprising such compounds, and methods involving lipid nanoparticle compositions to deliver one or more therapeutic and/or prophylactics to and/or produce polypeptides in mammalian cells or organs. In addition to a novel lipid, lipid nanoparticle compositions of the disclosure may include one or more cationic and/or ionizable amino lipids, phospholipids including polyunsaturated lipids, PEG lipids, structural lipids, and/or therapeutic and/or prophylactics in specific fractions.

Background of the Disclosure

[0004] The effective targeted delivery of biologically active substances such as small molecule drugs, proteins, and nucleic acids represents a continuing medical challenge. In particular, the delivery of nucleic acids to cells is made difficult by the relative instability and low cell permeability of such species. Thus, there exists a need to develop methods and compositions to facilitate the delivery of therapeutic and/or prophylactics such as nucleic acids to cells.

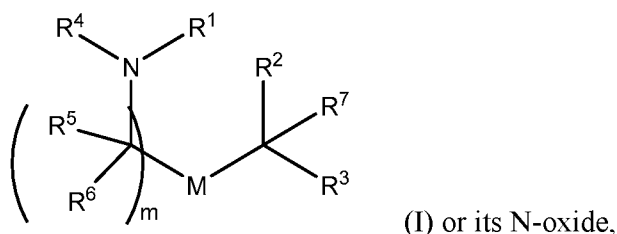
[0005] Lipid-containing nanoparticle compositions, liposomes, and lipoplexes have proven effective as transport vehicles into cells and/or intracellular compartments for biologically active substances such as small molecule drugs, proteins, and nucleic acids. Such compositions generally include one or more “cationic” and/or amino (ionizable) lipids, phospholipids including polyunsaturated lipids, structural lipids (*e.g.*, sterols), and/or lipids containing

polyethylene glycol (PEG lipids). Cationic and/or ionizable lipids include, for example, amine-containing lipids that can be readily protonated. Though a variety of such lipid-containing nanoparticle compositions have been demonstrated, improvements in safety, efficacy, and specificity are still lacking.

Summary of the Disclosure

[0006] The present disclosure provides novel compounds and compositions and methods involving the same.

[0007] Some aspects of the disclosure relate to a compound of Formula (I):



or a salt or isomer thereof, wherein:

R^1 is selected from the group consisting of C_{5-30} alkyl, C_{5-20} alkenyl, $-R^*YR''$, $-YR''$, and $-R''M^*R'$;

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is selected from the group consisting of hydrogen, a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, $-CQ(R)_2$, $-C(O)NQR$ and unsubstituted C_{1-6} alkyl, where Q is selected from a carbocycle, heterocycle, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-N(R)_2$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹² is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

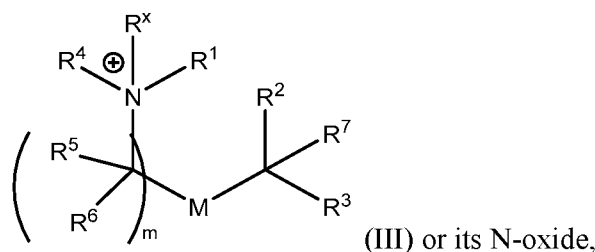
each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0008] Other aspects of the disclosure relate to a compound of Formula (III):



or a salt or isomer thereof, wherein

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)₆C(R¹²)₂(CH₂)_{n-6}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆

alkyl, where Q is selected from a carbocycle, heterocycle, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -N(R)₂, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, and -C(R)N(R)₂C(O)OR, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C₁₋₆ alkyl, C₂₋₆ alkenyl, -(CH₂)_vOH, and -(CH₂)_vN(R)₂,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹² is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

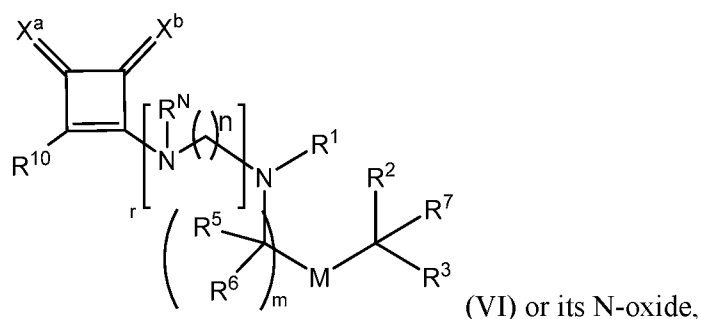
each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0009] Other aspects the disclosure relate to a compound of Formula (I), wherein R^4 is selected from the group consisting of $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, $-CQ(R)_2$, and $-C(O)NQR$, where Q is $-(CH_2)_nN(R)_2$.

[0010] Other aspects the disclosure relate to a compound of Formula (III), wherein R^4 is selected from the group consisting of $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, $-CQ(R)_2$, and $-C(O)NQR$, where Q is $-(CH_2)_nN(R)_2$.

[0011] Other aspects of the disclosure relate to a compound of Formula (VI):



or a salt or isomer thereof, wherein

R^1 is selected from the group consisting of C_{5-30} alkyl, C_{5-20} alkenyl, $-R^*YR''$, $-YR''$, and $-R''M'R'$;

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R is independently selected from the group consisting of H, C_{1-3} alkyl, and C_{2-3} alkenyl;

R^N is H, or C_{1-3} alkyl;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, and H;

each R'' is independently selected from the group consisting of C_{3-15} alkyl and

C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and

C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I;

X^a and X^b are each independently O or S;

R¹⁰ is selected from the group consisting of H, halo, -OH, R, -N(R)₂, -CN, -N₃, -C(O)OH, -C(O)OR, -OC(O)R, -OR, -SR, -S(O)R, -S(O)OR, -S(O)₂OR, -NO₂, -S(O)₂N(R)₂, -N(R)S(O)₂R, -NH(CH₂)_{t1}N(R)₂, -NH(CH₂)_{p1}O(CH₂)_{q1}N(R)₂, -NH(CH₂)_{s1}OR, -N((CH₂)_{s1}OR)₂, -N(R)-carbocycle, -N(R)-heterocycle, -N(R)-aryl, -N(R)-heteroaryl, -N(R)(CH₂)_{t1}-carbocycle, -N(R)(CH₂)_{t1}-heterocycle, -N(R)(CH₂)_{t1}-aryl, -N(R)(CH₂)_{t1}-heteroaryl, a carbocycle, a heterocycle, aryl and heteroaryl;

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13;

n is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10;

r is 0 or 1;

t¹ is selected from 1, 2, 3, 4, and 5;

p¹ is selected from 1, 2, 3, 4, and 5;

q¹ is selected from 1, 2, 3, 4, and 5; and

s¹ is selected from 1, 2, 3, 4, and 5.

[0012] In some aspects, the disclosure features a nanoparticle composition including a lipid component comprising a compound as described herein (e.g., a compound according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId)).

[0013] In some aspects, the disclosure features a pharmaceutical composition comprising a nanoparticle composition according to the preceding aspects and a pharmaceutically acceptable carrier. For example, the pharmaceutical composition is refrigerated or frozen for storage and/or shipment (e.g., being stored at a temperature of 4 °C or lower, such as a temperature between about -150 °C and about 0 °C or between about -80 °C and about -20 °C (e.g., about -5 °C, -10 °C, -15 °C, -20 °C, -25 °C, -30 °C, -40 °C, -50 °C, -60 °C, -70 °C, -80 °C, -90 °C, -130 °C or -150 °C). For example, the pharmaceutical composition is a solution that is refrigerated for storage and/or shipment at, for example, about -20° C, -30 °C, -40 °C, -50 °C, -60 °C, -70 °C, or -80 °C.

[0014] In some aspects, the disclosure provides a method of delivering a therapeutic and/or prophylactic (e.g., an mRNA) to a cell (e.g., a mammalian cell). This method includes the step

[0017] In some aspects, the disclosure provides a nanoparticle composition for use in the treatment of a disease or disorder in a mammal (*e.g.*, a human) in need thereof. The nanoparticle composition includes (i) a lipid component including a phospholipid (such as a polyunsaturated lipid), a PEG lipid, a structural lipid, and a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIIb-1), (VIIIb-2), (VIIIb-3), (VIIc), (VIId), (VIIIc), (VIIIc), or (VIIId) and (ii) a therapeutic and/or prophylactic (*e.g.*, an mRNA). In some embodiments, the disease or disorder is characterized by

dysfunctional or aberrant protein or polypeptide activity. For example, the disease or disorder is selected from the group consisting of rare diseases, infectious diseases, cancer and proliferative diseases, genetic diseases (*e.g.*, cystic fibrosis), autoimmune diseases, diabetes, neurodegenerative diseases, cardio- and reno-vascular diseases, and metabolic diseases.

[0018] In some aspects, the disclosure provides a nanoparticle composition for use in the manufacture of a medicament for the treatment of a disease or disorder in a mammal (*e.g.*, a human) in need thereof. The nanoparticle composition includes (i) a lipid component including a phospholipid (such as a polyunsaturated lipid), a PEG lipid, a structural lipid, and a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId) and (ii) a therapeutic and/or prophylactic (*e.g.*, an mRNA). In some embodiments, the disease or disorder is characterized by dysfunctional or aberrant protein or polypeptide activity. For example, the disease or disorder is selected from the group consisting of rare diseases, infectious diseases, cancer and proliferative diseases, genetic diseases (*e.g.*, cystic fibrosis), autoimmune diseases, diabetes, neurodegenerative diseases, cardio- and reno-vascular diseases, and metabolic diseases.

[0019] In some aspects, the disclosure provides the use of a nanoparticle composition in the manufacture of a medicament for the treatment a disease or disorder in a mammal (*e.g.*, a human) in need thereof. The nanoparticle composition includes (i) a lipid component including a phospholipid (such as a polyunsaturated lipid), a PEG lipid, a structural lipid, and a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId) and (ii) a therapeutic and/or prophylactic (*e.g.*, an mRNA). In some embodiments, the disease or disorder is characterized by dysfunctional or aberrant protein or polypeptide activity. For example, the disease or disorder is selected from the group consisting of rare diseases, infectious diseases, cancer and proliferative diseases, genetic diseases (*e.g.*, cystic fibrosis), autoimmune diseases, diabetes, neurodegenerative diseases, cardio- and reno-vascular diseases, and metabolic diseases.

[0020] In some aspects, the disclosure provides a method of delivering (*e.g.*, specifically delivering) a therapeutic and/or prophylactic to a mammalian organ (*e.g.*, a liver, spleen, lung, or femur). This method includes the step of administering to a subject (*e.g.*, a mammal) a nanoparticle composition including (i) a lipid component including a phospholipid, a PEG lipid, a structural lipid, and a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3),

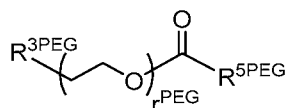
(VIIc), (VIId), (VIIIc), or (VIId) and (ii) a therapeutic and/or prophylactic (*e.g.*, an mRNA), in which administering involves contacting the cell with the nanoparticle composition, whereby the therapeutic and/or prophylactic is delivered to the target organ (*e.g.*, a liver, spleen, lung, or femur).

[0021] In some aspects, the disclosure features a method for the enhanced delivery of a therapeutic and/or prophylactic (*e.g.*, an mRNA) to a target tissue (*e.g.*, a liver, spleen, lung, or femur). This method includes administering to a subject (*e.g.*, a mammal) a nanoparticle composition, the composition including (i) a lipid component including a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId), a phospholipid, a structural lipid, and a PEG lipid; and (ii) a therapeutic and/or prophylactic, the administering including contacting the target tissue with the nanoparticle composition, whereby the therapeutic and/or prophylactic is delivered to the target tissue.

[0022] In some aspects, the disclosure features a method of lowering immunogenicity comprising introducing the nanoparticle composition of the disclosure into cells, wherein the nanoparticle composition reduces the induction of the cellular immune response of the cells to the nanoparticle composition, as compared to the induction of the cellular immune response in cells induced by a reference composition which comprises a reference lipid instead of a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId). For example, the cellular immune response is an innate immune response, an adaptive immune response, or both.

[0023] The disclosure also includes methods of synthesizing a compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId) and methods of making a nanoparticle composition including a lipid component comprising the compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId).

[0024] In certain embodiments, a PEG lipid may be of Formula (V):



(V), or a salt or isomer thereof, wherein:

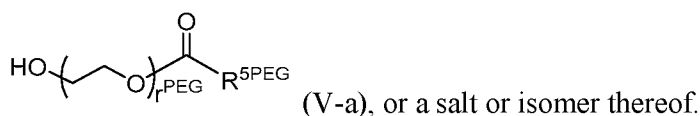
R^{3PEG} is $-OR^O$;

R^O is hydrogen, C_{1-6} alkyl or an oxygen protecting group;

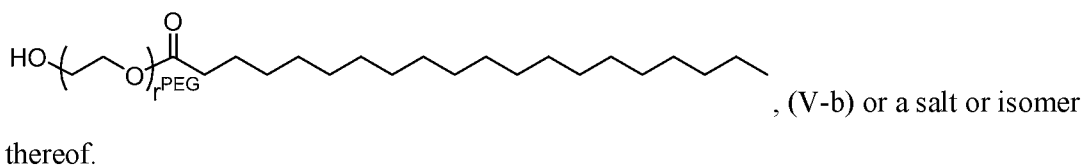
r^{PEG} is an integer between 1 and 100;

$R^{5\text{PEG}}$ is C_{10-40} alkyl, C_{10-40} alkenyl, or C_{10-40} alkynyl; and optionally one or more methylene groups of $R^{5\text{PEG}}$ are independently replaced with C_{3-10} carbocyclene, 4 to 10 membered heterocyclene, C_{6-10} arylene, 4 to 10 membered heteroarylene, $-N(R^{\text{NPEG}})-$, $-O-$, $-S-$, $-C(O)-$, $-C(O)N(R^{\text{NPEG}})-$, $-NR^{\text{NPEG}}C(O)-$, $-NR^{\text{NPEG}}C(O)N(R^{\text{NPEG}})-$, $-C(O)O-$, $-OC(O)-$, $-OC(O)O-$, $-OC(O)N(R^{\text{NPEG}})-$, $-NR^{\text{NPEG}}C(O)O-$, $-C(O)S-$, $-SC(O)-$, $-C(=NR^{\text{NPEG}})-$, $-C(=NR^{\text{NPEG}})N(R^{\text{NPEG}})-$, $-NR^{\text{NPEG}}C(=NR^{\text{NPEG}})-$, $-NR^{\text{NPEG}}C(=NR^{\text{NPEG}})N(R^{\text{NPEG}})-$, $-C(S)-$, $-C(S)N(R^{\text{NPEG}})-$, $-NR^{\text{NPEG}}C(S)-$, $-NR^{\text{NPEG}}C(S)N(R^{\text{NPEG}})-$, $-S(O)-$, $-OS(O)-$, $-S(O)O-$, $-OS(O)O-$, $-OS(O)_2-$, $-S(O)_2O-$, $-OS(O)_2O-$, $-N(R^{\text{NPEG}})S(O)-$, $-S(O)N(R^{\text{NPEG}})-$, $-N(R^{\text{NPEG}})S(O)N(R^{\text{NPEG}})-$, $-OS(O)N(R^{\text{NPEG}})-$, $-N(R^{\text{NPEG}})S(O)O-$, $-S(O)_2-$, $-N(R^{\text{NPEG}})S(O)_2-$, $-S(O)_2N(R^{\text{NPEG}})-$, $-N(R^{\text{NPEG}})S(O)_2N(R^{\text{NPEG}})-$, $-OS(O)_2N(R^{\text{NPEG}})-$, or $-N(R^{\text{NPEG}})S(O)_2O-$; and each instance of R^{NPEG} is independently hydrogen, C_{1-6} alkyl, or a nitrogen protecting group.

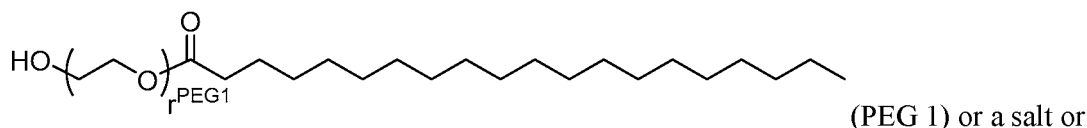
[0025] In certain embodiments, the compound of Formula (V) is of Formula (V-a):



[0026] In certain embodiments, a compound of Formula (V) is of Formula (V-b):

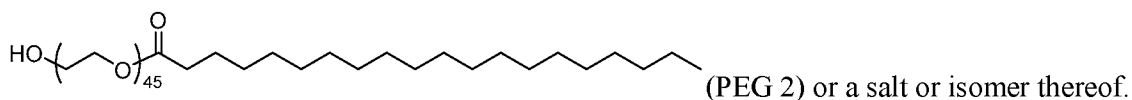


[0027] In certain embodiments, the compound of Formula (V-b) is a compound having the formula:



isomer thereof, wherein r^{PEG1} is an integer between 40 and 50.

[0028] In certain embodiments, the compound of Formula (V-b) is a compound having the formula:



Brief Description of the Drawings

[0029] Figure 1 shows the results of pretreating non-human primates with methotrexate or dexamethasone prior to administration of a nanoparticle composition including MC3.

[0030] Figure 2 shows the hEPO mRNA expression measured after intravenous administration of various nanoparticle compositions at a 0.01 mpk dose with 60 minutes infusion to naive cynomolgus monkeys.

[0031] Figure 3 shows the results of hEPO expression measured upon intravenous administration of a nanoparticle composition including Compound 26 to rats at various doses.

[0032] Figure 4 shows the results of hEPO expression measured upon intravenous administration of a nanoparticle composition including Compound 18 to rats at various doses.

[0033] Figure 5 shows the results of hEPO expression measured upon intravenous administration of a nanoparticle composition including Compound 25 to rats at various doses.

[0034] Figure 6 shows the results of hEPO expression measured upon intravenous administration of a nanoparticle composition including MC3 to rats at various doses.

[0035] Figure 7 shows the area under the curve (AUC) for nanoparticle compositions including Compounds 18, 25, and 26 and MC3 at various doses between 0.005 mpk and 2 mpk.

[0036] Figure 8 shows the results of luciferase expression measured upon intramuscular administration of various nanoparticle compositions including MC3, Compounds 168-170, and 173-175 to mice at 0.01 mpk at various time points: 3 hr (left block), 6 hr (middle block) and 24 hr (right block). The numbers 1-7 in this figure correspond to MC3, Compounds 168-170, and 173-175 respectively.

[0037] Figure 9 shows the results of hEPO expression measured upon intramuscular administration of various nanoparticle compositions including MC3, Compounds 18, 25, 30, 108-112, 60, and 122 to mice at 0.01 mpk at various time points: 3 hr (left block), 6 hr (middle block) and 24 hr (right block). The numbers 1-11 in this figure correspond to MC3, Compounds 18, 25, 30, 108-112, 60, and 122 respectively.

[0038] Figure 10 shows the results of luciferase expression (total flux) measured upon intravenous administration of various nanoparticle compositions including MC3 or various compounds disclosed herein. The numbers 1-12 in this figure correspond to Compound 18, MC3, Compounds 48-50, 54, 111, 60, 75, 68, 66, 128, 65, 130, 133-135, 147, 96, and 151 respectively.

[0039] Figures 11A and 11B show the results of anti-HA (anti-hemagglutinin) antibody expression measured after intravenous administration of various nanoparticle compositions including MC3 and Compound 18 at a 0.1 mpk (Figure 11A) or 0.3 mpk (Figure 11B) dose with 60 minutes infusion to naive cynomolgus monkeys.

[0040] Figures 12A-12C are a series of graphs summarizing luciferase expression levels at (Figure 12A) 3h, (Figure 12B) 6h and (Figure 12C) 24h after intravenous administration of

nanoparticle compositions containing compounds of the disclosure to mice. Total light flux values were acquired via body luminescent imaging (BLI). In the Figures, the numbers 1-14 refer to the compositions containing Compounds 160, 98, 161-165, 171, 172, 183-186, and MC3 respectively.

[0041] Figures 13A-13C are a series of graphs summarizing luciferase expression levels at (Figure 13A) 3h, (Figure 13B) 6h, and (Figure 13C) 24h after intravenous administration of nanoparticle compositions containing compounds of the disclosure to mice. Total light flux values were acquired via body luminescent imaging (BLI). PBS (phosphate buffered saline) was used as a control. The results are presented on a logarithmic scale. In these Figures, the numbers 1-15 refer to the compositions containing MC3, Compounds 18, 111, 168-170, 174, 175, 178, 179, 181, 182, 218, 198, and PBS respectively.

[0042] Figures 14A-14C are a series of graphs summarizing luciferase expression levels in (Figure 14A) liver (Figure 14B) spleen, and (Figure 14C) kidney, *ex vivo*, 6h after intravenous administration of nanoparticle compositions containing compounds of the disclosure to mice. Total light flux values were acquired via body luminescent imaging (BLI). PBS (phosphate buffered saline) was used as a control. In these Figures, the numbers 1-15 refer to the compositions containing MC3, Compounds 18, 111, 168-170, 174, 175, 178, 179, 181, 182, 218, 198, and PBS respectively.

[0043] Figures 15A and 15B are a pair of graphs showing activated B-cell frequencies in the spleens of CD-1 mice dosed with compounds of the disclosure, compared to MC3, and compared to mice not having received any treatment (naïve test subject). PBS is used as control. Figure 15A shows the percentage of CD19+ cells. Figure 15B shows the percentage of CD19+ CD69+ CD86+ cells. Numbers 1-16 refer to compositions containing an mRNA expressing luciferase the following: 1: MC3, 2: Compound 18, 3: Compound 111; 4: Compound 168; 5: Compound 169; 6: Compound 170; 7: Compound 174; 8: Compound 175; 9: Compound 178; 10: Compound 179; 11: Compound 181; 12: Compound 182; 13: Compound 218; 14: Compound 198; 15: PBS; 16: treatment naïve subject.

[0044] Figures 16A and 16B are a pair of graphs showing activated B-cell frequencies in the spleens of CD-1 mice dosed with compounds of the disclosure, compared to MC3, and compared to mice not having received any treatment (naïve test subject). PBS is used as control. Figure 16A shows the percentage of CD19+ cells. Figure 16B shows the percentage of CD19+ CD69+ CD86+ cells. Numbers 1-14 refer to compositions containing an mRNA expressing luciferase and the following: 1: Compound 147, 2: Compound 184, 3: Compound 232; 4: Compound 189; 5: Compound 200; 6: Compound 233; 7: Compound 234; 8: Compound 235; 9:

Compound 237; 10: Compound 239; 11: Compound 243; 12: MC3; 13: PBS; 14: treatment naïve subject.

[0045] Figure 17 is a graph showing the hEPO mRNA expression in CD1-mice measured 3h (left block), 6h (middle block) and 24h (right block) after intravenous administration of various nanoparticle compositions. Numbers 1-13 refer to compositions containing an mRNA expressing hEPO and the following: 1: Compound 147, 2: Compound 184, 3: Compound 232; 4: Compound 189; 5: Compound 200; 6: Compound 233; 7: Compound 234; 8: Compound 235; 9: Compound 237; 10: Compound 239; 11: Compound 243; 12: MC3; 13: PBS.

[0046] Figures 18A and 18B show the results of luciferase expression measured upon intramuscular administration of various nanoparticle compositions to CD-1 mice at 0.01 mpk. Figure 18A is a bar graph showing total flux at 6 hr after administration. The numbers above each bar indicate the expression ratio relative to MC3. Figure 18B shows the total flux at 3h, 6h, and 24h after administration. Numbers 1-11 in the Figures refer to compositions containing the following: 1: MC3, 2: Compound 143, 3: Compound 49; 4: Compound 113; 5: Compound 61; 6: Compound 72; 7: Compound 75; 8: Compound 71; 9: Compound 128; 10: Compound 156; 11: Compound 157.

[0047] Figures 19A and 19B show the results of luciferase expression measured upon subcutaneous administration of various nanoparticle compositions to CD-1 mice at 0.05 mpk. Figure 19A is a bar graph showing total flux at 6 hr after administration. The numbers above each bar indicate the expression ratio relative to MC3. Figure 19B shows the total flux at 3h, 6h, and 24h after administration. Numbers 1-12 in the Figures refer to compositions containing the following: 1: PBS, 2: MC3, 3: Compound 25; 4: Compound 30; 5: Compound 20; 6: Compound 110; 7: Compound 112; 8: Compound 113; 9: Compound 72; 10: Compound 75; 11: Compound 122, 12: Compound 24.

[0048] Figures 20A-20C are a series of graphs summarizing luciferase expression levels in (Figure 20A) spleen (Figure 20B) liver, and (Figure 20C) at the injection site, *ex vivo*, 24h after administration of nanoparticle compositions containing compounds of the disclosure to CD-1 mice. Total light flux values were acquired via body luminescent imaging (BLI). PBS (phosphate buffered saline) was used as a control. Numbers 1-12 in the Figures refer to compositions containing the following: 1: PBS, 2: MC3, 3: Compound 25; 4: Compound 30; 5: Compound 20; 6: Compound 110; 7: Compound 112; 8: Compound 113; 9: Compound 72; 10: Compound 75; 11: Compound 122, 12: Compound 24.

[0049] Figures 21A-21J are a series of graphs illustrating the cytokine expression induced by compositions comprising lipids of the disclosure. Figure 21A: G-CSF (12); Figure 21B: IFN-

gamma (38); Figure 21C: MCP-1 (51); Figure 21D: IFN-alpha (30); Figure 21E: IL-6 (28); Figure 21F: IL-12p70 (39); Figure 21G: IL-10 (22); Figure 21H: MIP-1 beta (72); Figure 21I: TNF-alpha (45); Figure 21J: RANTES (44). Numbers 1-12 in the Figures refer to compositions containing the following: 1: PBS, 2: MC3, 3: Compound 25; 4: Compound 30; 5: Compound 20; 6: Compound 110; 7: Compound 112; 8: Compound 113; 9: Compound 72; 10: Compound 75; 11: Compound 122, 12: Compound 24.

[0050] Figures 22A-22C are a series of graphs summarizing luciferase expression levels at (Figure 22A) 3h, (Figure 22B) 6h, and (Figure 22C) 24h after subcutaneous administration of nanoparticle compositions containing compounds of the disclosure to mice. Total light flux values were acquired via body luminescent imaging (BLI). PBS (phosphate buffered saline) was used as a control. Numbers 1-12 in the Figures refer to compositions containing the following: 1: PBS, 2: MC3, 3: Compound 168; 4: Compound 23; 5: Compound 19; 6: Compound 108; 7: Compound 109; 8: Compound 111; 9: Compound 60; 10: Compound 61; 11: Compound 69, 12: Compound 128.

[0051] Figure 23 shows the results of hEPO expression measured upon subcutaneous administration of various nanoparticle compositions including compounds of the disclosure to mice at 0.05 mpk at various time points: 3 hr (left block), 6 hr (middle block) and 24 hr (right block). The numbers 1-11 in this figure correspond to MC3, PBS, and Compounds 18, 25, 48, 49, 111, 60, 168, 207, and 233, respectively.

[0052] Figure 24 shows the results of luciferase expression measured upon intramuscular administration of various nanoparticle compositions including compounds of the disclosure to mice at 0.01 mpk at various time points: 3 hr (left block), 6 hr (middle block) and 24 hr (right block). The numbers 1-9 in this figure correspond to MC3, and Compounds 178, 181, 182, 218, 198, 200, 233, and 239, respectively.

[0053] Figure 25 shows the results of hEPO expression measured upon intravenous administration of nanoparticle compositions containing Compound 18, or MC3, and modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine or wherein each uridine was replaced with 5-methoxy uridine, to CD-1 mice at 0.5 mpk at 3h, 6h, and 24h after administration. The numbers 1-4 in the Figure refer to compositions containing the following: 1: A modified mRNAs wherein each uridine was replaced with 5-methoxy uridine, and MC3; 2: A modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine, and MC3; 3: A modified mRNAs wherein each uridine was replaced with 5-methoxy uridine, and Compound 18; 4: A modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine, and Compound 18.

[0054] Figure 26 is a graph showing B-cell activation in mouse splenocytes dosed with nanoparticle compositions containing Compound 18, or MC3, and modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine or wherein each uridine was replaced with 5-methoxy uridine. PBS is used as control. The numbers 1-5 in the Figure refer to compositions containing the following: 1: A modified mRNAs wherein each uridine was replaced with 5-methoxy uridine, and MC3; 2: A modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine, and MC3; 3: A modified mRNAs wherein each uridine was replaced with 5-methoxy uridine, and Compound 18; 4: A modified mRNAs wherein each uridine was replaced with N1-methyl pseudouridine, and Compound 18; 5: PBS.

[0055] Figure 27 is a graph showing the hEPO mRNA expression in CD1-mice measured 3h (left block), 6h (middle block) and 24h (right block) after subcutaneous administration of various nanoparticle compositions at 0.5 mpk. Numbers 1-9 refer to compositions containing an mRNA expressing hEPO and the following: 1: PBS, 2: Compound 18, 3: Compound 30; 4: Compound 96; 5: Compound 151; 6: Compound 98; 7: Compound 163; 8: Compound 164; 9: Compound 165.

[0056] Figures 28A-28J are a series of graphs illustrating the cytokine expression induced by compositions comprising lipids of the disclosure and a modified mRNA expressing hEPO, wherein each uridine was replaced with N1-methyl pseudouridine, measured 6h after subcutaneous administration to CD-1 mice. Figure 28A: G-CSF; Figure 28B: IFN-gamma; Figure 28C: IFN-alpha; Figure 28D: IL-12p70; Figure 28E: IP-10; F: IL-6; Figure 28G: MCP-1; Figure 28H: MIP-1beta; Figure 28I: RANTES; Figure 28J: TNF-alpha. Numbers 1-9 in the Figure refer to compositions containing the following: 1: PBS, 2: Compound 18, 3: Compound 30; 4: Compound 96; 5: Compound 151; 6: Compound 98; 7: Compound 163; 8: Compound 164; 9: Compound 165

[0057] Figures 29A – 29C are a series of graphs illustrating the optimization of the efficiency and clearance of amino lipids. Figure 29A is a whole body luciferase bioluminescence of novel LNPs versus MC3 LNPs, measured in CD-1 mice (n = 6), 6h after intravenous administration of a 0.5 mg/kg hEPO mRNA in lipid. The graph shows the serum hEPO concentrations; error bars indicate standard deviation of the ratio of novel lipid expression versus MC3 expression. * p < 0.05, ** p < 0.01, ***p < 0.001, n.s. = not statistically significant. Numbers 1-9 refer to compositions containing: 1: Compound 281; 2: Compound 138; 3: Compound 136; 4: Compound 6; 5: Compound 18; 6: Compound 29; 7: Compound 14; 8: Compound 25; and 9: Compound 26. Figure 29B summarizes the levels of compound 18 and compound 25, compared to MC3, measured in liver tissue from Sprague Dawley rats (n = 3 per

time point) administered with a 0.2 mg/kg dose of an LNP containing hEPO mRNA. $p < 0.05$ for Compound 18 and Compound 25 AUC relative to MC3. Figure 29C is a graph showing hEPO expression in Sprague Dawley rats. The hEPO serum concentrations were measured following intravenous administration of a 1 mg/kg dose of an LNP containing compound 18, compound 25, compound 26 or MC3, and a hEPO mRNA ($n=3$).

[0058] Figures 30A-30C are a series of graphs showing the pharmacokinetic and expression profile of Compound 18 after multiple doses. Figure 30A is a comparison of the tissue distribution of MC3 and Compound 18 after intravenous administration of three bolus doses containing 0.05 mg/kg mRNA to CD-1 mice ($n = 3$ per timepoint), dosed weekly. Figure 30B shows the hEPO serum concentration 6 h after intravenous administration of bolus doses containing 0.5 mg/kg of an LNP containing hEPO mRNA to CD-1 mice ($n = 8$), weekly dosing. Figure 30C illustrates liver tissue clearance of compound 18 and its primary metabolite, compound 166, after administration of doses containing 0.25 mg/kg of mRNA, to CD-1 mice ($n = 3$ per timepoint), weekly dosing.

[0059] Figures 31A-31C are a series of graphs illustrating the expression profile for lipid nanoparticles of the disclosure in a cynomolgus monkey study. Figure 31A illustrates hEPO serum concentrations after delivery of 0.01 mg/kg hEPO mRNA in MC3 or Compound 18. The lipid nanoparticles were administered intravenously, via a 60 min. infusion ($n = 3$). $p < 0.05$ for Compound 18 AUC relative to MC3. Figure 31B shows Human IgG influenza A antibody serum concentrations after delivery of 0.3 mg/kg antibody mRNA in MC3 or Compound 18 LNPs, administered intravenously, via a 60 min. infusion ($n = 3$), $p < 0.05$ for Compound 18 AUC relative to MC3. Figure 31C shows hEPO serum concentrations after delivery of 0.2 mg/kg hEPO mRNA in Compound 18 LNPs, weekly dosing, administered intravenously, via a 60 min. infusion ($n=4$).

[0060] Figures 32A-32C are a series of graphs summarizing the results of a one month toxicology evaluation in rat and non-human primate. PBS (phosphate buffered saline) was used as a control. Figure 32A shows the serum alanine aminotransferase levels in a Sprague Dawley rat, administered intravenously via a 10 min. infusion, dosed weekly for 5 weeks. The serum levels were measured 24 h post fifth dose ($n = 10$) No statistical difference between PBS and each dose level was observed. Figure 32B shows the serum aspartate aminotransferase levels in a Sprague Dawley rat, administered intravenously via a 10 min. infusion, dosed weekly for 5 weeks. The serum levels were measured 24 h post fifth dose ($n = 10$). * $p < 0.05$, no statistical difference between PBS and 0.05 and 2.0 mg/kg dose. Figure 32C shows the serum alanine aminotransferase levels in cynomolgus monkeys, administered with 1 mg/kg mRNA,

intravenously by 60 min infusion, dosed weekly. The serum levels were measured 24 post fifth dose (n = 4). No statistical difference between PBS pre-dose and day 30 levels with Compound 18 was observed. Figure 32D shows the serum aspartate aminotransferase levels in cynomolgus monkeys, administered with 1 mg/kg mRNA, intravenously by 60 min infusion, dosed weekly. The serum levels were measured 24 post fifth dose (n = 4). No statistical difference between PBS pre-dose and day 30 levels with Compound 18 was observed.

[0061] Figures 33A and 33B are a pair of graphs summarizing the results of a one month toxicology evaluation in rats and non-human primates. Figure 33A shows the C5b9 serum concentration in cynomolgus monkeys administered with 1 mg/kg mRNA, on day 1 and day 29 (n = 4). No statistical difference was observed between PBS and Compound 18 at all timepoints. Figure 33B shows the MCP-1 serum concentration in cynomolgus monkeys administered with 1 mg/kg mRNA, on day 1 and day 29. n = 4, * p < 0.05, no statistical difference between PBS and Compound 18 at any other timepoint.

[0062] Figures 34A-34C are a series of fixed cell images of the endosomal escape efficiency of lipid nanoparticles of the disclosure. HeLa cells were transfected with Rhodamine labeled MC3 and Compound 18 LNPs encapsulating Luciferase mRNA, and processed for single molecule FISH (smFISH, red) after 4 h incubation, alongside cells electroporated with unformulated mRNA. The mRNA molecules that egressed the endocytic organelles into the cytosol are shown in green (image analysis overlay). Endosomal escape efficiency was evaluated by computing the ratio between the number of cytosolic mRNA and the number of internalized LNPs per cell. Figure 34A is an image showing the electroporated HeLa cells. Figure 34B is an image showing MC3 treated HeLa cells. Figure 34C is an image showing Compound 18 treated HeLa cells.

[0063] Figures 35A and 35B are a pair of graphs comparing the tissue distribution of MC3 and compound 18. Figure 35A shows the tissue distribution of MC3 and compound 18 after three intravenous 0.05 mg/kg of mRNA administered to CD-1 mice (n = 3 per timepoint). Figure 35B shows the tissue distribution of MC3 and compound 18, 12 h after administration of 0.2 mg/kg mRNA to cynomolgus monkeys (n = 2).

[0064] Figure 36 is a graph illustrating Human IgG expression in a cynomolgus monkey administered with 0.1 mg/kg human IgG mRNA in a composition comprising MC3 or compound 18, intravenously via a 60 min. infusion (n = 3).

[0065] Figure 37 is a series of graphs illustrating MC3 single cell necrosis in rat liver and liver enzyme. The top row is a pair of images of livers of rats administered with 0.3 mg/kg of a liquid nanoparticle (LNP) not containing an mRNA (right) and PBS (phosphate buffered saline)

as a control (left). The bottom row is a pair of graphs showing expression of ALT (left) and AST(right) in the liver following administration of a 0.3 mg/kg of a MC3-based LNP containing an mRNA. ALT and AST were elevated and pathology showed evidence of necrosis.

[0066] Figure 38 is a graph showing mRNA levels in NHP after repeat dosing over the course of 29 days.

[0067] Figures 39A and 39B are a pair of graphs showing hEPO expression in ApoE knockout mice and LDLr knockout mice administered with compound 18 based LNPs. Figure 39A shows hEPO expression in ApoE knockout mice. Figure 39B shows hEPO expression in LDLr knockout mice

[0068] Figures 40A-40C are a series of graphs summarizing luciferase expression levels measured over the whole body (Figure 40A), in the liver (Figure 40B), and in the spleen (Figure 40C) of CD-1 mice, *ex vivo*, 6h after intravenous administration of 0.5mg/kg NPI-Luc mRNA in nanoparticle compositions containing DSPC, PEG 1, and lipids of the disclosure. Total light flux values were acquired via body luminescent imaging (BLI). PBS was used as a control. In these Figures, the numbers 1-4 refer to PBS and compositions containing Compound 18, Compound 50, and Compound 301, respectively.

[0069] Figure 41 shows a series of V5-tagged immunohistochemistry stains of livers of mice dosed with compositions of the disclosure. PBS was used as a control.

[0070] Figure 42 shows a series of V5-tagged immunohistochemistry stains of spleens of mice dosed with compositions of the disclosure. PBS was used as a control.

[0071] Figures 43A and 43B are a pair of graphs comparing the luciferase expression in livers (Figure 43A) and spleens (Figure 43B) of CD-1 mice following administration of 0.5mg/kg NPI-Luc mRNA in nanoparticle compositions containing DSPC, PEG 1, and lipids of the disclosure. PBS was used as a control. In these Figures, the numbers 1-4 refer to PBS and compositions containing Compound 18, Compound 50, and Compound 301, respectively.

[0072] Figure 44 is a graph illustrating hEPO expression in mice following administration of an mRNA expressing hEPO in nanoparticle compositions containing DSPC, PEG 1, and lipids of the disclosure.

[0073] Figures 45A and 45B are a pair of graphs illustrating pharmacokinetics of lipids of the disclosure in mice. Mice were administered compositions comprising Compound 50 (Figure 45A) or Compound 301 (Figure 45B), in nanoparticle compositions containing DSPC and PEG 1.

[0074] Figure 46 is a graph showing IgG1 expression in Sprague Dawley® rats dosed with of lipids of the disclosure, 48 after administration (*i.v.* bolus). Rats were administered

compositions comprising an mRNA encoding a broadly neutralizing influenza antibody (5mg/kg), and lipids of the disclosure in DSPC and PEG 1. PBS was used as a control. In these Figures, the numbers 1-4 refer to PBS and compositions containing Compound 18, Compound 301 at an N:P ratio (i.e., molar ratio of lipid nitrogen to RNA phosphate) of 5.83, and Compound 301 at an N:P ratio of 3, respectively.

[0075] Figures 47A-47E are a series of graphs summarizing the expression of various toxicity biomarkers in rats following administration of compositions comprising an mRNA encoding a broadly neutralizing influenza antibody (5mg/kg), and lipids of the disclosure in DSPC and PEG 1. Figure 47A shows expression of aspartate aminotransferase (AST). Figure 47B shows expression of alanine aminotransferase (ALT). Figure 47C shows expression of monocyte chemoattractant protein-1 (MCP-1), 8h after administration. Figure 47D shows expression of neutrophils. Figure 47E shows expression of lymphocytes. PBS was used as a control. In these Figures, the numbers 1-4 refer to PBS and compositions containing Compound 18, Compound 301 at an N:P ratio (i.e., molar ratio of lipid nitrogen to RNA phosphate) of 5.83, and Compound 301 at an N:P ratio of 3, respectively.

Detailed Description

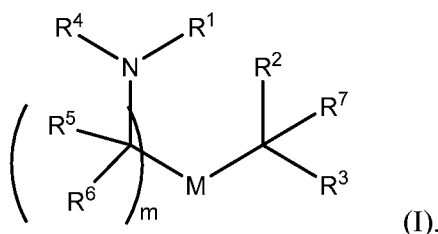
[0076] The disclosure relates to novel lipids and lipid nanoparticle compositions including a novel lipid. The disclosure also provides methods of delivering a therapeutic and/or prophylactic to a mammalian cell, specifically delivering a therapeutic and/or prophylactic to a mammalian organ, producing a polypeptide of interest in a mammalian cell, and treating a disease or disorder in a mammal in need thereof. For example, a method of producing a polypeptide of interest in a cell involves contacting a nanoparticle composition comprising an mRNA with a mammalian cell, whereby the mRNA may be translated to produce the polypeptide of interest. A method of delivering a therapeutic and/or prophylactic to a mammalian cell or organ may involve administration of a nanoparticle composition including the therapeutic and/or prophylactic to a subject, in which the administration involves contacting the cell or organ with the composition, whereby the therapeutic and/or prophylactic is delivered to the cell or organ.

Lipids

[0077] The present disclosure provides lipids including a central amine moiety and at least one biodegradable group. The lipids described herein may be advantageously used in lipid nanoparticle compositions for the delivery of therapeutic and/or prophylactics to mammalian cells or organs. For example, the lipids described herein have little or no immunogenicity. For

example, the lipid compound of any of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIE), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIIb-1), (VIIIb-2), (VIIIb-3), (VIIc), (VIId), (VIIf), or (VIIf) has a lower immunogenicity as compared to a reference lipid (*e.g.*, MC3, KC2, or DLinDMA). For example, a formulation comprising a lipid disclosed herein and a therapeutic or prophylactic agent has an increased therapeutic index as compared to a corresponding formulation which comprise a reference lipid (*e.g.*, MC3, KC2, or DLinDMA) and the same therapeutic or prophylactic agent.

[0078] In some aspects of the disclosure, the compounds described herein are of Formula (I):



or their N-oxides, or salts or isomers thereof, wherein:

R^1 is selected from the group consisting of C_{5-30} alkyl, C_{5-20} alkenyl, $-R^*YR''$, $-YR''$, and $-R''M^*R'$;

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is selected from the group consisting of hydrogen, a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{10})_2(CH_2)_{n-o}Q$, $-CHQR$, $-CQ(R)_2$, $-C(O)NQR$ and unsubstituted C_{1-6} alkyl, where Q is selected from a carbocycle, heterocycle, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-N(R)_2$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-,

-N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR-, -S(O)₂R-, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹⁰ is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

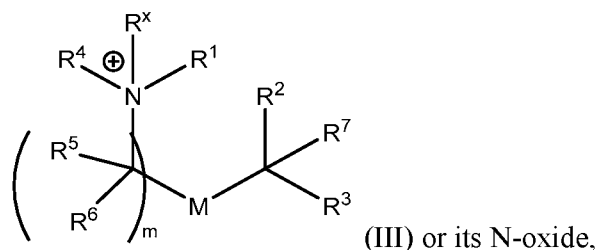
each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13; and wherein when R⁴ is -(CH₂)_nQ-, (CH₂)_nCHQR-, -CHQR-, or -CQ(R)₂-, then (i) Q is not -N(R)₂ when n is 1, 2, 3, 4 or 5, or (ii) Q is not 5, 6, or 7-membered heterocycloalkyl when n is 1 or 2.

[0079] Other aspects of the disclosure relate to a compound of Formula (III):



or a salt or isomer thereof, wherein

or a salt or isomer thereof, wherein

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is selected from the group consisting of hydrogen, a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_6C(R^{10})_2(CH_2)_{n-6}Q$, $-CHQR$, $-CQ(R)_2$, $-C(O)NQR$ and unsubstituted C_{1-6} alkyl, where Q is selected from a carbocycle, heterocycle, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-N(R)_2$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C_{1-6} alkyl, C_{2-6} alkenyl, $-(CH_2)_vOH$, and $-(CH_2)_vN(R)_2$,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')-$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

R^8 is selected from the group consisting of C_{3-6} carbocycle and heterocycle;

R^9 is selected from the group consisting of H, CN, NO_2 , C_{1-6} alkyl, $-OR$, $-S(O)_2R$, $-S(O)_2N(R)_2$, C_{2-6} alkenyl, C_{3-6} carbocycle and heterocycle;

R^{10} is selected from the group consisting of H, OH, C_{1-3} alkyl, and C_{2-3} alkenyl;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, $(CH_2)_qOR^*$, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, and H;

each R'' is independently selected from the group consisting of C_{3-15} alkyl and

C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and

C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0080] Other aspects the disclosure relate to a compound of Formula (I), wherein R⁴ is selected from the group consisting -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹²)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, and -C(O)NQR, where Q is -(CH₂)_nN(R)₂.

[0081] Other aspects the disclosure relate to a compound of Formula (III), wherein R⁴ is selected from the group consisting -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹²)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, and -C(O)NQR, where Q is -(CH₂)_nN(R)₂.

[0082] In some embodiments, a subset of compounds of Formula (I) includes those in which when R⁴ is -(CH₂)_nQ, -(CH₂)_nCHQR, -CHQR, or -CQ(R)₂, then (i) Q is not -N(R)₂ when n is 1, 2, 3, 4 or 5, or (ii) Q is not 5, 6, or 7-membered heterocycloalkyl when n is 1 or 2.

[0083] For example, when R⁴ is -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹⁰)₂(CH₂)_{n-o}Q, -CHQR, or -CQ(R)₂, then (i) Q is not -N(R)₂ when n is 1, 2, 3, 4 or 5, or (ii) Q is not 5, 6, or 7-membered heterocycloalkyl when n is 1 or 2.

[0084] In another embodiments, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R'';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹⁰)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a C₃₋₆ carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -CRN(R)₂C(O)OR, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, -(CH₂)_nN(R)₂, and a 5- to

14-membered heterocycloalkyl having one or more heteroatoms selected from N, O, and S which is substituted with one or more substituents selected from oxo (=O), OH, amino, mono- or di-alkylamino, and C₁₋₃ alkyl, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹⁰ is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0085] In yet another embodiments, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is selected from the group consisting of hydrogen, a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_6C(R^{10})_2(CH_2)_{n-6}Q$, $-CHQR$, $-CQ(R)_2$, $-C(O)NQR$ and unsubstituted C_{1-6} alkyl, where Q is selected from a C_{3-6} carbocycle, a 5- to 14-membered heterocycle having one or more heteroatoms selected from N, O, and S, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-CRN(R)_2C(O)OR$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(=NR^9)N(R)_2$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5; and when Q is a 5- to 14-membered heterocycle and (i) R^4 is $-(CH_2)_nQ$ in which n is 1 or 2, or (ii) R^4 is $-(CH_2)_nCHQR$ in which n is 1, or (iii) R^4 is $-CHQR$, and $-CQ(R)_2$, then Q is either a 5- to 14-membered heteroaryl or 8- to 14-membered heterocycloalkyl;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')-$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

R^8 is selected from the group consisting of C_{3-6} carbocycle and heterocycle;

R^9 is selected from the group consisting of H, CN, NO_2 , C_{1-6} alkyl, $-OR$, $-S(O)_2R$, $-S(O)_2N(R)_2$, C_{2-6} alkenyl, C_{3-6} carbocycle and heterocycle;

R^{10} is selected from the group consisting of H, OH, C_{1-3} alkyl, and C_{2-3} alkenyl;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, $(CH_2)_qOR^*$, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0086] In still another embodiments, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹⁰)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a C₃₋₆ carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -CRN(R)₂C(O)OR, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, -(CH₂)_nN(R)₂, each o is independently selected from 1, 2, 3, and 4, and -C(=NR⁹)N(R)₂, and each n is independently selected from 1, 2, 3, 4, and 5;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹⁰ is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl,

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0087] In still another embodiments, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)₆C(R¹⁰)₂(CH₂)_{n-6}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a carbocycle, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, -(CH₂)_nN(R)₂ and -C(R)N(R)₂C(O)OR, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR-, -S(O)₂R-, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹⁰ is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0088] In yet another embodiments, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₂₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is -(CH₂)_nQ or -(CH₂)_nCHQR, where Q is -N(R)₂, and n is selected from 3, 4, and 5;

each R⁵ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₁₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0089] In still another embodiment, another subset of compounds of Formula (I) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of -(CH₂)_nQ, -(CH₂)_nCHQR, -CHQR, and -CQ(R)₂, where Q is -N(R)₂, and n is selected from 1, 2, 3, 4, and 5;

each R⁵ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, and H;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, and H;

each R'' is independently selected from the group consisting of C_{3-15} alkyl and C_{3-15} alkenyl;

each R^* is independently selected from the group consisting of C_{1-12} alkyl and C_{1-12} alkenyl;

each Y is independently a C_{3-6} carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

In still another embodiment, another subset of compounds of Formula (I) includes those in which

R^1 is selected from the group consisting of C_{5-30} alkyl, C_{5-20} alkenyl, $-R^*YR''$, $-YR''$, and $-R''M'R'$;

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is $-C(O)NQR$, where Q is selected from a carbocycle, heterocycle, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-(CH_2)_nN(R)_2$, $-C(=NR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, and $-C(R)N(R)_2C(O)OR$, and each n is independently selected from 1, 2, 3, 4, and 5;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

R^9 is selected from the group consisting of H, CN, NO_2 , C_{1-6} alkyl, $-OR$, $-S(O)_2R$, $-S(O)_2N(R)_2$, C_{2-6} alkenyl, C_{3-6} carbocycle and heterocycle;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', (CH₂)_qOR*, and H, and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0090] In some embodiments, a subset of compounds of Formula (III) includes those in which, when R⁴ is -(CH₂)_nQ, -(CH₂)_nCHQR, -CHQR, or -CQ(R)₂, then (i) Q is not -N(R)₂ when n is 1, 2, 3, 4 or 5, or (ii) Q is not 5, 6, or 7-membered heterocycloalkyl when n is 1 or 2.

[0091] In another embodiments, another subset of compounds of Formula (III) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹⁰)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a C₃₋₆ carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -CRN(R)₂C(O)OR, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, -(CH₂)_nN(R)₂ and a 5- to 14-membered heterocycloalkyl having one or more heteroatoms selected from N, O, and S which is substituted with one or more substituents selected from oxo (=O), OH, amino, mono- or di-alkylamino, and C₁₋₃ alkyl, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C₁₋₆ alkyl, C₂₋₆ alkenyl, -(CH₂)_vOH, and -(CH₂)_vN(R)₂,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹⁰ is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0092] In yet another embodiments, another subset of compounds of Formula (III) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is selected from the group consisting of hydrogen, a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_6C(R^{12})_2(CH_2)_{n-6}Q$, $-CHQR$, $-CQ(R)_2$, $-C(O)NQR$ and unsubstituted C_{1-6} alkyl, where Q is selected from a C_{3-6} carbocycle, a 5- to 14-membered heterocycle having one or more heteroatoms selected from N, O, and S, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-CRN(R)_2C(O)OR$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(=NR^9)N(R)_2$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5; and when Q is a 5- to 14-membered heterocycle and (i) R^4 is $-(CH_2)_nQ$ in which n is 1 or 2, or (ii) R^4 is $-(CH_2)_nCHQR$ in which n is 1, or (iii) R^4 is $-CHQR$, and $-CQ(R)_2$, then Q is either a 5- to 14-membered heteroaryl or 8- to 14-membered heterocycloalkyl;

R^x is selected from the group consisting of C_{1-6} alkyl, C_{2-6} alkenyl, $-(CH_2)_vOH$, and $-(CH_2)_vN(R)_2$,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

R^8 is selected from the group consisting of C_{3-6} carbocycle and heterocycle;

R^9 is selected from the group consisting of H, CN, NO_2 , C_{1-6} alkyl, $-OR$, $-S(O)_2R$, $-S(O)_2N(R)_2$, C_{2-6} alkenyl, C_{3-6} carbocycle and heterocycle;

R^{12} is selected from the group consisting of H, OH, C_{1-3} alkyl, and C_{2-3} alkenyl;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, $(CH_2)_qOR^*$, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0093] In still another embodiments, another subset of compounds of Formula (III) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R'';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)₆C(R¹²)₂(CH₂)_{n-6}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a C₃₋₆ carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -N(R)C(S)N(R)₂, -CRN(R)₂C(O)OR, -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, -N(R)C(O)OR, -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, -N(OR)C(=CHR⁹)N(R)₂, -C(=NR⁹)R, -C(O)N(R)OR, -(CH₂)_nN(R)₂, each o is independently selected from 1, 2, 3, and 4, and -C(=NR⁹)N(R)₂, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C₁₋₆ alkyl, C₂₋₆ alkenyl, -(CH₂)_vOH, and -(CH₂)_vN(R)₂,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹² is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0094] In still another embodiments, another subset of compounds of Formula (III) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of hydrogen, a C₃₋₆ carbocycle, -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)₆C(R¹²)₂(CH₂)_{n-6}Q, -CHQR, -CQ(R)₂, -C(O)NQR and unsubstituted C₁₋₆ alkyl, where Q is selected from a carbocycle, -OR, -O(CH₂)_nN(R)₂, -C(O)OR, -OC(O)R, -CX₃, -CX₂H, -CXH₂, -CN, -C(O)N(R)₂, -N(R)C(O)R, -N(R)S(O)₂R, -N(R)C(O)N(R)₂, -

$N(R)C(S)N(R)_2$, $-N(R)R^8$, $-N(R)S(O)_2R^8$, $-O(CH_2)_nOR$, $-N(R)C(=NR^9)N(R)_2$, $-N(R)C(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)R$, $-N(OR)S(O)_2R$, $-N(OR)C(O)OR$, $-N(OR)C(O)N(R)_2$, $-N(OR)C(S)N(R)_2$, $-N(OR)C(=NR^9)N(R)_2$, $-N(OR)C(=CHR^9)N(R)_2$, $-C(=NR^9)N(R)_2$, $-C(=NR^9)R$, $-C(O)N(R)OR$, $-(CH_2)_nN(R)_2$ and $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C_{1-6} alkyl, C_{2-6} alkenyl, $-(CH_2)_vOH$, and $-(CH_2)_vN(R)_2$,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R^5 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')-$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

R^8 is selected from the group consisting of C_{3-6} carbocycle and heterocycle;

R^9 is selected from the group consisting of H, CN, NO_2 , C_{1-6} alkyl, $-OR$, $-S(O)_2R$, $-S(O)_2N(R)_2$, C_{2-6} alkenyl, C_{3-6} carbocycle and heterocycle;

R^{12} is selected from the group consisting of H, OH, C_{1-3} alkyl, and C_{2-3} alkenyl;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, and H;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, $(CH_2)_qOR^*$, and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C_{3-15} alkyl and C_{3-15} alkenyl;

each R^* is independently selected from the group consisting of C_{1-12} alkyl and C_{2-12} alkenyl;

each Y is independently a C_{3-6} carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

[0095] In yet another embodiments, another subset of compounds of Formula (III) includes those in which

R^1 is selected from the group consisting of C_{5-30} alkyl, C_{5-20} alkenyl, $-R^*YR''$, $-YR''$, and $-R''M'R'$;

R^2 and R^3 are independently selected from the group consisting of H, C_{2-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

R^4 is $-(CH_2)_nQ$ or $-(CH_2)_nCHQR$, where Q is $-N(R)_2$, and n is selected from 3, 4, and 5;

R^x is selected from the group consisting of C_{1-6} alkyl, C_{2-6} alkenyl, $-(CH_2)_vOH$, and $-(CH_2)_vN(R)_2$,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R^5 is independently selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R^6 is independently selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-N(R')C(O)-$, $-C(O)-$, $-C(S)-$, $-C(S)S-$, $-SC(S)-$, $-CH(OH)-$, $-P(O)(OR')O-$, $-S(O)_2-$, $-S-S-$, an aryl group, and a heteroaryl group, in which M'' is a bond, C_{1-13} alkyl or C_{2-13} alkenyl;

R^7 is selected from the group consisting of C_{1-3} alkyl, C_{2-3} alkenyl, and H;

each R is independently selected from the group consisting of C_{1-6} alkyl, C_{1-3} alkyl-aryl, C_{2-3} alkenyl, and H;

each R' is independently selected from the group consisting of C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR''$, $-YR''$, and H;

each R'' is independently selected from the group consisting of C_{3-15} alkyl and C_{3-15} alkenyl;

each R^* is independently selected from the group consisting of C_{1-12} alkyl and C_{1-12} alkenyl;

each Y is independently a C_{3-6} carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

or their N-oxides, or salts or isomers thereof.

[0096] In still another embodiments, another subset of compounds of Formula (III) includes those in which

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of -(CH₂)_nQ, -(CH₂)_nCHQR, -CHQR, and -CQ(R)₂, where Q is -N(R)₂, and n is selected from 1, 2, 3, 4, and 5;

R^x is selected from the group consisting of C₁₋₆ alkyl, C₂₋₆ alkenyl, -(CH₂)_vOH, and -(CH₂)_vN(R)₂,

wherein v is selected from 1, 2, 3, 4, 5, and 6;

each R⁵ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

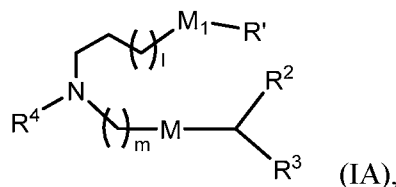
each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₁₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

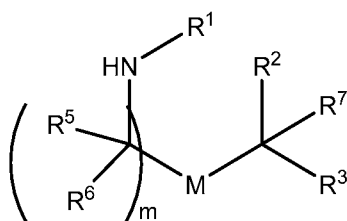
m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13,

[0097] or their N-oxides, or salts or isomers thereof. In certain embodiments, a subset of compounds of Formula (I) includes those of Formula (IA):

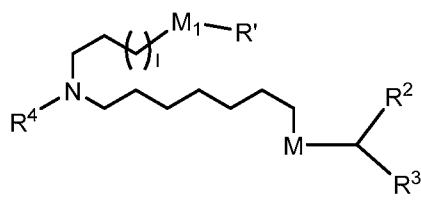


or its N-oxide, or a salt or isomer thereof, wherein l is selected from 1, 2, 3, 4, and 5; m is selected from 5, 6, 7, 8, and 9; M_1 is a bond or M' ; R^4 is hydrogen, unsubstituted C_{1-3} alkyl, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-C(O)NQR$ or $-(CH_2)_nQ$, in which Q is OH, $-NHC(S)N(R)_2$, $-NHC(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)R^8$, $-NHC(=NR^9)N(R)_2$, $-NHC(=CHR^9)N(R)_2$, $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-(CH_2)_nN(R)_2$, heteroaryl or heterocycloalkyl; M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-P(O)(OR')O-$, $-S-S-$, an aryl group, and a heteroaryl group; and R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, and C_{2-14} alkenyl. For example, m is 5, 7, or 9. For example, Q is OH, $-NHC(S)N(R)_2$, or $-NHC(O)N(R)_2$. For example, Q is $-N(R)C(O)R$, or $-N(R)S(O)_2R$.

[0098] In certain embodiments, a subset of compounds of Formula (I) includes those of Formula (IB):



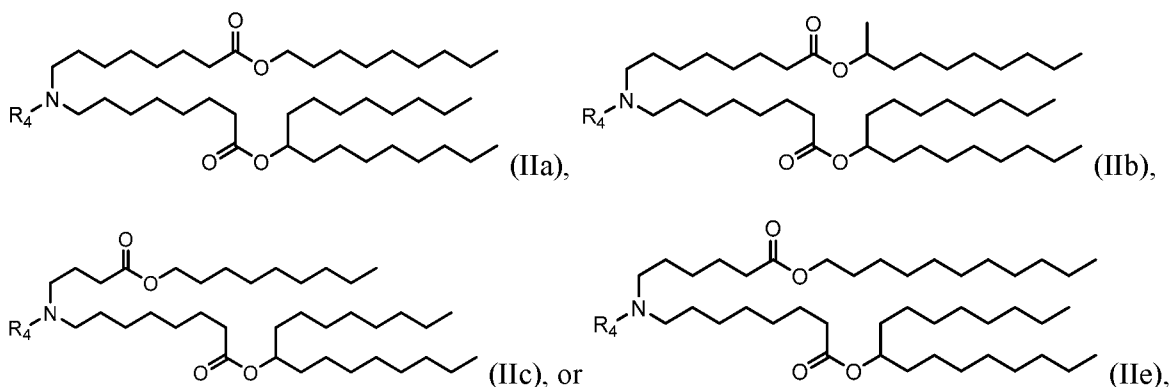
variables are as defined herein. For example, m is selected from 5, 6, 7, 8, and 9; M and M' are independently selected from $-C(O)O-$, $-OC(O)-$, $-OC(O)-M''-C(O)O-$, $-C(O)N(R')$, $-P(O)(OR')O-$, $-S-S-$, an aryl group, and a heteroaryl group; and R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, and C_{2-14} alkenyl. For example, m is 5, 7, or 9. In certain embodiments, a subset of compounds of Formula (I) includes those of Formula (II):



selected from 1, 2, 3, 4, and 5; M_1 is a bond or M' ; R^4 is hydrogen, unsubstituted C_{1-3} alkyl, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-C(O)NQR$ or $-(CH_2)_nQ$, in which n is 2, 3, or 4, and Q is OH, $-NHC(S)N(R)_2$, $-NHC(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)R^8$, $-NHC(=NR^9)N(R)_2$, $-$

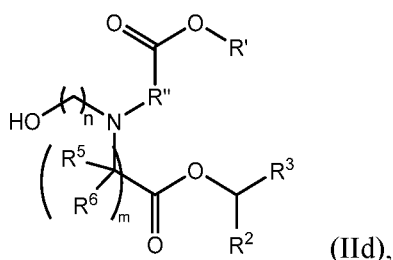
$\text{NHC}(=\text{CHR}^9)\text{N}(\text{R})_2$, $-\text{OC}(\text{O})\text{N}(\text{R})_2$, $-\text{N}(\text{R})\text{C}(\text{O})\text{OR}$, $-(\text{CH}_2)_n\text{N}(\text{R})_2$, heteroaryl or heterocycloalkyl; M and M' are independently selected from $-\text{C}(\text{O})\text{O}-$, $-\text{OC}(\text{O})-$, $-\text{OC}(\text{O})-\text{M}''-$, $\text{C}(\text{O})\text{O}-$, $-\text{C}(\text{O})\text{N}(\text{R}')-$, $-\text{P}(\text{O})(\text{OR}')\text{O}-$, $-\text{S}-\text{S}-$, an aryl group, and a heteroaryl group; and R^2 and R^3 are independently selected from the group consisting of H , C_{1-14} alkyl, and C_{2-14} alkenyl.

[0099] In certain embodiments, a subset of compounds of Formula (I) includes those of Formula (IIa), (IIb), (IIc), or (IIe):



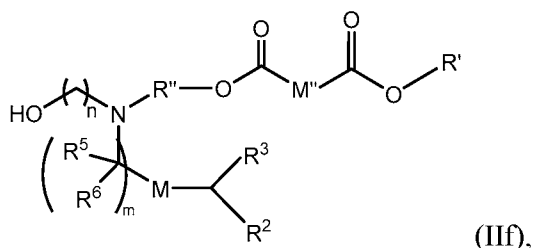
or its N-oxide, or a salt or isomer thereof, wherein R^4 is as described herein.

[00100] In certain embodiments, a subset of compounds of Formula (I) includes those of Formula (II d):



or its N-oxide, or a salt or isomer thereof, wherein n is 2, 3, or 4; and m , R^5 , R^6 , and R^2 through R^6 are as described herein. For example, each of R^2 and R^3 may be independently selected from the group consisting of C_{5-14} alkyl and C_{5-14} alkenyl.

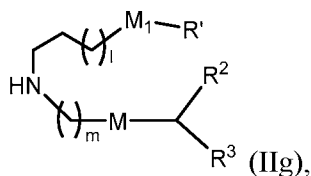
[00101] In another embodiment, a subset of compounds of Formula (I) includes those of Formula (II f):



or its N-oxide, or a salt or isomer thereof, wherein n is 2, 3, or 4; and m , M , M' , R^5 , R^6 , and R^2 through R^6 are as described herein. For example, each of R^2 and R^3 may be independently

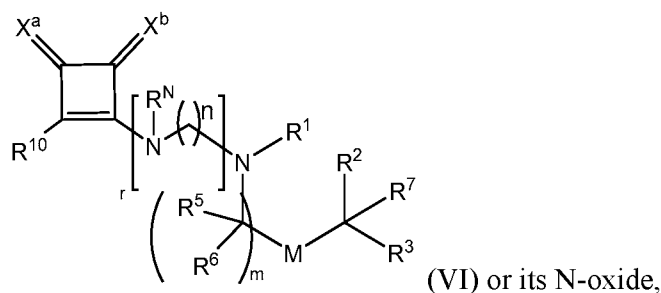
selected from the group consisting of C₅₋₁₄ alkyl and C₅₋₁₄ alkenyl, and n is selected from 2, 3, and 4.

[00102] In another embodiment, a subset of compounds of Formula (I) includes those of Formula (IIg):



or its N-oxide, or a salt or isomer thereof, wherein l, m, M, M₁, R¹, R² and R³ are as described herein. For example, each of R² and R³ may be independently selected from the group consisting of C₅₋₁₄ alkyl and C₅₋₁₄ alkenyl, l is selected from 1, 2, 3, 4, and 5, and m is selected from 5, 6, 7, 8, and 9.

[00103] Other aspects of the disclosure relate to compounds of Formula (VI):



or a salt or isomer thereof, wherein

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R is independently selected from the group consisting of H, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

R^N is H, or C₁₋₃ alkyl;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I;

X^a and X^b are each independently O or S;

R¹⁰ is selected from the group consisting of H, halo, -OH, R, -N(R)₂, -CN, -N₃, -C(O)OH, -C(O)OR, -OC(O)R, -OR, -SR, -S(O)R, -S(O)OR, -S(O)₂OR, -NO₂, -S(O)₂N(R)₂, -N(R)S(O)₂R, -NH(CH₂)_{t1}N(R)₂, -NH(CH₂)_{p1}O(CH₂)_{q1}N(R)₂, -NH(CH₂)_{s1}OR, -N((CH₂)_{s1}OR)₂, -N(R)-carbocycle, -N(R)-heterocycle, -N(R)-aryl, -N(R)-heteroaryl, -N(R)(CH₂)_{t1}-carbocycle, -N(R)(CH₂)_{t1}-heterocycle, -N(R)(CH₂)_{t1}-aryl, -N(R)(CH₂)_{t1}-heteroaryl, a carbocycle, a heterocycle, aryl and heteroaryl;

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13;

n is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10;

r is 0 or 1;

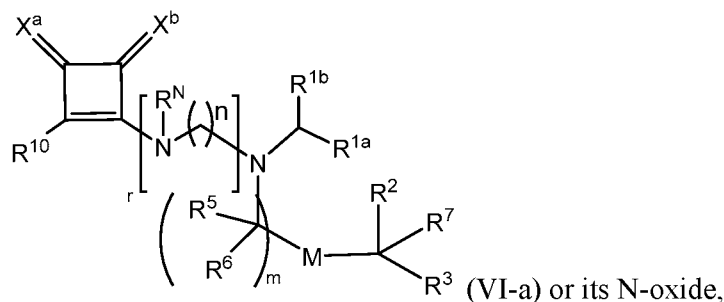
t¹ is selected from 1, 2, 3, 4, and 5;

p¹ is selected from 1, 2, 3, 4, and 5;

q¹ is selected from 1, 2, 3, 4, and 5; and

s¹ is selected from 1, 2, 3, 4, and 5.

[00104] In some embodiments, a subset of compounds of Formula (VI) includes those of Formula (VI-a):

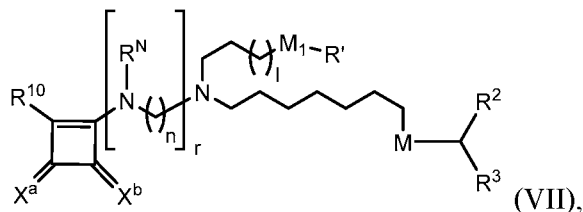


or a salt or isomer thereof, wherein

R^{1a} and R^{1b} are independently selected from the group consisting of C_{1-14} alkyl and C_{2-14} alkenyl; and

R^2 and R^3 are independently selected from the group consisting of C_{1-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle.

[00105] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VII):



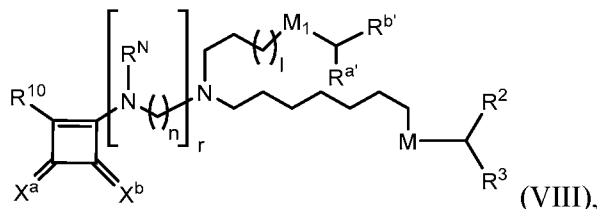
or its N-oxide, or a salt or isomer thereof, wherein

l is selected from 1, 2, 3, 4, and 5;

M_1 is a bond or M' ; and

R^2 and R^3 are independently selected from the group consisting of H, C_{1-14} alkyl, and C_{2-14} alkenyl.

[00106] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIII):



or its N-oxide, or a salt or isomer thereof, wherein

l is selected from 1, 2, 3, 4, and 5;

M_1 is a bond or M' ; and

$R^{a'}$ and $R^{b'}$ are independently selected from the group consisting of C_{1-14} alkyl and C_{2-14} alkenyl; and

R^2 and R^3 are independently selected from the group consisting of C_{1-14} alkyl, and C_{2-14} alkenyl.

[00107] The compounds of any one of formula (I), (IA), (VI), (VI-a), (VII) or (VIII) include one or more of the following features when applicable.

[00108] In some embodiments, M_1 is M' .

[00109] In some embodiments, M and M' are independently $-C(O)O-$ or $-OC(O)-$.

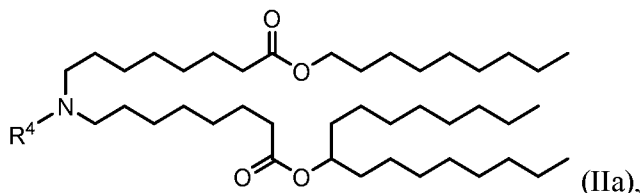
[00110] In some embodiments, at least one of M and M' is $-C(O)O-$ or $-OC(O)-$.

- [00111] In certain embodiments, at least one of M and M' is -OC(O)-.
- [00112] In certain embodiments, M is -OC(O)- and M' is -C(O)O-. In some embodiments, M is -C(O)O- and M' is -OC(O)-. In certain embodiments, M and M' are each -OC(O)-. In some embodiments, M and M' are each -C(O)O-.
- [00113] In certain embodiments, at least one of M and M' is -OC(O)-M''-C(O)O-.
- [00114] In some embodiments, M and M' are independently -S-S-.
- [00115] In some embodiments, at least one of M and M' is -S-S-.
- [00116] In some embodiments, one of M and M' is -C(O)O- or -OC(O)- and the other is -S-S-. For example, M is -C(O)O- or -OC(O)- and M' is -S-S- or M' is -C(O)O-, or -OC(O)- and M is -S-S-.
- [00117] In some embodiments, one of M and M' is -OC(O)-M''-C(O)O-, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl. In other embodiments, M'' is C₁₋₆ alkyl or C₂₋₆ alkenyl. In certain embodiments, M'' is C₁₋₄ alkyl or C₂₋₄ alkenyl. For example, in some embodiments, M'' is C₁ alkyl. For example, in some embodiments, M'' is C₂ alkyl. For example, in some embodiments, M'' is C₃ alkyl. For example, in some embodiments, M'' is C₄ alkyl. For example, in some embodiments, M'' is C₂ alkenyl. For example, in some embodiments, M'' is C₃ alkenyl. For example, in some embodiments, M'' is C₄ alkenyl.
- [00118] In some embodiments, l is 1, 3, or 5.
- [00119] In some embodiments, R⁴ is hydrogen.
- [00120] In some embodiments, R⁴ is not hydrogen.
- [00121] In some embodiments, R⁴ is unsubstituted methyl or -(CH₂)_nQ, in which Q is OH, -NHC(S)N(R)₂, -NHC(O)N(R)₂, -N(R)C(O)R, or -N(R)S(O)₂R.
- [00122] In some embodiments, Q is OH.
- [00123] In some embodiments, Q is -NHC(S)N(R)₂.
- [00124] In some embodiments, Q is -NHC(O)N(R)₂.
- [00125] In some embodiments, Q is -N(R)C(O)R.
- [00126] In some embodiments, Q is -N(R)S(O)₂R.
- [00127] In some embodiments, Q is -O(CH₂)_nN(R)₂.
- [00128] In some embodiments, Q is -O(CH₂)_nOR.
- [00129] In some embodiments, Q is -N(R)R⁸.
- [00130] In some embodiments, Q is -NHC(=NR⁹)N(R)₂.
- [00131] In some embodiments, Q is -NHC(=CHR⁹)N(R)₂.
- [00132] In some embodiments, Q is -OC(O)N(R)₂.
- [00133] In some embodiments, Q is -N(R)C(O)OR.

- [00134] In some embodiments, n is 2.
- [00135] In some embodiments, n is 3.
- [00136] In some embodiments, n is 4.
- [00137] In some embodiments, M_1 is absent.
- [00138] In some embodiments, at least one R^5 is hydroxyl. For example, one R^5 is hydroxyl.
- [00139] In some embodiments, at least one R^6 is hydroxyl. For example, one R^6 is hydroxyl.
- [00140] In some embodiments one of R^5 and R^6 is hydroxyl. For example, one R^5 is hydroxyl and each R^6 is hydrogen. For example, one R^6 is hydroxyl and each R^5 is hydrogen.
- [00141] In some embodiments, R^x is C_{1-6} alkyl. In some embodiments, R^x is C_{1-3} alkyl. For example, R^x is methyl. For example, R^x is ethyl. For example, R^x is propyl.
- [00142] In some embodiments, R^x is $-(CH_2)_vOH$ and, v is 1, 2 or 3. For example, R^x is methanoyl. For example, R^x is ethanoyl. For example, R^x is propanoyl.
- [00143] In some embodiments, R^x is $-(CH_2)_vN(R)_2$, v is 1, 2 or 3 and each R is H or methyl. For example, R^x is methanamino, methylmethanamino, or dimethylmethanamino. For example, R^x is aminomethanyl, methylaminomethanyl, or dimethylaminomethanyl. For example, R^x is aminoethanyl, methylaminoethanyl, or dimethylaminoethanyl. For example, R^x is aminopropanyl, methylaminopropanyl, or dimethylaminopropanyl.
- [00144] In some embodiments, R^y is C_{1-18} alkyl, C_{2-18} alkenyl, $-R^*YR^y$, or $-YR^y$.
- [00145] In some embodiments, R^2 and R^3 are independently C_{3-14} alkyl or C_{3-14} alkenyl.
- [00146] In some embodiments, R^{1b} is C_{1-14} alkyl. In some embodiments, R^{1b} is C_{2-14} alkyl. In some embodiments, R^{1b} is C_{3-14} alkyl. In some embodiments, R^{1b} is C_{1-8} alkyl. In some embodiments, R^{1b} is C_{1-5} alkyl. In some embodiments, R^{1b} is C_{1-3} alkyl. In some embodiments, R^{1b} is selected from C_1 alkyl, C_2 alkyl, C_3 alkyl, C_4 alkyl, and C_5 alkyl. For example, in some embodiments, R^{1b} is C_1 alkyl. For example, in some embodiments, R^{1b} is C_2 alkyl. For example, in some embodiments, R^{1b} is C_3 alkyl. For example, in some embodiments, R^{1b} is C_4 alkyl. For example, in some embodiments, R^{1b} is C_5 alkyl.
- [00147] In some embodiments, R^1 is different from $-(CHR^5R^6)_m-M-CR^2R^3R^7$.
- [00148] In some embodiments, $-CHR^{1a}R^{1b}-$ is different from $-(CHR^5R^6)_m-M-CR^2R^3R^7$.
- [00149] In some embodiments, R^7 is H. In some embodiments, R^7 is selected from C_{1-3} alkyl. For example, in some embodiments, R^7 is C_1 alkyl. For example, in some embodiments, R^7 is C_2 alkyl. For example, in some embodiments, R^7 is C_3 alkyl. In some embodiments, R^7 is selected from C_4 alkyl, C_4 alkenyl, C_5 alkyl, C_5 alkenyl, C_6 alkyl, C_6 alkenyl, C_7 alkyl, C_7 alkenyl, C_9 alkyl, C_9 alkenyl, C_{11} alkyl, C_{11} alkenyl, C_{17} alkyl, C_{17} alkenyl, C_{18} alkyl, and C_{18} alkenyl.

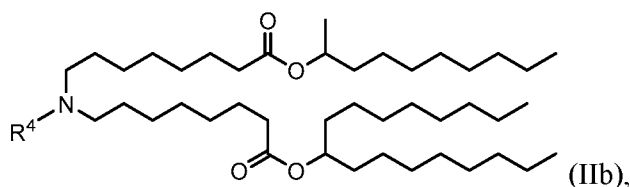
[00150] In some embodiments, $R^{b'}$ is C_{1-14} alkyl. In some embodiments, $R^{b'}$ is C_{2-14} alkyl. In some embodiments, $R^{b'}$ is C_{3-14} alkyl. In some embodiments, $R^{b'}$ is C_{1-8} alkyl. In some embodiments, $R^{b'}$ is C_{1-5} alkyl. In some embodiments, $R^{b'}$ is C_{1-3} alkyl. In some embodiments, $R^{b'}$ is selected from C_1 alkyl, C_2 alkyl, C_3 alkyl, C_4 alkyl and C_5 alkyl. For example, in some embodiments, $R^{b'}$ is C_1 alkyl. For example, in some embodiments, $R^{b'}$ is C_2 alkyl. For example, in some embodiments, $R^{b'}$ is C_3 alkyl. For example, in some embodiments, $R^{b'}$ is C_4 alkyl.

[00151] In some embodiments, the compounds of Formula (I) are of Formula (IIa):



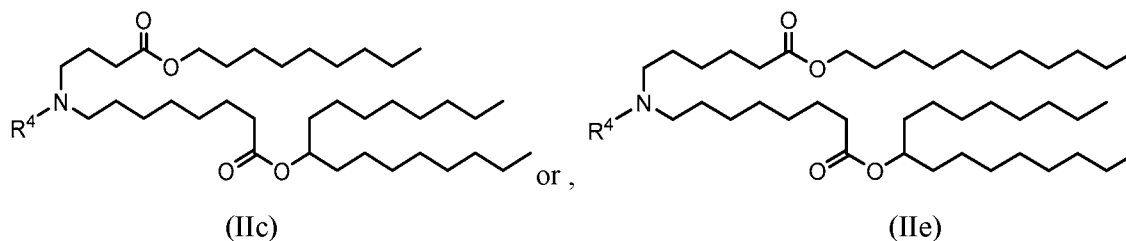
or their N-oxides, or salts or isomers thereof, wherein R^4 is as described herein.

[00152] In other embodiments, the compounds of Formula (I) are of Formula (IIb):



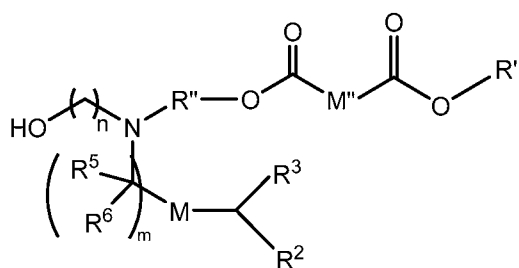
or their N-oxides, or salts or isomers thereof, wherein R^4 is as described herein.

[00153] In other embodiments, the compounds of Formula (I) are of Formula (IIc) or (Ile):



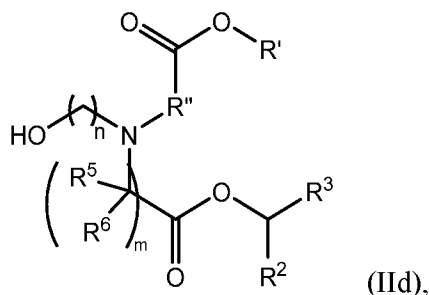
or their N-oxides, or salts or isomers thereof, wherein R^4 is as described herein.

[00154] In other embodiments, the compounds of Formula (I) are of Formula (IIf):



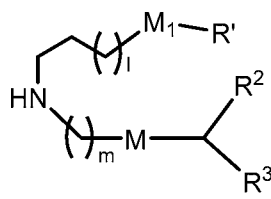
wherein M is -C(O)O- or -OC(O)-, M' is C₁₋₆ alkyl or C₂₋₆ alkenyl, R² and R³ are independently selected from the group consisting of C₅₋₁₄ alkyl and C₅₋₁₄ alkenyl, and n is selected from 2, 3, and 4.

[00155] In a further embodiment, the compounds of Formula (I) are of Formula (IIc):



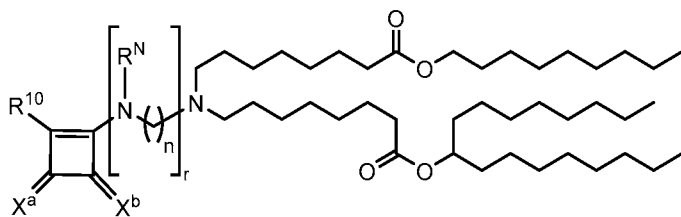
or their N-oxides, or salts or isomers thereof, wherein n is 2, 3, or 4; and m, R', R'', and R² through R₆ are as described herein. For example, each of R² and R³ may be independently selected from the group consisting of C₅₋₁₄ alkyl and C₅₋₁₄ alkenyl.

[00156] In a further embodiment, the compounds of Formula (I) are of Formula (IIg):



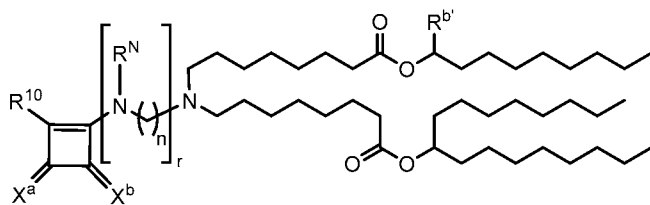
or their N-oxides, or salts or isomers thereof, wherein l is selected from 1, 2, 3, 4, and 5; m is selected from 5, 6, 7, 8, and 9; M₁ is a bond or M'; M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M'-C(O)O-, -C(O)N(R')-, -P(O)(OR')O-, -S-S-, an aryl group, and a heteroaryl group; and R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, and C₂₋₁₄ alkenyl. For example, M' is C₁₋₆ alkyl (e.g., C₁₋₄ alkyl) or C₂₋₆ alkenyl (e.g., C₂₋₄ alkenyl). For example, R² and R³ are independently selected from the group consisting of C₅₋₁₄ alkyl and C₅₋₁₄ alkenyl.

[00157] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIa):



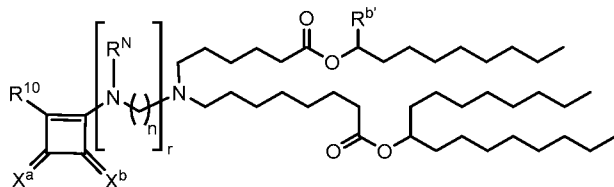
or its N-oxide, or a salt or isomer thereof.

[00158] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIIa):



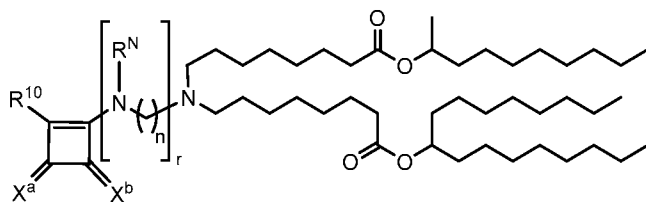
(VIIIa), or its N-oxide, or a salt or isomer thereof.

[00159] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIIb):



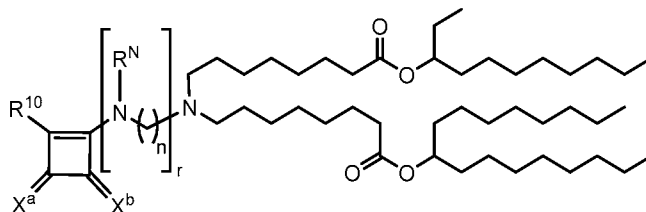
(VIIIb), or its N-oxide, or a salt or isomer thereof.

[00160] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIb-1):



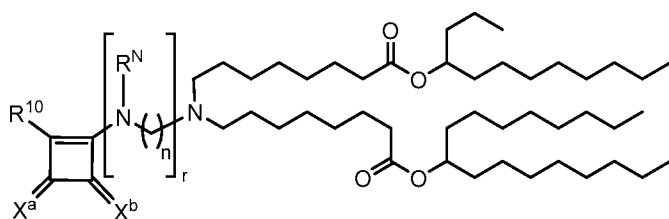
(VIIb-1), or its N-oxide, or a salt or isomer thereof.

[00161] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIb-2):



(VIIb-2), or its N-oxide, or a salt or isomer thereof.

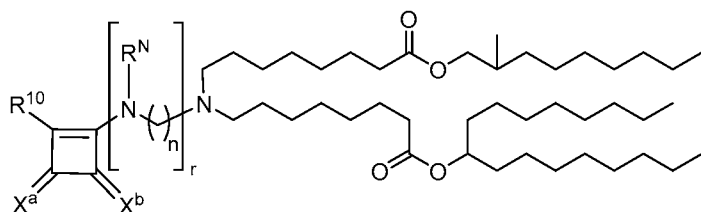
[00162] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIb-3):



(VIIb-3), or its N-oxide, or a salt or

isomer thereof.

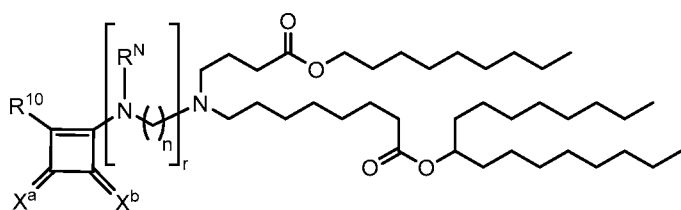
[00163] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIb-4):



(VIIb-4), or its N-oxide, or a salt or

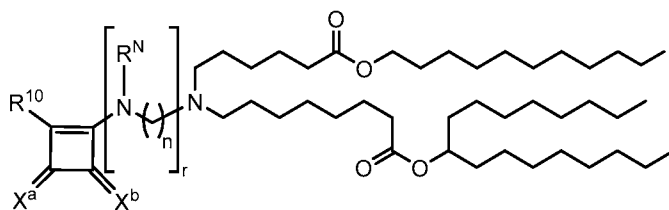
isomer thereof.

[00164] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIc):



(VIIc).

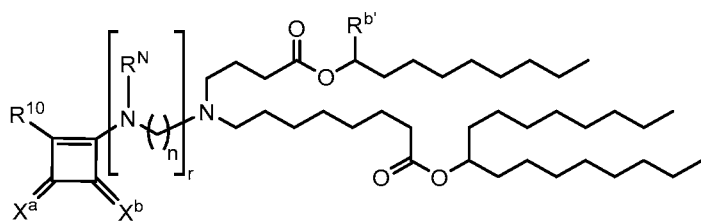
[00165] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIId):



(VIIId), or its N-oxide, or a salt or

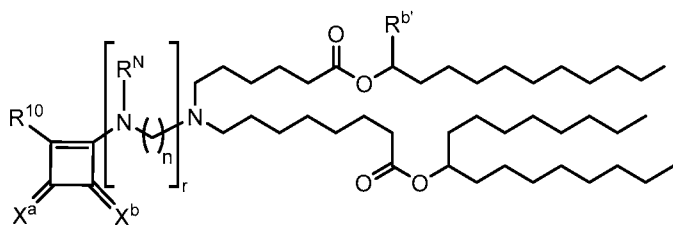
isomer thereof.

[00166] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIIc):



(VIIIc).

[00167] In other embodiments, a subset of compounds of Formula (VI) includes those of Formula (VIIId):



(VIIId), or its N-oxide, or a salt or

isomer thereof.

[00168] The compounds of any one of formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIa), (VIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIc), or (VIIId) include one or more of the following features when applicable.

[00169] In some embodiments, R^4 is selected from the group consisting of a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, and $-CQ(R)_2$, where Q is selected from a C_{3-6} carbocycle, 5- to 14- membered aromatic or non-aromatic heterocycle having one or more heteroatoms selected from N, O, S, and P, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-N(R)_2$, $-N(R)S(O)_2R^8$, $-C(O)N(R)_2$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, and $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5.

[00170] In some embodiments, R^4 is selected from the group consisting of a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, and $-CQ(R)_2$, where Q is selected from a C_{3-6} carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-N(R)S(O)_2R^8$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-C(R)N(R)_2C(O)OR$, and a 5- to 14-membered heterocycloalkyl having one or more heteroatoms selected from N, O, and S which is substituted with one or more substituents selected from oxo ($=O$), OH, amino, and C_{1-3} alkyl, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5.

[00171] In some embodiments, R^4 is selected from the group consisting of a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, and $-CQ(R)_2$, where Q is selected from a C_{3-6} carbocycle, a 5- to 14-membered heterocycle having one or more heteroatoms selected from N, O, and S, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-N(R)S(O)_2R^8$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and

each n is independently selected from 1, 2, 3, 4, and 5; and when Q is a 5- to 14-membered heterocycle and (i) R^4 is $-(CH_2)_nQ$ in which n is 1 or 2, or (ii) R^4 is $-(CH_2)_nCHQR$ in which n is 1, or (iii) R^4 is $-CHQR$, and $-CQ(R)_2$, then Q is either a 5- to 14-membered heteroaryl or 8- to 14-membered heterocycloalkyl.

[00172] In some embodiments, R^4 is selected from the group consisting of a C_{3-6} carbocycle, $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, $-CHQR$, and $-CQ(R)_2$, where Q is selected from a C_{3-6} carbocycle, a 5- to 14-membered heteroaryl having one or more heteroatoms selected from N, O, and S, $-OR$, $-O(CH_2)_nN(R)_2$, $-C(O)OR$, $-OC(O)R$, $-CX_3$, $-CX_2H$, $-CXH_2$, $-CN$, $-C(O)N(R)_2$, $-N(R)S(O)_2R^8$, $-N(R)C(O)R$, $-N(R)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(R)C(S)N(R)_2$, $-C(R)N(R)_2C(O)OR$, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5.

[00173] In some embodiments, R^4 is $-(CH_2)_nQ$, where Q is $-N(R)S(O)_2R^8$ and n is selected from 1, 2, 3, 4, and 5. In a further embodiment, R^4 is $-(CH_2)_nQ$, where Q is $-N(R)S(O)_2R^8$, in which R^8 is a C_{3-6} carbocycle such as C_{3-6} cycloalkyl, and n is selected from 1, 2, 3, 4, and 5. For example, R^4 is $-(CH_2)_3NHS(O)_2R^8$ and R^8 is cyclopropyl.

[00174] In some embodiments, R^4 is $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, where Q is $-N(R)C(O)R$, n is selected from 1, 2, 3, 4, and 5, and o is selected from 1, 2, 3, and 4. In a further embodiment, R^4 is $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, where Q is $-N(R)C(O)R$, wherein R is C_1 - C_3 alkyl and n is selected from 1, 2, 3, 4, and 5, and o is selected from 1, 2, 3, and 4. In another embodiment, R^4 is $-(CH_2)_oC(R^{12})_2(CH_2)_{n-o}Q$, where Q is $-N(R)C(O)R$, wherein R is C_1 - C_3 alkyl, n is 3, and o is 1. In some embodiments, R^{12} is H, OH, C_{1-3} alkyl, or C_{2-3} alkenyl. For example, R^4 is 3-acetamido-2,2-dimethylpropyl.

[00175] In some embodiments, R^4 is $-C(O)NQR$, where Q is $-(CH_2)_nN(R)_2$. In a further embodiment, R^4 is $-C(O)NH(CH_2)_3N(CH_3)_2$, $-C(O)NH(CH_2)_4N(CH_3)_2$, or $-C(O)NH(CH_2)_2N(CH_3)_2$.

[00176] In some embodiments, one R^{12} is H and one R^{12} is C_{1-3} alkyl or C_{2-3} alkenyl. In some embodiments, each R^{12} is C_{1-3} alkyl or C_{2-3} alkenyl. In some embodiments, each R^{12} is C_{1-3} alkyl (e.g. methyl, ethyl or propyl). For example, one R^{12} is methyl and one R^{12} is ethyl or propyl. For example, one R^{12} is ethyl and one R^{12} is methyl or propyl. For example, one R^{12} is propyl and one R^{12} is methyl or ethyl. For example, each R^{12} is methyl. For example, each R^{12} is ethyl. For example, each R^{12} is propyl.

[00177] In some embodiments, one R^{12} is H and one R^{12} is OH. In some embodiments, each R^{12} is OH.

[00178] In some embodiments, R^4 is unsubstituted C_{1-4} alkyl, e.g., unsubstituted methyl.

[00179] In some embodiments, R^4 is hydrogen.

[00180] In certain embodiments, the disclosure provides a compound having the Formula (I), wherein R^4 is $-(CH_2)_nQ$ or $-(CH_2)_nCHQR$, where Q is $-N(R)_2$, and n is selected from 3, 4, and 5.

[00181] In certain embodiments, the disclosure provides a compound having the Formula (I), wherein R^4 is selected from the group consisting of $-(CH_2)_nQ$, $-(CH_2)_nCHQR$, $-CHQR$, and $-CQ(R)_2$, where Q is $-N(R)_2$, and n is selected from 1, 2, 3, 4, and 5.

[00182] In certain embodiments, the disclosure provides a compound having the Formula (I), wherein R^2 and R^3 are independently selected from the group consisting of C_{2-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle, and R^4 is $-(CH_2)_nQ$ or $-(CH_2)_nCHQR$, where Q is $-N(R)_2$, and n is selected from 3, 4, and 5.

[00183] In certain embodiments, R^2 and R^3 are independently selected from the group consisting of C_{2-14} alkyl, C_{2-14} alkenyl, $-R^*YR''$, $-YR''$, and $-R^*OR''$, or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle. In some embodiments, R^2 and R^3 are independently selected from the group consisting of C_{2-14} alkyl, and C_{2-14} alkenyl. In some embodiments, R^2 and R^3 are independently selected from the group consisting of $-R^*YR''$, $-YR''$, and $-R^*OR''$. In some embodiments, R^2 and R^3 together with the atom to which they are attached, form a heterocycle or carbocycle.

[00184] In some embodiments, R^1 is selected from the group consisting of C_{5-20} alkyl and C_{5-20} alkenyl. In some embodiments, R^1 is C_{5-20} alkyl substituted with hydroxyl.

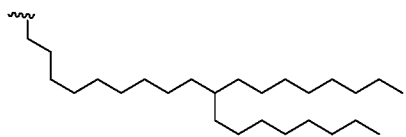
[00185] In other embodiments, R^1 is selected from the group consisting of $-R^*YR''$, $-YR''$, and $-R''M'R'$.

[00186] In certain embodiments, R^1 is selected from $-R^*YR''$ and $-YR''$. In some embodiments, Y is a cyclopropyl group. In some embodiments, R^* is C_8 alkyl or C_8 alkenyl. In certain embodiments, R'' is C_{3-12} alkyl. For example, in some embodiments, R'' is C_3 alkyl. For example, in some embodiments, R'' is C_{4-8} alkyl (e.g., C_4 , C_5 , C_6 , C_7 , or C_8 alkyl).

[00187] In some embodiments, R is $(CH_2)_qOR^*$, q is selected from 1, 2, and 3, and R^* is C_{1-12} alkyl substituted with one or more substituents selected from the group consisting of amino, C_1 - C_6 alkylamino, and C_1 - C_6 dialkylamino. For example, R is $(CH_2)_qOR^*$, q is selected from 1, 2, and 3 and R^* is C_{1-12} alkyl substituted with C_1 - C_6 dialkylamino. For example, R is $(CH_2)_qOR^*$, q is selected from 1, 2, and 3 and R^* is C_{1-3} alkyl substituted with C_1 - C_6 dialkylamino. For example, R is $(CH_2)_qOR^*$, q is selected from 1, 2, and 3 and R^* is C_{1-3} alkyl substituted with dimethylamino (e.g., dimethylaminoethyl).

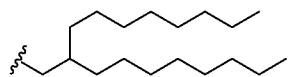
[00188] In some embodiments, R^1 is C_{5-20} alkyl. In some embodiments, R^1 is C_6 alkyl. In some embodiments, R^1 is C_8 alkyl. In other embodiments, R^1 is C_9 alkyl. In certain embodiments, R^1 is C_{14} alkyl. In other embodiments, R^1 is C_{18} alkyl.

[00189] In some embodiments, R^1 is C_{21-30} alkyl. In some embodiments, R^1 is C_{26} alkyl. In some embodiments, R^1 is C_{28} alkyl. In certain embodiments, R^1 is

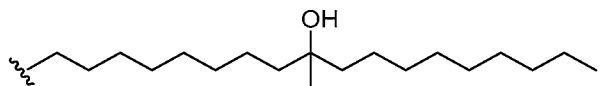


[00190] In some embodiments, R^1 is C_{5-20} alkenyl. In certain embodiments, R^1 is C_{18} alkenyl. In some embodiments, R^1 is linoleyl.

[00191] In certain embodiments, R^1 is branched (*e.g.*, decan-2-yl, undecan-3-yl, dodecan-4-yl, tridecan-5-yl, tetradecan-6-yl, 2-methylundecan-3-yl, 2-methyldecan-2-yl, 3-methylundecan-3-yl, 4-methyldodecan-4-yl, or heptadeca-9-yl). In certain embodiments, R^1 is



[00192] In certain embodiments, R^1 is unsubstituted C_{5-20} alkyl or C_{5-20} alkenyl. In certain embodiments, R^1 is substituted C_{5-20} alkyl or C_{5-20} alkenyl (*e.g.*, substituted with a C_{3-6} carbocycle such as 1-cyclopropylnonyl or substituted with OH or alkoxy). For example, R^1 is



[00193] In other embodiments, R^1 is $-R''M'R'$. In certain embodiments, M' is $-OC(O)-M''-$

$C(O)O-$. For example, R^1 is $\text{---}(\text{---})^{x^1}\text{---}O\text{---}C(=O)\text{---}(\text{---})^{x^2}\text{---}C(=O)\text{---}O\text{---}(\text{---})^{x^3}\text{---}$, wherein x^1 is an integer between 1 and 13 (*e.g.*, selected from 3, 4, 5, and 6), x^2 is an integer between 1 and 13 (*e.g.*, selected from 1, 2, and 3), and x^3 is an integer between 2 and 14 (*e.g.*, selected from 4, 5, and 6). For example, x^1 is selected from 3, 4, 5, and 6, x^2 is selected from 1, 2, and 3, and x^3 is selected from 4, 5, and 6.

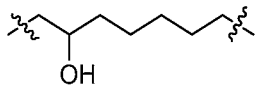
[00194] In other embodiments, R^1 is different from $-(CHR^5R^6)_m-M-CR^2R^3R^7$.

[00195] In some embodiments, R' is selected from $-R^*YR''$ and $-YR''$. In some embodiments, Y is C_{3-8} cycloalkyl. In some embodiments, Y is C_{6-10} aryl. In some embodiments, Y is a cyclopropyl group. In some embodiments, Y is a cyclohexyl group. In certain embodiments, R^* is C_1 alkyl.

[00196] In some embodiments, R'' is selected from the group consisting of C_{3-12} alkyl and C_{3-12} alkenyl. In some embodiments, R'' is C_8 alkyl. In some embodiments, R'' adjacent to Y is C_1

alkyl. In some embodiments, R'' adjacent to Y is C₄₋₉ alkyl (*e.g.*, C₄, C₅, C₆, C₇ or C₈ or C₉ alkyl).

[00197] In some embodiments, R'' is substituted C₃₋₁₂ alkyl (*e.g.*, C₃₋₁₂ alkyl substituted with,



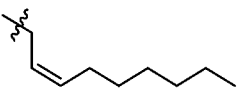
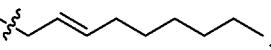
e.g., an hydroxyl). For example, R'' is

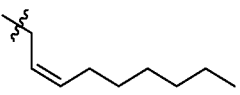
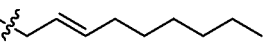
[00198] In some embodiments, R' is selected from C₄ alkyl and C₄ alkenyl. In certain embodiments, R' is selected from C₅ alkyl and C₅ alkenyl. In some embodiments, R' is selected from C₆ alkyl and C₆ alkenyl. In some embodiments, R' is selected from C₇ alkyl and C₇ alkenyl. In some embodiments, R' is selected from C₉ alkyl and C₉ alkenyl.

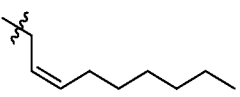
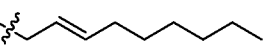
[00199] In some embodiments, R' is selected from C₄ alkyl, C₄ alkenyl, C₅ alkyl, C₅ alkenyl, C₆ alkyl, C₆ alkenyl, C₇ alkyl, C₇ alkenyl, C₉ alkyl, C₉ alkenyl, C₁₁ alkyl, C₁₁ alkenyl, C₁₇ alkyl, C₁₇ alkenyl, C₁₈ alkyl, and C₁₈ alkenyl, each of which is either linear or branched.

[00200] In some embodiments, R' is C₄ alkyl or C₄ alkenyl. In some embodiments, R' is C₅ alkyl or C₅ alkenyl. In some embodiments, R' is C₆ alkyl or C₆ alkenyl. In some embodiments, R' is C₇ alkyl or C₇ alkenyl. In some embodiments, R' is C₈ alkyl or C₈ alkenyl. In some embodiments, R' is C₉ alkyl or C₉ alkenyl. In some embodiments, R' is C₁₀ alkyl or C₁₀ alkenyl. In some embodiments, R' is C₁₁ alkyl or C₁₁ alkenyl.

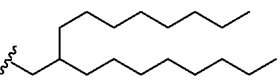
[00201] In some embodiments, R' is linear. In some embodiments, R' is branched.

[00202] In some embodiments, R' is  or . In some

embodiments, R' is  or  and M' is -OC(O)-. In other

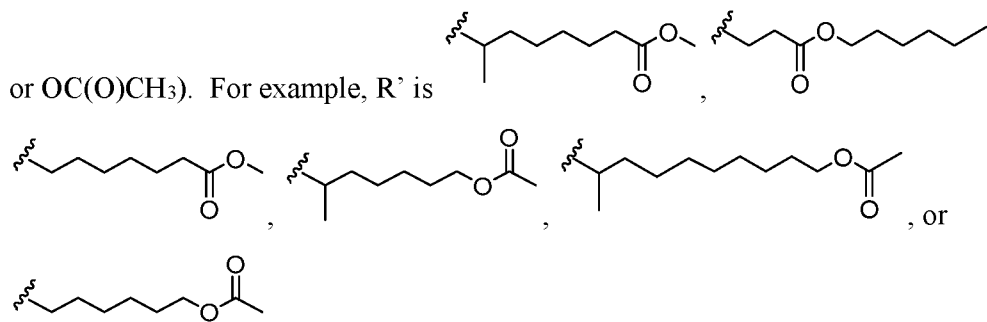
embodiments, R' is  or  and M' is -C(O)O-.

[00203] In other embodiments, R' is selected from C₁₁ alkyl and C₁₁ alkenyl. In other embodiments, R' is selected from C₁₂ alkyl, C₁₂ alkenyl, C₁₃ alkyl, C₁₃ alkenyl, C₁₄ alkyl, C₁₄ alkenyl, C₁₅ alkyl, C₁₅ alkenyl, C₁₆ alkyl, C₁₆ alkenyl, C₁₇ alkyl, C₁₇ alkenyl, C₁₈ alkyl, and C₁₈ alkenyl. In certain embodiments, R' is linear C₄₋₁₈ alkyl or C₄₋₁₈ alkenyl. In certain embodiments, R' is branched (*e.g.*, decan-2-yl, undecan-3-yl, dodecan-4-yl, tridecan-5-yl, tetradecan-6-yl, 2-methylundecan-3-yl, 2-methyldecan-2-yl, 3-methylundecan-3-yl, 4-

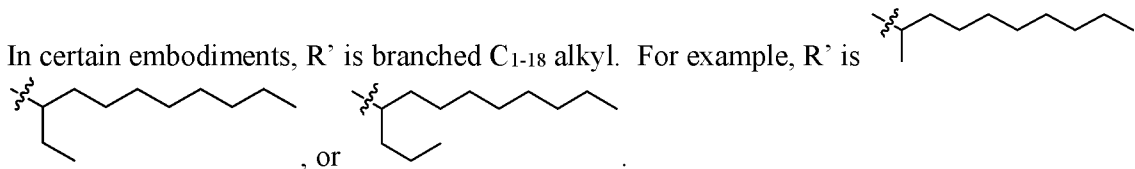
methylundecan-4-yl or heptadeca-9-yl). In certain embodiments, R' is .

[00204] In certain embodiments, R' is unsubstituted C₁₋₁₈ alkyl. In certain embodiments, R' is substituted C₁₋₁₈ alkyl (*e.g.*, C₁₋₁₅ alkyl substituted with, *e.g.*, an alkoxy such as methoxy, or a

C₃₋₆ carbocycle such as 1-cyclopropylonyl, or C(O)O-alkyl or OC(O)-alkyl such as C(O)OCH₃



In certain embodiments, R' is branched C₁₋₁₈ alkyl. For example, R' is



[00205] In some embodiments, R'' is selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl. In some embodiments, R'' is C₃ alkyl, C₄ alkyl, C₅ alkyl, C₆ alkyl, C₇ alkyl, or C₈ alkyl. In some embodiments, R'' is C₉ alkyl, C₁₀ alkyl, C₁₁ alkyl, C₁₂ alkyl, C₁₃ alkyl, C₁₄ alkyl, or C₁₅ alkyl.

[00206] In some embodiments, M' is -C(O)O-. In some embodiments, M' is -OC(O)-. In some embodiments, M' is -OC(O)-M''-C(O)O-. In some embodiments, M' is -S-S-.

[00207] In some embodiments, M' is -C(O)O-, -OC(O)-, or -OC(O)-M''-C(O)O-. In some embodiments wherein M' is -OC(O)-M''-C(O)O-, M'' is C₁₋₄ alkyl or C₂₋₄ alkenyl.

[00208] In other embodiments, M' is an aryl group or heteroaryl group. For example, in some embodiments, M' is selected from the group consisting of phenyl, oxazole, and thiazole.

[00209] In some embodiments, M is -C(O)O-. In some embodiments, M is -OC(O)-. In some embodiments, M is -C(O)N(R')-. In some embodiments, M is -P(O)(OR')O-. In some embodiments, M is -OC(O)-M''-C(O)O-. In some embodiments, M is -S-S-.

[00210] In some embodiments, M is -C(O). In some embodiments, M is -OC(O)- and M' is -C(O)O-. In some embodiments, M is -C(O)O- and M' is -OC(O)-. In some embodiments, M and M' are each -OC(O)-. In some embodiments, M and M' are each -C(O)O-.

[00211] In other embodiments, M is an aryl group or heteroaryl group. For example, in some embodiments, M is selected from the group consisting of phenyl, oxazole, and thiazole.

[00212] In some embodiments, M is the same as M'. In other embodiments, M is different from M'.

[00213] In some embodiments, M'' is a bond. In some embodiments, M'' is C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl. In some embodiments, M'' is C₁₋₆ alkyl or C₂₋₆ alkenyl. In certain embodiments, M'' is linear alkyl or alkenyl. In certain embodiments, M'' is branched, e.g., -CH(CH₃)CH₂-.

[00214] In some embodiments, each R^5 is H. In some embodiments, each R^6 is H. In certain such embodiments, each R^5 and each R^6 is H.

[00215] In some embodiments, R^7 is H. In other embodiments, R^7 is C_{1-3} alkyl (e.g., methyl, ethyl, propyl, or i-propyl).

[00216] In some embodiments, R^2 and R^3 are independently C_{5-14} alkyl or C_{5-14} alkenyl.

[00217] In some embodiments, R^2 and R^3 are the same. In some embodiments, R^2 and R^3 are C_8 alkyl. In certain embodiments, R^2 and R^3 are C_2 alkyl. In other embodiments, R^2 and R^3 are C_3 alkyl. In some embodiments, R^2 and R^3 are C_4 alkyl. In certain embodiments, R^2 and R^3 are C_5 alkyl. In other embodiments, R^2 and R^3 are C_6 alkyl. In some embodiments, R^2 and R^3 are C_7 alkyl.

[00218] In other embodiments, R^2 and R^3 are different. In certain embodiments, R^2 is C_8 alkyl. In some embodiments, R^3 is C_{1-7} (e.g., C_1 , C_2 , C_3 , C_4 , C_5 , C_6 , or C_7 alkyl) or C_9 alkyl.

[00219] In some embodiments, R^3 is C_1 alkyl. In some embodiments, R^3 is C_2 alkyl. In some embodiments, R^3 is C_3 alkyl. In some embodiments, R^3 is C_4 alkyl. In some embodiments, R^3 is C_5 alkyl. In some embodiments, R^3 is C_6 alkyl. In some embodiments, R^3 is C_7 alkyl. In some embodiments, R^3 is C_9 alkyl.

[00220] In some embodiments, R^7 and R^3 are H.

[00221] In certain embodiments, R^2 is H.

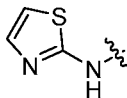
[00222] In some embodiments, m is 5, 6, 7, 8, or 9. In some embodiments, m is 5, 7, or 9. For example, in some embodiments, m is 5. For example, in some embodiments, m is 7. For example, in some embodiments, m is 9.

[00223] In some embodiments, R^4 is selected from $-(CH_2)_nQ$ and $-(CH_2)_nCHQR$.

[00224] In some embodiments, Q is selected from the group consisting of -OR, -OH, - $O(CH_2)_nN(R)_2$, -OC(O)R, -CX₃, -CN, -N(R)C(O)R, -N(H)C(O)R, -N(R)S(O)₂R, -N(H)S(O)₂R, -N(R)C(O)N(R)₂, -N(H)C(O)N(R)₂, -N(H)C(O)N(H)(R), -N(R)C(S)N(R)₂, -N(H)C(S)N(R)₂, -N(H)C(S)N(H)(R), -C(R)N(R)₂C(O)OR, -N(R)S(O)₂R⁸, a carbocycle, and a heterocycle.

[00225] In certain embodiments, Q is -N(R)R⁸, -N(R)S(O)₂R⁸, -O(CH₂)_nOR, -N(R)C(=NR⁹)N(R)₂, -N(R)C(=CHR⁹)N(R)₂, -OC(O)N(R)₂, or -N(R)C(O)OR.

[00226] In certain embodiments, Q is -N(OR)C(O)R, -N(OR)S(O)₂R, -N(OR)C(O)OR, -N(OR)C(O)N(R)₂, -N(OR)C(S)N(R)₂, -N(OR)C(=NR⁹)N(R)₂, or -N(OR)C(=CHR⁹)N(R)₂.

[00227] In certain embodiments, Q is thiourea or an isostere thereof, e.g.,  or -NHC(=NR⁹)N(R)₂.

[00228] In certain embodiments, Q is $-C(=NR^9)N(R)_2$. For example, when Q is $-C(=NR^9)N(R)_2$, n is 4 or 5. For example, R^9 is $-S(O)_2N(R)_2$.

[00229] In certain embodiments, Q is $-C(=NR^9)R$ or $-C(O)N(R)OR$, e.g., $-CH(=N-OCH_3)$, $-C(O)NH-OH$, $-C(O)NH-OCH_3$, $-C(O)N(CH_3)-OH$, or $-C(O)N(CH_3)-OCH_3$.

[00230] In certain embodiments, Q is $-OH$.

[00231] In certain embodiments, Q is a substituted or unsubstituted 5- to 10- membered heteroaryl, e.g., Q is a triazole, an imidazole, a pyrimidine, a purine, 2-amino-1,9-dihydro-6H-purin-6-one-9-yl (or guanine-9-yl), adenine-9-yl, cytosine-1-yl, or uracil-1-yl, each of which is optionally substituted with one or more substituents selected from alkyl, OH, alkoxy, $-alkyl-OH$, $-alkyl-O-alkyl$, and the substituent can be further substituted. In certain embodiments, Q is a substituted 5- to 14-membered heterocycloalkyl, e.g., substituted with one or more substituents selected from oxo ($=O$), OH, amino, mono- or di-alkylamino, and C_{1-3} alkyl. For example, Q is 4-methylpiperazinyl, 4-(4-methoxybenzyl)piperazinyl, isoindolin-2-yl-1,3-dione, pyrrolidin-1-yl-2,5-dione, or imidazolidin-3-yl-2,4-dione.

[00232] In certain embodiments, Q is $-NHR^8$, in which R^8 is a C_{3-6} cycloalkyl optionally substituted with one or more substituents selected from oxo ($=O$), amino (NH_2), mono- or di-alkylamino, C_{1-3} alkyl and halo. For example, R^8 is cyclobutenyl, e.g., 3-(dimethylamino)-cyclobut-3-ene-4-yl-1,2-dione. In further embodiments, R^8 is a C_{3-6} cycloalkyl optionally substituted with one or more substituents selected from oxo ($=O$), thio ($=S$), amino (NH_2), mono- or di-alkylamino, C_{1-3} alkyl, heterocycloalkyl, and halo, wherein the mono- or di-alkylamino, C_{1-3} alkyl, and heterocycloalkyl are further substituted. For example R^8 is cyclobutenyl substituted with one or more of oxo, amino, and alkylamino, wherein the alkylamino is further substituted, e.g., with one or more of C_{1-3} alkoxy, amino, mono- or di-alkylamino, and halo. For example, R^8 is 3-(((dimethylamino)ethyl)amino)cyclobut-3-enyl-1,2-dione. For example R^8 is cyclobutenyl substituted with one or more of oxo, and alkylamino. For example, R^8 is 3-(ethylamino)cyclobut-3-ene-1,2-dione. For example R^8 is cyclobutenyl substituted with one or more of oxo, thio, and alkylamino. For example R^8 is 3-(ethylamino)-4-thioxocyclobut-2-en-1-one or 2-(ethylamino)-4-thioxocyclobut-2-en-1-one. For example R^8 is cyclobutenyl substituted with one or more of thio, and alkylamino. For example R^8 is 3-(ethylamino)cyclobut-3-ene-1,2-dithione. For example R^8 is cyclobutenyl substituted with one or more of oxo and dialkylamino. For example R^8 is 3-(diethylamino)cyclobut-3-ene-1,2-dione. For example, R^8 is cyclobutenyl substituted with one or more of oxo, thio, and dialkylamino. For example, R^8 is 2-(diethylamino)-4-thioxocyclobut-2-en-1-one or 3-(diethylamino)-4-thioxocyclobut-2-en-1-one. For example, R^8 is cyclobutenyl substituted with one or more of

thio, and dialkylamino. For example, R^8 is 3-(diethylamino)cyclobut-3-ene-1,2-dithione. For example, R^8 is cyclobutenyl substituted with one or more of oxo and alkylamino or dialkylamino, wherein alkylamino or dialkylamino is further substituted, e.g. with one or more alkoxy. For example, R^8 is 3-(bis(2-methoxyethyl)amino)cyclobut-3-ene-1,2-dione. For example, R^8 is cyclobutenyl substituted with one or more of oxo, and heterocycloalkyl. For example, R^8 is cyclobutenyl substituted with one or more of oxo, and piperidinyl, piperazinyl, or morpholinyl. For example, R^8 is cyclobutenyl substituted with one or more of oxo, and heterocycloalkyl, wherein heterocycloalkyl is further substituted, e.g., with one or more C_{1-3} alkyl. For example, R^8 is cyclobutenyl substituted with one or more of oxo, and heterocycloalkyl, wherein heterocycloalkyl (e.g., piperidinyl, piperazinyl, or morpholinyl) is further substituted with methyl.

[00233] In certain embodiments, Q is $-NHR^8$, in which R^8 is a heteroaryl optionally substituted with one or more substituents selected from amino (NH_2), mono- or di-alkylamino, C_{1-3} alkyl and halo. For example, R^8 is thiazole or imidazole.

[00234] In certain embodiments, Q is $-NHR^8$ and R^8 is purine.

[00235] In certain embodiments, Q is $-NHC(=NR^9)N(R)_2$ in which R^9 is CN, C_{1-6} alkyl, NO_2 , $-S(O)_2N(R)_2$, $-OR$, $-S(O)_2R$, or H. For example, Q is $-NHC(=NR^9)N(CH_3)_2$, $-NHC(=NR^9)NHCH_3$, $-NHC(=NR^9)NH_2$. In some embodiments, Q is $-NHC(=NR^9)N(R)_2$ in which R^9 is CN and R is C_{1-3} alkyl substituted with mono- or di-alkylamino, e.g., R is ((dimethylamino)ethyl)amino. In some embodiments, Q is $-NHC(=NR^9)N(R)_2$ in which R^9 is C_{1-6} alkyl, NO_2 , $-S(O)_2N(R)_2$, $-OR$, $-S(O)_2R$, or H and R is C_{1-3} alkyl substituted with mono- or di-alkylamino, e.g., R is ((dimethylamino)ethyl)amino.

[00236] In certain embodiments, Q is $-NHC(=CHR^9)N(R)_2$, in which R^9 is NO_2 , CN, C_{1-6} alkyl, $-S(O)_2N(R)_2$, $-OR$, $-S(O)_2R$, or H. For example, Q is $-NHC(=CHR^9)N(CH_3)_2$, $-NHC(=CHR^9)NHCH_3$, or $-NHC(=CHR^9)NH_2$.

[00237] In certain embodiments, Q is $-OC(O)N(R)_2$, $-N(R)C(O)OR$, $-N(OR)C(O)OR$, such as $-OC(O)NHCH_3$, $-N(OH)C(O)OCH_3$, $-N(OH)C(O)CH_3$, $-N(OCH_3)C(O)OCH_3$, $-N(OCH_3)C(O)CH_3$, $-N(OH)S(O)_2CH_3$, or $-NHC(O)OCH_3$.

[00238] In certain embodiments, Q is $-N(R)C(O)R$, in which R is alkyl optionally substituted with C_{1-3} alkoxy or $S(O)_2C_{1-3}$ alkyl, in which z is 0, 1, or 2.

[00239] In certain embodiments, Q is an unsubstituted or substituted C_{6-10} aryl (such as phenyl) or C_{3-6} cycloalkyl.

[00240] In some embodiments, n is 1. In other embodiments, n is 2. In further embodiments, n is 3. In certain other embodiments, n is 4. In some embodiments, n is 5. For example, in

some embodiments, R^4 is $-(CH_2)_2OH$. For example, in some embodiments, R^4 is $-(CH_2)_3OH$. For example, in some embodiments, R^4 is $-(CH_2)_4OH$. For example, in some embodiments, R^4 is $-(CH_2)_5OH$. For example, in some embodiments, R^4 is benzyl. For example, in some embodiments, R^4 may be 4-methoxybenzyl.

[00241] In some embodiments, R^4 is a C_{3-6} carbocycle. In some embodiments, R^4 is a C_{3-6} cycloalkyl. For example, in some embodiments, R^4 is cyclohexyl optionally substituted with *e.g.*, OH, halo, C_{1-6} alkyl, etc. For example, in some embodiments, R^4 is 2-hydroxycyclohexyl.

[00242] In some embodiments, R is H.

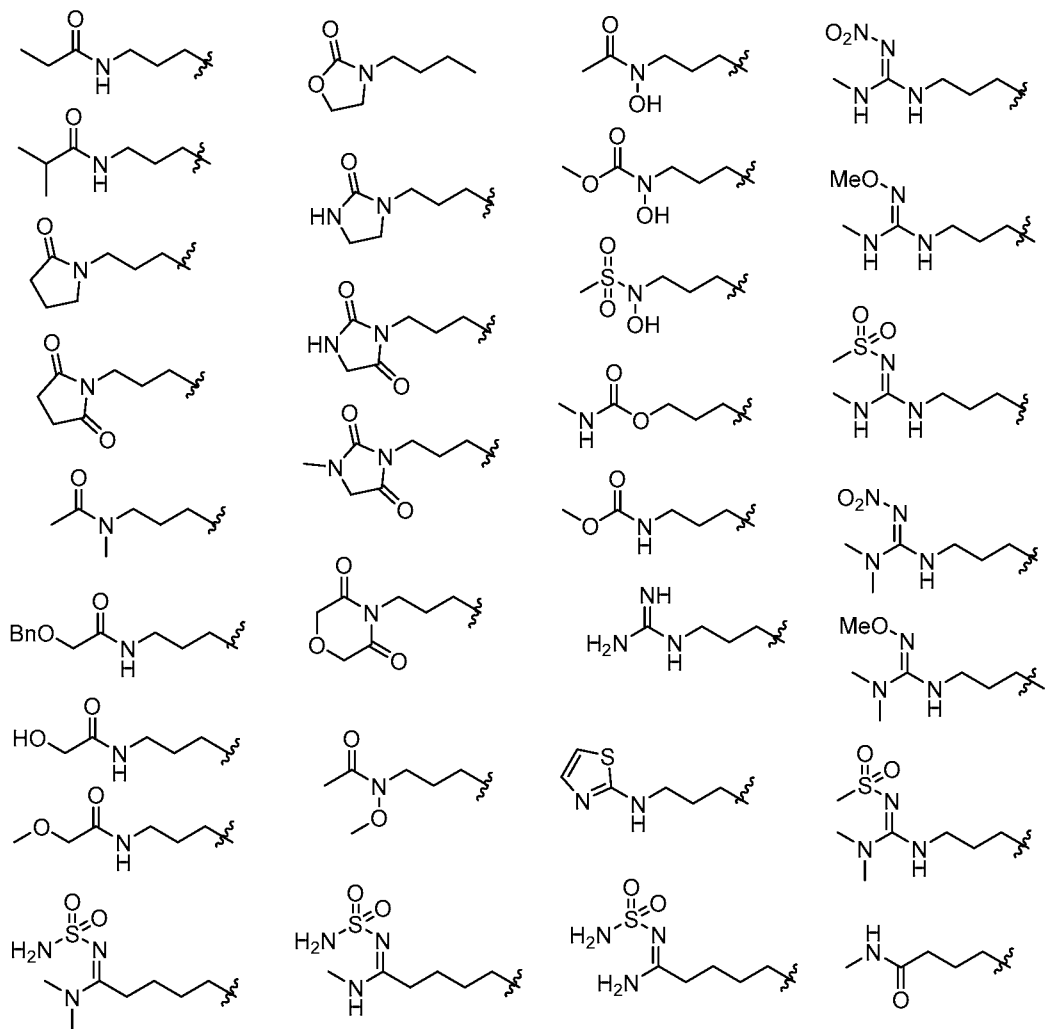
[00243] In some embodiments, R is C_{1-3} alkyl substituted with mono- or di-alkylamino, *e.g.*, R is ((dimethylamino)ethyl)amino.

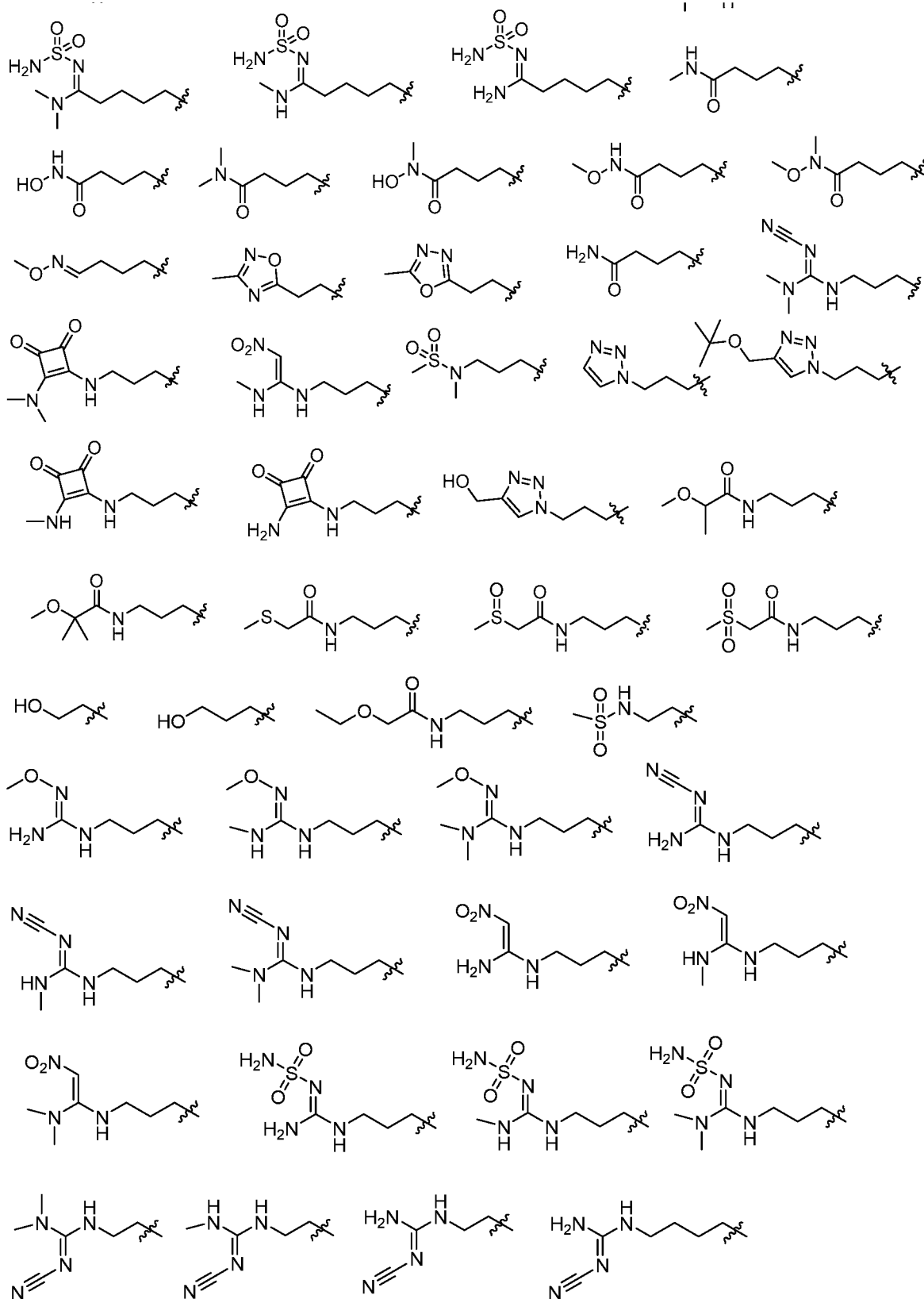
[00244] In some embodiments, R is C_{1-6} alkyl substituted with one or more substituents selected from the group consisting of C_{1-3} alkoxy, amino, and C_1 - C_3 dialkylamino.

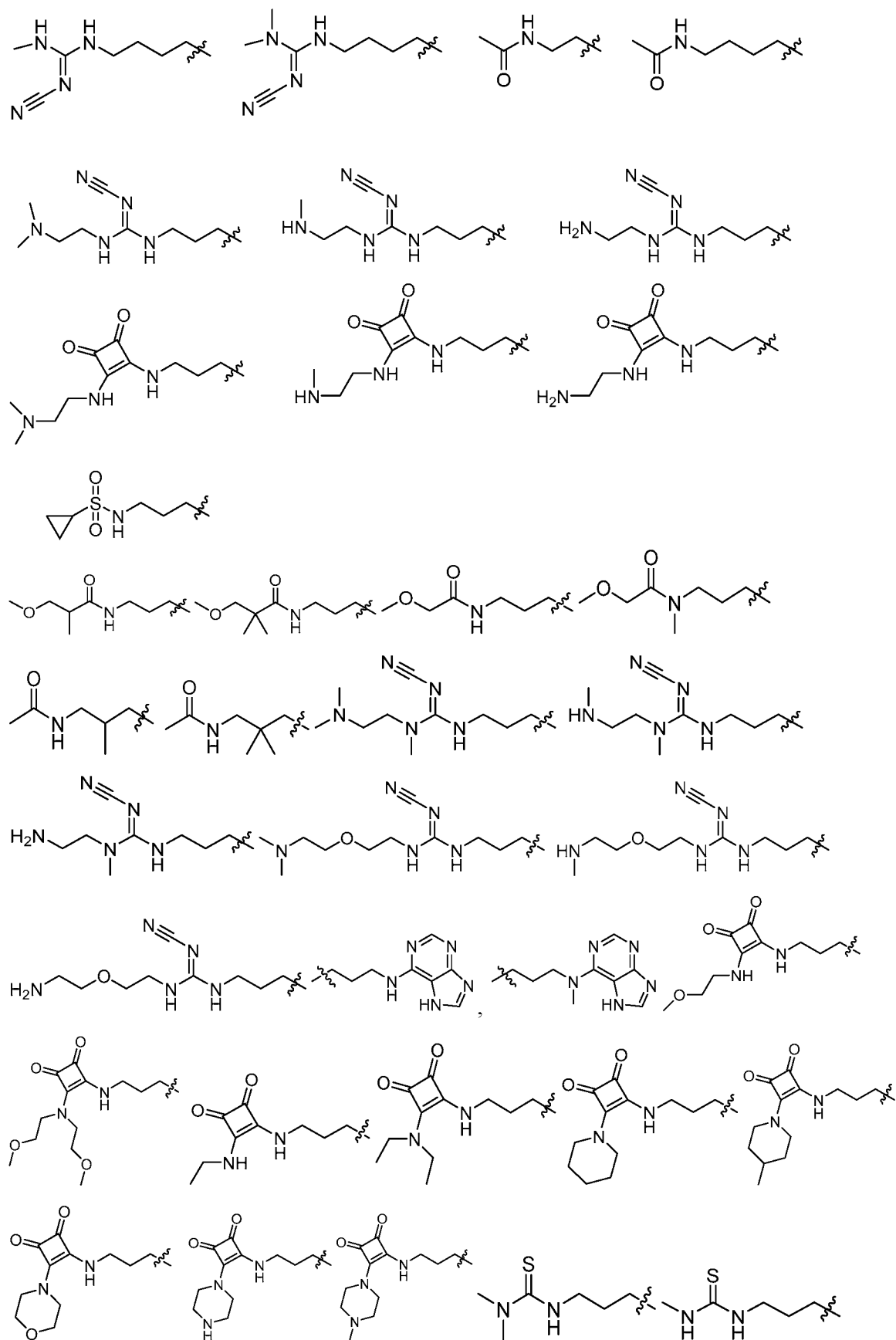
[00245] In some embodiments, R is unsubstituted C_{1-3} alkyl or unsubstituted C_{2-3} alkenyl. For example, in some embodiments R^4 is $-CH_2CH(OH)CH_3$, $-CH(CH_3)CH_2OH$, or $-CH_2CH(OH)CH_2CH_3$.

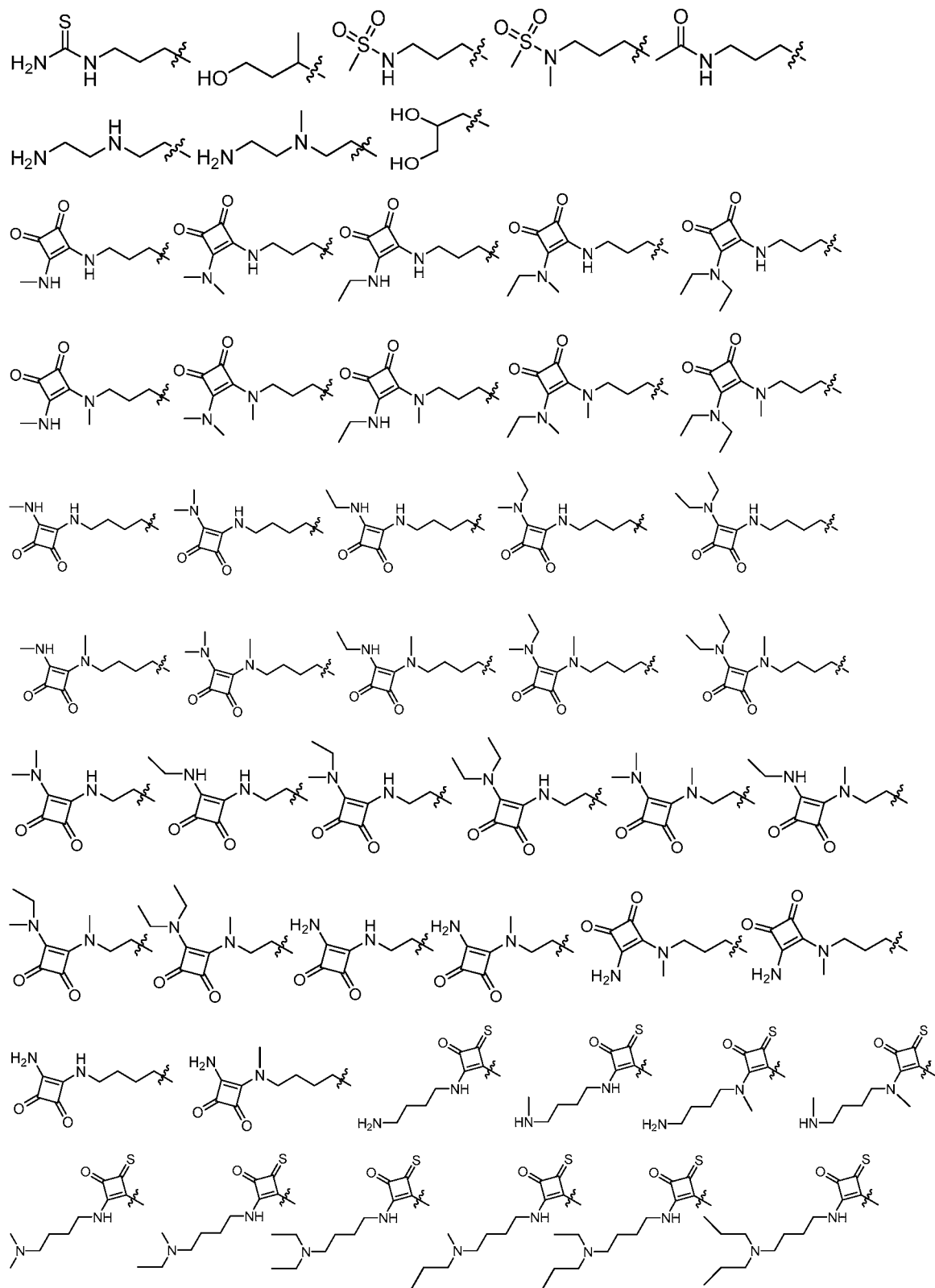
[00246] In some embodiments, R is substituted C_{1-3} alkyl, *e.g.*, CH_2OH . For example, in some embodiments, R^4 is $-CH_2CH(OH)CH_2OH$, $-(CH_2)_3NHC(O)CH_2OH$, $-(CH_2)_3NHC(O)CH_2OBn$, $-(CH_2)_2O(CH_2)_2OH$, $-(CH_2)_3NHCH_2OCH_3$, $-(CH_2)_3NHCH_2OCH_2CH_3$, CH_2SCH_3 , $CH_2S(O)CH_3$, $CH_2S(O)_2CH_3$, or $-CH(CH_2OH)_2$.

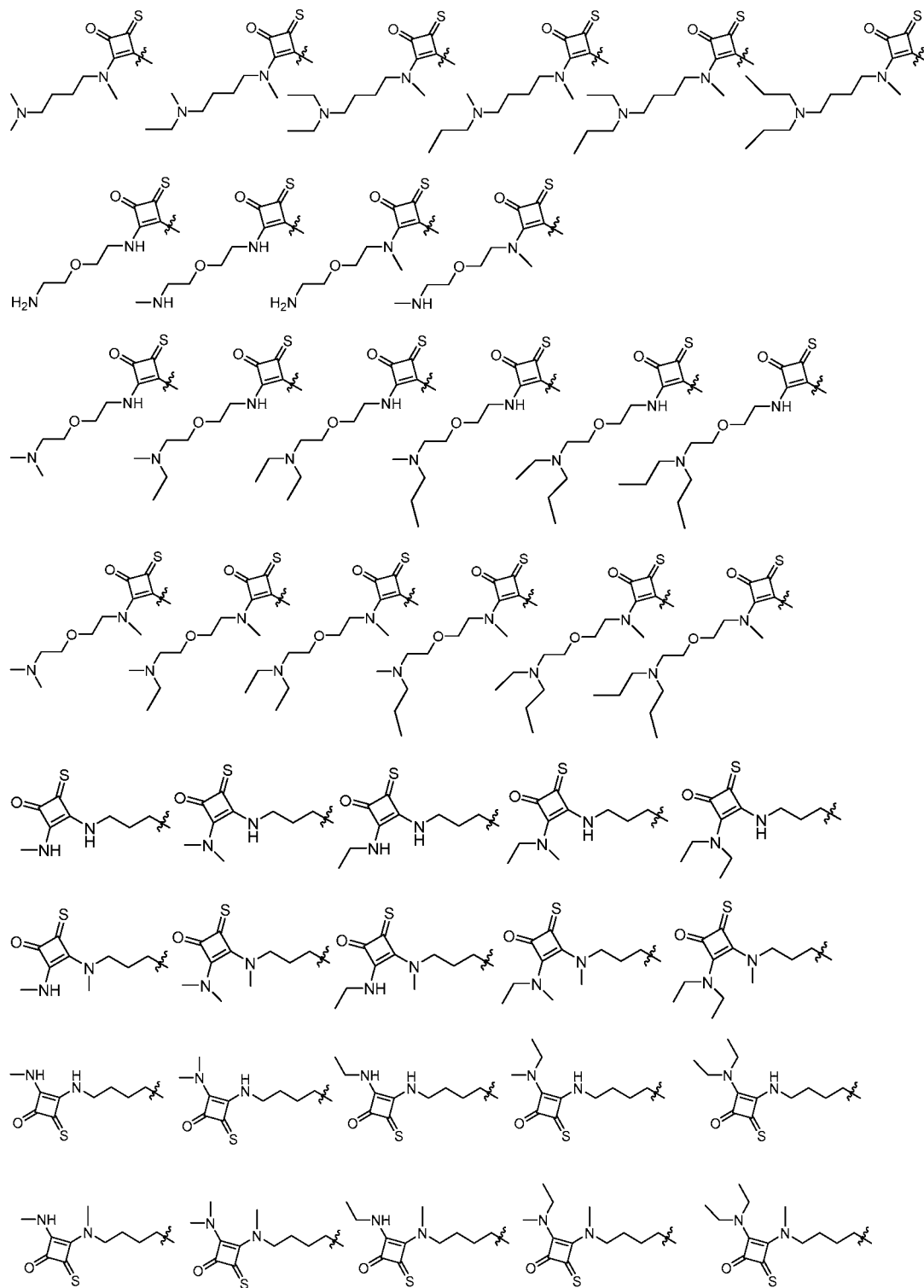
[00247] In some embodiments, R^4 is selected from any of the following groups:

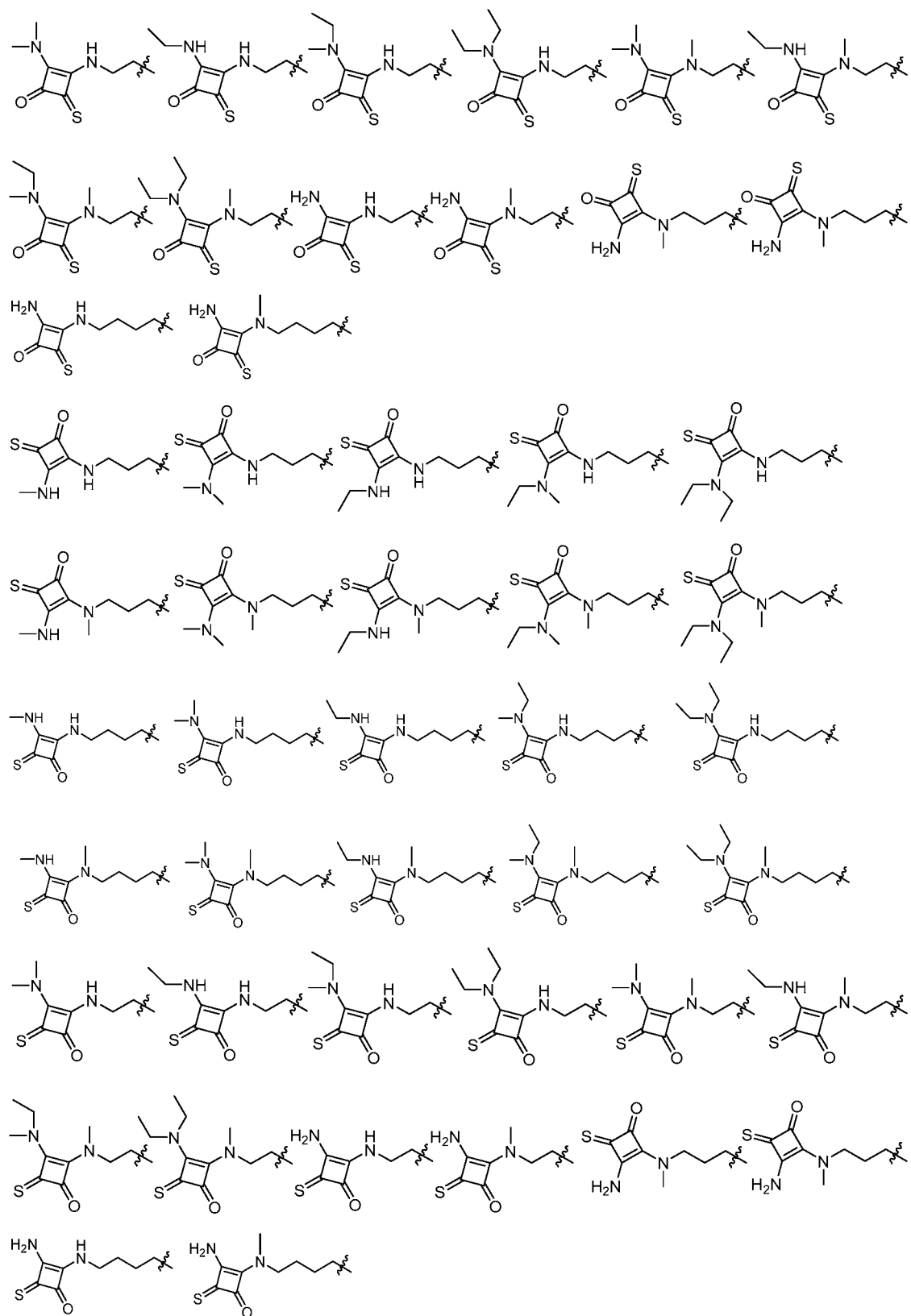


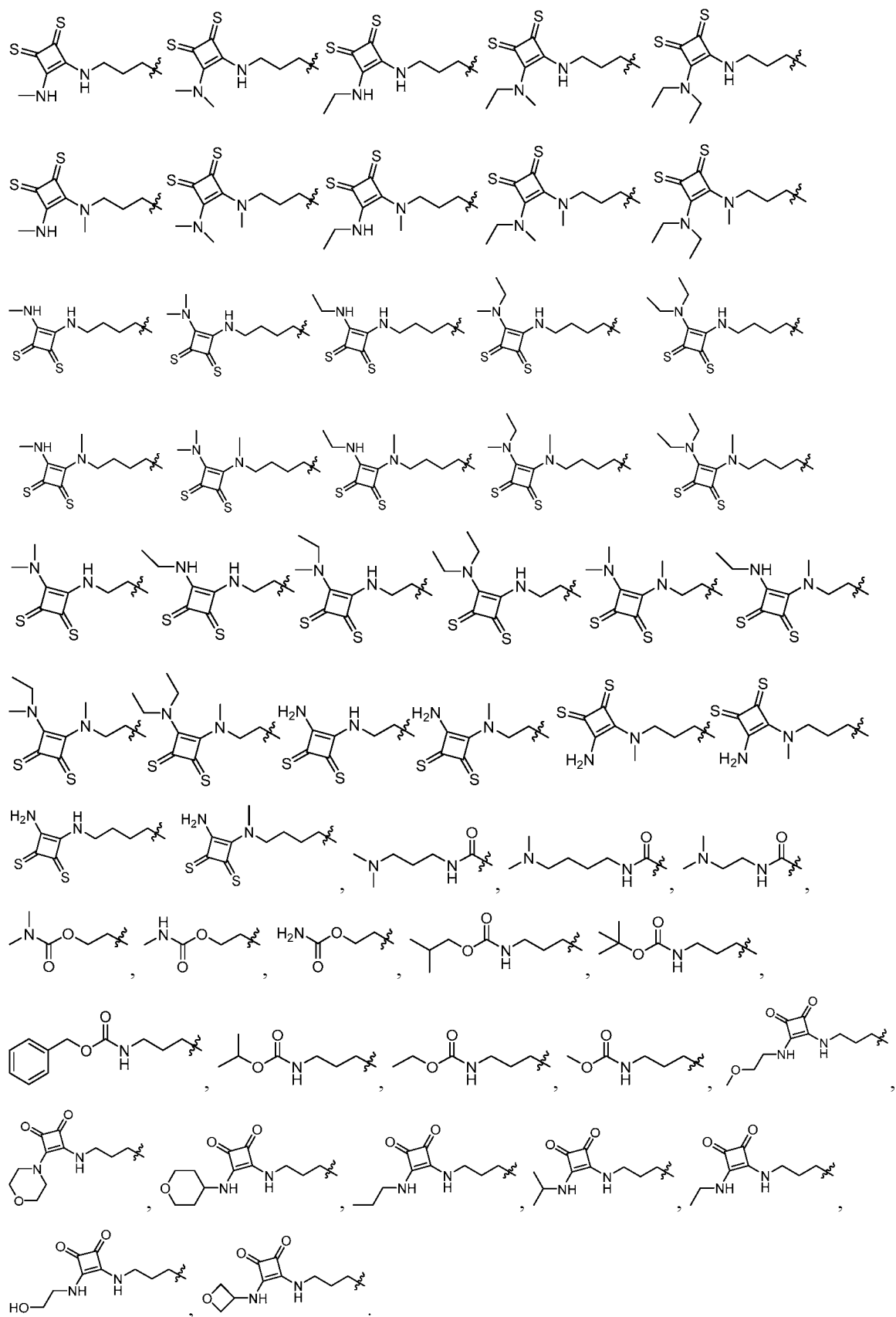


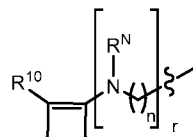




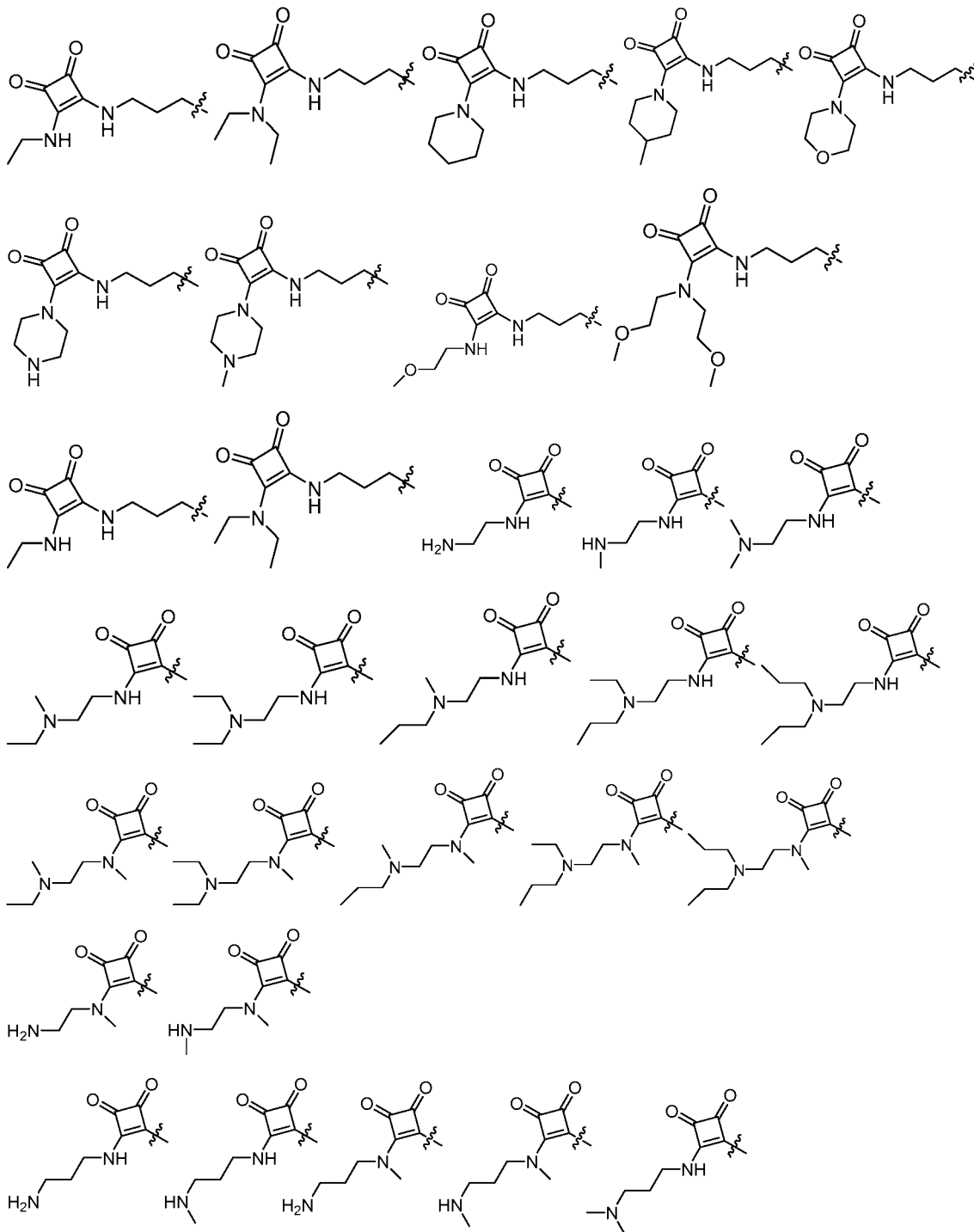


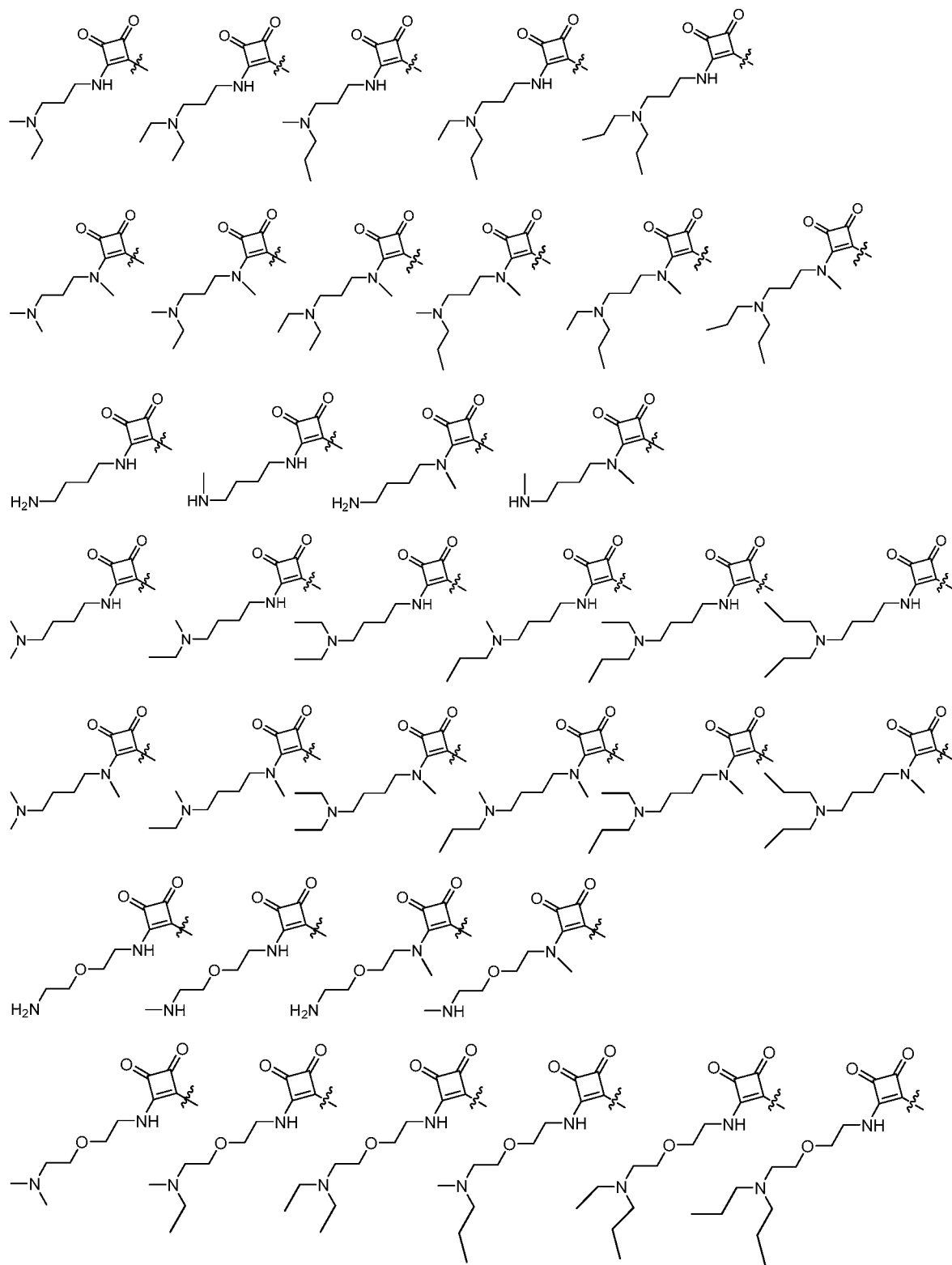


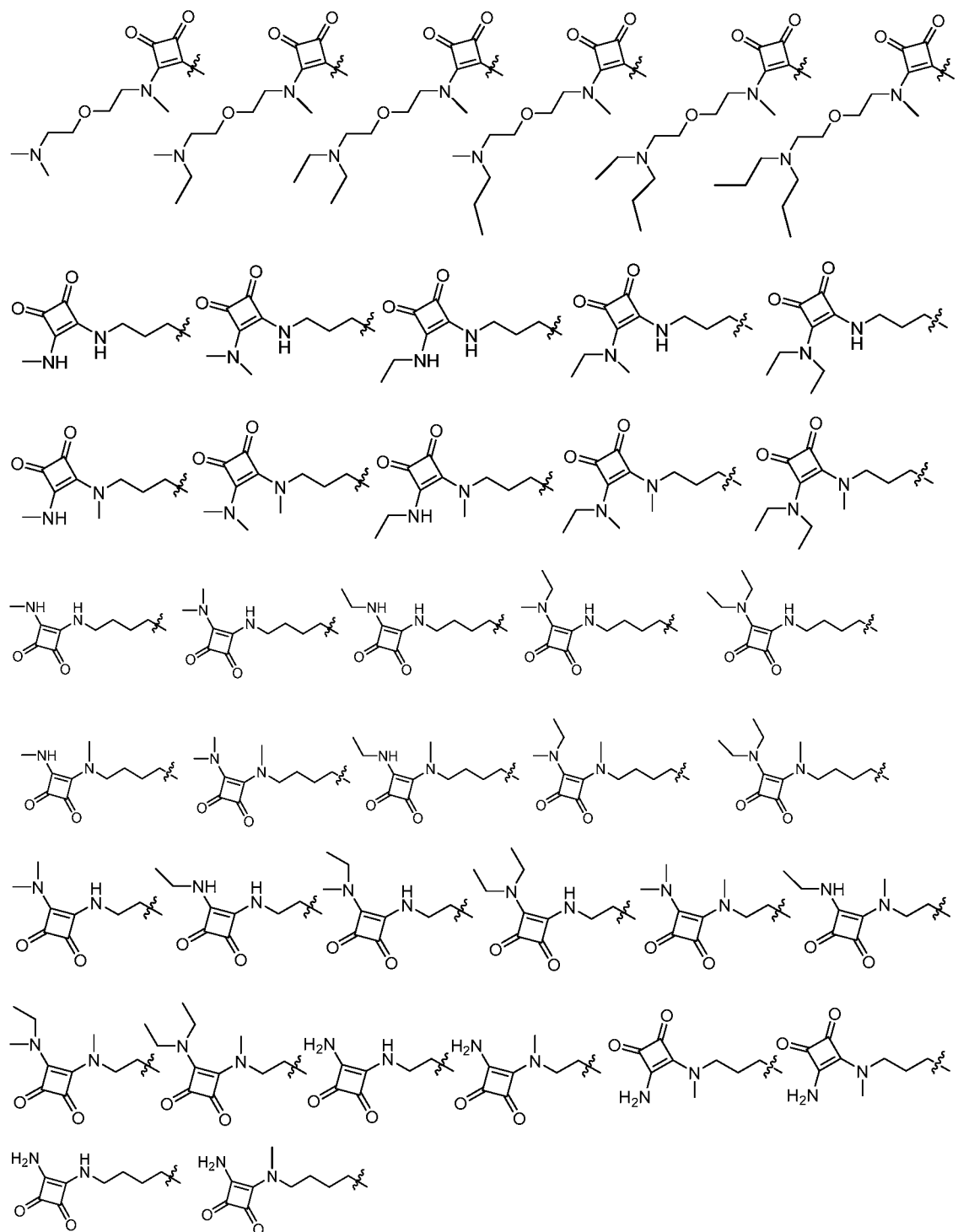


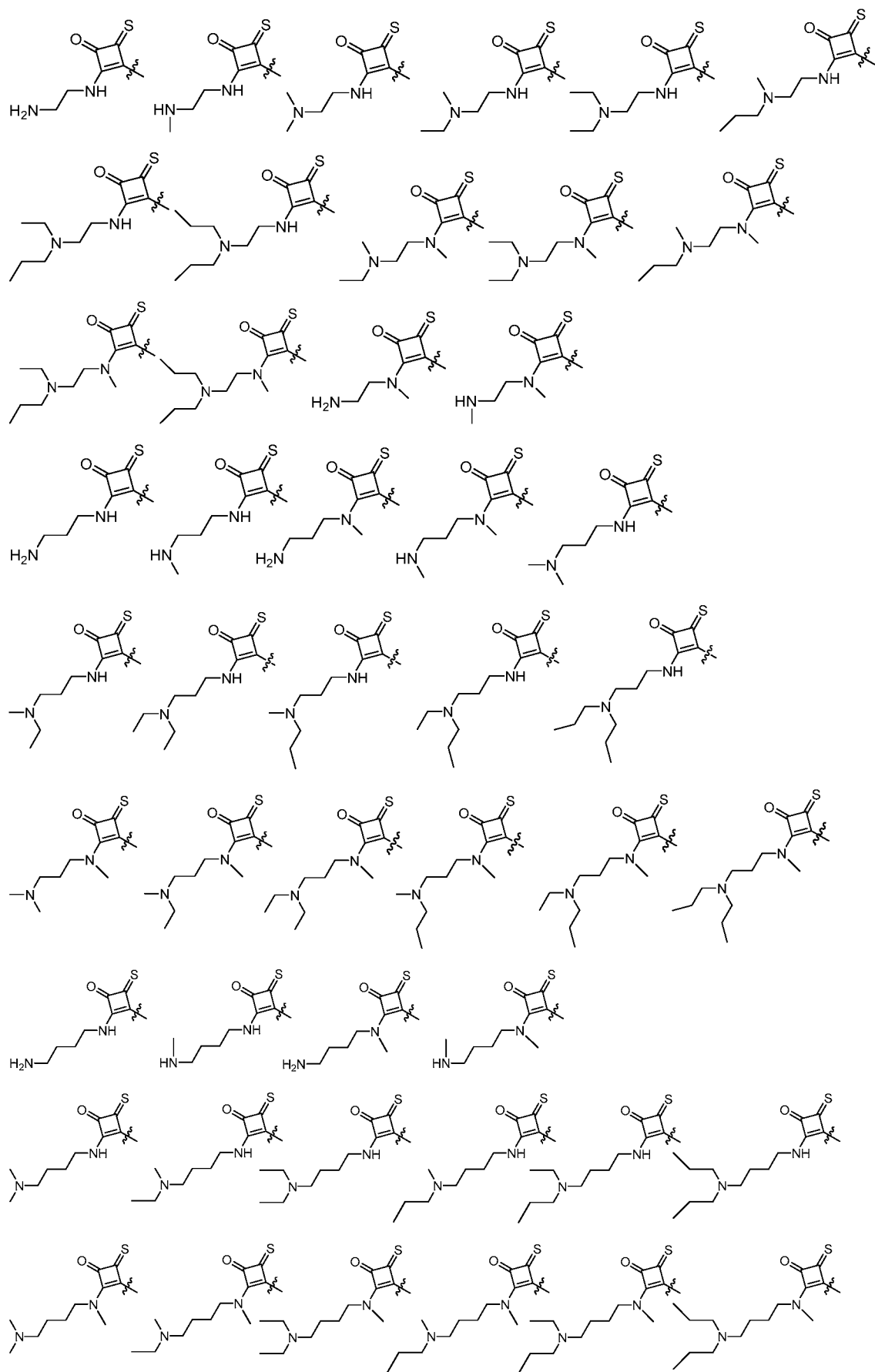


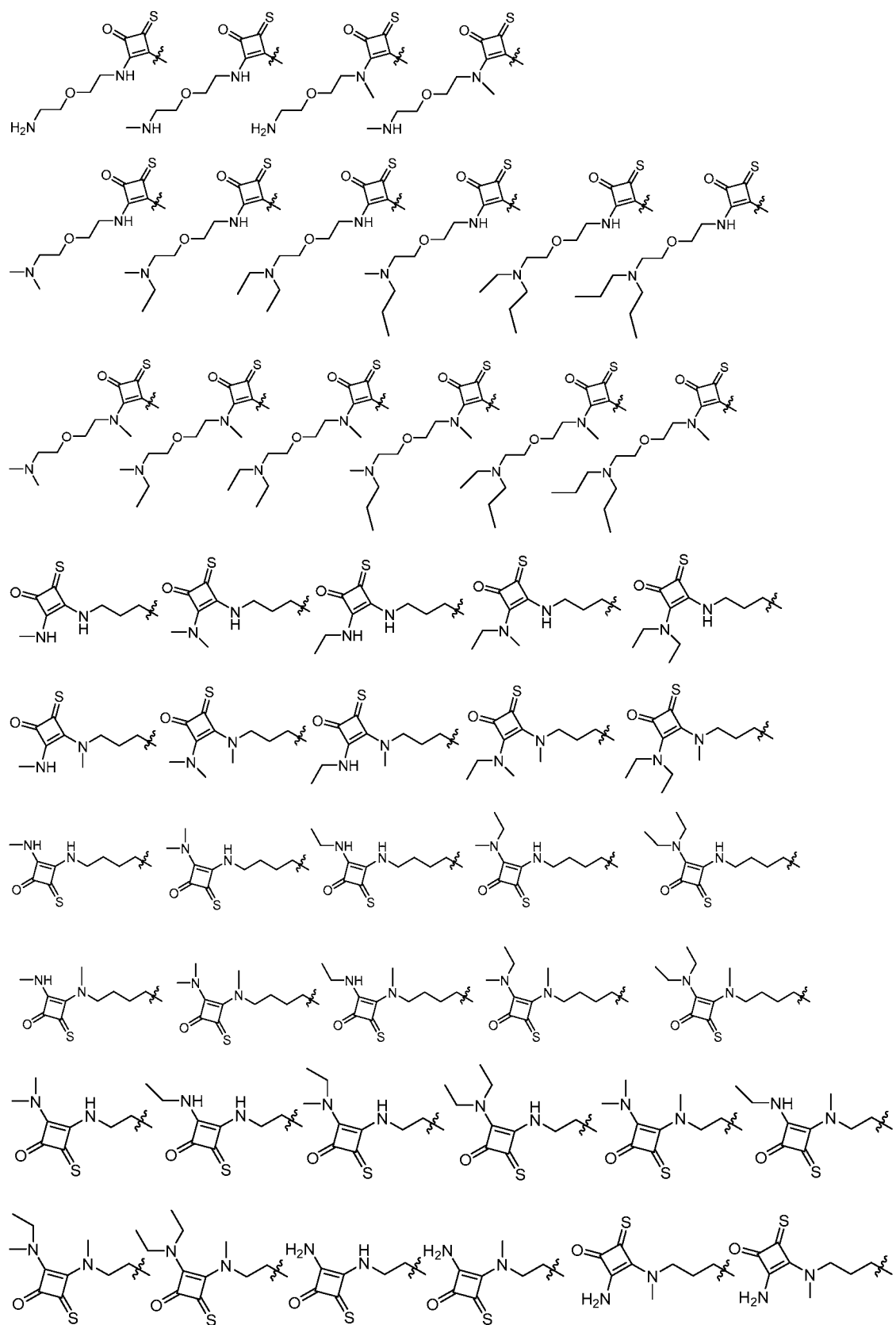
[00248] In some embodiments, x^a  x^b is selected from any of the following groups:

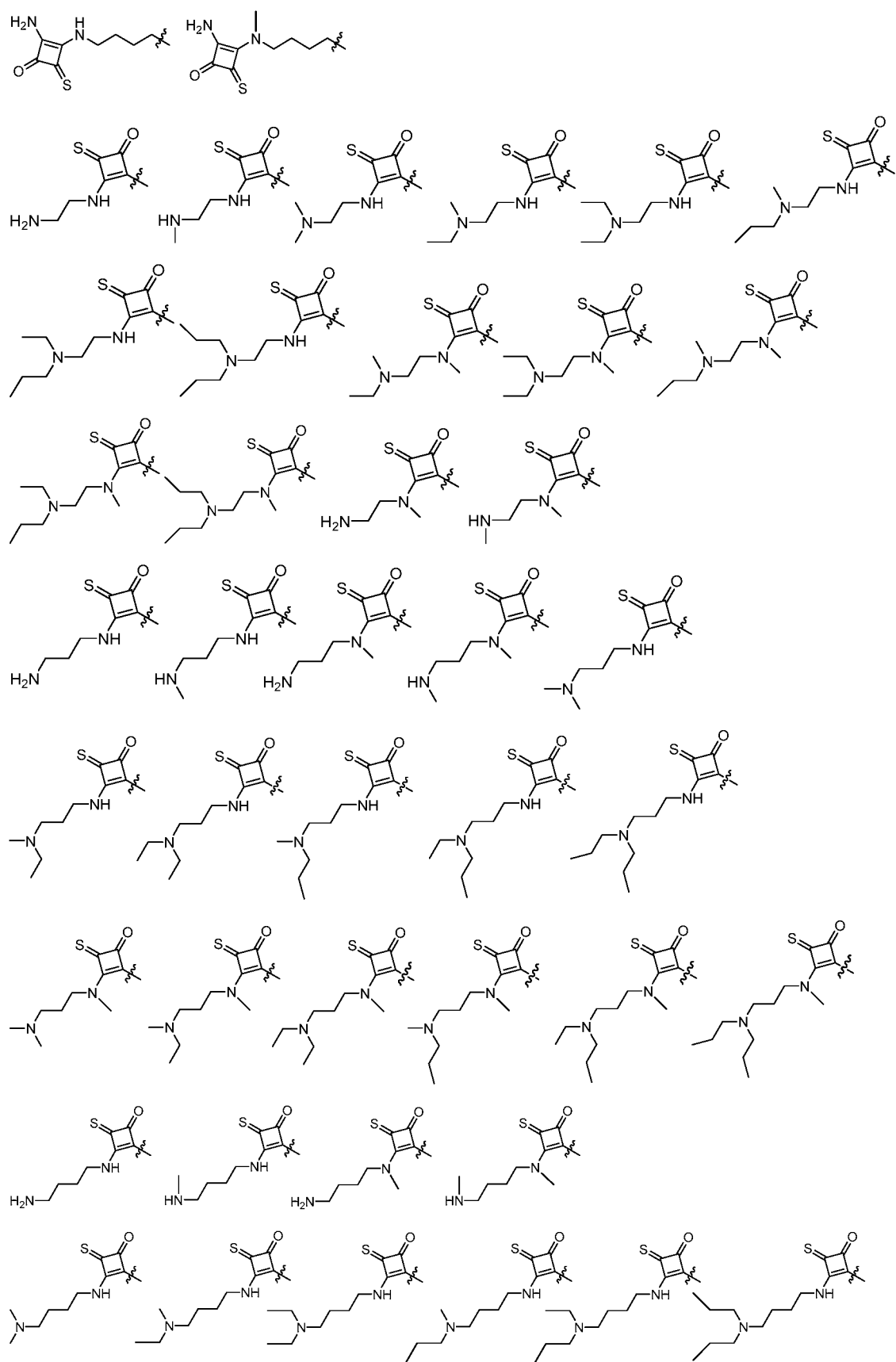


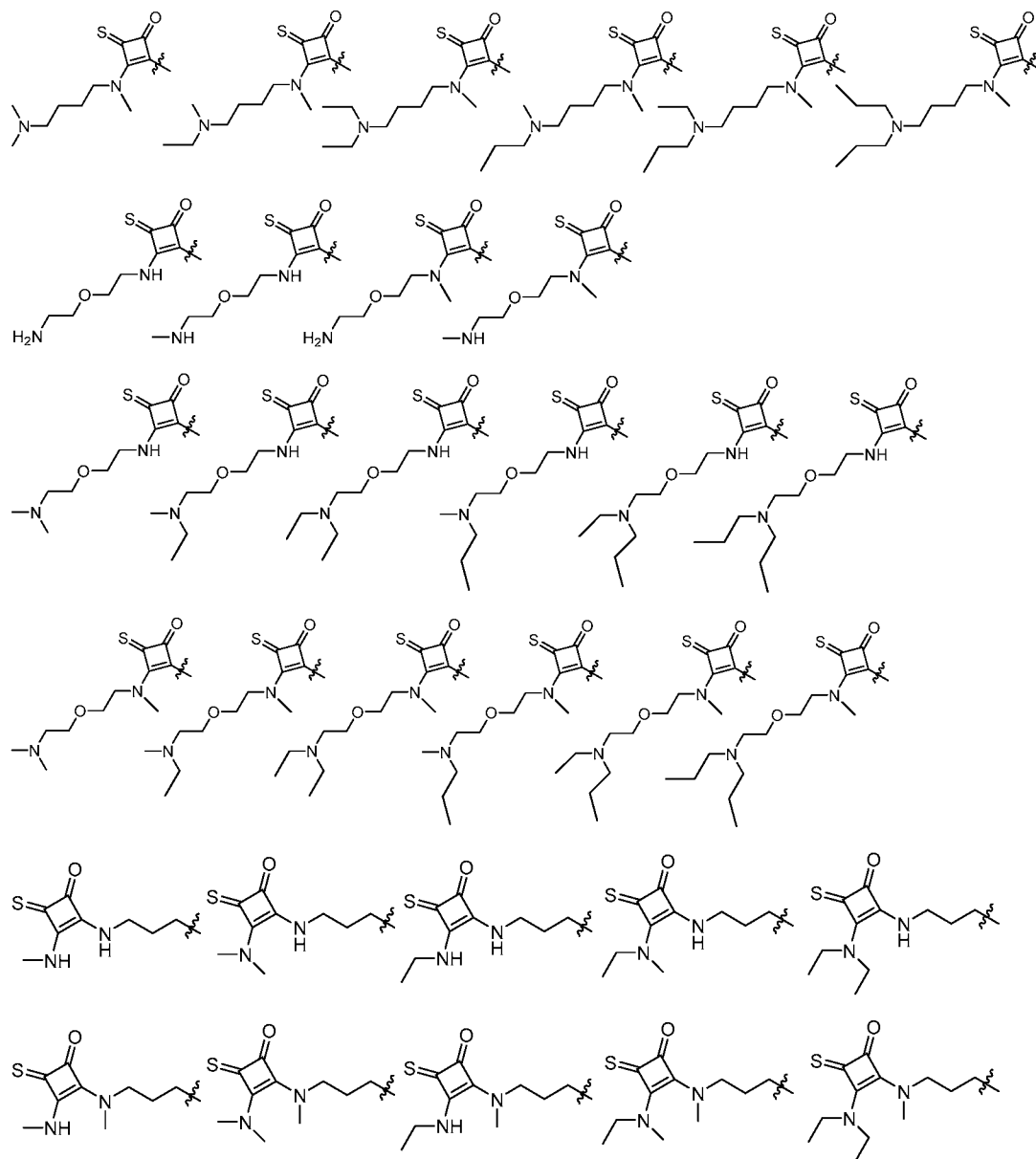


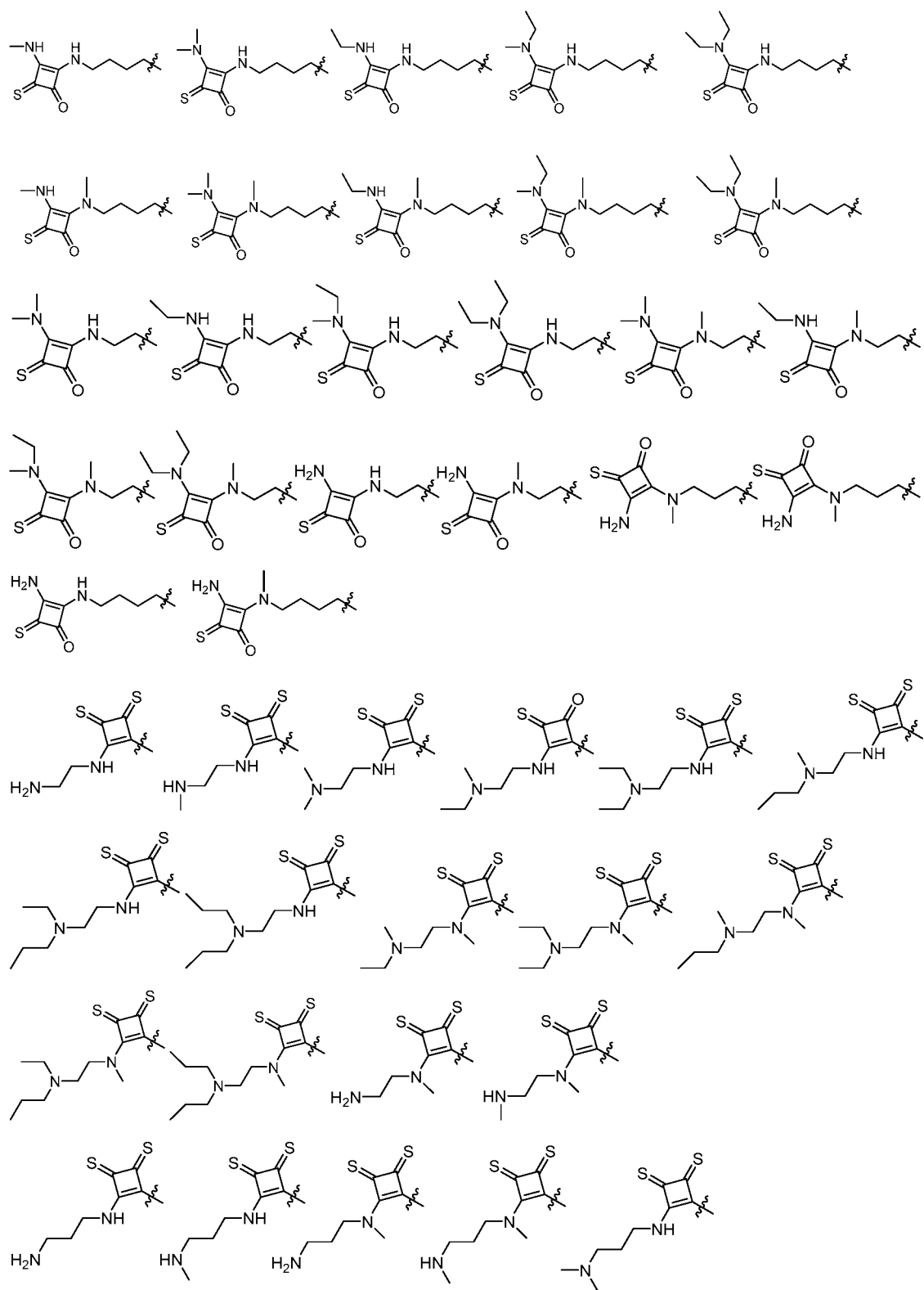


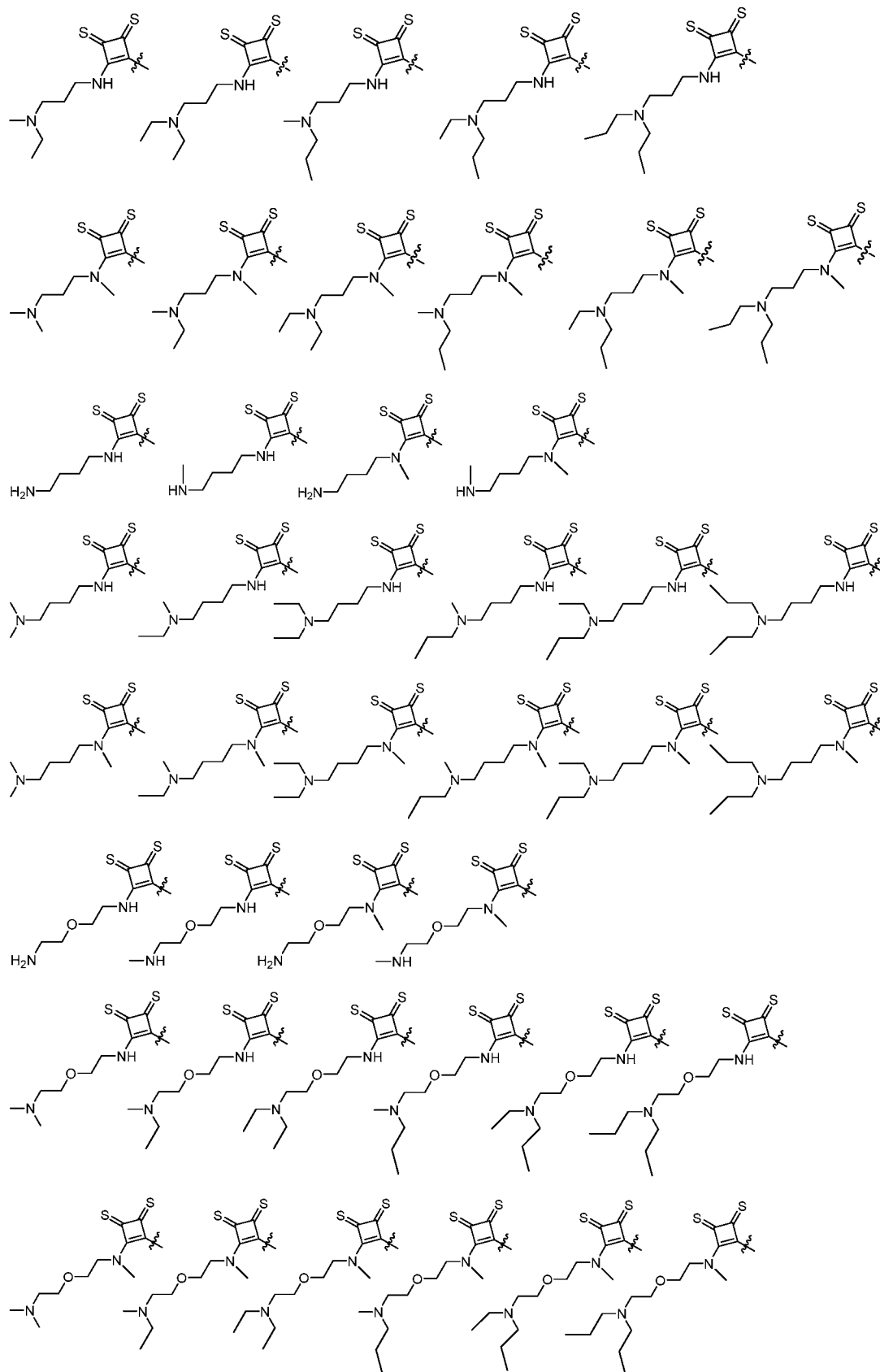


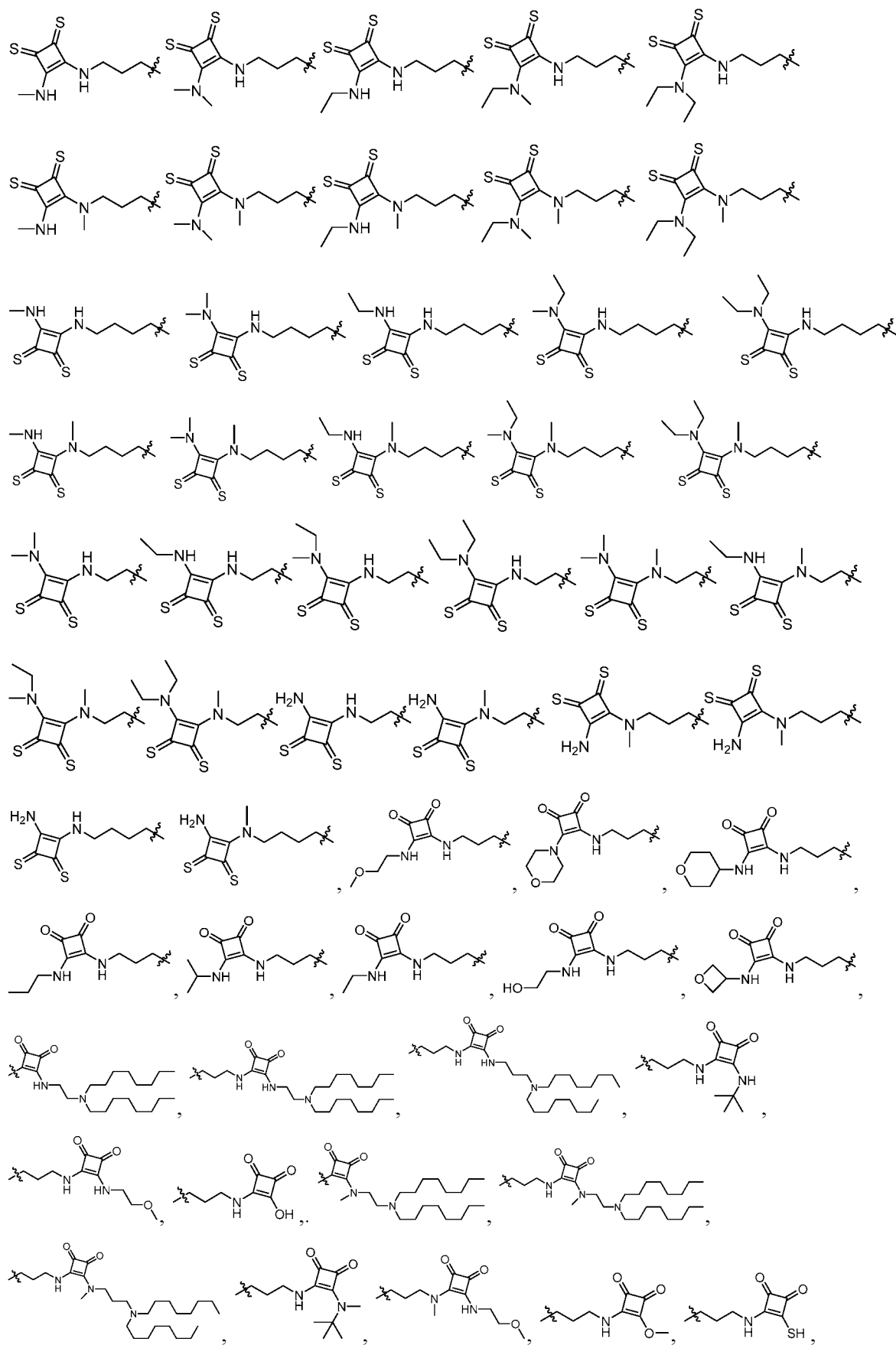


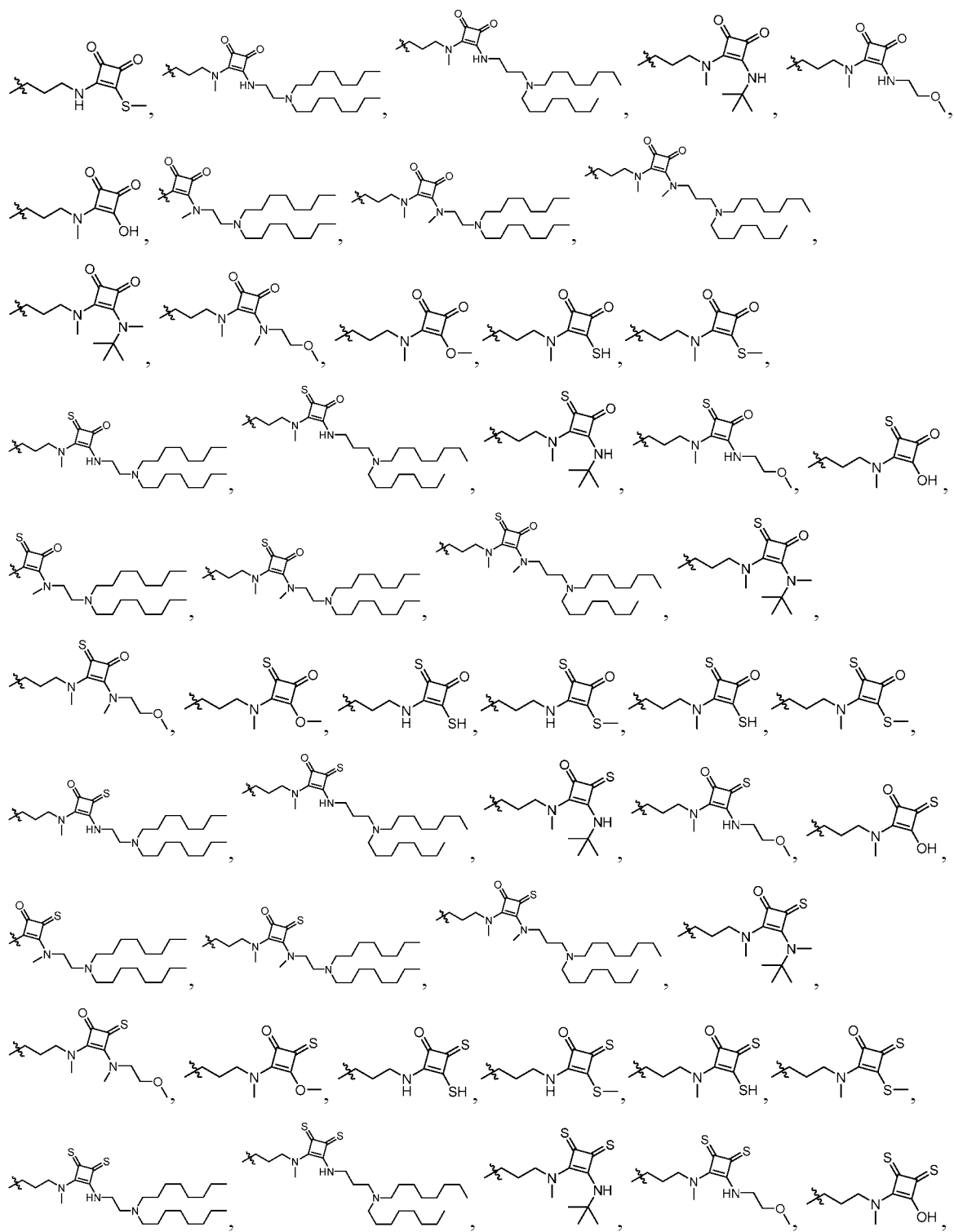






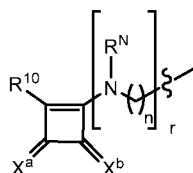
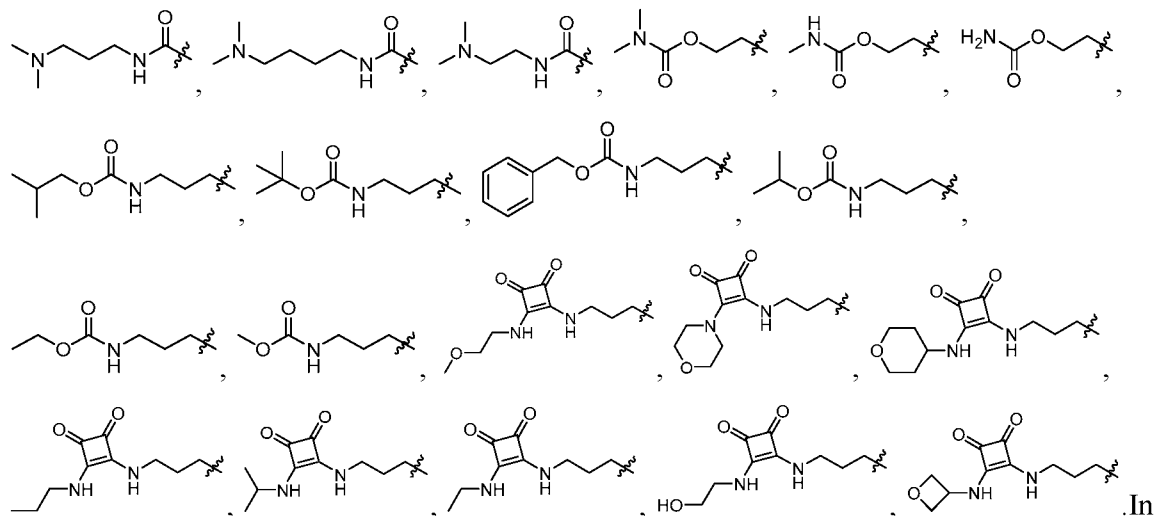




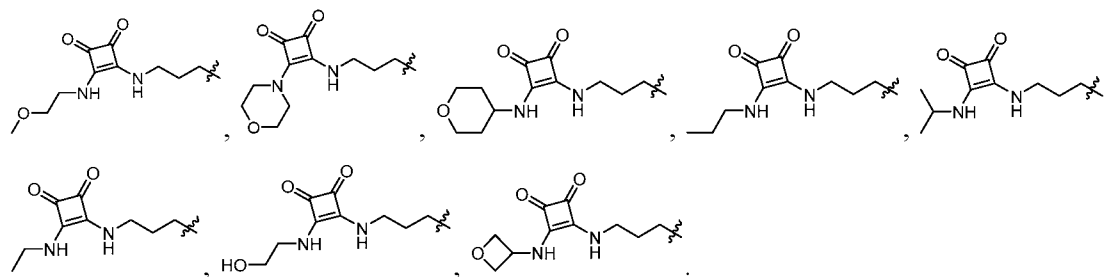


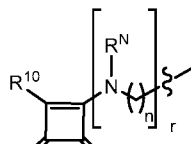




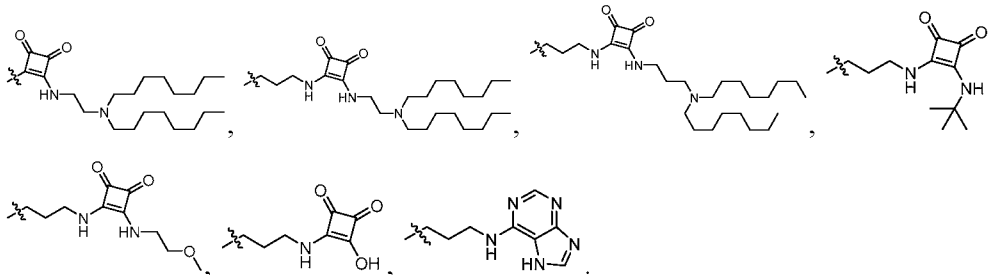


some embodiments, $\begin{array}{c} \diagup \\ \text{X}^a \\ \diagdown \end{array} \begin{array}{c} \diagdown \\ \text{X}^b \\ \diagup \end{array}$ is selected from any of the following groups:





[00252] In some embodiments, X^a is selected from any of the following groups:



[00253] In some embodiments, a compound of Formula (III) further comprises an anion. As described herein, and anion can be any anion capable of reacting with an amine to form an ammonium salt. Examples include, but are not limited to, chloride, bromide, iodide, fluoride, acetate, formate, trifluoroacetate, difluoroacetate, trichloroacetate, and phosphate.

[00254] In some embodiments the compound of any of the formulae described herein is suitable for making a nanoparticle composition for intramuscular administration.

[00255] In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a 5- to 14- membered aromatic or non-aromatic heterocycle having one or more heteroatoms selected from N, O, S, and P. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form an optionally substituted C_{3-20} carbocycle (e.g., C_{3-18} carbocycle, C_{3-15} carbocycle, C_{3-12} carbocycle, or C_{3-10} carbocycle), either aromatic or non-aromatic. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a C_{3-6} carbocycle. In other embodiments, R^2 and R^3 , together with the atom to which they are attached, form a C_6 carbocycle, such as a cyclohexyl or phenyl group. In certain embodiments, the heterocycle or C_{3-6} carbocycle is substituted with one or more alkyl groups (e.g., at the same ring atom or at adjacent or non-adjacent ring atoms). For example, R^2 and R^3 , together with the atom to which they are attached, may form a cyclohexyl or phenyl group bearing one or more C_5 alkyl substitutions. In certain embodiments, the heterocycle or C_{3-6} carbocycle formed by R^2 and R^3 , is substituted with a carbocycle groups. For example, R^2 and R^3 , together with the atom to which they are attached, may form a cyclohexyl or phenyl group that is substituted with cyclohexyl. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a C_{7-15} carbocycle, such as a cycloheptyl, cyclopentadecanyl, or naphthyl group.

[00256] In some embodiments, R^4 is selected from $-(CH_2)_nQ$ and $-(CH_2)_nCHQR$. In some embodiments, Q is selected from the group consisting of $-OR$, $-OH$, $-O(CH_2)_nN(R)_2$, $-OC(O)R$, $-CX_3$, $-CN$, $-N(R)C(O)R$, $-N(H)C(O)R$, $-N(R)S(O)_2R$, $-N(H)S(O)_2R$, $-N(R)C(O)N(R)_2$, $-N(H)C(O)N(R)_2$, $-N(R)S(O)_2R^8$, $-N(H)C(O)N(H)(R)$, $-N(R)C(S)N(R)_2$, $-N(H)C(S)N(R)_2$, $-N(H)C(S)N(H)(R)$, and a heterocycle. In other embodiments, Q is selected from the group consisting of an imidazole, a pyrimidine, and a purine.

[00257] In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a C_{3-6} carbocycle. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a C_6 carbocycle. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a phenyl group. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a cyclohexyl group. In some embodiments, R^2 and R^3 , together with the atom to which they are attached, form a heterocycle. In certain embodiments, the heterocycle or C_{3-6} carbocycle is substituted with one or more alkyl groups (*e.g.*, at the same ring atom or at adjacent or non-adjacent ring atoms). For example, R^2 and R^3 , together with the atom to which they are attached, may form a phenyl group bearing one or more C_5 alkyl substitutions.

[00258] In some embodiments, at least one occurrence of R^5 and R^6 is C_{1-3} alkyl, *e.g.*, methyl. In some embodiments, one of the R^5 and R^6 adjacent to M is C_{1-3} alkyl, *e.g.*, methyl, and the other is H . In some embodiments, one of the R^5 and R^6 adjacent to M is C_{1-3} alkyl, *e.g.*, methyl and the other is H , and M is $-OC(O)-$ or $-C(O)O-$.

[00259] In some embodiments, at most one occurrence of R^5 and R^6 is C_{1-3} alkyl, *e.g.*, methyl. In some embodiments, one of the R^5 and R^6 adjacent to M is C_{1-3} alkyl, *e.g.*, methyl, and the other is H . In some embodiments, one of the R^5 and R^6 adjacent to M is C_{1-3} alkyl, *e.g.*, methyl and the other is H , and M is $-OC(O)-$ or $-C(O)O-$.

[00260] In some embodiments, at least one occurrence of R^5 and R^6 is methyl.

[00261] The compounds of any one of formula (VI), (VI-a), (VII), (VIIa), (VIIb), (VIIc), (VIId), (VIII), (VIIIa), (VIIIb), (VIIIc) or (VIId) include one or more of the following features when applicable.

[00262] In some embodiments, r is 0. In some embodiments, r is 1.

[00263] In some embodiments, n is 2, 3, or 4. In some embodiments, n is 2. In some embodiments, n is 4. In some embodiments, n is not 3.

[00264] In some embodiments, R^N is H. In some embodiments, R^N is C_{1-3} alkyl. For example, in some embodiments R^N is C_1 alkyl. For example, in some embodiments R^N is C_2 alkyl. For example, in some embodiments R^N is C_2 alkyl.

[00265] In some embodiments, X^a is O. In some embodiments, X^a is S. In some embodiments, X^b is O. In some embodiments, X^b is S.

[00266] In some embodiments, R^{10} is selected from the group consisting of $N(R)_2$, $-NH(CH_2)_{t1}N(R)_2$, $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, $-NH(CH_2)_{s1}OR$, $-N((CH_2)_{s1}OR)_2$, and a heterocycle.

[00267] In some embodiments, when R^{10} is $N(R)_2$, R is selected from H and C_{1-4} alkyl. For example, in some embodiments, one R is H and one R is C_1 alkyl. For example, in some embodiments, one R is H and one R is C_2 alkyl. For example, in some embodiments, one R is H and one R is C_3 alkyl. For example, in some embodiments, one R is H and one R is C_4 alkyl. For example, in some embodiments, one R is H and one R is *tert*-butyl. In some embodiments, when R^{10} is $N(R)_2$, each R is a C_{1-4} alkyl. For example, in some embodiments, each R is C_1 -alkyl. For example, in some embodiments, each R is C_2 -alkyl. For example, in some embodiments, each R is C_3 -alkyl. For example, in some embodiments, each R is C_4 -alkyl. In some embodiments, when R^{10} is $N(R)_2$, each R is H.

[00268] In some embodiments, R^{10} is selected from the group consisting of $-NH(CH_2)_{t1}N(R)_2$, $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, $-NH(CH_2)_{s1}OR$, $-N((CH_2)_{s1}OR)_2$, and a heterocycle.

[00269] In some embodiments, R^{10} is selected from the group consisting of $-N(R)$ -carbocycle, $-N(R)$ -heterocycle, $-N(R)$ -aryl, and $-N(R)$ -heteroaryl.

[00270] In some embodiments, R^{10} is selected from the group consisting of $-NH$ -carbocycle, $-NH$ -heterocycle, $-NH$ -aryl, and $-NH$ -heteroaryl. For example, in some embodiments, R^{10} is $-NH$ -heterocycle wherein the heterocycle is tetrahydropyran or oxetane.

[00271] In some embodiments, R^{10} is selected from the group consisting of $-N(R)(CH_2)_{t1}$ -carbocycle, $-N(R)(CH_2)_{t1}$ -heterocycle, $-N(R)(CH_2)_{t1}$ -aryl, and $-N(R)(CH_2)_{t1}$ -heteroaryl.

[00272] In some embodiments, R^{10} is selected from the group consisting of $-NH(CH_2)_{t1}$ -carbocycle, $-NH(CH_2)_{t1}$ -heterocycle, $-NH(CH_2)_{t1}$ -aryl, and $-NH(CH_2)_{t1}$ -heteroaryl.

[00273] In some embodiments wherein R^{10} is $-NH(CH_2)_oN(R)_2$, o is 2, 3, or 4.

[00274] In some embodiments wherein $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, p^1 is 2. In some embodiments wherein $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, q^1 is 2.

[00275] In some embodiments wherein R^{10} is $-N((CH_2)_{s1}OR)_2$, s^1 is 2.

[00276] In some embodiments, R^{10} is $-OH$.

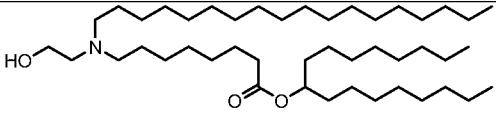
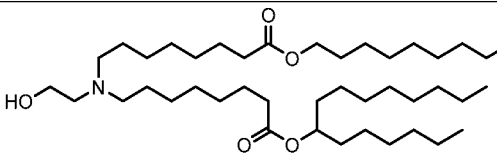
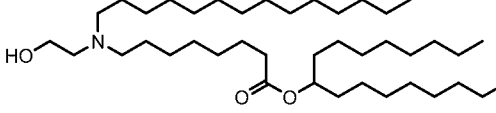
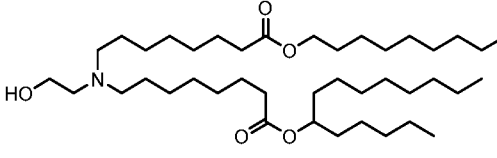
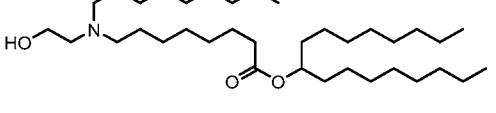
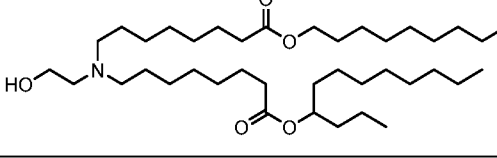
[00277] In some embodiments wherein R^{10} is $-\text{NH}(\text{CH}_2)_o\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_p\text{O}(\text{CH}_2)_q\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_s\text{OR}$, or $-\text{N}((\text{CH}_2)_s\text{OR})_2$, R is H or C_1 - C_3 alkyl. For example, in some embodiments, R is C_1 alkyl. For example, in some embodiments, R is C_2 alkyl. For example, in some embodiments, R is H. For example, in some embodiments, R is H and one R is C_1 - C_3 alkyl. For example, in some embodiments, R is H and one R is C_1 alkyl. For example, in some embodiments, R is H and one R is C_2 alkyl. In some embodiments wherein R^{10} is $-\text{NH}(\text{CH}_2)_t\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_p\text{O}(\text{CH}_2)_q\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_s\text{OR}$, or $-\text{N}((\text{CH}_2)_s\text{OR})_2$, each R is C_2 - C_4 alkyl.

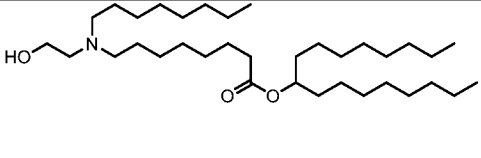
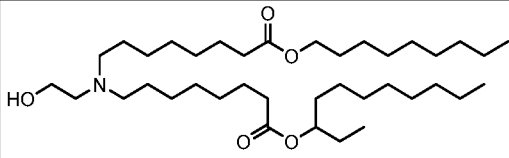
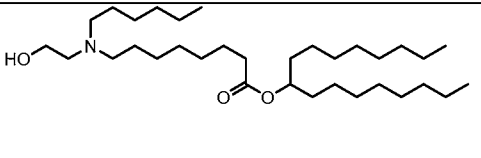
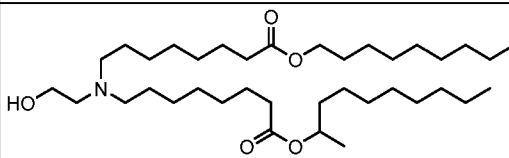
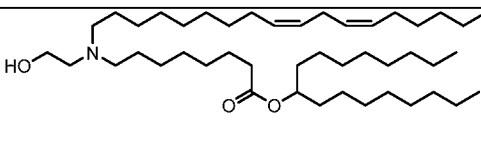
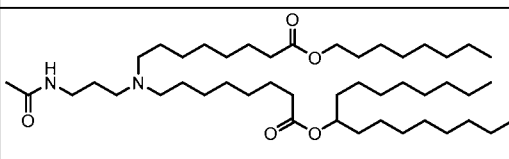
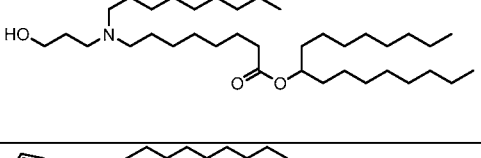
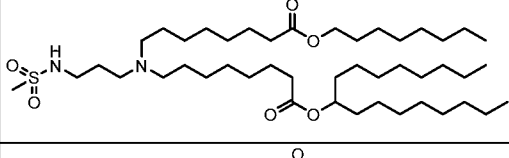
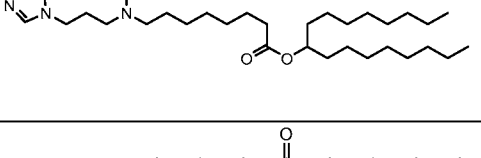
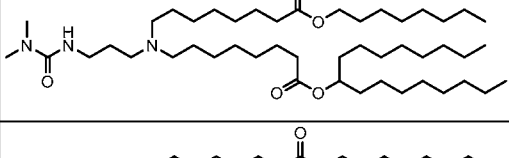
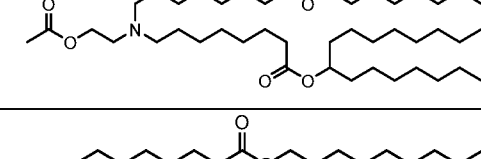
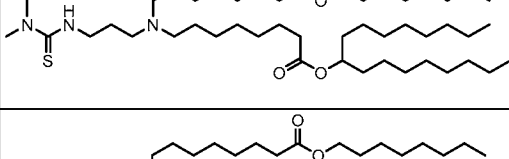
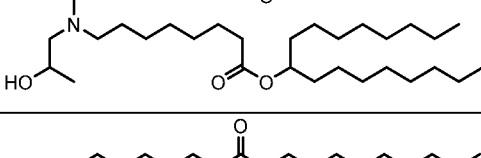
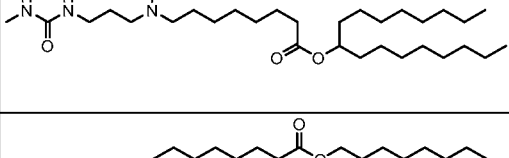
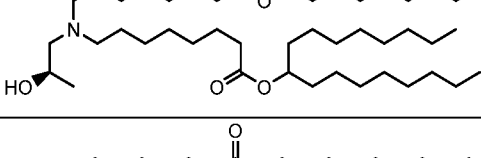
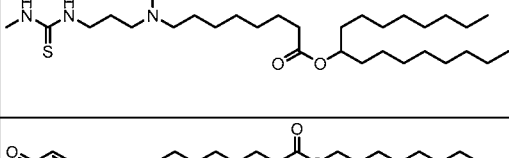
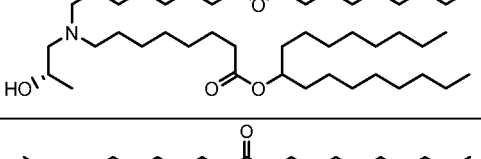
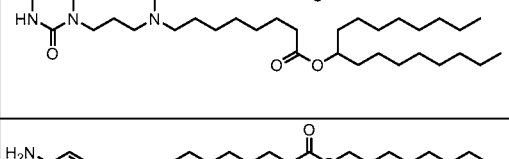
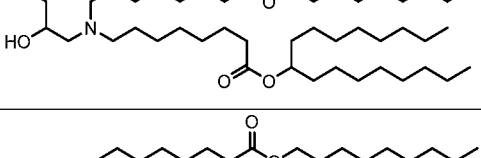
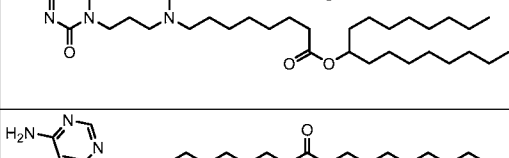
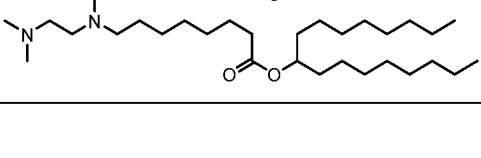
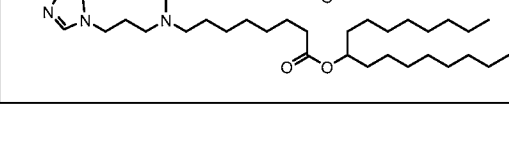
[00278] In some embodiments wherein R^{10} is $-\text{NH}(\text{CH}_2)_o\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_p\text{O}(\text{CH}_2)_q\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_s\text{OR}$, or $-\text{N}((\text{CH}_2)_s\text{OR})_2$, R is H or C_4 - C_{10} alkyl. For example, in some embodiments, R is C_8 alkyl. For example, in some embodiments, R is C_4 alkyl. For example in some embodiments, R is *tert*-butyl. For example, in some embodiments, R is H and one R is C_4 - C_{10} alkyl. In some embodiments wherein R^{10} is $-\text{NH}(\text{CH}_2)_t\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_p\text{O}(\text{CH}_2)_q\text{N}(\text{R})_2$, $-\text{NH}(\text{CH}_2)_s\text{OR}$, or $-\text{N}((\text{CH}_2)_s\text{OR})_2$, each R is C_4 - C_{10} alkyl. For example, in some embodiments, each R is C_8 -alkyl.

[00279] For example, in some embodiments, one R is H and one R is C_2 - C_4 alkyl. In some embodiments, R^{10} is a heterocycle. For example, in some embodiments, R^{10} is morpholinyl. For example, in some embodiments, R^{10} is methylpiperazinyl.

[00280] In some embodiments, each occurrence of R^5 and R^6 is H.

[00281] In some embodiments, the compound of Formula (I) is selected from the group consisting of:

Cpd	Structure	Cpd	Structure
1		32	
2		33	
3		34	

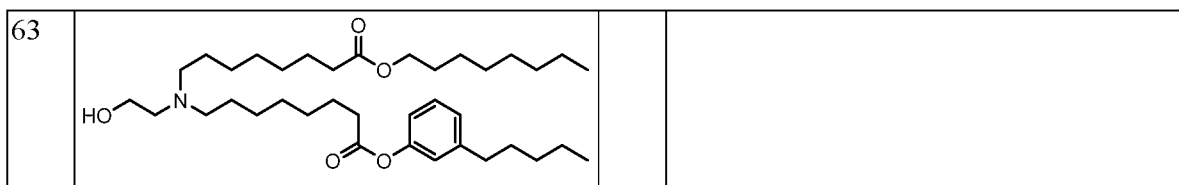
4		35	
5		36	
6		37	
7		38	
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9		40	
10		41	
11		42	
12		43	
13		44	
14		45	

15		46	
16		47	
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19		50	
20		51	
21		52	
22		53	
23		54	
24		55	

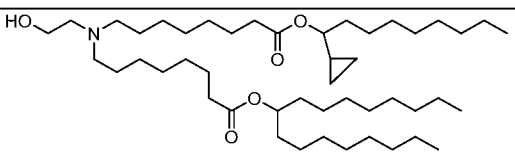
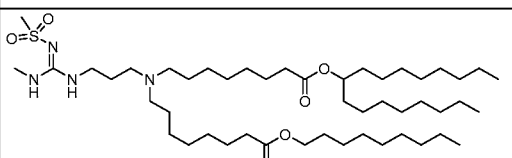
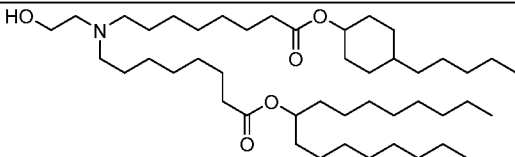
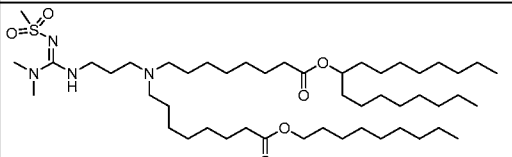
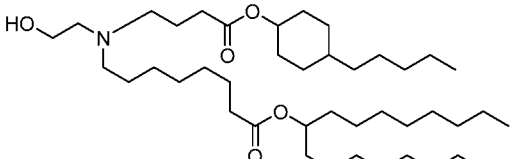
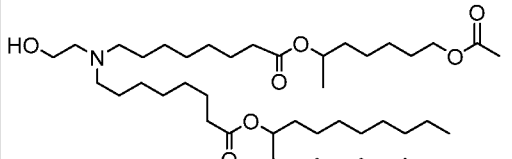
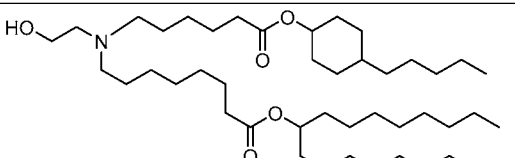
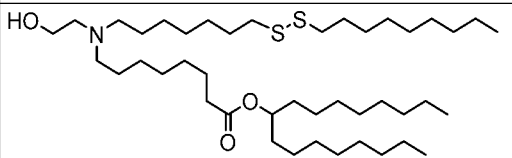
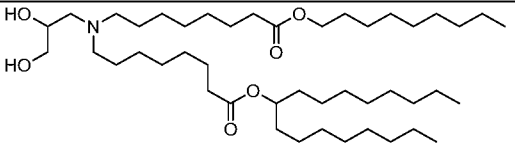
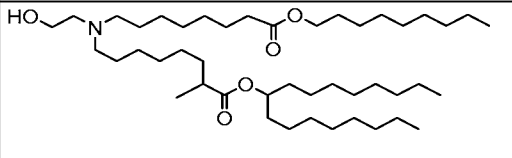
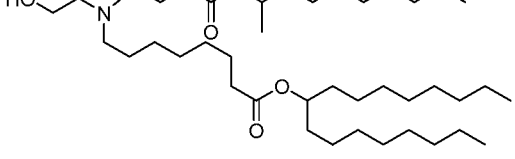
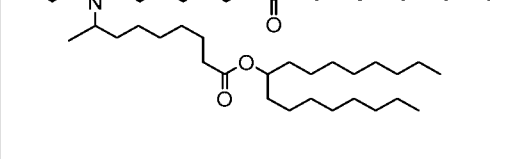
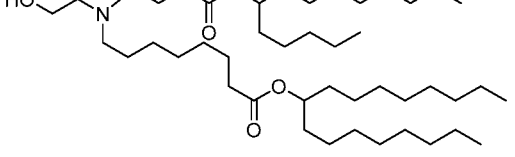
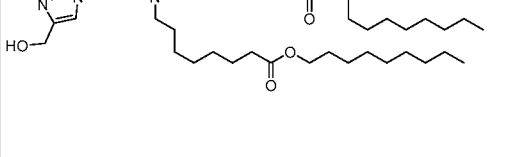
25		56	
26		57	
27		58	
28		59	
29		60	
30		61	
31			

[00282] In further embodiments, the compound of Formula (I) is selected from the group consisting of:

Cpd	Structure	Cpd	Structure
62		64	



[00283] In some embodiments, the compound of Formula (I) or Formula (VI) is selected from the group consisting of:

Cpd	Structure	Cpd	Structure
65		212	
66		213	
67		214	
68		215	
69		216	
70		217	
71		218	

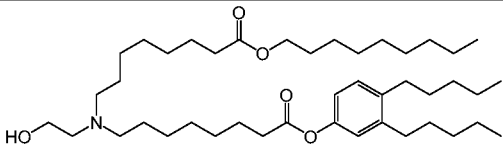
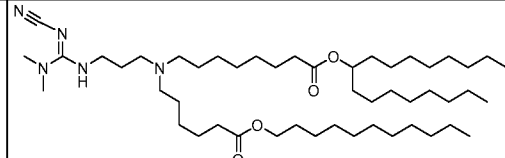
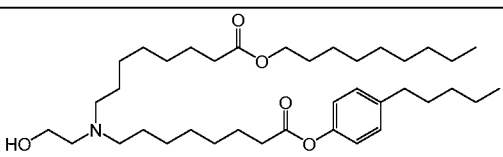
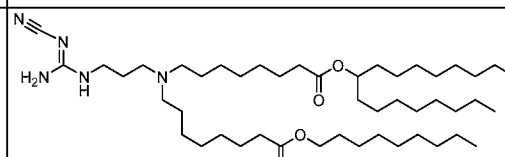
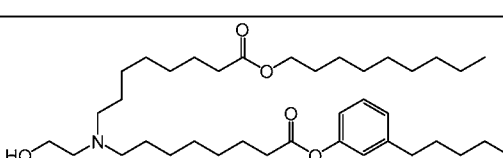
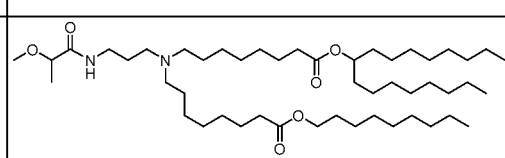
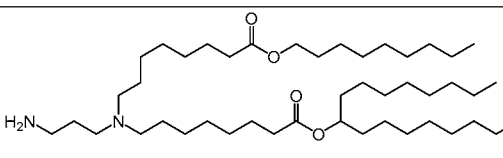
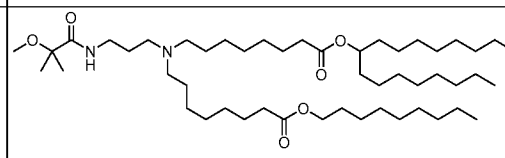
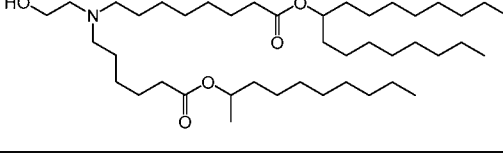
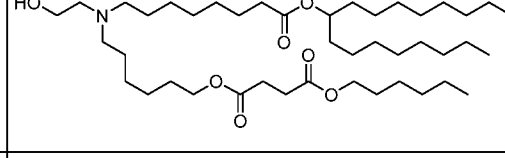
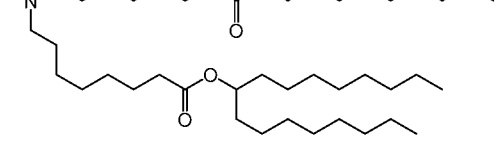
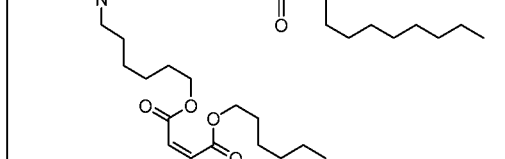
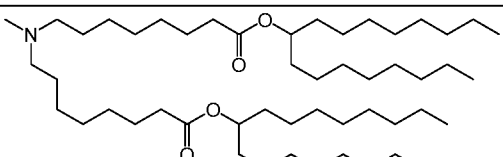
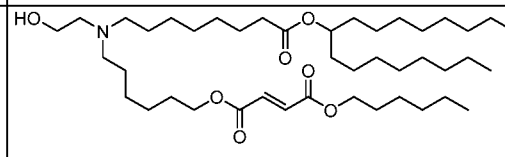
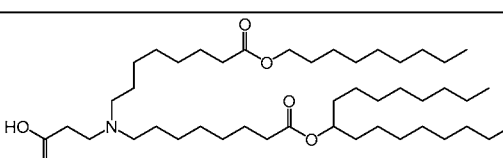
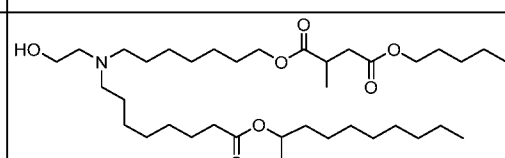
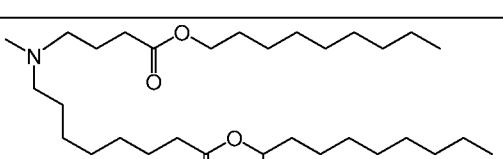
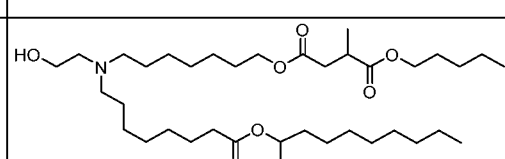
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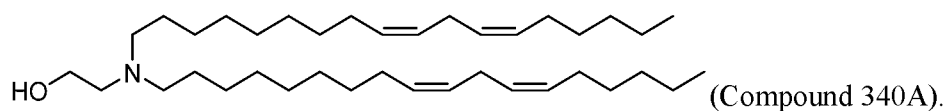
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391		392	

[00284] In some embodiments, a lipid of the disclosure comprises Compound 340A:



[00285] The central amine moiety of a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId) may be protonated at a physiological pH. Thus, a lipid may have a positive or partial positive charge at physiological pH. Such lipids

may be referred to as cationic or ionizable (amino)lipids. Lipids may also be zwitterionic, i.e., neutral molecules having both a positive and a negative charge.

[00286] As used herein, the term “alkyl” or “alkyl group” means a linear or branched, saturated hydrocarbon including one or more carbon atoms (*e.g.*, one, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, or more carbon atoms), which is optionally substituted. The notation “C₁₋₁₄ alkyl” means an optionally substituted linear or branched, saturated hydrocarbon including 1-14 carbon atoms. Unless otherwise specified, an alkyl group described herein refers to both unsubstituted and substituted alkyl groups.

[00287] As used herein, the term “alkenyl” or “alkenyl group” means a linear or branched hydrocarbon including two or more carbon atoms (*e.g.*, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, or more carbon atoms) and at least one double bond, which is optionally substituted. The notation “C₂₋₁₄ alkenyl” means an optionally substituted linear or branched hydrocarbon including 2-14 carbon atoms and at least one carbon-carbon double bond. An alkenyl group may include one, two, three, four, or more carbon-carbon double bonds. For example, C₁₈ alkenyl may include one or more double bonds. A C₁₈ alkenyl group including two double bonds may be a linoleyl group. Unless otherwise specified, an alkenyl group described herein refers to both unsubstituted and substituted alkenyl groups.

[00288] As used herein, the term “alkynyl” or “alkynyl group” means a linear or branched hydrocarbon including two or more carbon atoms (*e.g.*, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, twenty, or more carbon atoms) and at least one carbon-carbon triple bond, which is optionally substituted. The notation “C₂₋₁₄ alkynyl” means an optionally substituted linear or branched hydrocarbon including 2-14 carbon atoms and at least one carbon-carbon triple bond. An alkynyl group may include one, two, three, four, or more carbon-carbon triple bonds. For example, C₁₈ alkynyl may include one or more carbon-carbon triple bonds. Unless otherwise specified, an alkynyl group described herein refers to both unsubstituted and substituted alkynyl groups.

[00289] As used herein, the term “carbocycle” or “carbocyclic group” means an optionally substituted mono- or multi-cyclic system including one or more rings of carbon atoms. Rings may be three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, fifteen, sixteen, seventeen, eighteen, nineteen, or twenty membered rings. The notation “C₃₋₆ carbocycle” means a carbocycle including a single ring having 3-6 carbon atoms. Carbocycles

may include one or more carbon-carbon double or triple bonds and may be non-aromatic or aromatic (*e.g.*, cycloalkyl or aryl groups). Examples of carbocycles include cyclopropyl, cyclopentyl, cyclohexyl, phenyl, naphthyl, and 1,2-dihydronaphthyl groups. The term “cycloalkyl” as used herein means a non-aromatic carbocycle and may or may not include any double or triple bond. Unless otherwise specified, carbocycles described herein refers to both unsubstituted and substituted carbocycle groups, *i.e.*, optionally substituted carbocycles.

[00290] As used herein, the term “heterocycle” or “heterocyclic group” means an optionally substituted mono- or multi-cyclic system including one or more rings, where at least one ring includes at least one heteroatom. Heteroatoms may be, for example, nitrogen, oxygen, or sulfur atoms. Rings may be three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, or fourteen membered rings. Heterocycles may include one or more double or triple bonds and may be non-aromatic or aromatic (*e.g.*, heterocycloalkyl or heteroaryl groups). Examples of heterocycles include imidazolyl, imidazolidinyl, oxazolyl, oxazolidinyl, thiazolyl, thiazolidinyl, pyrazolidinyl, pyrazolyl, isoxazolidinyl, isoxazolyl, isothiazolidinyl, isothiazolyl, morpholinyl, pyrrolyl, pyrrolidinyl, furyl, tetrahydrofuryl, thiophenyl, pyridinyl, piperidinyl, quinolyl, and isoquinolyl groups. The term “heterocycloalkyl” as used herein means a non-aromatic heterocycle and may or may not include any double or triple bond. Unless otherwise specified, heterocycles described herein refers to both unsubstituted and substituted heterocycle groups, *i.e.*, optionally substituted heterocycles.

[00291] As used herein, a “biodegradable group” is a group that may facilitate faster metabolism of a lipid in a mammalian entity. A biodegradable group may be selected from the group consisting of, but is not limited to, -C(O)O-, -OC(O)-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, an aryl group, and a heteroaryl group. As used herein, an “aryl group” is an optionally substituted carbocyclic group including one or more aromatic rings. Examples of aryl groups include phenyl and naphthyl groups. As used herein, a “heteroaryl group” is an optionally substituted heterocyclic group including one or more aromatic rings. Examples of heteroaryl groups include pyrrolyl, furyl, thiophenyl, imidazolyl, oxazolyl, and thiazolyl. Both aryl and heteroaryl groups may be optionally substituted. For example, M and M' can be selected from the non-limiting group consisting of optionally substituted phenyl, oxazole, and thiazole. In the formulas herein, M and M' can be independently selected from the list of biodegradable groups above. Unless otherwise specified, aryl or heteroaryl groups described herein refers to both unsubstituted and substituted groups, *i.e.*, optionally substituted aryl or heteroaryl groups.

[00292] Alkyl, alkenyl, and cyclyl (*e.g.*, carbocyclyl and heterocyclyl) groups may be optionally substituted unless otherwise specified. Optional substituents may be selected from the group consisting of, but are not limited to, a halogen atom (*e.g.*, a chloride, bromide, fluoride, or iodide group), a carboxylic acid (*e.g.*, -C(O)OH), an alcohol (*e.g.*, a hydroxyl, -OH), an ester (*e.g.*, -C(O)OR or -OC(O)R), an aldehyde (*e.g.*, -C(O)H), a carbonyl (*e.g.*, -C(O)R, alternatively represented by C=O), an acyl halide (*e.g.*, -C(O)X, in which X is a halide selected from bromide, fluoride, chloride, and iodide), a carbonate (*e.g.*, -OC(O)OR), an alkoxy (*e.g.*, -OR), an acetal (*e.g.*, -C(OR)₂R^{'''}), in which each OR are alkoxy groups that can be the same or different and R^{'''} is an alkyl or alkenyl group), a phosphate (*e.g.*, P(O)₄³⁻), a thiol (*e.g.*, -SH), a sulfoxide (*e.g.*, -S(O)R), a sulfinic acid (*e.g.*, -S(O)OH), a sulfonic acid (*e.g.*, -S(O)₂OH), a thial (*e.g.*, -C(S)H), a sulfate (*e.g.*, S(O)₄²⁻), a sulfonyl (*e.g.*, -S(O)₂-), an amide (*e.g.*, -C(O)NR₂, or -N(R)C(O)R), an azido (*e.g.*, -N₃), a nitro (*e.g.*, -NO₂), a cyano (*e.g.*, -CN), an isocyano (*e.g.*, -NC), an acyloxy (*e.g.*, -OC(O)R), an amino (*e.g.*, -NR₂, -NRH, or -NH₂), a carbamoyl (*e.g.*, -OC(O)NR₂, -OC(O)NRH, or -OC(O)NH₂), a sulfonamide (*e.g.*, -S(O)₂NR₂, -S(O)₂NRH, -S(O)₂NH₂, -N(R)S(O)₂R, -N(H)S(O)₂R, -N(R)S(O)₂H, or -N(H)S(O)₂H), an alkyl group, an alkenyl group, and a cyclyl (*e.g.*, carbocyclyl or heterocyclyl) group. In any of the preceding, R is an alkyl or alkenyl group, as defined herein. In some embodiments, the substituent groups themselves may be further substituted with, for example, one, two, three, four, five, or six substituents as defined herein. For example, a C₁₋₆ alkyl group may be further substituted with one, two, three, four, five, or six substituents as described herein.

[00293] Compounds of the disclosure that contain nitrogens can be converted to N-oxides by treatment with an oxidizing agent (*e.g.*, 3-chloroperoxybenzoic acid (*m*CPBA) and/or hydrogen peroxides) to afford other compounds of the disclosure. Thus, all shown and claimed nitrogen-containing compounds are considered, when allowed by valency and structure, to include both the compound as shown and its N-oxide derivative (which can be designated as N→O or N⁺-O⁻). Furthermore, in other instances, the nitrogens in the compounds of the disclosure can be converted to N-hydroxy or N-alkoxy compounds. For example, N-hydroxy compounds can be prepared by oxidation of the parent amine by an oxidizing agent such as *m*-CPBA. All shown and claimed nitrogen-containing compounds are also considered, when allowed by valency and structure, to cover both the compound as shown and its N-hydroxy (*i.e.*, N-OH) and N-alkoxy (*i.e.*, N-OR, wherein R is substituted or unsubstituted C₁-C₆ alkyl, C₁-C₆ alkenyl, C₁-C₆ alkynyl, 3-14-membered carbocycle or 3-14-membered heterocycle) derivatives.

[00294] About, Approximately: As used herein, the terms “approximately” and “about,” as applied to one or more values of interest, refer to a value that is similar to a stated reference

value. In certain embodiments, the term “approximately” or “about” refers to a range of values that fall within 25%, 20%, 19%, 18%, 17%, 16%, 15%, 14%, 13%, 12%, 11%, 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or less in either direction (greater than or less than) of the stated reference value unless otherwise stated or otherwise evident from the context (except where such number would exceed 100% of a possible value). For example, when used in the context of an amount of a given compound in a lipid component of a nanoparticle composition, “about” may mean +/- 10% of the recited value. For instance, a nanoparticle composition including a lipid component having about 40% of a given compound may include 30-50% of the compound.

[00295] As used herein, the term “compound,” is meant to include all isomers and isotopes of the structure depicted. “Isotopes” refers to atoms having the same atomic number but different mass numbers resulting from a different number of neutrons in the nuclei. For example, isotopes of hydrogen include tritium and deuterium. Further, a compound, salt, or complex of the present disclosure can be prepared in combination with solvent or water molecules to form solvates and hydrates by routine methods.

[00296] As used herein, the term “contacting” means establishing a physical connection between two or more entities. For example, contacting a mammalian cell with a nanoparticle composition means that the mammalian cell and a nanoparticle are made to share a physical connection. Methods of contacting cells with external entities both in vivo and ex vivo are well known in the biological arts. For example, contacting a nanoparticle composition and a mammalian cell disposed within a mammal may be performed by varied routes of administration (*e.g.*, intravenous, intramuscular, intradermal, and subcutaneous) and may involve varied amounts of nanoparticle compositions. Moreover, more than one mammalian cell may be contacted by a nanoparticle composition.

[00297] As used herein, the term “delivering” means providing an entity to a destination. For example, delivering a therapeutic and/or prophylactic to a subject may involve administering a nanoparticle composition including the therapeutic and/or prophylactic to the subject (*e.g.*, by an intravenous, intramuscular, intradermal, or subcutaneous route). Administration of a nanoparticle composition to a mammal or mammalian cell may involve contacting one or more cells with the nanoparticle composition.

[00298] As used herein, the term “enhanced delivery” means delivery of more (*e.g.*, at least 1.5 fold more, at least 2-fold more, at least 3-fold more, at least 4-fold more, at least 5-fold more, at least 6-fold more, at least 7-fold more, at least 8-fold more, at least 9-fold more, at least 10-fold more) of a therapeutic and/or prophylactic by a nanoparticle to a target tissue of interest (*e.g.*, mammalian liver) compared to the level of delivery of a therapeutic and/or prophylactic by

a control nanoparticle to a target tissue of interest (*e.g.*, MC3, KC2, or DLinDMA). The level of delivery of a nanoparticle to a particular tissue may be measured by comparing the amount of protein produced in a tissue to the weight of said tissue, comparing the amount of therapeutic and/or prophylactic in a tissue to the weight of said tissue, comparing the amount of protein produced in a tissue to the amount of total protein in said tissue, or comparing the amount of therapeutic and/or prophylactic in a tissue to the amount of total therapeutic and/or prophylactic in said tissue. It will be understood that the enhanced delivery of a nanoparticle to a target tissue need not be determined in a subject being treated, it may be determined in a surrogate such as an animal model (*e.g.*, a rat model). In certain embodiments, a nanoparticle composition including a compound according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIf), or (VIId) has substantively the same level of delivery enhancement regardless of administration routes. For example, certain compounds disclosed herein exhibit similar delivery enhancement when they are used for delivering a therapeutic and/or prophylactic either intravenously or intramuscularly. In other embodiments, certain compounds disclosed herein exhibit a higher level of delivery enhancement when they are used for delivering a therapeutic and/or prophylactic intramuscularly than intravenously.

[00299] As used herein, the term “specific delivery,” “specifically deliver,” or “specifically delivering” means delivery of more (*e.g.*, at least 1.5 fold more, at least 2-fold more, at least 3-fold more, at least 4-fold more, at least 5-fold more, at least 6-fold more, at least 7-fold more, at least 8-fold more, at least 9-fold more, at least 10-fold more) of a therapeutic and/or prophylactic by a nanoparticle to a target tissue of interest (*e.g.*, mammalian liver) compared to an off-target tissue (*e.g.*, mammalian spleen). The level of delivery of a nanoparticle to a particular tissue may be measured by comparing the amount of protein produced in a tissue to the weight of said tissue, comparing the amount of therapeutic and/or prophylactic in a tissue to the weight of said tissue, comparing the amount of protein produced in a tissue to the amount of total protein in said tissue, or comparing the amount of therapeutic and/or prophylactic in a tissue to the amount of total therapeutic and/or prophylactic in said tissue. For example, for renovascular targeting, a therapeutic and/or prophylactic is specifically provided to a mammalian kidney as compared to the liver and spleen if 1.5, 2-fold, 3-fold, 5-fold, 10-fold, 15 fold, or 20 fold more therapeutic and/or prophylactic per 1 g of tissue is delivered to a kidney compared to that delivered to the liver or spleen following systemic administration of the therapeutic and/or prophylactic. It will be understood that the ability of a nanoparticle to specifically deliver to a target tissue need not

be determined in a subject being treated, it may be determined in a surrogate such as an animal model (*e.g.*, a rat model).

[00300] As used herein, “encapsulation efficiency” refers to the amount of a therapeutic and/or prophylactic that becomes part of a nanoparticle composition, relative to the initial total amount of therapeutic and/or prophylactic used in the preparation of a nanoparticle composition. For example, if 97 mg of therapeutic and/or prophylactic are encapsulated in a nanoparticle composition out of a total 100 mg of therapeutic and/or prophylactic initially provided to the composition, the encapsulation efficiency may be given as 97%. As used herein, “encapsulation” may refer to complete, substantial, or partial enclosure, confinement, surrounding, or encasement.

[00301] As used herein, “expression” of a nucleic acid sequence refers to translation of an mRNA into a polypeptide or protein and/or post-translational modification of a polypeptide or protein.

[00302] As used herein, the term “in vitro” refers to events that occur in an artificial environment, *e.g.*, in a test tube or reaction vessel, in cell culture, in a Petri dish, etc., rather than within an organism (*e.g.*, animal, plant, or microbe).

[00303] As used herein, the term “in vivo” refers to events that occur within an organism (*e.g.*, animal, plant, or microbe or cell or tissue thereof).

[00304] As used herein, the term “ex vivo” refers to events that occur outside of an organism (*e.g.*, animal, plant, or microbe or cell or tissue thereof). Ex vivo events may take place in an environment minimally altered from a natural (*e.g.*, in vivo) environment.

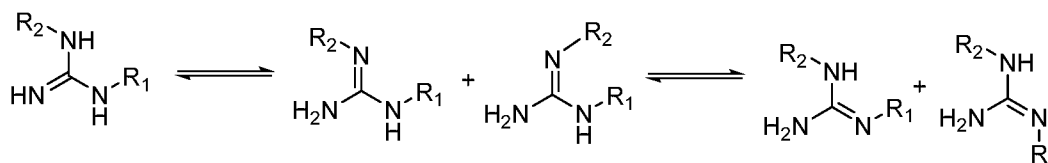
[00305] As used herein, the term “isomer” means any geometric isomer, tautomer, zwitterion, stereoisomer, enantiomer, or diastereomer of a compound. Compounds may include one or more chiral centers and/or double bonds and may thus exist as stereoisomers, such as double-bond isomers (*i.e.*, geometric E/Z isomers) or diastereomers (*e.g.*, enantiomers (*i.e.*, (+) or (-)) or *cis/trans* isomers). The present disclosure encompasses any and all isomers of the compounds described herein, including stereomerically pure forms (*e.g.*, geometrically pure, enantiomerically pure, or diastereomerically pure) and enantiomeric and stereoisomeric mixtures, *e.g.*, racemates. Enantiomeric and stereomeric mixtures of compounds and means of resolving them into their component enantiomers or stereoisomers are well-known.

[00306] “Tautomer” is one of two or more structural isomers that exist in equilibrium and is readily converted from one isomeric form to another. This conversion results in the formal migration of a hydrogen atom accompanied by a switch of adjacent conjugated double bonds. Tautomers exist as a mixture of a tautomeric set in solution. In solutions where tautomerization

is possible, a chemical equilibrium of the tautomers will be reached. The exact ratio of the tautomers depends on several factors, including temperature, solvent and pH. The concept of tautomers that are interconvertible by tautomerization is called tautomerism.

[00307] Of the various types of tautomerism that are possible, two are commonly observed. In keto-enol tautomerism a simultaneous shift of electrons and a hydrogen atom occurs. Ring-chain tautomerism arises as a result of the aldehyde group (-CHO) in a sugar chain molecule reacting with one of the hydroxy groups (-OH) in the same molecule to give it a cyclic (ring-shaped) form as exhibited by glucose.

[00308] Common tautomeric pairs are: ketone-enol, amide-nitrile, lactam-lactim, amide-imidic acid tautomerism in heterocyclic rings (*e.g.*, in nucleobases such as guanine, thymine and cytosine), imine-enamine and enamine-enamine. An example of tautomerism in di-substituted guanidine is shown below.



[00309] It is to be understood that the compounds of the disclosure may be depicted as different tautomers. It should also be understood that when compounds have tautomeric forms, all tautomeric forms are intended to be included in the scope of the disclosure, and the naming of the compounds does not exclude any tautomer form.

[00310] As used herein, a “lipid component” is that component of a nanoparticle composition that includes one or more lipids. For example, the lipid component may include one or more cationic/ionizable, PEGylated, structural, or other lipids, such as phospholipids.

[00311] As used herein, a “linker” is a moiety connecting two moieties, for example, the connection between two nucleosides of a cap species. A linker may include one or more groups including but not limited to phosphate groups (*e.g.*, phosphates, boranophosphates, thiophosphates, selenophosphates, and phosphonates), alkyl groups, amidates, or glycerols. For example, two nucleosides of a cap analog may be linked at their 5' positions by a triphosphate group or by a chain including two phosphate moieties and a boranophosphate moiety.

[00312] As used herein, “methods of administration” may include intravenous, intramuscular, intradermal, subcutaneous, or other methods of delivering a composition to a subject. A method of administration may be selected to target delivery (*e.g.*, to specifically deliver) to a specific region or system of a body.

[00313] As used herein, “modified” means non-natural. For example, an RNA may be a modified RNA. That is, an RNA may include one or more nucleobases, nucleosides,

nucleotides, or linkers that are non-naturally occurring. A “modified” species may also be referred to herein as an “altered” species. Species may be modified or altered chemically, structurally, or functionally. For example, a modified nucleobase species may include one or more substitutions that are not naturally occurring.

[00314] As used herein, the “N:P ratio” is the molar ratio of ionizable (in the physiological pH range) nitrogen atoms in a lipid to phosphate groups in an RNA, *e.g.*, in a nanoparticle composition including a lipid component and an RNA.

[00315] As used herein, a “nanoparticle composition” is a composition comprising one or more lipids. Nanoparticle compositions are typically sized on the order of micrometers or smaller and may include a lipid bilayer. Nanoparticle compositions encompass lipid nanoparticles (LNPs), liposomes (*e.g.*, lipid vesicles), and lipoplexes. For example, a nanoparticle composition may be a liposome having a lipid bilayer with a diameter of 500 nm or less.

[00316] As used herein, “naturally occurring” means existing in nature without artificial aid.

[00317] As used herein, “patient” refers to a subject who may seek or be in need of treatment, requires treatment, is receiving treatment, will receive treatment, or a subject who is under care by a trained professional for a particular disease or condition.

[00318] As used herein, a “PEG lipid” or “PEGylated lipid” refers to a lipid comprising a polyethylene glycol component.

[00319] The phrase “pharmaceutically acceptable” is used herein to refer to those compounds, materials, compositions, and/or dosage forms which are, within the scope of sound medical judgment, suitable for use in contact with the tissues of human beings and animals without excessive toxicity, irritation, allergic response, or other problem or complication, commensurate with a reasonable benefit/risk ratio.

[00320] The phrase “pharmaceutically acceptable excipient,” as used herein, refers to any ingredient other than the compounds described herein (for example, a vehicle capable of suspending, complexing, or dissolving the active compound) and having the properties of being substantially nontoxic and non-inflammatory in a patient. Excipients may include, for example: anti-adherents, antioxidants, binders, coatings, compression aids, disintegrants, dyes (colors), emollients, emulsifiers, fillers (diluent), film formers or coatings, flavors, fragrances, glidants (flow enhancers), lubricants, preservatives, printing inks, sorbents, suspending or dispersing agents, sweeteners, and waters of hydration. Exemplary excipients include, but are not limited to: butylated hydroxytoluene (BHT), calcium carbonate, calcium phosphate (dibasic), calcium stearate, croscarmellose, cross-linked polyvinyl pyrrolidone, citric acid, crospovidone, cysteine,

ethylcellulose, gelatin, hydroxypropyl cellulose, hydroxypropyl methylcellulose, lactose, magnesium stearate, maltitol, mannitol, methionine, methylcellulose, methyl paraben, microcrystalline cellulose, polyethylene glycol, polyvinyl pyrrolidone, povidone, pregelatinized starch, propyl paraben, retinyl palmitate, shellac, silicon dioxide, sodium carboxymethyl cellulose, sodium citrate, sodium starch glycolate, sorbitol, starch (corn), stearic acid, sucrose, talc, titanium dioxide, vitamin A, vitamin E (alpha-tocopherol), vitamin C, xylitol, and other species disclosed herein.

[00321] In the present specification, the structural formula of the compound represents a certain isomer for convenience in some cases, but the present disclosure includes all isomers, such as geometrical isomers, optical isomers based on an asymmetrical carbon, stereoisomers, tautomers, and the like, it being understood that not all isomers may have the same level of activity. In addition, a crystal polymorphism may be present for the compounds represented by the formula. It is noted that any crystal form, crystal form mixture, or anhydride or hydrate thereof is included in the scope of the present disclosure.

[00322] The term “crystal polymorphs”, “polymorphs” or “crystal forms” means crystal structures in which a compound (or a salt or solvate thereof) can crystallize in different crystal packing arrangements, all of which have the same elemental composition. Different crystal forms usually have different X-ray diffraction patterns, infrared spectral, melting points, density hardness, crystal shape, optical and electrical properties, stability and solubility. Recrystallization solvent, rate of crystallization, storage temperature, and other factors may cause one crystal form to dominate. Crystal polymorphs of the compounds can be prepared by crystallization under different conditions.

[00323] Compositions may also include salts of one or more compounds. Salts may be pharmaceutically acceptable salts. As used herein, “pharmaceutically acceptable salts” refers to derivatives of the disclosed compounds wherein the parent compound is altered by converting an existing acid or base moiety to its salt form (*e.g.*, by reacting a free base group with a suitable organic acid). Examples of pharmaceutically acceptable salts include, but are not limited to, mineral or organic acid salts of basic residues such as amines; alkali or organic salts of acidic residues such as carboxylic acids; and the like. Representative acid addition salts include acetate, adipate, alginate, ascorbate, aspartate, benzenesulfonate, benzoate, bisulfate, borate, butyrate, camphorate, camphorsulfonate, citrate, cyclopentanepropionate, digluconate, dodecylsulfate, ethanesulfonate, fumarate, glucoheptonate, glycerophosphate, hemisulfate, heptonate, hexanoate, hydrobromide, hydrochloride, hydroiodide, 2-hydroxy-ethanesulfonate, lactobionate, lactate, laurate, lauryl sulfate, malate, maleate, malonate, methanesulfonate, 2-

naphthalenesulfonate, nicotinate, nitrate, oleate, oxalate, palmitate, pamoate, pectinate, persulfate, 3-phenylpropionate, phosphate, picrate, pivalate, propionate, stearate, succinate, sulfate, tartrate, thiocyanate, toluenesulfonate, undecanoate, valerate salts, and the like. Representative alkali or alkaline earth metal salts include sodium, lithium, potassium, calcium, magnesium, and the like, as well as nontoxic ammonium, quaternary ammonium, and amine cations, including, but not limited to ammonium, tetramethylammonium, tetraethylammonium, methylamine, dimethylamine, trimethylamine, triethylamine, ethylamine, and the like. The pharmaceutically acceptable salts of the present disclosure include the conventional non-toxic salts of the parent compound formed, for example, from non-toxic inorganic or organic acids. The pharmaceutically acceptable salts of the present disclosure can be synthesized from the parent compound which contains a basic or acidic moiety by conventional chemical methods. Generally, such salts can be prepared by reacting the free acid or base forms of these compounds with a stoichiometric amount of the appropriate base or acid in water or in an organic solvent, or in a mixture of the two; generally, nonaqueous media like ether, ethyl acetate, ethanol, isopropanol, or acetonitrile are preferred. Lists of suitable salts are found in Remington's Pharmaceutical Sciences, 17th ed., Mack Publishing Company, Easton, Pa., 1985, p. 1418, Pharmaceutical Salts: Properties, Selection, and Use, P.H. Stahl and C.G. Wermuth (eds.), Wiley-VCH, 2008, and Berge et al., Journal of Pharmaceutical Science, 66, 1-19 (1977), each of which is incorporated herein by reference in its entirety.

[00324] As used herein, a “phospholipid” is a lipid that includes a phosphate moiety and one or more carbon chains, such as unsaturated fatty acid chains. A phospholipid may include one or more multiple (*e.g.*, double or triple) bonds (*e.g.*, one or more unsaturations). Particular phospholipids may facilitate fusion to a membrane. For example, a cationic phospholipid may interact with one or more negatively charged phospholipids of a membrane (*e.g.*, a cellular or intracellular membrane). Fusion of a phospholipid to a membrane may allow one or more elements of a lipid-containing composition to pass through the membrane permitting, *e.g.*, delivery of the one or more elements to a cell.

[00325] As used herein, the “polydispersity index” is a ratio that describes the homogeneity of the particle size distribution of a system. A small value, *e.g.*, less than 0.3, indicates a narrow particle size distribution.

[00326] As used herein, the term “polypeptide” or “polypeptide of interest” refers to a polymer of amino acid residues typically joined by peptide bonds that can be produced naturally (*e.g.*, isolated or purified) or synthetically.

[00327] As used herein, an “RNA” refers to a ribonucleic acid that may be naturally or non-naturally occurring. For example, an RNA may include modified and/or non-naturally occurring components such as one or more nucleobases, nucleosides, nucleotides, or linkers. An RNA may include a cap structure, a chain terminating nucleoside, a stem loop, a poly A sequence, and/or a polyadenylation signal. An RNA may have a nucleotide sequence encoding a polypeptide of interest. For example, an RNA may be a messenger RNA (mRNA). Translation of an mRNA encoding a particular polypeptide, for example, *in vivo* translation of an mRNA inside a mammalian cell, may produce the encoded polypeptide. RNAs may be selected from the non-limiting group consisting of small interfering RNA (siRNA), asymmetrical interfering RNA (aiRNA), microRNA (miRNA), Dicer-substrate RNA (dsRNA), small hairpin RNA (shRNA), mRNA, single-guide RNA (sgRNA), cas9 mRNA, and mixtures thereof.

[00328] As used herein, a “single unit dose” is a dose of any therapeutic administered in one dose/at one time/single route/single point of contact, i.e., single administration event.

[00329] As used herein, a “split dose” is the division of single unit dose or total daily dose into two or more doses.

[00330] As used herein, a “total daily dose” is an amount given or prescribed in 24 hour period. It may be administered as a single unit dose.

[00331] As used herein, “size” or “mean size” in the context of nanoparticle compositions refers to the mean diameter of a nanoparticle composition.

[00332] As used herein, the term “subject” or “patient” refers to any organism to which a composition in accordance with the disclosure may be administered, *e.g.*, for experimental, diagnostic, prophylactic, and/or therapeutic purposes. Typical subjects include animals (*e.g.*, mammals such as mice, rats, rabbits, non-human primates, and humans) and/or plants.

[00333] As used herein, “targeted cells” refers to any one or more cells of interest. The cells may be found *in vitro*, *in vivo*, *in situ*, or in the tissue or organ of an organism. The organism may be an animal, preferably a mammal, more preferably a human and most preferably a patient.

[00334] As used herein “target tissue” refers to any one or more tissue types of interest in which the delivery of a therapeutic and/or prophylactic would result in a desired biological and/or pharmacological effect. Examples of target tissues of interest include specific tissues, organs, and systems or groups thereof. In particular applications, a target tissue may be a kidney, a lung, a spleen, vascular endothelium in vessels (*e.g.*, intra-coronary or intra-femoral), or tumor tissue (*e.g.*, via intratumoral injection). An “off-target tissue” refers to any one or more tissue types in which the expression of the encoded protein does not result in a desired biological

and/or pharmacological effect. In particular applications, off-target tissues may include the liver and the spleen.

[00335] The term “therapeutic agent” or “prophylactic agent” refers to any agent that, when administered to a subject, has a therapeutic, diagnostic, and/or prophylactic effect and/or elicits a desired biological and/or pharmacological effect. Therapeutic agents are also referred to as “actives” or “active agents.” Such agents include, but are not limited to, cytotoxins, radioactive ions, chemotherapeutic agents, small molecule drugs, proteins, and nucleic acids.

[00336] As used herein, the term “therapeutically effective amount” means an amount of an agent to be delivered (*e.g.*, nucleic acid, drug, composition, therapeutic agent, diagnostic agent, prophylactic agent, etc.) that is sufficient, when administered to a subject suffering from or susceptible to an infection, disease, disorder, and/or condition, to treat, improve symptoms of, diagnose, prevent, and/or delay the onset of the infection, disease, disorder, and/or condition.

[00337] As used herein, “transfection” refers to the introduction of a species (*e.g.*, an RNA) into a cell. Transfection may occur, for example, *in vitro*, *ex vivo*, or *in vivo*.

[00338] As used herein, the term “treating” refers to partially or completely alleviating, ameliorating, improving, relieving, delaying onset of, inhibiting progression of, reducing severity of, and/or reducing incidence of one or more symptoms or features of a particular infection, disease, disorder, and/or condition. For example, “treating” cancer may refer to inhibiting survival, growth, and/or spread of a tumor. Treatment may be administered to a subject who does not exhibit signs of a disease, disorder, and/or condition and/or to a subject who exhibits only early signs of a disease, disorder, and/or condition for the purpose of decreasing the risk of developing pathology associated with the disease, disorder, and/or condition.

[00339] As used herein, the “zeta potential” is the electrokinetic potential of a lipid, *e.g.*, in a particle composition.

Nanoparticle compositions

[00340] The disclosure also features nanoparticle compositions comprising a lipid component comprising a compound according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIf), or (VIId) as described herein.

[00341] In some embodiments, the largest dimension of a nanoparticle composition is 1 μm or shorter (*e.g.*, 1 μm , 900 nm, 800 nm, 700 nm, 600 nm, 500 nm, 400 nm, 300 nm, 200 nm, 175 nm, 150 nm, 125 nm, 100 nm, 75 nm, 50 nm, or shorter), *e.g.*, when measured by dynamic light

scattering (DLS), transmission electron microscopy, scanning electron microscopy, or another method. Nanoparticle compositions include, for example, lipid nanoparticles (LNPs), liposomes, lipid vesicles, and lipoplexes. In some embodiments, nanoparticle compositions are vesicles including one or more lipid bilayers. In certain embodiments, a nanoparticle composition includes two or more concentric bilayers separated by aqueous compartments. Lipid bilayers may be functionalized and/or cross-linked to one another. Lipid bilayers may include one or more ligands, proteins, or channels.

[00342] Nanoparticle compositions comprise a lipid component including at least one compound according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIf), or (VIId). For example, the lipid component of a nanoparticle composition may include one or more of Compounds 1-392. Nanoparticle compositions may also include a variety of other components. For example, the lipid component of a nanoparticle composition may include one or more other lipids in addition to a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIf), or (VIId).

Cationic/ionizable lipids

[00343] A nanoparticle composition may include one or more cationic and/or ionizable lipids (*e.g.*, lipids that may have a positive or partial positive charge at physiological pH) in addition to a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIf), or (VIId). Cationic and/or ionizable lipids may be selected from the non-limiting group consisting of 3-(didodecylamino)-N1,N1,4-tridodecyl-1-piperazineethanamine (KL10), N1-[2-(didodecylamino)ethyl]-N1,N4,N4-tridodecyl-1,4-piperazinediethanamine (KL22), 14,25-ditridecyl-15,18,21,24-tetraaza-octatriacontane (KL25), 1,2-dilinolexyloxy-N,N-dimethylaminopropane (DLin-DMA), 2,2-dilinoleyl-4-dimethylaminomethyl-[1,3]-dioxolane (DLin-K-DMA), heptatriaconta-6,9,28,31-tetraen-19-yl 4-(dimethylamino)butanoate (DLin-MC3-DMA), 2,2-dilinoleyl-4-(2-dimethylaminoethyl)-[1,3]-dioxolane (DLin-KC2-DMA), 1,2-diolexyloxy-N,N-dimethylaminopropane (DODMA), 2-({8-[(3 β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-[(9Z,12Z)-octadeca-9,12-dien-1-yloxy]propan-1-amine (Octyl-CLinDMA), (2R)-2-({8-[(3 β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-[(9Z,12Z)-octadeca-9,12-dien-1-yloxy]propan-1-amine (Octyl-CLinDMA (2R)), and (2S)-2-({8-[(3 β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-[(9Z,12Z)-octadeca-9,12-dien-1-

xyloxy]propan-1-amine (Octyl-CLinDMA (2S)). In addition to these, a cationic lipid may also be a lipid including a cyclic amine group.

PEG lipids

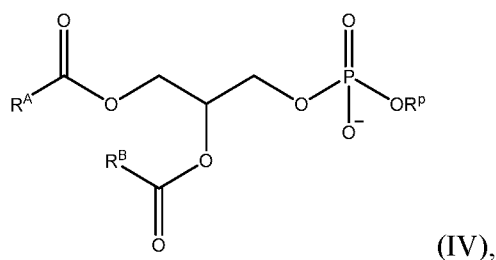
[00344] The lipid component of a nanoparticle composition may include one or more PEG or PEG-modified lipids. Such species may be alternately referred to as PEGylated lipids. A PEG lipid is a lipid modified with polyethylene glycol. A PEG lipid may be selected from the non-limiting group consisting of PEG-modified phosphatidylethanolamines, PEG-modified phosphatidic acids, PEG-modified ceramides (PEG-CER), PEG-modified dialkylamines, PEG-modified diacylglycerols (PEG-DEG), PEG-modified dialkylglycerols, and mixtures thereof. For example, a PEG lipid may be PEG-c-DOMG, PEG-DMG, PEG-DLPE, PEG-DMPE, PEG-DPPC, or a PEG-DSPE lipid.

Structural lipids

[00345] The lipid component of a nanoparticle composition may include one or more structural lipids. Structural lipids can be selected from the group consisting of, but are not limited to, cholesterol, fecosterol, sitosterol, ergosterol, campesterol, stigmasterol, brassicasterol, tomatidine, tomatine, ursolic acid, alpha-tocopherol, and mixtures thereof. In some embodiments, the structural lipid is cholesterol. In some embodiments, the structural lipid includes cholesterol and a corticosteroid (such as prednisolone, dexamethasone, prednisone, and hydrocortisone), or a combination thereof.

Phospholipids

[00346] The lipid component of a nanoparticle composition may include one or more phospholipids, such as one or more (poly)unsaturated lipids. Phospholipids may assemble into one or more lipid bilayers. In general, phospholipids may include a phospholipid moiety and one or more fatty acid moieties. For example, a phospholipid may be a lipid according to Formula (IV):



in which R_P represents a phospholipid moiety and R^A and R^B represent fatty acid moieties with or without unsaturation that may be the same or different. A phospholipid moiety may be selected from the non-limiting group consisting of phosphatidyl choline, phosphatidyl ethanolamine, phosphatidyl glycerol, phosphatidyl serine, phosphatidic acid, 2-lysophosphatidyl

choline, and a sphingomyelin. A fatty acid moiety may be selected from the non-limiting group consisting of lauric acid, myristic acid, myristoleic acid, palmitic acid, palmitoleic acid, stearic acid, oleic acid, linoleic acid, alpha-linolenic acid, erucic acid, phytanic acid, arachidic acid, arachidonic acid, eicosapentaenoic acid, behenic acid, docosapentaenoic acid, and docosahexaenoic acid. Non-natural species including natural species with modifications and substitutions including branching, oxidation, cyclization, and alkynes are also contemplated. For example, a phospholipid may be functionalized with or cross-linked to one or more alkynes (*e.g.*, an alkenyl group in which one or more double bonds is replaced with a triple bond). Under appropriate reaction conditions, an alkyne group may undergo a copper-catalyzed cycloaddition upon exposure to an azide. Such reactions may be useful in functionalizing a lipid bilayer of a nanoparticle composition to facilitate membrane permeation or cellular recognition or in conjugating a nanoparticle composition to a useful component such as a targeting or imaging moiety (*e.g.*, a dye).

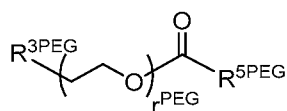
[00347] Phospholipids useful in the compositions and methods may be selected from the non-limiting group consisting of 1,2-distearoyl-*sn*-glycero-3-phosphocholine (DSPC), 1,2-dioleoyl-*sn*-glycero-3-phosphoethanolamine (DOPE), 1,2-dilinoleoyl-*sn*-glycero-3-phosphocholine (DLPC), 1,2-dimyristoyl-*sn*-glycero-3-phosphocholine (DMPC), 1,2-dioleoyl-*sn*-glycero-3-phosphocholine (DOPC), 1,2-dipalmitoyl-*sn*-glycero-3-phosphocholine (DPPC), 1,2-diundecanoyl-*sn*-glycero-3-phosphocholine (DUPC), 1-palmitoyl-2-oleoyl-*sn*-glycero-3-phosphocholine (POPC), 1,2-di-O-octadecenyl-*sn*-glycero-3-phosphocholine (18:0 Diether PC), 1-oleoyl-2-cholesterylhemisuccinoyl-*sn*-glycero-3-phosphocholine (OChemPC), 1-hexadecyl-*sn*-glycero-3-phosphocholine (C16 Lyso PC), 1,2-dilinolenoyl-*sn*-glycero-3-phosphocholine, 1,2-diarachidonoyl-*sn*-glycero-3-phosphocholine, 1,2-didocosahexaenoyl-*sn*-glycero-3-phosphocholine, 1,2-diphytanoyl-*sn*-glycero-3-phosphoethanolamine (ME 16.0 PE), 1,2-distearoyl-*sn*-glycero-3-phosphoethanolamine, 1,2-dilinoleoyl-*sn*-glycero-3-phosphoethanolamine, 1,2-dilinolenoyl-*sn*-glycero-3-phosphoethanolamine, 1,2-diarachidonoyl-*sn*-glycero-3-phosphoethanolamine, 1,2-didocosahexaenoyl-*sn*-glycero-3-phosphoethanolamine, 1,2-dioleoyl-*sn*-glycero-3-phospho-rac-(1-glycerol) sodium salt (DOPG), dipalmitoylphosphatidylglycerol (DPPG), palmitoyl-oleoylphosphatidylethanolamine (POPE), distearoyl-phosphatidyl-ethanolamine (DSPE), dipalmitoyl phosphatidyl ethanolamine (DPPE), dimyristoylphosphoethanolamine (DMPE), 1-stearoyl-2-oleoyl-phosphatidylethanolamine (SOPE), 1-stearoyl-2-oleoyl-phosphatidylcholine (SOPC), sphingomyelin, phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, phosphatidic acid, palmitoyl-oleoyl phosphatidylcholine, lysophosphatidylcholine, lysophosphatidylethanolamine

(LPE), and mixtures thereof. In some embodiments, a nanoparticle composition includes DSPC. In certain embodiments, a nanoparticle composition includes DOPE. In some embodiments, a nanoparticle composition includes both DSPC and DOPE.

PEG Lipids

[00348] In some embodiments, the lipid component of the nanoparticle composition includes a PEG lipid. In certain embodiments, the PEG lipid is selected from the group consisting of a PEG-modified phosphatidylethanolamine, a PEG-modified phosphatidic acid, a PEG-modified ceramide, a PEG-modified dialkylamine, a PEG-modified diacylglycerol, and a PEG-modified dialkylglycerol.

[00349] In certain embodiments, a PEG lipid may be of Formula (V):



(V), or a salt or isomer thereof, wherein:

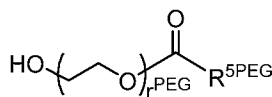
$\text{R}^{3\text{PEG}}$ is $-\text{OR}^{\text{O}}$;

R^{O} is hydrogen, C_{1-6} alkyl or an oxygen protecting group;

r^{PEG} is an integer between 1 and 100;

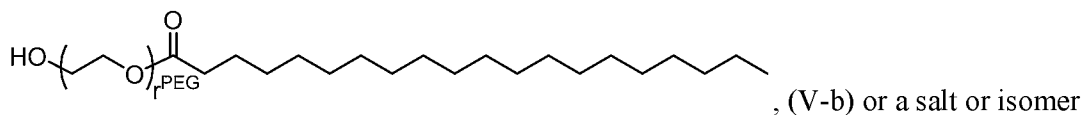
$\text{R}^{5\text{PEG}}$ is C_{10-40} alkyl, C_{10-40} alkenyl, or C_{10-40} alkynyl; and optionally one or more methylene groups of $\text{R}^{5\text{PEG}}$ are independently replaced with C_{3-10} carbocyclene, 4 to 10 membered heterocyclene, C_{6-10} arylene, 4 to 10 membered heteroarylene, $-\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{O}-$, $-\text{S}-$, $-\text{C}(\text{O})-$, $-\text{C}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{NR}^{\text{NPEG}}\text{C}(\text{O})-$, $-\text{NR}^{\text{NPEG}}\text{C}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{C}(\text{O})\text{O}-$, $-\text{OC}(\text{O})-$, $-\text{OC}(\text{O})\text{O}-$, $-\text{OC}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{NR}^{\text{NPEG}}\text{C}(\text{O})\text{O}-$, $-\text{C}(\text{O})\text{S}-$, $-\text{SC}(\text{O})-$, $-\text{C}(=\text{NR}^{\text{NPEG}})-$, $-\text{C}(=\text{NR}^{\text{NPEG}})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{NR}^{\text{NPEG}}\text{C}(=\text{NR}^{\text{NPEG}})-$, $-\text{NR}^{\text{NPEG}}\text{C}(=\text{NR}^{\text{NPEG}})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{C}(\text{S})-$, $-\text{C}(\text{S})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{NR}^{\text{NPEG}}\text{C}(\text{S})-$, $-\text{NR}^{\text{NPEG}}\text{C}(\text{S})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{S}(\text{O})-$, $-\text{OS}(\text{O})-$, $-\text{S}(\text{O})\text{O}-$, $-\text{OS}(\text{O})\text{O}-$, $-\text{OS}(\text{O})_2-$, $-\text{S}(\text{O})_2\text{O}-$, $-\text{OS}(\text{O})_2\text{O}-$, $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})-$, $-\text{S}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{OS}(\text{O})\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})\text{O}-$, $-\text{S}(\text{O})_2-$, $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})_2-$, $-\text{S}(\text{O})_2\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})_2\text{N}(\text{R}^{\text{NPEG}})-$, $-\text{OS}(\text{O})_2\text{N}(\text{R}^{\text{NPEG}})-$, or $-\text{N}(\text{R}^{\text{NPEG}})\text{S}(\text{O})_2\text{O}-$; and each instance of R^{NPEG} is independently hydrogen, C_{1-6} alkyl, or a nitrogen protecting group.

[00350] In certain embodiments, the compound of Formula (V) is of Formula (V-a):



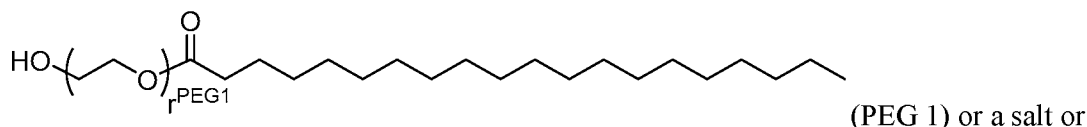
(V-a), or a salt or isomer thereof.

[00351] In certain embodiments, a compound of Formula (V) is of Formula (V-b):



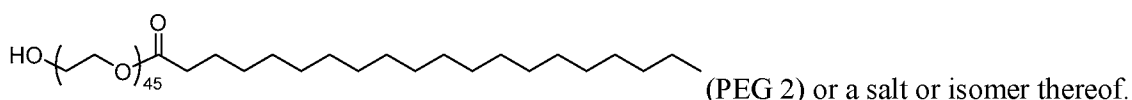
thereof.

[00352] In certain embodiments, the compound of Formula (V-b) is a compound having the formula:



isomer thereof, wherein r^{PEG1} is an integer between 40 and 50.

[00353] In certain embodiments, the compound of Formula (V-b) is a compound having the formula:



[00354] In certain embodiments, the incorporation of lipids of one of formulae (V), (V-a) or (V-b), PEG 1, or PEG 2 in the nanoparticle formulation can improve the pharmacokinetics and/or biodistribution of the lipid nanoparticle formulations. For example, incorporation of lipids of one of formulae (V), (V-a) or (V-b), PEG 1, or PEG 2 in the nanoparticle formulation can reduce the accelerated blood clearance (ABC) effect.

[00355] In some embodiments, the nanoparticle composition includes a lipid component comprising a compound according to one of formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIId), (VIIIc), (VIIIc), and (VIId) a phospholipid (which may or may not be unsaturated), a PEG lipid, and a structural lipid. In certain embodiments, the lipid component of the nanoparticle composition includes about 30 mol % to about 60 mol % compound of one of formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIId), (VIIIc), (VIIIc), and (VIId), about 0 mol % to about 30 mol % phospholipid, about 18.5 mol % to about 48.5 mol % structural lipid, and about 0 mol % to about 10 mol % of PEG lipid. In some embodiments, the lipid component of the nanoparticle composition includes about 30 mol % to about 45 mol % compound of one of formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), or (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIId), (VIIIc), (VIIIc), and (VIId), about 5 mol % to about 25 mol % phospholipid, about 30 mol % to about 40 mol % structural lipid, and about 0 mol % to about 10 mol % of PEG lipid. In some embodiments, the lipid component of the nanoparticle

composition includes about 35 mol % to about 55 mol % compound of one of formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), or (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIId), (VIIIc), (VIIIc), and (VIId), about 5 mol % to about 25 mol % phospholipid, about 30 mol % to about 40 mol % structural lipid, and about 0 mol % to about 10 mol % of PEG lipid. In certain embodiments, the lipid component includes about 50 mol % said compound, about 10 mol % phospholipid, about 38.5 mol % structural lipid, and about 1.5 mol % of PEG lipid. In other embodiments, the lipid component includes about 40 mol % said compound, about 20 mol % phospholipid, about 38.5 mol % structural lipid, and about 1.5 mol % of PEG lipid. In some of these embodiments, the phospholipid is DOPE, while in other embodiments the phospholipid is DSPC. In certain embodiments, the structural lipid is cholesterol. In certain embodiments, the PEG lipid is PEG-DMG. In certain embodiments, the PEG lipid is a compound of one of formulae (V), (V-a) or (V-b). In any of the above, the total content of the lipid component may not exceed 100%.

[00356] In some embodiments of the compositions provided herein, the PEG lipid is a PEG lipid described in International Patent Application No. PCT/US2016/000129, filed December 10, 2016, published as International Patent Application Publication No WO 2017/099823, and International Patent Application No. PCT/US2018/037541, filed June 14, 2018, the entire contents of each of which are incorporated herein by reference.

Adjuvants

[00357] In some embodiments, a nanoparticle composition that includes one or more lipids described herein may further include one or more adjuvants, e.g., Glucopyranosyl Lipid Adjuvant (GLA), CpG oligodeoxynucleotides (e.g., Class A or B), poly(I:C), aluminum hydroxide, and Pam3CSK4.

Therapeutic agents

[00358] Nanoparticle compositions may include one or more therapeutic and/or prophylactics. The disclosure features methods of delivering a therapeutic and/or prophylactic to a mammalian cell or organ, producing a polypeptide of interest in a mammalian cell, and treating a disease or disorder in a mammal in need thereof comprising administering to a mammal and/or contacting a mammalian cell with a nanoparticle composition including a therapeutic and/or prophylactic.

[00359] Therapeutic and/or prophylactics include biologically active substances and are alternately referred to as “active agents.” A therapeutic and/or prophylactic may be a substance that, once delivered to a cell or organ, brings about a desirable change in the cell, organ, or other bodily tissue or system. Such species may be useful in the treatment of one or more diseases,

disorders, or conditions. In some embodiments, a therapeutic and/or prophylactic is a small molecule drug useful in the treatment of a particular disease, disorder, or condition. Examples of drugs useful in the nanoparticle compositions include, but are not limited to, antineoplastic agents (*e.g.*, vincristine, doxorubicin, mitoxantrone, camptothecin, cisplatin, bleomycin, cyclophosphamide, methotrexate, and streptozotocin), antitumor agents (*e.g.*, actinomycin D, vincristine, vinblastine, cytosine arabinoside, anthracyclines, alkylating agents, platinum compounds, antimetabolites, and nucleoside analogs, such as methotrexate and purine and pyrimidine analogs), anti-infective agents, local anesthetics (*e.g.*, dibucaine and chlorpromazine), beta-adrenergic blockers (*e.g.*, propranolol, timolol, and labetalol), antihypertensive agents (*e.g.*, clonidine and hydralazine), anti-depressants (*e.g.*, imipramine, amitriptyline, and doxepin), anti-convulsants (*e.g.*, phenytoin), antihistamines (*e.g.*, diphenhydramine, chlorpheniramine, and promethazine), antibiotic/antibacterial agents (*e.g.*, gentamycin, ciprofloxacin, and cefoxitin), antifungal agents (*e.g.*, miconazole, terconazole, econazole, isoconazole, butaconazole, clotrimazole, itraconazole, nystatin, naftifine, and amphotericin B), antiparasitic agents, hormones, hormone antagonists, immunomodulators, neurotransmitter antagonists, antiglaucoma agents, vitamins, narcotics, and imaging agents.

[00360] In some embodiments, a therapeutic and/or prophylactic is a cytotoxin, a radioactive ion, a chemotherapeutic, a vaccine, a compound that elicits an immune response, and/or another therapeutic and/or prophylactic. A cytotoxin or cytotoxic agent includes any agent that may be detrimental to cells. Examples include, but are not limited to, taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin, etoposide, teniposide, vincristine, vinblastine, colchicine, doxorubicin, daunorubicin, dihydroxyanthracenedione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, puromycin, maytansinoids, *e.g.*, maytansinol, rachelmycin (CC-1065), and analogs or homologs thereof. Radioactive ions include, but are not limited to iodine (*e.g.*, iodine 125 or iodine 131), strontium 89, phosphorous, palladium, cesium, iridium, phosphate, cobalt, yttrium 90, samarium 153, and praseodymium. Vaccines include compounds and preparations that are capable of providing immunity against one or more conditions related to infectious diseases such as influenza, measles, human papillomavirus (HPV), rabies, meningitis, whooping cough, tetanus, plague, hepatitis, and tuberculosis and can include mRNAs encoding infectious disease derived antigens and/or epitopes. Vaccines also include compounds and preparations that direct an immune response against cancer cells and can include mRNAs encoding tumor cell derived antigens, epitopes, and/or neoepitopes. Compounds eliciting immune responses may include vaccines, corticosteroids (*e.g.*, dexamethasone), and other species. In some embodiments, a

vaccine and/or a compound capable of eliciting an immune response is administered intramuscularly via a composition including a compound according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId). Other therapeutic and/or prophylactics include, but are not limited to, antimetabolites (*e.g.*, methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-fluorouracil dacarbazine), alkylating agents (*e.g.*, mechlorethamine, thiotepa chlorambucil, rachelmycin (CC-1065), melphalan, carmustine (BSNU), lomustine (CCNU), cyclophosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin), anthracyclines (*e.g.*, daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (*e.g.*, dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC)), and anti-mitotic agents (*e.g.*, vincristine, vinblastine, taxol and maytansinoids).

[00361] In other embodiments, a therapeutic and/or prophylactic is a protein. Therapeutic proteins useful in the nanoparticles in the disclosure include, but are not limited to, gentamycin, amikacin, insulin, erythropoietin (EPO), granulocyte-colony stimulating factor (G-CSF), granulocyte-macrophage colony stimulating factor (GM-CSF), Factor VIR, luteinizing hormone-releasing hormone (LHRH) analogs, interferons, heparin, Hepatitis B surface antigen, typhoid vaccine, and cholera vaccine.

Polynucleotides and nucleic acids

[00362] In some embodiments, a therapeutic agent is a polynucleotide or nucleic acid (*e.g.*, ribonucleic acid or deoxyribonucleic acid). The term “polynucleotide,” in its broadest sense, includes any compound and/or substance that is or can be incorporated into an oligonucleotide chain. Exemplary polynucleotides for use in accordance with the present disclosure include, but are not limited to, one or more of deoxyribonucleic acid (DNA), ribonucleic acid (RNA) including messenger mRNA (mRNA), hybrids thereof, RNAi-inducing agents, RNAi agents, siRNAs, shRNAs, miRNAs, antisense RNAs, ribozymes, catalytic DNA, RNAs that induce triple helix formation, aptamers, vectors, etc. In some embodiments, a therapeutic and/or prophylactic is an RNA. RNAs useful in the compositions and methods described herein can be selected from the group consisting of, but are not limited to, shortmers, antagomirs, antisense, ribozymes, small interfering RNA (siRNA), asymmetrical interfering RNA (aiRNA), microRNA (miRNA), Dicer-substrate RNA (dsRNA), small hairpin RNA (shRNA), transfer RNA (tRNA), messenger RNA (mRNA), and mixtures thereof. In certain embodiments, the RNA is an mRNA.

[00363] In certain embodiments, a therapeutic and/or prophylactic is an mRNA. An mRNA may encode any polypeptide of interest, including any naturally or non-naturally occurring or otherwise modified polypeptide. A polypeptide encoded by an mRNA may be of any size and may have any secondary structure or activity. In some embodiments, a polypeptide encoded by an mRNA may have a therapeutic effect when expressed in a cell.

[00364] In other embodiments, a therapeutic and/or prophylactic is an siRNA. An siRNA may be capable of selectively knocking down or down regulating expression of a gene of interest. For example, an siRNA could be selected to silence a gene associated with a particular disease, disorder, or condition upon administration to a subject in need thereof of a nanoparticle composition including the siRNA. An siRNA may comprise a sequence that is complementary to an mRNA sequence that encodes a gene or protein of interest. In some embodiments, the siRNA may be an immunomodulatory siRNA.

[00365] In certain embodiments, a therapeutic and/or prophylactic is an sgRNA and/or cas9 mRNA. sgRNA and/or cas9 mRNA can be used as gene editing tools. For example, an sgRNA-cas9 complex can affect mRNA translation of cellular genes.

[00366] In some embodiments, a therapeutic and/or prophylactic is an shRNA or a vector or plasmid encoding the same. An shRNA may be produced inside a target cell upon delivery of an appropriate construct to the nucleus. Constructs and mechanisms relating to shRNA are well known in the relevant arts.

[00367] Nucleic acids and polynucleotides useful in the disclosure typically include a first region of linked nucleosides encoding a polypeptide of interest (*e.g.*, a coding region), a first flanking region located at the 5'-terminus of the first region (*e.g.*, a 5'-UTR), a second flanking region located at the 3'-terminus of the first region (*e.g.*, a 3'-UTR), at least one 5'-cap region, and a 3'-stabilizing region. In some embodiments, a nucleic acid or polynucleotide further includes a poly-A region or a Kozak sequence (*e.g.*, in the 5'-UTR). In some cases, polynucleotides may contain one or more intronic nucleotide sequences capable of being excised from the polynucleotide. In some embodiments, a polynucleotide or nucleic acid (*e.g.*, an mRNA) may include a 5' cap structure, a chain terminating nucleotide, a stem loop, a polyA sequence, and/or a polyadenylation signal. Any one of the regions of a nucleic acid may include one or more alternative components (*e.g.*, an alternative nucleoside). For example, the 3'-stabilizing region may contain an alternative nucleoside such as an L-nucleoside, an inverted thymidine, or a 2'-O-methyl nucleoside and/or the coding region, 5'-UTR, 3'-UTR, or cap region may include an alternative nucleoside such as a 5-substituted uridine (*e.g.*, 5-

methoxyuridine), a 1-substituted pseudouridine (*e.g.*, 1-methyl-pseudouridine or 1-ethyl-pseudouridine), and/or a 5-substituted cytidine (*e.g.*, 5-methyl-cytidine).

[00368] Generally, the shortest length of a polynucleotide can be the length of the polynucleotide sequence that is sufficient to encode for a dipeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a tripeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a tetrapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a pentapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a hexapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a heptapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for an octapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a nonapeptide. In some embodiments, the length of the polynucleotide sequence is sufficient to encode for a decapeptide.

[00369] Examples of dipeptides that the alternative polynucleotide sequences can encode for include, but are not limited to, carnosine and anserine.

[00370] In some cases, a polynucleotide is greater than 30 nucleotides in length. In some embodiments, the polynucleotide molecule is greater than 35 nucleotides in length. In some embodiments, the length is at least 40 nucleotides. In some embodiments, the length is at least 45 nucleotides. In some embodiments, the length is at least 55 nucleotides. In some embodiments, the length is at least 50 nucleotides. In some embodiments, the length is at least 60 nucleotides. In some embodiments, the length is at least 80 nucleotides. In some embodiments, the length is at least 90 nucleotides. In some embodiments, the length is at least 100 nucleotides. In some embodiments, the length is at least 120 nucleotides. In some embodiments, the length is at least 140 nucleotides. In some embodiments, the length is at least 160 nucleotides. In some embodiments, the length is at least 180 nucleotides. In some embodiments, the length is at least 200 nucleotides. In some embodiments, the length is at least 250 nucleotides. In some embodiments, the length is at least 300 nucleotides. In some embodiments, the length is at least 350 nucleotides. In some embodiments, the length is at least 400 nucleotides. In some embodiments, the length is at least 450 nucleotides. In some embodiments, the length is at least 500 nucleotides. In some embodiments, the length is at least 600 nucleotides. In some embodiments, the length is at least 700 nucleotides. In some embodiments, the length is at least 800 nucleotides. In some embodiments, the length is at least 900 nucleotides. In some embodiments, the length is at least 1000 nucleotides. In some

embodiments, the length is at least 1100 nucleotides. In some embodiments, the length is at least 1200 nucleotides. In some embodiments, the length is at least 1300 nucleotides. In some embodiments, the length is at least 1400 nucleotides. In some embodiments, the length is at least 1500 nucleotides. In some embodiments, the length is at least 1600 nucleotides. In some embodiments, the length is at least 1800 nucleotides. In some embodiments, the length is at least 2000 nucleotides. In some embodiments, the length is at least 2500 nucleotides. In some embodiments, the length is at least 3000 nucleotides. In some embodiments, the length is at least 4000 nucleotides. In some embodiments, the length is at least 5000 nucleotides, or greater than 5000 nucleotides.

[00371] Nucleic acids and polynucleotides may include one or more naturally occurring components, including any of the canonical nucleotides A (adenosine), G (guanosine), C (cytosine), U (uridine), or T (thymidine). In some embodiments, all or substantially all of the nucleotides comprising (a) the 5'-UTR, (b) the open reading frame (ORF), (c) the 3'-UTR, (d) the poly A tail, and any combination of (a, b, c, or d above) comprise naturally occurring canonical nucleotides A (adenosine), G (guanosine), C (cytosine), U (uridine), or T (thymidine).

[00372] Nucleic acids and polynucleotides may include one or more alternative components, as described herein, which impart useful properties including increased stability and/or the lack of a substantial induction of the innate immune response of a cell into which the polynucleotide is introduced. For example, an alternative polynucleotide or nucleic acid exhibits reduced degradation in a cell into which the polynucleotide or nucleic acid is introduced, relative to a corresponding unaltered polynucleotide or nucleic acid. These alternative species may enhance the efficiency of protein production, intracellular retention of the polynucleotides, and/or viability of contacted cells, as well as possess reduced immunogenicity.

[00373] Polynucleotides and nucleic acids may be naturally or non-naturally occurring. Polynucleotides and nucleic acids may include one or more modified (*e.g.*, altered or alternative) nucleobases, nucleosides, nucleotides, or combinations thereof. The nucleic acids and polynucleotides useful in a nanoparticle composition can include any useful modification or alteration, such as to the nucleobase, the sugar, or the internucleoside linkage (*e.g.*, to a linking phosphate / to a phosphodiester linkage / to the phosphodiester backbone). In certain embodiments, alterations (*e.g.*, one or more alterations) are present in each of the nucleobase, the sugar, and the internucleoside linkage. Alterations according to the present disclosure may be alterations of ribonucleic acids (RNAs) to deoxyribonucleic acids (DNAs), *e.g.*, the substitution of the 2'-OH of the ribofuranosyl ring to 2'-H, threose nucleic acids (TNAs), glycol

nucleic acids (GNAs), peptide nucleic acids (PNAs), locked nucleic acids (LNAs), or hybrids thereof. Additional alterations are described herein.

[00374] Polynucleotides and nucleic acids may or may not be uniformly altered along the entire length of the molecule. For example, one or more or all types of nucleotide (*e.g.*, purine or pyrimidine, or any one or more or all of A, G, U, C) may or may not be uniformly altered in a polynucleotide or nucleic acid, or in a given predetermined sequence region thereof. In some instances, all nucleotides X in a polynucleotide (or in a given sequence region thereof) are altered, wherein X may any one of nucleotides A, G, U, C, or any one of the combinations A+G, A+U, A+C, G+U, G+C, U+C, A+G+U, A+G+C, G+U+C or A+G+C.

[00375] Different sugar alterations and/or internucleoside linkages (*e.g.*, backbone structures) may exist at various positions in a polynucleotide. One of ordinary skill in the art will appreciate that the nucleotide analogs or other alteration(s) may be located at any position(s) of a polynucleotide such that the function of the polynucleotide is not substantially decreased. An alteration may also be a 5'- or 3'-terminal alteration. In some embodiments, the polynucleotide includes an alteration at the 3'-terminus. The polynucleotide may contain from about 1% to about 100% alternative nucleotides (either in relation to overall nucleotide content, or in relation to one or more types of nucleotide, *i.e.*, any one or more of A, G, U or C) or any intervening percentage (*e.g.*, from 1% to 20%, from 1% to 25%, from 1% to 50%, from 1% to 60%, from 1% to 70%, from 1% to 80%, from 1% to 90%, from 1% to 95%, from 10% to 20%, from 10% to 25%, from 10% to 50%, from 10% to 60%, from 10% to 70%, from 10% to 80%, from 10% to 90%, from 10% to 95%, from 10% to 100%, from 20% to 25%, from 20% to 50%, from 20% to 60%, from 20% to 70%, from 20% to 80%, from 20% to 90%, from 20% to 95%, from 20% to 100%, from 50% to 60%, from 50% to 70%, from 50% to 80%, from 50% to 90%, from 50% to 95%, from 50% to 100%, from 70% to 80%, from 70% to 90%, from 70% to 95%, from 70% to 100%, from 80% to 90%, from 80% to 95%, from 80% to 100%, from 90% to 95%, from 90% to 100%, and from 95% to 100%). It will be understood that any remaining percentage is accounted for by the presence of a canonical nucleotide (*e.g.*, A, G, U, or C).

[00376] Polynucleotides may contain at a minimum zero and at maximum 100% alternative nucleotides, or any intervening percentage, such as at least 5% alternative nucleotides, at least 10% alternative nucleotides, at least 25% alternative nucleotides, at least 50% alternative nucleotides, at least 80% alternative nucleotides, or at least 90% alternative nucleotides. For example, polynucleotides may contain an alternative pyrimidine such as an alternative uracil or cytosine. In some embodiments, at least 5%, at least 10%, at least 25%, at least 50%, at least 80%, at least 90% or 100% of the uracil in a polynucleotide is replaced with an alternative uracil

(*e.g.*, a 5-substituted uracil). The alternative uracil can be replaced by a compound having a single unique structure, or can be replaced by a plurality of compounds having different structures (*e.g.*, 2, 3, 4 or more unique structures). In some instances, at least 5%, at least 10%, at least 25%, at least 50%, at least 80%, at least 90% or 100% of the cytosine in the polynucleotide is replaced with an alternative cytosine (*e.g.*, a 5-substituted cytosine). The alternative cytosine can be replaced by a compound having a single unique structure, or can be replaced by a plurality of compounds having different structures (*e.g.*, 2, 3, 4 or more unique structures).

[00377] In some instances, nucleic acids do not substantially induce an innate immune response of a cell into which the polynucleotide (*e.g.*, mRNA) is introduced. Features of an induced innate immune response include 1) increased expression of pro-inflammatory cytokines, 2) activation of intracellular PRRs (RIG-I, MDA5, etc., and/or 3) termination or reduction in protein translation.

[00378] The nucleic acids can optionally include other agents (*e.g.*, RNAi-inducing agents, RNAi agents, siRNAs, shRNAs, miRNAs, antisense RNAs, ribozymes, catalytic DNA, tRNA, RNAs that induce triple helix formation, aptamers, and vectors). In some embodiments, the nucleic acids may include one or more messenger RNAs (mRNAs) having one or more alternative nucleoside or nucleotides (*i.e.*, alternative mRNA molecules).

[00379] In some embodiments, a nucleic acid (*e.g.* mRNA) molecule, formula, composition or method associated therewith comprises one or more polynucleotides comprising features as described in WO2002/098443, WO2003/051401, WO2008/052770, WO2009127230, WO2006122828, WO2008/083949, WO2010088927, WO2010/037539, WO2004/004743, WO2005/016376, WO2006/024518, WO2007/095976, WO2008/014979, WO2008/077592, WO2009/030481, WO2009/095226, WO2011069586, WO2011026641, WO2011/144358, WO2012019780, WO2012013326, WO2012089338, WO2012113513, WO2012116811, WO2012116810, WO2013113502, WO2013113501, WO2013113736, WO2013143698, WO2013143699, WO2013143700, WO2013/120626, WO2013120627, WO2013120628, WO2013120629, WO2013174409, WO2014127917, WO2015/024669, WO2015/024668, WO2015/024667, WO2015/024665, WO2015/024666, WO2015/024664, WO2015101415, WO2015101414, WO2015024667, WO2015062738, WO2015101416, all of which are incorporated by reference herein.

Nucleobase alternatives

[00380] The alternative nucleosides and nucleotides can include an alternative nucleobase. A nucleobase of a nucleic acid is an organic base such as a purine or pyrimidine or a derivative

thereof. A nucleobase may be a canonical base (*e.g.*, adenine, guanine, uracil, thymine, and cytosine). These nucleobases can be altered or wholly replaced to provide polynucleotide molecules having enhanced properties, *e.g.*, increased stability such as resistance to nucleases. Non-canonical or modified bases may include, for example, one or more substitutions or modifications including but not limited to alkyl, aryl, halo, oxo, hydroxyl, alkyloxy, and/or thio substitutions; one or more fused or open rings; oxidation; and/or reduction.

[00381] Alternative nucleotide base pairing encompasses not only the standard adenine-thymine, adenine-uracil, or guanine-cytosine base pairs, but also base pairs formed between nucleotides and/or alternative nucleotides including non-standard or alternative bases, wherein the arrangement of hydrogen bond donors and hydrogen bond acceptors permits hydrogen bonding between a non-standard base and a standard base or between two complementary non-standard base structures. One example of such non-standard base pairing is the base pairing between the alternative nucleotide inosine and adenine, cytosine, or uracil.

[00382] In some embodiments, the nucleobase is an alternative uracil. Exemplary nucleobases and nucleosides having an alternative uracil include pseudouridine (ψ), pyridin-4-one ribonucleoside, 5-aza-uracil, 6-aza-uracil, 2-thio-5-aza-uracil, 2-thio-uracil (s^2U), 4-thio-uracil (s^4U), 4-thio-pseudouridine, 2-thio-pseudouridine, 5-hydroxy-uracil (ho^5U), 5-aminoallyl-uracil, 5-halo-uracil (*e.g.*, 5-iodo-uracil or 5-bromo-uracil), 3-methyl-uracil (m^3U), 5-methoxy-uracil (mo^5U), uracil 5-oxyacetic acid (cmo^5U), uracil 5-oxyacetic acid methyl ester ($mcmo^5U$), 5-carboxymethyl-uracil (cm^5U), 1-carboxymethyl-pseudouridine, 5-carboxyhydroxymethyl-uracil (chm^5U), 5-carboxyhydroxymethyl-uracil methyl ester ($mchm^5U$), 5-methoxycarbonylmethyl-uracil (mcm^5U), 5-methoxycarbonylmethyl-2-thio-uracil (mcm^5s^2U), 5-aminomethyl-2-thio-uracil (nm^5s^2U), 5-methylaminomethyl-uracil (nm^5U), 5-methylaminomethyl-2-thio-uracil (nm^5s^2U), 5-methylaminomethyl-2-seleno-uracil (nm^5se^2U), 5-carbamoylmethyl-uracil (ncm^5U), 5-carboxymethylaminomethyl-uracil ($cmnm^5U$), 5-carboxymethylaminomethyl-2-thio-uracil ($cmnm^5s^2U$), 5-propynyl-uracil, 1-propynyl-pseudouracil, 5-taurinomethyl-uracil (τm^5U), 1-taurinomethyl-pseudouridine, 5-taurinomethyl-2-thio-uracil (τm^5s^2U), 1-taurinomethyl-4-thio-pseudouridine, 5-methyl-uracil (m^5U , *i.e.*, having the nucleobase deoxythymine), 1-methyl-pseudouridine ($m^1\psi$), 1-ethyl-pseudouridine ($Et^1\psi$), 5-methyl-2-thio-uracil (m^5s^2U), 1-methyl-4-thio-pseudouridine ($m^1s^4\psi$), 4-thio-1-methyl-pseudouridine, 3-methyl-pseudouridine ($m^3\psi$), 2-thio-1-methyl-pseudouridine, 1-methyl-1-deaza-pseudouridine, 2-thio-1-methyl-1-deaza-pseudouridine, dihydrouracil (D), dihydropseudouridine, 5,6-dihydrouracil, 5-methyl-dihydrouracil (m^5D), 2-thio-dihydrouracil, 2-thio-dihydropseudouridine, 2-methoxy-uracil, 2-methoxy-4-thio-uracil, 4-methoxy-

pseudouridine, 4-methoxy-2-thio-pseudouridine, N1-methyl-pseudouridine, 3-(3-amino-3-carboxypropyl)uracil (acp³U), 1-methyl-3-(3-amino-3-carboxypropyl)pseudouridine (acp³ψ), 5-(isopentenylaminomethyl)uracil (inm⁵U), 5-(isopentenylaminomethyl)-2-thio-uracil (inm⁵s²U), 5,2'-O-dimethyl-uridine (m⁵Um), 2-thio-2'-O-methyl-uridine (s²Um), 5-methoxycarbonylmethyl-2'-O-methyl-uridine (mcm⁵Um), 5-carbamoylmethyl-2'-O-methyl-uridine (ncm⁵Um), 5-carboxymethylaminomethyl-2'-O-methyl-uridine (cmnm⁵Um), 3,2'-O-dimethyl-uridine (m³Um), and 5-(isopentenylaminomethyl)-2'-O-methyl-uridine (inm⁵Um), 1-thio-uracil, deoxythymidine, 5-(2-carbomethoxyvinyl)-uracil, 5-(carbamoylhydroxymethyl)-uracil, 5-carbamoylmethyl-2-thio-uracil, 5-carboxymethyl-2-thio-uracil, 5-cyanomethyl-uracil, 5-methoxy-2-thio-uracil, and 5-[3-(1-E-propenylamino)]uracil.

[00383] In some embodiments, the nucleobase is an alternative cytosine. Exemplary nucleobases and nucleosides having an alternative cytosine include 5-aza-cytosine, 6-aza-cytosine, pseudoisocytidine, 3-methyl-cytosine (m3C), N4-acetyl-cytosine (ac4C), 5-formyl-cytosine (f5C), N4-methyl-cytosine (m4C), 5-methyl-cytosine (m5C), 5-halo-cytosine (*e.g.*, 5-iodo-cytosine), 5-hydroxymethyl-cytosine (hm5C), 1-methyl-pseudoisocytidine, pyrrolo-cytosine, pyrrolo-pseudoisocytidine, 2-thio-cytosine (s2C), 2-thio-5-methyl-cytosine, 4-thio-pseudoisocytidine, 4-thio-1-methyl-pseudoisocytidine, 4-thio-1-methyl-1-deaza-pseudoisocytidine, 1-methyl-1-deaza-pseudoisocytidine, zebularine, 5-aza-zebularine, 5-methyl-zebularine, 5-aza-2-thio-zebularine, 2-thio-zebularine, 2-methoxy-cytosine, 2-methoxy-5-methyl-cytosine, 4-methoxy-pseudoisocytidine, 4-methoxy-1-methyl-pseudoisocytidine, lysidine (k2C), 5,2'-O-dimethyl-cytidine (m5Cm), N4-acetyl-2'-O-methyl-cytidine (ac4Cm), N4,2'-O-dimethyl-cytidine (m4Cm), 5-formyl-2'-O-methyl-cytidine (f5Cm), N4,N4,2'-O-trimethyl-cytidine (m42Cm), 1-thio-cytosine, 5-hydroxy-cytosine, 5-(3-azidopropyl)-cytosine, and 5-(2-azidoethyl)-cytosine.

[00384] In some embodiments, the nucleobase is an alternative adenine. Exemplary nucleobases and nucleosides having an alternative adenine include 2-amino-purine, 2,6-diaminopurine, 2-amino-6-halo-purine (*e.g.*, 2-amino-6-chloro-purine), 6-halo-purine (*e.g.*, 6-chloro-purine), 2-amino-6-methyl-purine, 8-azido-adenine, 7-deaza-adenine, 7-deaza-8-aza-adenine, 7-deaza-2-amino-purine, 7-deaza-8-aza-2-amino-purine, 7-deaza-2,6-diaminopurine, 7-deaza-8-aza-2,6-diaminopurine, 1-methyl-adenine (m1A), 2-methyl-adenine (m2A), N6-methyl-adenine (m6A), 2-methylthio-N6-methyl-adenine (ms2m6A), N6-isopentenyl-adenine (i6A), 2-methylthio-N6-isopentenyl-adenine (ms2i6A), N6-(cis-hydroxyisopentenyl)adenine (io6A), 2-methylthio-N6-(cis-hydroxyisopentenyl)adenine (ms2io6A), N6-glycylcarbamoyl-adenine (g6A), N6-threonylcarbamoyl-adenine (t6A), N6-methyl-N6-threonylcarbamoyl-adenine

(m6t6A), 2-methylthio-N6-threonylcarbamoyl-adenine (ms2g6A), N6,N6-dimethyl-adenine (m62A), N6-hydroxynorvalylcarbamoyl-adenine (hn6A), 2-methylthio-N6-hydroxynorvalylcarbamoyl-adenine (ms2hn6A), N6-acetyl-adenine (ac6A), 7-methyl-adenine, 2-methylthio-adenine, 2-methoxy-adenine, N6,2'-O-dimethyl-adenosine (m6Am), N6,N6,2'-O-trimethyl-adenosine (m62Am), 1,2'-O-dimethyl-adenosine (m1Am), 2-amino-N6-methyl-purine, 1-thio-adenine, 8-azido-adenine, N6-(19-amino-pentaoxanonadecyl)-adenine, 2,8-dimethyl-adenine, N6-formyl-adenine, and N6-hydroxymethyl-adenine.

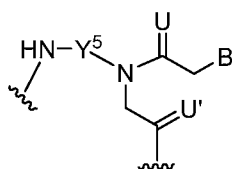
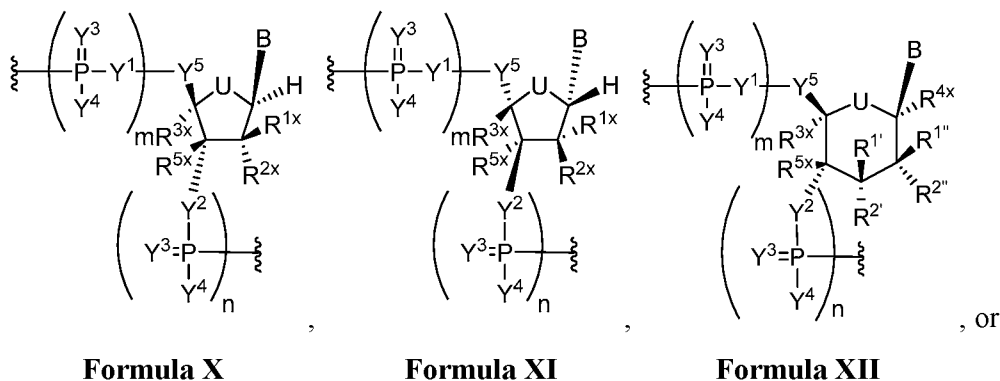
[00385] In some embodiments, the nucleobase is an alternative guanine. Exemplary nucleobases and nucleosides having an alternative guanine include inosine (I), 1-methyl-inosine (m1I), wyosine (imG), methylwyosine (mimG), 4-demethyl-wyosine (imG-14), isowyosine (imG2), wybutosine (yW), peroxywybutosine (o2yW), hydroxywybutosine (OHyW), undermodified hydroxywybutosine (OHyW*), 7-deaza-guanine, queuosine (Q), epoxyqueuosine (oQ), galactosyl-queuosine (galQ), mannosyl-queuosine (manQ), 7-cyano-7-deaza-guanine (preQ0), 7-aminomethyl-7-deaza-guanine (preQ1), archaeosine (G+), 7-deaza-8-aza-guanine, 6-thio-guanine, 6-thio-7-deaza-guanine, 6-thio-7-deaza-8-aza-guanine, 7-methyl-guanine (m7G), 6-thio-7-methyl-guanine, 7-methyl-inosine, 6-methoxy-guanine, 1-methyl-guanine (m1G), N2-methyl-guanine (m2G), N2,N2-dimethyl-guanine (m22G), N2,7-dimethyl-guanine (m2,7G), N2,N2,7-dimethyl-guanine (m2,2,7G), 8-oxo-guanine, 7-methyl-8-oxo-guanine, 1-methyl-6-thio-guanine, N2-methyl-6-thio-guanine, N2,N2-dimethyl-6-thio-guanine, N2-methyl-2'-O-methyl-guanosine (m2Gm), N2,N2-dimethyl-2'-O-methyl-guanosine (m22Gm), 1-methyl-2'-O-methyl-guanosine (m1Gm), N2,7-dimethyl-2'-O-methyl-guanosine (m2,7Gm), 2'-O-methyl-inosine (Im), 1,2'-O-dimethyl-inosine (m1Im), 1-thio-guanine, and O-6-methyl-guanine.

[00386] The alternative nucleobase of a nucleotide can be independently a purine, a pyrimidine, a purine or pyrimidine analog. For example, the nucleobase can be an alternative to adenine, cytosine, guanine, uracil, or hypoxanthine. In some embodiments, the nucleobase can also include, for example, naturally-occurring and synthetic derivatives of a base, including pyrazolo[3,4-d]pyrimidines, 5-methylcytosine (5-me-C), 5-hydroxymethyl cytosine, xanthine, hypoxanthine, 2-aminoadenine, 6-methyl and other alkyl derivatives of adenine and guanine, 2-propyl and other alkyl derivatives of adenine and guanine, 2-thiouracil, 2-thiothymine and 2-thiocytosine, 5-propynyl uracil and cytosine, 6-azo uracil, cytosine and thymine, 5-uracil (pseudouracil), 4-thiouracil, 8-halo (*e.g.*, 8-bromo), 8-amino, 8-thiol, 8-thioalkyl, 8-hydroxy and other 8-substituted adenines and guanines, 5-halo particularly 5-bromo, 5-trifluoromethyl and other 5-substituted uracils and cytosines, 7-methylguanine and 7-methyladenine, 8-azaguanine and 8-azaadenine, deazaguanine, 7-deazaguanine, 3-deazaguanine, deazaadenine, 7-

deazaadenine, 3-deazaadenine, pyrazolo[3,4-d]pyrimidine, imidazo[1,5-a]1,3,5 triazinones, 9-deazapurines, imidazo[4,5-d]pyrazines, thiazolo[4,5-d]pyrimidines, pyrazin-2-ones, 1,2,4-triazine, pyridazine; or 1,3,5 triazine. When the nucleotides are depicted using the shorthand A, G, C, T or U, each letter refers to the representative base and/or derivatives thereof, *e.g.*, A includes adenine or adenine analogs, *e.g.*, 7-deaza adenine).

Alterations on the sugar

[00387] Nucleosides include a sugar molecule (*e.g.*, a 5-carbon or 6-carbon sugar, such as pentose, ribose, arabinose, xylose, glucose, galactose, or a deoxy derivative thereof) in combination with a nucleobase, while nucleotides are nucleosides containing a nucleoside and a phosphate group or alternative group (*e.g.*, boranophosphate, thiophosphate, selenophosphate, phosphonate, alkyl group, amidate, and glycerol). A nucleoside or nucleotide may be a canonical species, *e.g.*, a nucleoside or nucleotide including a canonical nucleobase, sugar, and, in the case of nucleotides, a phosphate group, or may be an alternative nucleoside or nucleotide including one or more alternative components. For example, alternative nucleosides and nucleotides can be altered on the sugar of the nucleoside or nucleotide. In some embodiments, the alternative nucleosides or nucleotides include the structure:



Formula XII.

In each of the Formulae X, XI, XII and XIII,

each of *m* and *n* is independently, an integer from 0 to 5,

each of *U* and *U'* independently, is O, S, N(R^U)_{nu}, or C(R^U)_{nu}, wherein *nu* is an integer from 0 to 2 and each R^U is, independently, H, halo, or optionally substituted alkyl;

each of R^{1'}, R^{2'}, R^{1''}, R^{2''}, R^{1x}, R^{2x}, R^{3x}, R^{4x}, and R^{5x} is, independently, if present, H, halo, hydroxy, thiol, optionally substituted alkyl, optionally substituted alkoxy, optionally substituted

alkenyloxy, optionally substituted alkynyloxy, optionally substituted aminoalkoxy, optionally substituted alkoxyalkoxy, optionally substituted hydroxyalkoxy, optionally substituted amino, azido, optionally substituted aryl, optionally substituted aminoalkyl, optionally substituted aminoalkenyl, optionally substituted aminoalkynyl, or absent; wherein the combination of R^{3x} with one or more of $R^{1'}$, $R^{1''}$, $R^{2'}$, $R^{2''}$, or R^{5x} (e.g., the combination of $R^{1'}$ and R^{3x} , the combination of $R^{1''}$ and R^{3x} , the combination of $R^{2'}$ and R^{3x} , the combination of $R^{2''}$ and R^{3x} , or the combination of R^{5x} and R^{3x}) can join together to form optionally substituted alkylene or optionally substituted heteroalkylene and, taken together with the carbons to which they are attached, provide an optionally substituted heterocyclyl (e.g., a bicyclic, tricyclic, or tetracyclic heterocyclyl); wherein the combination of R^{5x} with one or more of $R^{1'}$, $R^{1''}$, $R^{2'}$, or $R^{2''}$ (e.g., the combination of $R^{1'}$ and R^{5x} , the combination of $R^{1''}$ and R^{5x} , the combination of $R^{2'}$ and R^{5x} , or the combination of $R^{2''}$ and R^{5x}) can join together to form optionally substituted alkylene or optionally substituted heteroalkylene and, taken together with the carbons to which they are attached, provide an optionally substituted heterocyclyl (e.g., a bicyclic, tricyclic, or tetracyclic heterocyclyl); and wherein the combination of R^{4x} and one or more of $R^{1'}$, $R^{1''}$, $R^{2'}$, $R^{2''}$, R^{3x} , or R^{5x} can join together to form optionally substituted alkylene or optionally substituted heteroalkylene and, taken together with the carbons to which they are attached, provide an optionally substituted heterocyclyl (e.g., a bicyclic, tricyclic, or tetracyclic heterocyclyl); each of m' and m'' is, independently, an integer from 0 to 3 (e.g., from 0 to 2, from 0 to 1, from 1 to 3, or from 1 to 2);

each of Y^1 , Y^2 , and Y^3 , is, independently, O, S, Se, $—NR^{N1}—$, optionally substituted alkylene, or optionally substituted heteroalkylene, wherein R^{N1} is H, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted aryl, or absent;

each Y^4 is, independently, H, hydroxy, thiol, boranyl, optionally substituted alkyl, optionally substituted alkenyl, optionally substituted alkynyl, optionally substituted alkoxy, optionally substituted alkenyloxy, optionally substituted alkynyloxy, optionally substituted thioalkoxy, optionally substituted alkoxyalkoxy, or optionally substituted amino;

each Y^5 is, independently, O, S, Se, optionally substituted alkylene (e.g., methylene), or optionally substituted heteroalkylene; and

B is a nucleobase, either modified or unmodified. In some embodiments, the 2'-hydroxy group (OH) can be modified or replaced with a number of different substituents. Exemplary substitutions at the 2'-position include, but are not limited to, H, azido, halo (e.g., fluoro), optionally substituted C_{1-6} alkyl (e.g., methyl); optionally substituted C_{1-6} alkoxy (e.g., methoxy

or ethoxy); optionally substituted C₆₋₁₀ aryloxy; optionally substituted C₃₋₈ cycloalkyl; optionally substituted C₆₋₁₀ aryl-C₁₋₆ alkoxy, optionally substituted C₁₋₁₂ (heterocycl)oxy; a sugar (*e.g.*, ribose, pentose, or any described herein); a polyethyleneglycol (PEG), -O(CH₂CH₂O)_nCH₂CH₂OR, where R is H or optionally substituted alkyl, and n is an integer from 0 to 20 (*e.g.*, from 0 to 4, from 0 to 8, from 0 to 10, from 0 to 16, from 1 to 4, from 1 to 8, from 1 to 10, from 1 to 16, from 1 to 20, from 2 to 4, from 2 to 8, from 2 to 10, from 2 to 16, from 2 to 20, from 4 to 8, from 4 to 10, from 4 to 16, and from 4 to 20); “locked” nucleic acids (LNA) in which the 2'-hydroxy is connected by a C₁₋₆ alkylene or C₁₋₆ heteroalkylene bridge to the 4'-carbon of the same ribose sugar, where exemplary bridges included methylene, propylene, ether, or amino bridges; aminoalkyl, as defined herein; aminoalkoxy, as defined herein; amino as defined herein; and amino acid, as defined herein.

[00389] Generally, RNA includes the sugar group ribose, which is a 5-membered ring having an oxygen. Exemplary, non-limiting alternative nucleotides include replacement of the oxygen in ribose (*e.g.*, with S, Se, or alkylene, such as methylene or ethylene); addition of a double bond (*e.g.*, to replace ribose with cyclopentenyl or cyclohexenyl); ring contraction of ribose (*e.g.*, to form a 4-membered ring of cyclobutane or oxetane); ring expansion of ribose (*e.g.*, to form a 6- or 7-membered ring having an additional carbon or heteroatom, such as for anhydrohexitol, alritol, mannitol, cyclohexanyl, cyclohexenyl, and morpholino (that also has a phosphoramidate backbone)); multicyclic forms (*e.g.*, tricyclo and “unlocked” forms, such as glycol nucleic acid (GNA) (*e.g.*, R-GNA or S-GNA, where ribose is replaced by glycol units attached to phosphodiester bonds), threose nucleic acid (TNA, where ribose is replaced with α-L-threofuranosyl-(3'→2')), and peptide nucleic acid (PNA, where 2-amino-ethyl-glycine linkages replace the ribose and phosphodiester backbone).

[00390] In some embodiments, the sugar group contains one or more carbons that possess the opposite stereochemical configuration of the corresponding carbon in ribose. Thus, a polynucleotide molecule can include nucleotides containing, *e.g.*, arabinose or L-ribose, as the sugar.

[00391] In some embodiments, the polynucleotide includes at least one nucleoside wherein the sugar is L-ribose, 2'-O-methyl-ribose, 2'-fluoro-ribose, arabinose, hexitol, an LNA, or a PNA.

Alterations on the internucleoside linkage

[00392] Alternative nucleotides can be altered on the internucleoside linkage (*e.g.*, phosphate backbone). Herein, in the context of the polynucleotide backbone, the phrases “phosphate” and

“phosphodiester” are used interchangeably. Backbone phosphate groups can be altered by replacing one or more of the oxygen atoms with a different substituent.

[00393] The alternative nucleotides can include the wholesale replacement of an unaltered phosphate moiety with another internucleoside linkage as described herein. Examples of alternative phosphate groups include, but are not limited to, phosphorothioate, phosphoroselenates, boranophosphates, boranophosphate esters, hydrogen phosphonates, phosphoramidates, phosphorodiamidates, alkyl or aryl phosphonates, and phosphotriesters. Phosphorodithioates have both non-linking oxygens replaced by sulfur. The phosphate linker can also be altered by the replacement of a linking oxygen with nitrogen (bridged phosphoramidates), sulfur (bridged phosphorothioates), and carbon (bridged methylene-phosphonates).

[00394] The alternative nucleosides and nucleotides can include the replacement of one or more of the non-bridging oxygens with a borane moiety (BH₃), sulfur (thio), methyl, ethyl, and/or methoxy. As a non-limiting example, two non-bridging oxygens at the same position (*e.g.*, the alpha (α), beta (β) or gamma (γ) position) can be replaced with a sulfur (thio) and a methoxy.

[00395] The replacement of one or more of the oxygen atoms at the α position of the phosphate moiety (*e.g.*, α -thio phosphate) is provided to confer stability (such as against exonucleases and endonucleases) to RNA and DNA through the unnatural phosphorothioate backbone linkages. Phosphorothioate DNA and RNA have increased nuclease resistance and subsequently a longer half-life in a cellular environment.

[00396] Other internucleoside linkages that may be employed according to the present disclosure, including internucleoside linkages which do not contain a phosphorous atom, are described herein.

Internal ribosome entry sites

[00397] Polynucleotides may contain an internal ribosome entry site (IRES). An IRES may act as the sole ribosome binding site, or may serve as one of multiple ribosome binding sites of an mRNA. A polynucleotide containing more than one functional ribosome binding site may encode several peptides or polypeptides that are translated independently by the ribosomes (*e.g.*, multicistronic mRNA). When polynucleotides are provided with an IRES, further optionally provided is a second translatable region. Examples of IRES sequences that can be used according to the present disclosure include without limitation, those from picornaviruses (*e.g.*, FMDV), pest viruses (CFFV), polio viruses (PV), encephalomyocarditis viruses (ECMV), foot-and-mouth disease viruses (FMDV), hepatitis C viruses (HCV), classical swine fever viruses

(CSFV), murine leukemia virus (MLV), simian immune deficiency viruses (SIV) or cricket paralysis viruses (CrPV).

5'-cap structure

[00398] A polynucleotide (*e.g.*, an mRNA) may include a 5'-cap structure. The 5'-cap structure of a polynucleotide is involved in nuclear export and increasing polynucleotide stability and binds the mRNA Cap Binding Protein (CBP), which is responsible for polynucleotide stability in the cell and translation competency through the association of CBP with poly-A binding protein to form the mature cyclic mRNA species. The cap further assists the removal of 5'-proximal introns removal during mRNA splicing.

[00399] Endogenous polynucleotide molecules may be 5'-end capped generating a 5'-ppp-5'-triphosphate linkage between a terminal guanosine cap residue and the 5'-terminal transcribed sense nucleotide of the polynucleotide. This 5'-guanylate cap may then be methylated to generate an N7-methyl-guanylate residue. The ribose sugars of the terminal and/or antiterminal transcribed nucleotides of the 5' end of the polynucleotide may optionally also be 2'-O-methylated. 5'-decapping through hydrolysis and cleavage of the guanylate cap structure may target a polynucleotide molecule, such as an mRNA molecule, for degradation.

[00400] Alterations to polynucleotides may generate a non-hydrolyzable cap structure preventing decapping and thus increasing polynucleotide half-life. Because cap structure hydrolysis requires cleavage of 5'-ppp-5' phosphodiester linkages, alternative nucleotides may be used during the capping reaction. For example, a Vaccinia Capping Enzyme from New England Biolabs (Ipswich, MA) may be used with α -thio-guanosine nucleotides according to the manufacturer's instructions to create a phosphorothioate linkage in the 5'-ppp-5' cap. Additional alternative guanosine nucleotides may be used such as α -methyl-phosphonate and seleno-phosphate nucleotides.

[00401] Additional alterations include, but are not limited to, 2'-O-methylation of the ribose sugars of 5'-terminal and/or 5'-antiterminal nucleotides of the polynucleotide (as mentioned above) on the 2'-hydroxy group of the sugar. Multiple distinct 5'-cap structures can be used to generate the 5'-cap of a polynucleotide, such as an mRNA molecule.

[00402] 5'-Cap structures include those described in International Patent Publication Nos. WO2008127688, WO 2008016473, and WO 2011015347, the cap structures of each of which are incorporated herein by reference.

[00403] Cap analogs, which herein are also referred to as synthetic cap analogs, chemical caps, chemical cap analogs, or structural or functional cap analogs, differ from natural (*i.e.*, endogenous, wild-type, or physiological) 5'-caps in their chemical structure, while retaining cap

function. Cap analogs may be chemically (i.e., non-enzymatically) or enzymatically synthesized and/linked to a polynucleotide.

[00404] For example, the Anti-Reverse Cap Analog (ARCA) cap contains two guanosines linked by a 5'-5'-triphosphate group, wherein one guanosine contains an N7-methyl group as well as a 3'-O-methyl group (i.e., N7,3'-O-dimethyl-guanosine-5'-triphosphate-5'-guanosine, m⁷G-3'mppp-G, which may equivalently be designated 3' O-Me-m⁷G(5')ppp(5')G). The 3'-O atom of the other, unaltered, guanosine becomes linked to the 5'-terminal nucleotide of the capped polynucleotide (e.g., an mRNA). The N7- and 3'-O-methylated guanosine provides the terminal moiety of the capped polynucleotide (e.g., mRNA).

[00405] Another exemplary cap is mCAP, which is similar to ARCA but has a 2'-O-methyl group on guanosine (i.e., N7,2'-O-dimethyl-guanosine-5'-triphosphate-5'-guanosine, m⁷Gm-ppp-G).

[00406] A cap may be a dinucleotide cap analog. As a non-limiting example, the dinucleotide cap analog may be modified at different phosphate positions with a boranophosphate group or a phosphoroselenoate group such as the dinucleotide cap analogs described in US Patent No. 8,519,110, the cap structures of which are herein incorporated by reference.

[00407] Alternatively, a cap analog may be a N7-(4-chlorophenoxyethyl) substituted dinucleotide cap analog known in the art and/or described herein. Non-limiting examples of N7-(4-chlorophenoxyethyl) substituted dinucleotide cap analogs include a N7-(4-chlorophenoxyethyl)-G(5')ppp(5')G and a N7-(4-chlorophenoxyethyl)-m3'-OG(5')ppp(5')G cap analog (see, e.g., the various cap analogs and the methods of synthesizing cap analogs described in Kore et al. *Bioorganic & Medicinal Chemistry* 2013 21:4570-4574; the cap structures of which are herein incorporated by reference). In other instances, a cap analog useful in the polynucleotides of the present disclosure is a 4-chloro/bromophenoxyethyl analog.

[00408] While cap analogs allow for the concomitant capping of a polynucleotide in an *in vitro* transcription reaction, up to 20% of transcripts remain uncapped. This, as well as the structural differences of a cap analog from endogenous 5'-cap structures of polynucleotides produced by the endogenous, cellular transcription machinery, may lead to reduced translational competency and reduced cellular stability.

[00409] Alternative polynucleotides may also be capped post-transcriptionally, using enzymes, in order to generate more authentic 5'-cap structures. As used herein, the phrase "more authentic" refers to a feature that closely mirrors or mimics, either structurally or functionally, an endogenous or wild type feature. That is, a "more authentic" feature is better

representative of an endogenous, wild-type, natural or physiological cellular function, and/or structure as compared to synthetic features or analogs of the prior art, or which outperforms the corresponding endogenous, wild-type, natural, or physiological feature in one or more respects. Non-limiting examples of more authentic 5'-cap structures useful in the polynucleotides of the present disclosure are those which, among other things, have enhanced binding of cap binding proteins, increased half-life, reduced susceptibility to 5'-endonucleases, and/or reduced 5'-decapping, as compared to synthetic 5'-cap structures known in the art (or to a wild-type, natural or physiological 5'-cap structure). For example, recombinant Vaccinia Virus Capping Enzyme and recombinant 2'-O-methyltransferase enzyme can create a canonical 5'-5'-triphosphate linkage between the 5'-terminal nucleotide of a polynucleotide and a guanosine cap nucleotide wherein the cap guanosine contains an N7-methylation and the 5'-terminal nucleotide of the polynucleotide contains a 2'-O-methyl. Such a structure is termed the Cap1 structure. This cap results in a higher translational-competency, cellular stability, and a reduced activation of cellular pro-inflammatory cytokines, as compared, *e.g.*, to other 5' cap analog structures known in the art. Other exemplary cap structures include 7mG(5')ppp(5')N,pN2p (Cap 0), 7mG(5')ppp(5')NImpNp (Cap 1), 7mG(5')-ppp(5')NImpN2mp (Cap 2), and m(7)Gpppm(3)(6,6,2')Apm(2')Apm(2')Cpm(2)(3,2')Up (Cap 4).

[00410] Because the alternative polynucleotides may be capped post-transcriptionally, and because this process is more efficient, nearly 100% of the alternative polynucleotides may be capped. This is in contrast to ~80% when a cap analog is linked to a polynucleotide in the course of an *in vitro* transcription reaction.

[00411] 5'-terminal caps may include endogenous caps or cap analogs. A 5'-terminal cap may include a guanosine analog. Useful guanosine analogs include inosine, N1-methyl-guanosine, 2'-fluoro-guanosine, 7-deaza-guanosine, 8-oxo-guanosine, 2-amino-guanosine, LNA-guanosine, and 2-azido-guanosine.

[00412] In some cases, a polynucleotide contains a modified 5'-cap. A modification on the 5'-cap may increase the stability of polynucleotide, increase the half-life of the polynucleotide, and could increase the polynucleotide translational efficiency. The modified 5'-cap may include, but is not limited to, one or more of the following modifications: modification at the 2'- and/or 3'-position of a capped guanosine triphosphate (GTP), a replacement of the sugar ring oxygen (that produced the carbocyclic ring) with a methylene moiety (CH₂), a modification at the triphosphate bridge moiety of the cap structure, or a modification at the nucleobase (G) moiety.

5'-UTRs

[00413] A 5'-UTR may be provided as a flanking region to polynucleotides (*e.g.*, mRNAs). A 5'-UTR may be homologous or heterologous to the coding region found in a polynucleotide. Multiple 5'-UTRs may be included in the flanking region and may be the same or of different sequences. Any portion of the flanking regions, including none, may be codon optimized and any may independently contain one or more different structural or chemical alterations, before and/or after codon optimization.

[00414] Shown in Table 21 in US Provisional Application No 61/775,509, and in Table 21 and in Table 22 in US Provisional Application No. 61/829,372, of which are incorporated herein by reference, is a listing of the start and stop site of alternative polynucleotides (*e.g.*, mRNA). In Table 21 each 5'-UTR (5'-UTR-005 to 5'-UTR 68511) is identified by its start and stop site relative to its native or wild type (homologous) transcript (ENST; the identifier used in the ENSEMBL database).

[00415] To alter one or more properties of a polynucleotide (*e.g.*, mRNA), 5'-UTRs which are heterologous to the coding region of an alternative polynucleotide (*e.g.*, mRNA) may be engineered. The polynucleotides (*e.g.*, mRNA) may then be administered to cells, tissue or organisms and outcomes such as protein level, localization, and/or half-life may be measured to evaluate the beneficial effects the heterologous 5'-UTR may have on the alternative polynucleotides (mRNA). Variants of the 5'-UTRs may be utilized wherein one or more nucleotides are added or removed to the termini, including A, T, C or G. 5'-UTRs may also be codon-optimized, or altered in any manner described herein.

5'-UTRs, 3'-UTRs, and translation enhancer elements (TEEs)

[00416] The 5'-UTR of a polynucleotides (*e.g.*, mRNA) may include at least one translation enhancer element. The term "translational enhancer element" refers to sequences that increase the amount of polypeptide or protein produced from a polynucleotide. As a non-limiting example, the TEE may be located between the transcription promoter and the start codon. The polynucleotides (*e.g.*, mRNA) with at least one TEE in the 5'-UTR may include a cap at the 5'-UTR. Further, at least one TEE may be located in the 5'-UTR of polynucleotides (*e.g.*, mRNA) undergoing cap-dependent or cap-independent translation.

[00417] In one aspect, TEEs are conserved elements in the UTR which can promote translational activity of a polynucleotide such as, but not limited to, cap-dependent or cap-independent translation. The conservation of these sequences has been previously shown by Panek et al. (Nucleic Acids Research, 2013, 1-10) across 14 species including humans.

[00418] In one non-limiting example, the TEEs known may be in the 5'-leader of the Gtx homeodomain protein (Chappell et al., Proc. Natl. Acad. Sci. USA 101:9590-9594, 2004, the TEEs of which are incorporated herein by reference).

[00419] In another non-limiting example, TEEs are disclosed in US Patent Publication Nos. 2009/0226470 and 2013/0177581, International Patent Publication Nos. WO2009/075886, WO2012/009644, and WO1999/024595, and US Patent Nos. 6,310,197 and 6,849,405, the TEE sequences of each of which are incorporated herein by reference.

[00420] In yet another non-limiting example, the TEE may be an internal ribosome entry site (IRES), HCV-IRES or an IRES element such as, but not limited to, those described in US Patent No. 7,468,275, US Patent Publication Nos. 2007/0048776 and 2011/0124100 and International Patent Publication Nos. WO2007/025008 and WO2001/055369, the IRES sequences of each of which are incorporated herein by reference. The IRES elements may include, but are not limited to, the Gtx sequences (*e.g.*, Gtx9-nt, Gtx8-nt, Gtx7-nt) described by Chappell et al. (Proc. Natl. Acad. Sci. USA 101:9590-9594, 2004) and Zhou et al. (PNAS 102:6273-6278, 2005) and in US Patent Publication Nos. 2007/0048776 and 2011/0124100 and International Patent Publication No. WO2007/025008, the IRES sequences of each of which are incorporated herein by reference.

[00421] "Translational enhancer polynucleotides" are polynucleotides which include one or more of the specific TEE exemplified herein and/or disclosed in the art (see *e.g.*, U.S. Patent Nos. 6,310,197, 6,849,405, 7,456,273, 7,183,395, U.S. Patent Publication Nos. 2009/0226470, 2007/0048776, 2011/0124100, 2009/0093049, 2013/0177581, International Patent Publication Nos. WO2009/075886, WO2007/025008, WO2012/009644, WO2001/055371 WO1999/024595, and European Patent Nos. 2610341 and 2610340; the TEE sequences of each of which are incorporated herein by reference) or their variants, homologs or functional derivatives. One or multiple copies of a specific TEE can be present in a polynucleotide (*e.g.*, mRNA). The TEEs in the translational enhancer polynucleotides can be organized in one or more sequence segments. A sequence segment can harbor one or more of the specific TEEs exemplified herein, with each TEE being present in one or more copies. When multiple sequence segments are present in a translational enhancer polynucleotide, they can be homogenous or heterogeneous. Thus, the multiple sequence segments in a translational enhancer polynucleotide can harbor identical or different types of the specific TEEs exemplified herein, identical or different number of copies of each of the specific TEEs, and/or identical or different organization of the TEEs within each sequence segment.

[00422] A polynucleotide (*e.g.*, mRNA) may include at least one TEE that is described in International Patent Publication Nos. WO1999/024595, WO2012/009644, WO2009/075886, WO2007/025008, WO1999/024595, European Patent Publication Nos. 2610341 and 2610340, US Patent Nos. 6,310,197, 6,849,405, 7,456,273, 7,183,395, and US Patent Publication Nos. 2009/0226470, 2011/0124100, 2007/0048776, 2009/0093049, and 2013/0177581 the TEE sequences of each of which are incorporated herein by reference. The TEE may be located in the 5'-UTR of the polynucleotides (*e.g.*, mRNA).

[00423] A polynucleotide (*e.g.*, mRNA) may include at least one TEE that has at least 50%, at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95% or at least 99% identity with the TEEs described in US Patent Publication Nos. 2009/0226470, 2007/0048776, 2013/0177581 and 2011/0124100, International Patent Publication Nos. WO1999/024595, WO2012/009644, WO2009/075886 and WO2007/025008, European Patent Publication Nos. 2610341 and 2610340, US Patent Nos. 6,310,197, 6,849,405, 7,456,273, 7,183,395, the TEE sequences of each of which are incorporated herein by reference.

[00424] The 5'-UTR of a polynucleotide (*e.g.*, mRNA) may include at least 1, at least 2, at least 3, at least 4, at least 5, at least 6, at least 7, at least 8, at least 9, at least 10, at least 11, at least 12, at least 13, at least 14, at least 15, at least 16, at least 17, at least 18 at least 19, at least 20, at least 21, at least 22, at least 23, at least 24, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 55 or more than 60 TEE sequences. The TEE sequences in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) may be the same or different TEE sequences. The TEE sequences may be in a pattern such as ABABAB, AABBAABBAABB, or ABCABCABC, or variants thereof, repeated once, twice, or more than three times. In these patterns, each letter, A, B, or C represent a different TEE sequence at the nucleotide level.

[00425] In some cases, the 5'-UTR may include a spacer to separate two TEE sequences. As a non-limiting example, the spacer may be a 15 nucleotide spacer and/or other spacers known in the art. As another non-limiting example, the 5'-UTR may include a TEE sequence-spacer module repeated at least once, at least twice, at least 3 times, at least 4 times, at least 5 times, at least 6 times, at least 7 times, at least 8 times, at least 9 times, or more than 9 times in the 5'-UTR.

[00426] In other instances, the spacer separating two TEE sequences may include other sequences known in the art which may regulate the translation of the polynucleotides (*e.g.*, mRNA) of the present disclosure such as, but not limited to, miR sequences (*e.g.*, miR binding sites and miR seeds). As a non-limiting example, each spacer used to separate two TEE

sequences may include a different miR sequence or component of a miR sequence (*e.g.*, miR seed sequence).

[00427] In some instances, the TEE in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) may include at least 5%, at least 10%, at least 15%, at least 20%, at least 25%, at least 30%, at least 35%, at least 40%, at least 45%, at least 50%, at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 99% or more than 99% of the TEE sequences disclosed in US Patent Publication Nos. 2009/0226470, 2007/0048776, 2013/0177581 and 2011/0124100, International Patent Publication Nos. WO1999/024595, WO2012/009644, WO2009/075886 and WO2007/025008, European Patent Publication Nos. 2610341 and 2610340, and US Patent Nos. 6,310,197, 6,849,405, 7,456,273, and 7,183,395 the TEE sequences of each of which are incorporated herein by reference. In some embodiments, the TEE in the 5'-UTR of the polynucleotides (*e.g.*, mRNA) of the present disclosure may include a 5-30 nucleotide fragment, a 5-25 nucleotide fragment, a 5-20 nucleotide fragment, a 5-15 nucleotide fragment, a 5-10 nucleotide fragment of the TEE sequences disclosed in US Patent Publication Nos. 2009/0226470, 2007/0048776, 2013/0177581 and 2011/0124100, International Patent Publication Nos. WO1999/024595, WO2012/009644, WO2009/075886 and WO2007/025008, European Patent Publication Nos. 2610341 and 2610340, and US Patent Nos. 6,310,197, 6,849,405, 7,456,273, and 7,183,395; the TEE sequences of each of which are incorporated herein by reference.

[00428] In certain cases, the TEE in the 5'-UTR of the polynucleotides (*e.g.*, mRNA) of the present disclosure may include at least 5%, at least 10%, at least 15%, at least 20%, at least 25%, at least 30%, at least 35%, at least 40%, at least 45%, at least 50%, at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 99% or more than 99% of the TEE sequences disclosed in Chappell et al. (Proc. Natl. Acad. Sci. USA 101:9590-9594, 2004) and Zhou et al. (PNAS 102:6273-6278, 2005), in Supplemental Table 1 and in Supplemental Table 2 disclosed by Wellensiek et al (Genome-wide profiling of human cap-independent translation-enhancing elements, Nature Methods, 2013; DOI:10.1038/NMETH.2522); the TEE sequences of each of which are herein incorporated by reference. In some embodiments, the TEE in the 5'-UTR of the polynucleotides (*e.g.*, mRNA) of the present disclosure may include a 5-30 nucleotide fragment, a 5-25 nucleotide fragment, a 5-20 nucleotide fragment, a 5-15 nucleotide fragment, a 5-10 nucleotide fragment of the TEE sequences disclosed in Chappell et al. (Proc. Natl. Acad. Sci. USA 101:9590-9594, 2004) and Zhou et al. (PNAS 102:6273-6278, 2005), in Supplemental Table 1 and in Supplemental Table 2 disclosed by Wellensiek et al (Genome-wide profiling of human cap-independent translation-

enhancing elements, Nature Methods, 2013; DOI:10.1038/NMETH.2522); the TEE sequences of each of which is incorporated herein by reference.

[00429] In some cases, the TEE used in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) is an IRES sequence such as, but not limited to, those described in US Patent No. 7,468,275 and International Patent Publication No. WO2001/055369, the TEE sequences of each of which are incorporated herein by reference.

[00430] In some instances, the TEEs used in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) may be identified by the methods described in US Patent Publication Nos. 2007/0048776 and 2011/0124100 and International Patent Publication Nos. WO2007/025008 and WO2012/009644, the methods of each of which are incorporated herein by reference.

[00431] In some cases, the TEEs used in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) of the present disclosure may be a transcription regulatory element described in US Patent Nos. 7,456,273 and 7,183,395, US Patent Publication No. 2009/0093049, and International Publication No. WO2001/055371, the TEE sequences of each of which is incorporated herein by reference. The transcription regulatory elements may be identified by methods known in the art, such as, but not limited to, the methods described in US Patent Nos. 7,456,273 and 7,183,395, US Patent Publication No. 2009/0093049, and International Publication No. WO2001/055371, the methods of each of which is incorporated herein by reference.

[00432] In yet other instances, the TEE used in the 5'-UTR of a polynucleotide (*e.g.*, mRNA) is a polynucleotide or portion thereof as described in US Patent Nos. 7,456,273 and 7,183,395, US Patent Publication No. 2009/0093049, and International Publication No. WO2001/055371, the TEE sequences of each of which are incorporated herein by reference.

[00433] The 5'-UTR including at least one TEE described herein may be incorporated in a monocistronic sequence such as, but not limited to, a vector system or a polynucleotide vector. As a non-limiting example, the vector systems and polynucleotide vectors may include those described in US Patent Nos. 7,456,273 and 7,183,395, US Patent Publication Nos. 2007/0048776, 2009/0093049 and 2011/0124100, and International Patent Publication Nos. WO2007/025008 and WO2001/055371, the TEE sequences of each of which are incorporated herein by reference.

[00434] The TEEs described herein may be located in the 5'-UTR and/or the 3'-UTR of the polynucleotides (*e.g.*, mRNA). The TEEs located in the 3'-UTR may be the same and/or different than the TEEs located in and/or described for incorporation in the 5'-UTR.

[00435] In some cases, the 3'-UTR of a polynucleotide (*e.g.*, mRNA) may include at least 1, at least 2, at least 3, at least 4, at least 5, at least 6, at least 7, at least 8, at least 9, at least 10, at

least 11, at least 12, at least 13, at least 14, at least 15, at least 16, at least 17, at least 18 at least 19, at least 20, at least 21, at least 22, at least 23, at least 24, at least 25, at least 30, at least 35, at least 40, at least 45, at least 50, at least 55 or more than 60 TEE sequences. The TEE sequences in the 3'-UTR of the polynucleotides (*e.g.*, mRNA) of the present disclosure may be the same or different TEE sequences. The TEE sequences may be in a pattern such as ABABAB, AABBAABBAABB, or ABCABCABC, or variants thereof, repeated once, twice, or more than three times. In these patterns, each letter, A, B, or C represent a different TEE sequence at the nucleotide level.

[00436] In one instance, the 3'-UTR may include a spacer to separate two TEE sequences. As a non-limiting example, the spacer may be a 15 nucleotide spacer and/or other spacers known in the art. As another non-limiting example, the 3'-UTR may include a TEE sequence-spacer module repeated at least once, at least twice, at least 3 times, at least 4 times, at least 5 times, at least 6 times, at least 7 times, at least 8 times, at least 9 times, or more than 9 times in the 3'-UTR.

[00437] In other cases, the spacer separating two TEE sequences may include other sequences known in the art which may regulate the translation of the polynucleotides (*e.g.*, mRNA) of the present disclosure such as, but not limited to, miR sequences described herein (*e.g.*, miR binding sites and miR seeds). As a non-limiting example, each spacer used to separate two TEE sequences may include a different miR sequence or component of a miR sequence (*e.g.*, miR seed sequence).

[00438] In yet other cases, the incorporation of a miR sequence and/or a TEE sequence changes the shape of the stem loop region which may increase and/or decrease translation. (see *e.g.*, Kedde et al. A Pumilio-induced RNA structure switch in p27-3'UTR controls miR-221 and miR-22 accessibility. *Nature Cell Biology*. 2010).

Stem loops

[00439] Polynucleotides (*e.g.*, mRNAs) may include a stem loop such as, but not limited to, a histone stem loop. The stem loop may be a nucleotide sequence that is about 25 or about 26 nucleotides in length such as, but not limited to, those described in International Patent Publication No. WO2013/103659, which is incorporated herein by reference. The histone stem loop may be located 3'-relative to the coding region (*e.g.*, at the 3'-terminus of the coding region). As a non-limiting example, the stem loop may be located at the 3'-end of a polynucleotide described herein. In some cases, a polynucleotide (*e.g.*, an mRNA) includes more than one stem loop (*e.g.*, two stem loops). Examples of stem loop sequences are described in International Patent Publication Nos. WO2012/019780 and WO201502667, the stem loop

sequences of which are herein incorporated by reference. In some instances, a polynucleotide includes the stem loop sequence CAAAGGCTCTTTTCAGAGCCACCA (SEQ ID NO: 1). In others, a polynucleotide includes the stem loop sequence CAAAGGCUCUUUUCAGAGCCACCA (SEQ ID NO: 2).

[00440] A stem loop may be located in a second terminal region of a polynucleotide. As a non-limiting example, the stem loop may be located within an untranslated region (*e.g.*, 3'-UTR) in a second terminal region.

[00441] In some cases, a polynucleotide such as, but not limited to mRNA, which includes the histone stem loop may be stabilized by the addition of a 3'-stabilizing region (*e.g.*, a 3'-stabilizing region including at least one chain terminating nucleoside). Not wishing to be bound by theory, the addition of at least one chain terminating nucleoside may slow the degradation of a polynucleotide and thus can increase the half-life of the polynucleotide.

[00442] In other cases, a polynucleotide such as, but not limited to mRNA, which includes the histone stem loop may be stabilized by an alteration to the 3'-region of the polynucleotide that can prevent and/or inhibit the addition of oligio(U) (see *e.g.*, International Patent Publication No. WO2013/103659).

[00443] In yet other cases, a polynucleotide such as, but not limited to mRNA, which includes the histone stem loop may be stabilized by the addition of an oligonucleotide that terminates in a 3'-deoxynucleoside, 2',3'-dideoxynucleoside 3'-O- methylnucleosides, 3'-O- ethylnucleosides, 3'-arabinosides, and other alternative nucleosides known in the art and/or described herein.

[00444] In some instances, the polynucleotides of the present disclosure may include a histone stem loop, a poly-A region, and/or a 5'-cap structure. The histone stem loop may be before and/or after the poly-A region. The polynucleotides including the histone stem loop and a poly-A region sequence may include a chain terminating nucleoside described herein.

[00445] In other instances, the polynucleotides of the present disclosure may include a histone stem loop and a 5'-cap structure. The 5'-cap structure may include, but is not limited to, those described herein and/or known in the art.

[00446] In some cases, the conserved stem loop region may include a miR sequence described herein. As a non-limiting example, the stem loop region may include the seed sequence of a miR sequence described herein. In another non-limiting example, the stem loop region may include a miR-122 seed sequence.

[00447] In certain instances, the conserved stem loop region may include a miR sequence described herein and may also include a TEE sequence.

[00448] In some cases, the incorporation of a miR sequence and/or a TEE sequence changes the shape of the stem loop region which may increase and/or decrease translation. (See, e.g., Kedde et al. A Pumilio-induced RNA structure switch in p27-3'UTR controls miR-221 and miR-22 accessibility. *Nature Cell Biology*. 2010, herein incorporated by reference in its entirety).

[00449] Polynucleotides may include at least one histone stem-loop and a poly-A region or polyadenylation signal. Non-limiting examples of polynucleotide sequences encoding for at least one histone stem-loop and a poly-A region or a polyadenylation signal are described in International Patent Publication No. WO2013/120497, WO2013/120629, WO2013/120500, WO2013/120627, WO2013/120498, WO2013/120626, WO2013/120499 and WO2013/120628, the sequences of each of which are incorporated herein by reference. In certain cases, the polynucleotide encoding for a histone stem loop and a poly-A region or a polyadenylation signal may code for a pathogen antigen or fragment thereof such as the polynucleotide sequences described in International Patent Publication No WO2013/120499 and WO2013/120628, the sequences of both of which are incorporated herein by reference. In other cases, the polynucleotide encoding for a histone stem loop and a poly-A region or a polyadenylation signal may code for a therapeutic protein such as the polynucleotide sequences described in International Patent Publication No WO2013/120497 and WO2013/120629, the sequences of both of which are incorporated herein by reference. In some cases, the polynucleotide encoding for a histone stem loop and a poly-A region or a polyadenylation signal may code for a tumor antigen or fragment thereof such as the polynucleotide sequences described in International Patent Publication No WO2013/120500 and WO2013/120627, the sequences of both of which are incorporated herein by reference. In other cases, the polynucleotide encoding for a histone stem loop and a poly-A region or a polyadenylation signal may code for an allergenic antigen or an autoimmune self-antigen such as the polynucleotide sequences described in International Patent Publication No WO2013/120498 and WO2013/120626, the sequences of both of which are incorporated herein by reference.

Poly-A regions

[00450] A polynucleotide or nucleic acid (e.g., an mRNA) may include a polyA sequence and/or polyadenylation signal. A polyA sequence may be comprised entirely or mostly of adenine nucleotides or analogs or derivatives thereof. A polyA sequence may be a tail located adjacent to a 3' untranslated region of a nucleic acid.

[00451] During RNA processing, a long chain of adenosine nucleotides (poly-A region) is normally added to messenger RNA (mRNA) molecules to increase the stability of the molecule.

Immediately after transcription, the 3'-end of the transcript is cleaved to free a 3'-hydroxy. Then poly-A polymerase adds a chain of adenosine nucleotides to the RNA. The process, called polyadenylation, adds a poly-A region that is between 100 and 250 residues long.

[00452] Unique poly-A region lengths may provide certain advantages to the alternative polynucleotides of the present disclosure.

[00453] Generally, the length of a poly-A region of the present disclosure is at least 30 nucleotides in length. In some embodiments, the poly-A region is at least 35 nucleotides in length. In some embodiments, the length is at least 40 nucleotides. In some embodiments, the length is at least 45 nucleotides. In some embodiments, the length is at least 55 nucleotides. In some embodiments, the length is at least 60 nucleotides. In some embodiments, the length is at least 70 nucleotides. In some embodiments, the length is at least 80 nucleotides. In some embodiments, the length is at least 90 nucleotides. In some embodiments, the length is at least 100 nucleotides. In some embodiments, the length is at least 120 nucleotides. In some embodiments, the length is at least 140 nucleotides. In some embodiments, the length is at least 160 nucleotides. In some embodiments, the length is at least 180 nucleotides. In some embodiments, the length is at least 200 nucleotides. In some embodiments, the length is at least 250 nucleotides. In some embodiments, the length is at least 300 nucleotides. In some embodiments, the length is at least 350 nucleotides. In some embodiments, the length is at least 400 nucleotides. In some embodiments, the length is at least 450 nucleotides. In some embodiments, the length is at least 500 nucleotides. In some embodiments, the length is at least 600 nucleotides. In some embodiments, the length is at least 700 nucleotides. In some embodiments, the length is at least 800 nucleotides. In some embodiments, the length is at least 900 nucleotides. In some embodiments, the length is at least 1000 nucleotides. In some embodiments, the length is at least 1100 nucleotides. In some embodiments, the length is at least 1200 nucleotides. In some embodiments, the length is at least 1300 nucleotides. In some embodiments, the length is at least 1400 nucleotides. In some embodiments, the length is at least 1500 nucleotides. In some embodiments, the length is at least 1600 nucleotides. In some embodiments, the length is at least 1700 nucleotides. In some embodiments, the length is at least 1800 nucleotides. In some embodiments, the length is at least 1900 nucleotides. In some embodiments, the length is at least 2000 nucleotides. In some embodiments, the length is at least 2500 nucleotides. In some embodiments, the length is at least 3000 nucleotides.

[00454] In some instances, the poly-A region may be 80 nucleotides, 120 nucleotides, 160 nucleotides in length on an alternative polynucleotide molecule described herein.

[00455] In other instances, the poly-A region may be 20, 40, 80, 100, 120, 140 or 160 nucleotides in length on an alternative polynucleotide molecule described herein.

[00456] In some cases, the poly-A region is designed relative to the length of the overall alternative polynucleotide. This design may be based on the length of the coding region of the alternative polynucleotide, the length of a particular feature or region of the alternative polynucleotide (such as mRNA), or based on the length of the ultimate product expressed from the alternative polynucleotide. When relative to any feature of the alternative polynucleotide (*e.g.*, other than the mRNA portion which includes the poly-A region) the poly-A region may be 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100% greater in length than the additional feature. The poly-A region may also be designed as a fraction of the alternative polynucleotide to which it belongs. In this context, the poly-A region may be 10, 20, 30, 40, 50, 60, 70, 80, or 90% or more of the total length of the construct or the total length of the construct minus the poly-A region.

[00457] In certain cases, engineered binding sites and/or the conjugation of polynucleotides (*e.g.*, mRNA) for poly-A binding protein may be used to enhance expression. The engineered binding sites may be sensor sequences which can operate as binding sites for ligands of the local microenvironment of the polynucleotides (*e.g.*, mRNA). As a non-limiting example, the polynucleotides (*e.g.*, mRNA) may include at least one engineered binding site to alter the binding affinity of poly-A binding protein (PABP) and analogs thereof. The incorporation of at least one engineered binding site may increase the binding affinity of the PABP and analogs thereof.

[00458] Additionally, multiple distinct polynucleotides (*e.g.*, mRNA) may be linked together to the PABP (poly-A binding protein) through the 3'-end using alternative nucleotides at the 3'-terminus of the poly-A region. Transfection experiments can be conducted in relevant cell lines and protein production can be assayed by ELISA at 12 hours, 24 hours, 48 hours, 72 hours, and day 7 post-transfection. As a non-limiting example, the transfection experiments may be used to evaluate the effect on PABP or analogs thereof binding affinity as a result of the addition of at least one engineered binding site.

[00459] In certain cases, a poly-A region may be used to modulate translation initiation. While not wishing to be bound by theory, the poly-A region recruits PABP which in turn can interact with translation initiation complex and thus may be essential for protein synthesis.

[00460] In some cases, a poly-A region may also be used in the present disclosure to protect against 3'-5'-exonuclease digestion.

[00461] In some instances, a polynucleotide (*e.g.*, mRNA) may include a poly-A-G Quartet. The G-quartet is a cyclic hydrogen bonded array of four guanosine nucleotides that can be formed by G-rich sequences in both DNA and RNA. In this embodiment, the G-quartet is incorporated at the end of the poly-A region. The resultant polynucleotides (*e.g.*, mRNA) may be assayed for stability, protein production and other parameters including half-life at various time points. It has been discovered that the poly-A-G quartet results in protein production equivalent to at least 75% of that seen using a poly-A region of 120 nucleotides alone.

[00462] In some cases, a polynucleotide (*e.g.*, mRNA) may include a poly-A region and may be stabilized by the addition of a 3'-stabilizing region. The polynucleotides (*e.g.*, mRNA) with a poly-A region may further include a 5'-cap structure.

[00463] In other cases, a polynucleotide (*e.g.*, mRNA) may include a poly-A-G Quartet. The polynucleotides (*e.g.*, mRNA) with a poly-A-G Quartet may further include a 5'-cap structure.

[00464] In some cases, the 3'-stabilizing region which may be used to stabilize a polynucleotide (*e.g.*, mRNA) including a poly-A region or poly-A-G Quartet may be, but is not limited to, those described in International Patent Publication No. WO2013/103659, the poly-A regions and poly-A-G Quartets of which are incorporated herein by reference. In other cases, the 3'-stabilizing region which may be used with the present disclosure include a chain termination nucleoside such as 3'-deoxyadenosine (cordycepin), 3'-deoxyuridine, 3'-deoxycytosine, 3'-deoxyguanosine, 3'-deoxythymine, 2',3'-dideoxynucleosides, such as 2',3'-dideoxyadenosine, 2',3'-dideoxyuridine, 2',3'-dideoxycytosine, 2',3'-dideoxyguanosine, 2',3'-dideoxythymine, a 2'-deoxynucleoside, or an O-methylnucleoside.

[00465] In other cases, a polynucleotide such as, but not limited to mRNA, which includes a polyA region or a poly-A-G Quartet may be stabilized by an alteration to the 3'-region of the polynucleotide that can prevent and/or inhibit the addition of oligio(U) (see *e.g.*, International Patent Publication No. WO2013/103659).

[00466] In yet other instances, a polynucleotide such as, but not limited to mRNA, which includes a poly-A region or a poly-A-G Quartet may be stabilized by the addition of an oligonucleotide that terminates in a 3'-deoxynucleoside, 2',3'-dideoxynucleoside 3'-O-methylnucleosides, 3'-O-ethylnucleosides, 3'-arabinosides, and other alternative nucleosides known in the art and/or described herein.

Chain terminating nucleosides

[00467] A nucleic acid may include a chain terminating nucleoside. For example, a chain terminating nucleoside may include those nucleosides deoxygenated at the 2' and/or 3' positions of their sugar group. Such species may include 3'-deoxyadenosine (cordycepin), 3'-

deoxyuridine, 3'-deoxycytosine, 3'-deoxyguanosine, 3'-deoxythymine, and 2',3'-dideoxynucleosides, such as 2',3'-dideoxyadenosine, 2',3'-dideoxyuridine, 2',3'-dideoxycytosine, 2',3'-dideoxyguanosine, and 2',3'-dideoxythymine.

Other components

[00468] A nanoparticle composition may include one or more components in addition to those described in the preceding sections. For example, a nanoparticle composition may include one or more small hydrophobic molecules such as a vitamin (*e.g.*, vitamin A or vitamin E) or a sterol.

[00469] Nanoparticle compositions may also include one or more permeability enhancer molecules, carbohydrates, polymers, surface altering agents, or other components. A permeability enhancer molecule may be a molecule described by U.S. patent application publication No. 2005/0222064, for example. Carbohydrates may include simple sugars (*e.g.*, glucose) and polysaccharides (*e.g.*, glycogen and derivatives and analogs thereof).

[00470] A polymer may be included in and/or used to encapsulate or partially encapsulate a nanoparticle composition. A polymer may be biodegradable and/or biocompatible. A polymer may be selected from, but is not limited to, polyamines, polyethers, polyamides, polyesters, polycarbamates, polyureas, polycarbonates, polystyrenes, polyimides, polysulfones, polyurethanes, polyacetylenes, polyethylenes, polyethyleneimines, polyisocyanates, polyacrylates, polymethacrylates, polyacrylonitriles, and polyarylates. For example, a polymer may include poly(caprolactone) (PCL), ethylene vinyl acetate polymer (EVA), poly(lactic acid) (PLA), poly(L-lactic acid) (PLLA), poly(glycolic acid) (PGA), poly(lactic acid-co-glycolic acid) (PLGA), poly(L-lactic acid-co-glycolic acid) (PLLGA), poly(D,L-lactide) (PDLA), poly(L-lactide) (PLLA), poly(D,L-lactide-co-caprolactone), poly(D,L-lactide-co-caprolactone-co-glycolide), poly(D,L-lactide-co-PEO-co-D,L-lactide), poly(D,L-lactide-co-PPO-co-D,L-lactide), polyalkyl cyanoacrylate, polyurethane, poly-L-lysine (PLL), hydroxypropyl methacrylate (HPMA), polyethyleneglycol, poly-L-glutamic acid, poly(hydroxy acids), polyanhydrides, polyorthoesters, poly(ester amides), polyamides, poly(ester ethers), polycarbonates, polyalkylenes such as polyethylene and polypropylene, polyalkylene glycols such as poly(ethylene glycol) (PEG), polyalkylene oxides (PEO), polyalkylene terephthalates such as poly(ethylene terephthalate), polyvinyl alcohols (PVA), polyvinyl ethers, polyvinyl esters such as poly(vinyl acetate), polyvinyl halides such as poly(vinyl chloride) (PVC), polyvinylpyrrolidone (PVP), polysiloxanes, polystyrene (PS), polyurethanes, derivatized celluloses such as alkyl celluloses, hydroxyalkyl celluloses, cellulose ethers, cellulose esters, nitro celluloses, hydroxypropylcellulose, carboxymethylcellulose, polymers of acrylic acids,

such as poly(methyl(meth)acrylate) (PMMA), poly(ethyl(meth)acrylate), poly(butyl(meth)acrylate), poly(isobutyl(meth)acrylate), poly(hexyl(meth)acrylate), poly(isodecyl(meth)acrylate), poly(lauryl(meth)acrylate), poly(phenyl(meth)acrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate), poly(octadecyl acrylate) and copolymers and mixtures thereof, polydioxanone and its copolymers, polyhydroxyalkanoates, polypropylene fumarate, polyoxymethylene, poloxamers, polyoxamines, poly(ortho)esters, poly(butyric acid), poly(valeric acid), poly(lactide-co-caprolactone), trimethylene carbonate, poly(*N*-acryloylmorpholine) (PACM), poly(2-methyl-2-oxazoline) (PMOX), poly(2-ethyl-2-oxazoline) (PEOZ), and polyglycerol.

[00471] Surface altering agents may include, but are not limited to, anionic proteins (*e.g.*, bovine serum albumin), surfactants (*e.g.*, cationic surfactants such as dimethyldioctadecyl-ammonium bromide), sugars or sugar derivatives (*e.g.*, cyclodextrin), nucleic acids, polymers (*e.g.*, heparin, polyethylene glycol, and poloxamer), mucolytic agents (*e.g.*, acetylcysteine, mugwort, bromelain, papain, clerodendrum, bromhexine, carbocysteine, eprazinone, mesna, ambroxol, sobrerol, domiodol, letosteine, stepronin, tiopronin, gelsolin, thymosin β 4, dornase alfa, neltexine, and erdosteine), and DNases (*e.g.*, rhDNase). A surface altering agent may be disposed within a nanoparticle and/or on the surface of a nanoparticle composition (*e.g.*, by coating, adsorption, covalent linkage, or other process).

[00472] A nanoparticle composition may also comprise one or more functionalized lipids. For example, a lipid may be functionalized with an alkyne group that, when exposed to an azide under appropriate reaction conditions, may undergo a cycloaddition reaction. In particular, a lipid bilayer may be functionalized in this fashion with one or more groups useful in facilitating membrane permeation, cellular recognition, or imaging. The surface of a nanoparticle composition may also be conjugated with one or more useful antibodies. Functional groups and conjugates useful in targeted cell delivery, imaging, and membrane permeation are well known in the art.

[00473] In addition to these components, nanoparticle compositions may include any substance useful in pharmaceutical compositions. For example, the nanoparticle composition may include one or more pharmaceutically acceptable excipients or accessory ingredients such as, but not limited to, one or more solvents, dispersion media, diluents, dispersion aids, suspension aids, granulating aids, disintegrants, fillers, glidants, liquid vehicles, binders, surface active agents, isotonic agents, thickening or emulsifying agents, buffering agents, lubricating agents, oils, preservatives, and other species. Excipients such as waxes, butters, coloring agents, coating agents, flavorings, and perfuming agents may also be included. Pharmaceutically

acceptable excipients are well known in the art (see for example Remington's *The Science and Practice of Pharmacy*, 21st Edition, A. R. Gennaro; Lippincott, Williams & Wilkins, Baltimore, MD, 2006).

[00474] Examples of diluents may include, but are not limited to, calcium carbonate, sodium carbonate, calcium phosphate, dicalcium phosphate, calcium sulfate, calcium hydrogen phosphate, sodium phosphate lactose, sucrose, cellulose, microcrystalline cellulose, kaolin, mannitol, sorbitol, inositol, sodium chloride, dry starch, cornstarch, powdered sugar, and/or combinations thereof. Granulating and dispersing agents may be selected from the non-limiting list consisting of potato starch, corn starch, tapioca starch, sodium starch glycolate, clays, alginic acid, guar gum, citrus pulp, agar, bentonite, cellulose and wood products, natural sponge, cation-exchange resins, calcium carbonate, silicates, sodium carbonate, cross-linked poly(vinyl-pyrrolidone) (crospovidone), sodium carboxymethyl starch (sodium starch glycolate), carboxymethyl cellulose, cross-linked sodium carboxymethyl cellulose (croscarmellose), methylcellulose, pregelatinized starch (starch 1500), microcrystalline starch, water insoluble starch, calcium carboxymethyl cellulose, magnesium aluminum silicate (VEEGUM®), sodium lauryl sulfate, quaternary ammonium compounds, and/or combinations thereof.

[00475] Surface active agents and/or emulsifiers may include, but are not limited to, natural emulsifiers (*e.g.* acacia, agar, alginic acid, sodium alginate, tragacanth, chondrux, cholesterol, xanthan, pectin, gelatin, egg yolk, casein, wool fat, cholesterol, wax, and lecithin), colloidal clays (*e.g.* bentonite [aluminum silicate] and VEEGUM® [magnesium aluminum silicate]), long chain amino acid derivatives, high molecular weight alcohols (*e.g.* stearyl alcohol, cetyl alcohol, oleyl alcohol, triacetin monostearate, ethylene glycol distearate, glyceryl monostearate, and propylene glycol monostearate, polyvinyl alcohol), carbomers (*e.g.* carboxy polymethylene, polyacrylic acid, acrylic acid polymer, and carboxyvinyl polymer), carrageenan, cellulosic derivatives (*e.g.* carboxymethylcellulose sodium, powdered cellulose, hydroxymethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, methylcellulose), sorbitan fatty acid esters (*e.g.* polyoxyethylene sorbitan monolaurate [TWEEN®20], polyoxyethylene sorbitan [TWEEN® 60], polyoxyethylene sorbitan monooleate [TWEEN®80], sorbitan monopalmitate [SPAN®40], sorbitan monostearate [SPAN®60], sorbitan tristearate [SPAN®65], glyceryl monooleate, sorbitan monooleate [SPAN®80]), polyoxyethylene esters (*e.g.* polyoxyethylene monostearate [MYRJ® 45], polyoxyethylene hydrogenated castor oil, polyethoxylated castor oil, polyoxymethylene stearate, and SOLUTOL®), sucrose fatty acid esters, polyethylene glycol fatty acid esters (*e.g.* CREMOPHOR®), polyoxyethylene ethers, (*e.g.* polyoxyethylene lauryl ether [BRIJ® 30]), poly(vinyl-pyrrolidone), diethylene glycol monolaurate, triethanolamine

oleate, sodium oleate, potassium oleate, ethyl oleate, oleic acid, ethyl laurate, sodium lauryl sulfate, PLURONIC®F 68, POLOXAMER® 188, cetrimonium bromide, cetylpyridinium chloride, benzalkonium chloride, docusate sodium, and/or combinations thereof.

[00476] A binding agent may be starch (*e.g.* cornstarch and starch paste); gelatin; sugars (*e.g.* sucrose, glucose, dextrose, dextrin, molasses, lactose, lactitol, mannitol); natural and synthetic gums (*e.g.*, acacia, sodium alginate, extract of Irish moss, panwar gum, ghatti gum, mucilage of isapol husks, carboxymethylcellulose, methylcellulose, ethylcellulose, hydroxyethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, microcrystalline cellulose, cellulose acetate, poly(vinyl-pyrrolidone), magnesium aluminum silicate (VEEGUM®), and larch arabogalactan); alginates; polyethylene oxide; polyethylene glycol; inorganic calcium salts; silicic acid; polymethacrylates; waxes; water; alcohol; and combinations thereof, or any other suitable binding agent.

[00477] Examples of preservatives may include, but are not limited to, antioxidants, chelating agents, antimicrobial preservatives, antifungal preservatives, alcohol preservatives, acidic preservatives, and/or other preservatives. Examples of antioxidants include, but are not limited to, alpha tocopherol, ascorbic acid, acorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, monothioglycerol, potassium metabisulfite, propionic acid, propyl gallate, sodium ascorbate, sodium bisulfite, sodium metabisulfite, and/or sodium sulfite. Examples of chelating agents include ethylenediaminetetraacetic acid (EDTA), citric acid monohydrate, disodium edetate, dipotassium edetate, edetic acid, fumaric acid, malic acid, phosphoric acid, sodium edetate, tartaric acid, and/or trisodium edetate. Examples of antimicrobial preservatives include, but are not limited to, benzalkonium chloride, benzethonium chloride, benzyl alcohol, bronopol, cetrimide, cetylpyridinium chloride, chlorhexidine, chlorobutanol, chlorocresol, chloroxylonol, cresol, ethyl alcohol, glycerin, hexetidine, imidurea, phenol, phenoxyethanol, phenylethyl alcohol, phenylmercuric nitrate, propylene glycol, and/or thimerosal. Examples of antifungal preservatives include, but are not limited to, butyl paraben, methyl paraben, ethyl paraben, propyl paraben, benzoic acid, hydroxybenzoic acid, potassium benzoate, potassium sorbate, sodium benzoate, sodium propionate, and/or sorbic acid. Examples of alcohol preservatives include, but are not limited to, ethanol, polyethylene glycol, benzyl alcohol, phenol, phenolic compounds, bisphenol, chlorobutanol, hydroxybenzoate, and/or phenylethyl alcohol. Examples of acidic preservatives include, but are not limited to, vitamin A, vitamin C, vitamin E, beta-carotene, citric acid, acetic acid, dehydroascorbic acid, ascorbic acid, sorbic acid, and/or phytic acid. Other preservatives include, but are not limited to, tocopherol, tocopherol acetate, deteroxime mesylate, cetrimide, butylated hydroxyanisole (BHA), butylated

hydroxytoluene (BHT), ethylenediamine, sodium lauryl sulfate (SLS), sodium lauryl ether sulfate (SLES), sodium bisulfite, sodium metabisulfite, potassium sulfite, potassium metabisulfite, GLYDANT PLUS®, PHENONIP®, methylparaben, GERMALL® 115, GERMABEN®II, NEOLONE™, KATHON™, and/or EUXYL®.

[00478] Examples of buffering agents include, but are not limited to, citrate buffer solutions, acetate buffer solutions, phosphate buffer solutions, ammonium chloride, calcium carbonate, calcium chloride, calcium citrate, calcium gluconate, calcium gluceptate, calcium gluconate, d-gluconic acid, calcium glycerophosphate, calcium lactate, calcium lactobionate, propanoic acid, calcium levulinate, pentanoic acid, dibasic calcium phosphate, phosphoric acid, tribasic calcium phosphate, calcium hydroxide phosphate, potassium acetate, potassium chloride, potassium gluconate, potassium mixtures, dibasic potassium phosphate, monobasic potassium phosphate, potassium phosphate mixtures, sodium acetate, sodium bicarbonate, sodium chloride, sodium citrate, sodium lactate, dibasic sodium phosphate, monobasic sodium phosphate, sodium phosphate mixtures, tromethamine, amino-sulfonate buffers (*e.g.*, HEPES), magnesium hydroxide, aluminum hydroxide, alginic acid, pyrogen-free water, isotonic saline, Ringer's solution, ethyl alcohol, and/or combinations thereof. Lubricating agents may selected from the non-limiting group consisting of magnesium stearate, calcium stearate, stearic acid, silica, talc, malt, glyceryl behenate, hydrogenated vegetable oils, polyethylene glycol, sodium benzoate, sodium acetate, sodium chloride, leucine, magnesium lauryl sulfate, sodium lauryl sulfate, and combinations thereof.

[00479] Examples of oils include, but are not limited to, almond, apricot kernel, avocado, babassu, bergamot, black current seed, borage, cade, camomile, canola, caraway, carnauba, castor, cinnamon, cocoa butter, coconut, cod liver, coffee, corn, cotton seed, emu, eucalyptus, evening primrose, fish, flaxseed, geraniol, gourd, grape seed, hazel nut, hyssop, isopropyl myristate, jojoba, kukui nut, lavandin, lavender, lemon, litsea cubeba, macademia nut, mallow, mango seed, meadowfoam seed, mink, nutmeg, olive, orange, orange roughy, palm, palm kernel, peach kernel, peanut, poppy seed, pumpkin seed, rapeseed, rice bran, rosemary, safflower, sandalwood, sasquana, savoury, sea buckthorn, sesame, shea butter, silicone, soybean, sunflower, tea tree, thistle, tsubaki, vetiver, walnut, and wheat germ oils as well as butyl stearate, caprylic triglyceride, capric triglyceride, cyclomethicone, diethyl sebacate, dimethicone 360, simethicone, isopropyl myristate, mineral oil, octyldodecanol, oleyl alcohol, silicone oil, and/or combinations thereof.

Formulations

[00480] Nanoparticle compositions may include a lipid component and one or more additional components, such as a therapeutic and/or prophylactic. A nanoparticle composition may be designed for one or more specific applications or targets. The elements of a nanoparticle composition may be selected based on a particular application or target, and/or based on the efficacy, toxicity, expense, ease of use, availability, or other feature of one or more elements. Similarly, the particular formulation of a nanoparticle composition may be selected for a particular application or target according to, for example, the efficacy and toxicity of particular combinations of elements.

[00481] The lipid component of a nanoparticle composition may include, for example, a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIIId), a phospholipid (such as an unsaturated lipid, *e.g.*, DOPE or DSPC), a PEG lipid, and a structural lipid. The elements of the lipid component may be provided in specific fractions.

[00482] In some embodiments, the lipid component of a nanoparticle composition includes a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIIId), a phospholipid, a PEG lipid, and a structural lipid. In certain embodiments, the lipid component of the nanoparticle composition includes about 30 mol % to about 60 mol % compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIIId), about 0 mol % to about 30 mol % phospholipid, about 18.5 mol % to about 48.5 mol % structural lipid, and about 0 mol % to about 10 mol % of PEG lipid, provided that the total mol % does not exceed 100%. In some embodiments, the lipid component of the nanoparticle composition includes about 35 mol % to about 55 mol % compound of Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIIId), about 5 mol % to about 25 mol % phospholipid, about 30 mol % to about 40 mol % structural lipid, and about 0 mol % to about 10 mol % of PEG lipid. In a particular embodiment, the lipid component includes about 50 mol % said compound, about 10 mol % phospholipid, about 38.5 mol % structural lipid, and about 1.5 mol % of PEG lipid. In another particular embodiment, the lipid component includes about 40 mol % said compound, about 20 mol % phospholipid, about 38.5 mol % structural lipid, and about 1.5 mol % of PEG lipid. In some embodiments, the phospholipid may be DOPE or DSPC. In other embodiments, the PEG lipid may be PEG-DMG

or a PEG lipid according to one of formulae (V), (V-a), or (V-b), and/or the structural lipid may be cholesterol.

[00483] Nanoparticle compositions may be designed for one or more specific applications or targets. For example, a nanoparticle composition may be designed to deliver a therapeutic and/or prophylactic such as an RNA to a particular cell, tissue, organ, or system or group thereof in a mammal's body. Physiochemical properties of nanoparticle compositions may be altered in order to increase selectivity for particular bodily targets. For instance, particle sizes may be adjusted based on the fenestration sizes of different organs. The therapeutic and/or prophylactic included in a nanoparticle composition may also be selected based on the desired delivery target or targets. For example, a therapeutic and/or prophylactic may be selected for a particular indication, condition, disease, or disorder and/or for delivery to a particular cell, tissue, organ, or system or group thereof (*e.g.*, localized or specific delivery). In certain embodiments, a nanoparticle composition may include an mRNA encoding a polypeptide of interest capable of being translated within a cell to produce the polypeptide of interest. Such a composition may be designed to be specifically delivered to a particular organ. In some embodiments, a composition may be designed to be specifically delivered to a mammalian liver.

[00484] The amount of a therapeutic and/or prophylactic in a nanoparticle composition may depend on the size, composition, desired target and/or application, or other properties of the nanoparticle composition as well as on the properties of the therapeutic and/or prophylactic. For example, the amount of an RNA useful in a nanoparticle composition may depend on the size, sequence, and other characteristics of the RNA. The relative amounts of a therapeutic and/or prophylactic and other elements (*e.g.*, lipids) in a nanoparticle composition may also vary. In some embodiments, the wt/wt ratio of the lipid component to a therapeutic and/or prophylactic in a nanoparticle composition may be from about 5:1 to about 60:1, such as 5:1, 6:1, 7:1, 8:1, 9:1, 10:1, 11:1, 12:1, 13:1, 14:1, 15:1, 16:1, 17:1, 18:1, 19:1, 20:1, 25:1, 30:1, 35:1, 40:1, 45:1, 50:1, and 60:1. For example, the wt/wt ratio of the lipid component to a therapeutic and/or prophylactic may be from about 10:1 to about 40:1. In certain embodiments, the wt/wt ratio is about 20:1. The amount of a therapeutic and/or prophylactic in a nanoparticle composition may, for example, be measured using absorption spectroscopy (*e.g.*, ultraviolet-visible spectroscopy).

[00485] In some embodiments, a nanoparticle composition includes one or more RNAs, and the one or more RNAs, lipids, and amounts thereof may be selected to provide a specific N:P ratio. The N:P ratio of the composition refers to the molar ratio of nitrogen atoms in one or more lipids to the number of phosphate groups in an RNA. In general, a lower N:P ratio is preferred. The one or more RNA, lipids, and amounts thereof may be selected to provide an N:P

ratio from about 2:1 to about 30:1, such as 2:1, 3:1, 4:1, 5:1, 6:1, 7:1, 8:1, 9:1, 10:1, 12:1, 14:1, 16:1, 18:1, 20:1, 22:1, 24:1, 26:1, 28:1, or 30:1. In certain embodiments, the N:P ratio may be from about 2:1 to about 8:1. In other embodiments, the N:P ratio is from about 5:1 to about 8:1. For example, the N:P ratio may be about 5.0:1, about 5.5:1, about 5.67:1, about 6.0:1, about 6.5:1, or about 7.0:1. For example, the N:P ratio may be about 5.67:1.

Physical properties

[00486] The characteristics of a nanoparticle composition may depend on the components thereof. For example, a nanoparticle composition including cholesterol as a structural lipid may have different characteristics than a nanoparticle composition that includes a different structural lipid. Similarly, the characteristics of a nanoparticle composition may depend on the absolute or relative amounts of its components. For instance, a nanoparticle composition including a higher molar fraction of a phospholipid may have different characteristics than a nanoparticle composition including a lower molar fraction of a phospholipid. Characteristics may also vary depending on the method and conditions of preparation of the nanoparticle composition.

[00487] Nanoparticle compositions may be characterized by a variety of methods. For example, microscopy (*e.g.*, transmission electron microscopy or scanning electron microscopy) may be used to examine the morphology and size distribution of a nanoparticle composition. Dynamic light scattering or potentiometry (*e.g.*, potentiometric titrations) may be used to measure zeta potentials. Dynamic light scattering may also be utilized to determine particle sizes. Instruments such as the Zetasizer Nano ZS (Malvern Instruments Ltd, Malvern, Worcestershire, UK) may also be used to measure multiple characteristics of a nanoparticle composition, such as particle size, polydispersity index, and zeta potential.

[00488] The mean size of a nanoparticle composition may be between 10s of nm and 100s of nm, *e.g.*, measured by dynamic light scattering (DLS). For example, the mean size may be from about 40 nm to about 150 nm, such as about 40 nm, 45 nm, 50 nm, 55 nm, 60 nm, 65 nm, 70 nm, 75 nm, 80 nm, 85 nm, 90 nm, 95 nm, 100 nm, 105 nm, 110 nm, 115 nm, 120 nm, 125 nm, 130 nm, 135 nm, 140 nm, 145 nm, or 150 nm. In some embodiments, the mean size of a nanoparticle composition may be from about 50 nm to about 100 nm, from about 50 nm to about 90 nm, from about 50 nm to about 80 nm, from about 50 nm to about 70 nm, from about 50 nm to about 60 nm, from about 60 nm to about 100 nm, from about 60 nm to about 90 nm, from about 60 nm to about 80 nm, from about 60 nm to about 70 nm, from about 70 nm to about 150 nm, from about 70 nm to about 130 nm, from about 70 nm to about 100 nm, from about 70 nm to about 90 nm, from about 70 nm to about 80 nm, from about 80 nm to about 150 nm, from about 80 nm to about 130 nm, from about 80 nm to about 100 nm, from about 80 nm to about 90 nm

nm, from about 90 nm to about 150 nm, from about 90 nm to about 130 nm, or from about 90 nm to about 100 nm. In certain embodiments, the mean size of a nanoparticle composition may from about 70 nm to about 130 nm or be from about 70 nm to about 100 nm. In a particular embodiment, the mean size may be about 80 nm. In other embodiments, the mean size may be about 100 nm. In other embodiments, the mean size may be about 120 nm.

[00489] A nanoparticle composition may be relatively homogenous. A polydispersity index may be used to indicate the homogeneity of a nanoparticle composition, *e.g.*, the particle size distribution of the nanoparticle compositions. A small (*e.g.*, less than 0.3) polydispersity index generally indicates a narrow particle size distribution. A nanoparticle composition may have a polydispersity index from about 0 to about 0.25, such as 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.12, 0.13, 0.14, 0.15, 0.16, 0.17, 0.18, 0.19, 0.20, 0.21, 0.22, 0.23, 0.24, or 0.25. In some embodiments, the polydispersity index of a nanoparticle composition may be from about 0.10 to about 0.20.

[00490] The zeta potential of a nanoparticle composition may be used to indicate the electrokinetic potential of the composition. For example, the zeta potential may describe the surface charge of a nanoparticle composition. Nanoparticle compositions with relatively low charges, positive or negative, are generally desirable, as more highly charged species may interact undesirably with cells, tissues, and other elements in the body. In some embodiments, the zeta potential of a nanoparticle composition may be from about -10 mV to about +20 mV, from about -10 mV to about +15 mV, from about -10 mV to about +10 mV, from about -10 mV to about +5 mV, from about -10 mV to about 0 mV, from about -10 mV to about -5 mV, from about -5 mV to about +20 mV, from about -5 mV to about +15 mV, from about -5 mV to about +10 mV, from about -5 mV to about +5 mV, from about -5 mV to about 0 mV, from about 0 mV to about +20 mV, from about 0 mV to about +15 mV, from about 0 mV to about +10 mV, from about 0 mV to about +5 mV, from about +5 mV to about +20 mV, from about +5 mV to about +15 mV, or from about +5 mV to about +10 mV.

[00491] The efficiency of encapsulation of a therapeutic and/or prophylactic describes the amount of therapeutic and/or prophylactic that is encapsulated or otherwise associated with a nanoparticle composition after preparation, relative to the initial amount provided. The encapsulation efficiency is desirably high (*e.g.*, close to 100%). The encapsulation efficiency may be measured, for example, by comparing the amount of therapeutic and/or prophylactic in a solution containing the nanoparticle composition before and after breaking up the nanoparticle composition with one or more organic solvents or detergents. Fluorescence may be used to measure the amount of free therapeutic and/or prophylactic (*e.g.*, RNA) in a solution. For the

nanoparticle compositions described herein, the encapsulation efficiency of a therapeutic and/or prophylactic may be at least 50%, for example 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, or 100%. In some embodiments, the encapsulation efficiency may be at least 80%. In certain embodiments, the encapsulation efficiency may be at least 90%.

[00492] A nanoparticle composition may optionally comprise one or more coatings. For example, a nanoparticle composition may be formulated in a capsule, film, or tablet having a coating. A capsule, film, or tablet including a composition described herein may have any useful size, tensile strength, hardness, or density.

Pharmaceutical compositions

[00493] Nanoparticle compositions may be formulated in whole or in part as pharmaceutical compositions. Pharmaceutical compositions may include one or more nanoparticle compositions. For example, a pharmaceutical composition may include one or more nanoparticle compositions including one or more different therapeutic and/or prophylactics. Pharmaceutical compositions may further include one or more pharmaceutically acceptable excipients or accessory ingredients such as those described herein. General guidelines for the formulation and manufacture of pharmaceutical compositions and agents are available, for example, in Remington's *The Science and Practice of Pharmacy*, 21st Edition, A. R. Gennaro; Lippincott, Williams & Wilkins, Baltimore, MD, 2006. Conventional excipients and accessory ingredients may be used in any pharmaceutical composition, except insofar as any conventional excipient or accessory ingredient may be incompatible with one or more components of a nanoparticle composition. An excipient or accessory ingredient may be incompatible with a component of a nanoparticle composition if its combination with the component may result in any undesirable biological effect or otherwise deleterious effect.

[00494] In some embodiments, one or more excipients or accessory ingredients may make up greater than 50% of the total mass or volume of a pharmaceutical composition including a nanoparticle composition. For example, the one or more excipients or accessory ingredients may make up 50%, 60%, 70%, 80%, 90%, or more of a pharmaceutical convention. In some embodiments, a pharmaceutically acceptable excipient is at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, or 100% pure. In some embodiments, an excipient is approved for use in humans and for veterinary use. In some embodiments, an excipient is approved by United States Food and Drug Administration. In some embodiments, an excipient is pharmaceutical grade. In some embodiments, an excipient meets the standards of the United

[00496] In certain embodiments, the nanoparticle compositions and/or pharmaceutical compositions of the disclosure are refrigerated or frozen for storage and/or shipment (e.g., being stored at a temperature of 4 °C or lower, such as a temperature between about -150 °C and about 0 °C or between about -80 °C and about -20 °C (e.g., about -5 °C, -10 °C, -15 °C, -20 °C, -25 °C, -30 °C, -40 °C, -50 °C, -60 °C, -70 °C, -80 °C, -90 °C, -130 °C or -150 °C). For example, the pharmaceutical composition comprising a compound of any of Formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIE), (IIF), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIIb-1), (VIIIb-2), (VIIIb-3), (VIIC), (VIId), (VIICc), or (VIIdc)) is a solution that is refrigerated for storage and/or shipment at, for example, about -20 °C, -30 °C, -40 °C, -50 °C, -60 °C, -70 °C, or -80 °C. In certain embodiments, the disclosure also relates to a method of increasing stability of the nanoparticle compositions and/or pharmaceutical compositions comprising a compound of any of Formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIE), (IIF), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIIb-1), (VIIIb-2), (VIIIb-3), (VIIC), (VIId), (VIICc), or (VIIdc)) by storing the nanoparticle compositions and/or pharmaceutical compositions at a temperature of 4 °C or lower, such as a temperature between about -150 °C and about 0 °C or between about -80 °C and about -20 °C, e.g., about -5 °C, -10 °C, -15 °C, -20 °C, -25 °C, -30 °C, -40 °C, -50 °C, -60 °C, -70 °C, -80 °C, -90 °C, -130 °C or -150 °C). For example, the nanoparticle compositions and/or pharmaceutical compositions disclosed herein are stable for about at least 1 week, at least 2 weeks, at least 3 weeks, at least 4 weeks, at least 5 weeks, at least 6 weeks, at least 1 month, at least 2 months, at least 4 months, at least 6 months, at least 8 months, at least 10 months, at least 12 months, at least 14 months, at least 16 months, at least 18 months, at least 20 months, at least 22 months, or at least 24 months, e.g., at a temperature of 4 °C or lower (e.g., between about 4 °C and -20 °C). In some embodiments, the formulation is stabilized for at least 4 weeks at about 4 °C. In certain embodiments, the pharmaceutical composition of the disclosure comprises a nanoparticle composition disclosed herein and a pharmaceutically acceptable carrier selected from one or more of Tris, an acetate

(e.g., sodium acetate), an citrate (e.g., sodium citrate), saline, PBS, and sucrose. In certain embodiments, the pharmaceutical composition of the disclosure has a pH value between about 7 and 8 (e.g., 6.8 6.9, 7.0, 7.1, 7.2, 7.3, 7.4, 7.5, 7.6, 7.7, 7.8, 7.9 or 8.0, or between 7.5 and 8 or between 7 and 7.8). For example, a pharmaceutical composition of the disclosure comprises a nanoparticle composition disclosed herein, Tris, saline and sucrose, and has a pH of about 7.5-8, which is suitable for storage and/or shipment at, for example, about -20 °C. For example, a pharmaceutical composition of the disclosure comprises a nanoparticle composition disclosed herein and PBS and has a pH of about 7-7.8, suitable for storage and/or shipment at, for example, about 4 °C or lower. “Stability,” “stabilized,” and “stable” in the context of the present disclosure refers to the resistance of nanoparticle compositions and/or pharmaceutical compositions disclosed herein to chemical or physical changes (e.g., degradation, particle size change, aggregation, change in encapsulation, etc.) under given manufacturing, preparation, transportation, storage and/or in-use conditions, e.g., when stress is applied such as shear force, freeze/thaw stress, etc.

[00497] Nanoparticle compositions and/or pharmaceutical compositions including one or more nanoparticle compositions may be administered to any patient or subject, including those patients or subjects that may benefit from a therapeutic effect provided by the delivery of a therapeutic and/or prophylactic to one or more particular cells, tissues, organs, or systems or groups thereof, such as the renal system. Although the descriptions provided herein of nanoparticle compositions and pharmaceutical compositions including nanoparticle compositions are principally directed to compositions which are suitable for administration to humans, it will be understood by the skilled artisan that such compositions are generally suitable for administration to any other mammal. Modification of compositions suitable for administration to humans in order to render the compositions suitable for administration to various animals is well understood, and the ordinarily skilled veterinary pharmacologist can design and/or perform such modification with merely ordinary, if any, experimentation. Subjects to which administration of the compositions is contemplated include, but are not limited to, humans, other primates, and other mammals, including commercially relevant mammals such as cattle, pigs, horses, sheep, cats, dogs, mice, and/or rats.

[00498] A pharmaceutical composition including one or more nanoparticle compositions may be prepared by any method known or hereafter developed in the art of pharmacology. In general, such preparatory methods include bringing the active ingredient into association with an excipient and/or one or more other accessory ingredients, and then, if desirable or necessary, dividing, shaping, and/or packaging the product into a desired single- or multi-dose unit.

[00499] A pharmaceutical composition in accordance with the present disclosure may be prepared, packaged, and/or sold in bulk, as a single unit dose, and/or as a plurality of single unit doses. As used herein, a “unit dose” is discrete amount of the pharmaceutical composition comprising a predetermined amount of the active ingredient (*e.g.*, nanoparticle composition). The amount of the active ingredient is generally equal to the dosage of the active ingredient which would be administered to a subject and/or a convenient fraction of such a dosage such as, for example, one-half or one-third of such a dosage.

[00500] Pharmaceutical compositions may be prepared in a variety of forms suitable for a variety of routes and methods of administration. For example, pharmaceutical compositions may be prepared in liquid dosage forms (*e.g.*, emulsions, microemulsions, nanoemulsions, solutions, suspensions, syrups, and elixirs), injectable forms, solid dosage forms (*e.g.*, capsules, tablets, pills, powders, and granules), dosage forms for topical and/or transdermal administration (*e.g.*, ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants, and patches), suspensions, powders, and other forms.

[00501] Liquid dosage forms for oral and parenteral administration include, but are not limited to, pharmaceutically acceptable emulsions, microemulsions, nanoemulsions, solutions, suspensions, syrups, and/or elixirs. In addition to active ingredients, liquid dosage forms may comprise inert diluents commonly used in the art such as, for example, water or other solvents, solubilizing agents and emulsifiers such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, dimethylformamide, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor, and sesame oils), glycerol, tetrahydrofurfuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof. Besides inert diluents, oral compositions can include additional therapeutic and/or prophylactics, additional agents such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, and/or perfuming agents. In certain embodiments for parenteral administration, compositions are mixed with solubilizing agents such as Cremophor[®], alcohols, oils, modified oils, glycols, polysorbates, cyclodextrins, polymers, and/or combinations thereof.

[00502] Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing agents, wetting agents, and/or suspending agents. Sterile injectable preparations may be sterile injectable solutions, suspensions, and/or emulsions in nontoxic parenterally acceptable diluents and/or solvents, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, U.S.P., and isotonic sodium

chloride solution. Sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. Fatty acids such as oleic acid can be used in the preparation of injectables.

[00503] Injectable formulations can be sterilized, for example, by filtration through a bacterial-retaining filter, and/or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium prior to use.

[00504] In order to prolong the effect of an active ingredient, it is often desirable to slow the absorption of the active ingredient from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered drug form is accomplished by dissolving or suspending the drug in an oil vehicle. Injectable depot forms are made by forming microencapsulated matrices of the drug in biodegradable polymers such as polylactide-polyglycolide. Depending upon the ratio of drug to polymer and the nature of the particular polymer employed, the rate of drug release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable formulations are prepared by entrapping the drug in liposomes or microemulsions which are compatible with body tissues.

[00505] Compositions for rectal or vaginal administration are typically suppositories which can be prepared by mixing compositions with suitable non-irritating excipients such as cocoa butter, polyethylene glycol or a suppository wax which are solid at ambient temperature but liquid at body temperature and therefore melt in the rectum or vaginal cavity and release the active ingredient.

[00506] Solid dosage forms for oral administration include capsules, tablets, pills, films, powders, and granules. In such solid dosage forms, an active ingredient is mixed with at least one inert, pharmaceutically acceptable excipient such as sodium citrate or dicalcium phosphate and/or fillers or extenders (*e.g.* starches, lactose, sucrose, glucose, mannitol, and silicic acid), binders (*e.g.*, carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidinone, sucrose, and acacia), humectants (*e.g.*, glycerol), disintegrating agents (*e.g.*, agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates, and sodium carbonate), solution retarding agents (*e.g.*, paraffin), absorption accelerators (*e.g.*, quaternary ammonium compounds), wetting agents (*e.g.*, cetyl alcohol and glycerol monostearate), absorbents (*e.g.*, kaolin and bentonite clay,

silicates), and lubricants (*e.g.*, talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium lauryl sulfate), and mixtures thereof. In the case of capsules, tablets and pills, the dosage form may comprise buffering agents.

[00507] Solid compositions of a similar type may be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like. Solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings and other coatings well known in the pharmaceutical formulating art. They may optionally comprise opacifying agents and can be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions which can be used include polymeric substances and waxes. Solid compositions of a similar type may be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like.

[00508] Dosage forms for topical and/or transdermal administration of a composition may include ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants, and/or patches. Generally, an active ingredient is admixed under sterile conditions with a pharmaceutically acceptable excipient and/or any needed preservatives and/or buffers as may be required. Additionally, the present disclosure contemplates the use of transdermal patches, which often have the added advantage of providing controlled delivery of a compound to the body. Such dosage forms may be prepared, for example, by dissolving and/or dispensing the compound in the proper medium. Alternatively or additionally, rate may be controlled by either providing a rate controlling membrane and/or by dispersing the compound in a polymer matrix and/or gel.

[00509] Suitable devices for use in delivering intradermal pharmaceutical compositions described herein include short needle devices such as those described in U.S. Patents 4,886,499; 5,190,521; 5,328,483; 5,527,288; 4,270,537; 5,015,235; 5,141,496; and 5,417,662. Intradermal compositions may be administered by devices which limit the effective penetration length of a needle into the skin, such as those described in PCT publication WO 99/34850 and functional equivalents thereof. Jet injection devices which deliver liquid compositions to the dermis via a liquid jet injector and/or via a needle which pierces the stratum corneum and produces a jet which reaches the dermis are suitable. Jet injection devices are described, for example, in U.S. Patents 5,480,381; 5,599,302; 5,334,144; 5,993,412; 5,649,912; 5,569,189; 5,704,911; 5,383,851; 5,893,397; 5,466,220; 5,339,163; 5,312,335; 5,503,627; 5,064,413; 5,520,639;

4,596,556; 4,790,824; 4,941,880; 4,940,460; and PCT publications WO 97/37705 and WO 97/13537. Ballistic powder/particle delivery devices which use compressed gas to accelerate vaccine in powder form through the outer layers of the skin to the dermis are suitable.

Alternatively or additionally, conventional syringes may be used in the classical mantoux method of intradermal administration.

[00510] Formulations suitable for topical administration include, but are not limited to, liquid and/or semi liquid preparations such as liniments, lotions, oil in water and/or water in oil emulsions such as creams, ointments and/or pastes, and/or solutions and/or suspensions.

Topically-administrable formulations may, for example, comprise from about 1% to about 10% (wt/wt) active ingredient, although the concentration of active ingredient may be as high as the solubility limit of the active ingredient in the solvent. Formulations for topical administration may further comprise one or more of the additional ingredients described herein.

[00511] A pharmaceutical composition may be prepared, packaged, and/or sold in a formulation suitable for pulmonary administration via the buccal cavity. Such a formulation may comprise dry particles which comprise the active ingredient. Such compositions are conveniently in the form of dry powders for administration using a device comprising a dry powder reservoir to which a stream of propellant may be directed to disperse the powder and/or using a self-propelling solvent/powder dispensing container such as a device comprising the active ingredient dissolved and/or suspended in a low-boiling propellant in a sealed container. Dry powder compositions may include a solid fine powder diluent such as sugar and are conveniently provided in a unit dose form.

[00512] Low boiling propellants generally include liquid propellants having a boiling point of below 65 °F at atmospheric pressure. Generally the propellant may constitute 50% to 99.9% (wt/wt) of the composition, and active ingredient may constitute 0.1% to 20% (wt/wt) of the composition. A propellant may further comprise additional ingredients such as a liquid non-ionic and/or solid anionic surfactant and/or a solid diluent (which may have a particle size of the same order as particles comprising the active ingredient).

[00513] Pharmaceutical compositions formulated for pulmonary delivery may provide an active ingredient in the form of droplets of a solution and/or suspension. Such formulations may be prepared, packaged, and/or sold as aqueous and/or dilute alcoholic solutions and/or suspensions, optionally sterile, comprising active ingredient, and may conveniently be administered using any nebulization and/or atomization device. Such formulations may further comprise one or more additional ingredients including, but not limited to, a flavoring agent such as saccharin sodium, a volatile oil, a buffering agent, a surface active agent, and/or a

preservative such as methylhydroxybenzoate. Droplets provided by this route of administration may have an average diameter in the range from about 1 nm to about 200 nm.

[00514] Formulations described herein as being useful for pulmonary delivery are useful for intranasal delivery of a pharmaceutical composition. Another formulation suitable for intranasal administration is a coarse powder comprising the active ingredient and having an average particle from about 0.2 μm to 500 μm . Such a formulation is administered in the manner in which snuff is taken, i.e. by rapid inhalation through the nasal passage from a container of the powder held close to the nose.

[00515] Formulations suitable for nasal administration may, for example, comprise from about as little as 0.1% (wt/wt) and as much as 100% (wt/wt) of active ingredient, and may comprise one or more of the additional ingredients described herein. A pharmaceutical composition may be prepared, packaged, and/or sold in a formulation suitable for buccal administration. Such formulations may, for example, be in the form of tablets and/or lozenges made using conventional methods, and may, for example, 0.1% to 20% (wt/wt) active ingredient, the balance comprising an orally dissolvable and/or degradable composition and, optionally, one or more of the additional ingredients described herein. Alternately, formulations suitable for buccal administration may comprise a powder and/or an aerosolized and/or atomized solution and/or suspension comprising active ingredient. Such powdered, aerosolized, and/or aerosolized formulations, when dispersed, may have an average particle and/or droplet size in the range from about 0.1 nm to about 200 nm, and may further comprise one or more of any additional ingredients described herein.

[00516] A pharmaceutical composition may be prepared, packaged, and/or sold in a formulation suitable for ophthalmic administration. Such formulations may, for example, be in the form of eye drops including, for example, a 0.1/1.0% (wt/wt) solution and/or suspension of the active ingredient in an aqueous or oily liquid excipient. Such drops may further comprise buffering agents, salts, and/or one or more other of any additional ingredients described herein. Other ophthalmically-administrable formulations which are useful include those which comprise the active ingredient in microcrystalline form and/or in a liposomal preparation. Ear drops and/or eye drops are contemplated as being within the scope of this present disclosure.

mRNA Therapies

[00517] mRNA as a drug modality has the potential to deliver transmembrane and intracellular proteins, i.e., targets that standard biologics are unable to access due to their inability to cross the cell membrane. (See Sahin, U., Karikó K., Türeci Ö. Nat. Rev. Drug. Discov. 2014, 13, 759-780, the content of which is incorporated by reference herein in its

entirety). One major challenge to making mRNA based therapies a reality is the identification of an optimal delivery vehicle. Due to its large size, chemical instability and potential immunogenicity, mRNA requires a delivery vehicle that can offer protection from endo- and exo-nucleases, as well as shield the cargo from immune sentinels. Lipid nanoparticles (LNPs) have been identified as a leading option in this regard. (See Hajj, K.A., Whitehead, K.A. *Nat. Rev. Mater.* 2017, 2, 1-17, the content of which is incorporated by reference herein in its entirety). This approach has recently been validated by demonstrating safe and effective delivery of an mRNA based vaccine formulated in LNPs. (See Bahl, K. *et al. Mol. Ther.* 2017, 25, 1316-1327, the content of which is incorporated by reference herein in its entirety).

[00518] Key performance criteria for a lipid nanoparticle delivery system are to maximize cellular uptake and enable efficient release of mRNA from the endosome. At the same time the LNP must provide a stable drug product and be able to be dosed safely at therapeutically relevant levels. LNPs are multi-component systems which typically consist of an amino lipid, phospholipid, cholesterol, and a PEG-lipid. Each component is required for aspects of efficient delivery of the nucleic acid cargo and stability of the particle. The key component thought to drive cellular uptake, endosomal escape, and tolerability is the amino lipid. Cholesterol and the PEG-lipid contribute to the stability of the drug product both *in vivo* and on the shelf, while the phospholipid provides additional fusogenicity to the LNP, thus helping to drive endosomal escape and rendering the nucleic acid bioavailable in the cytosol of cells.

[00519] Several amino lipid series have been developed for oligonucleotide delivery over the past couple of decades. (See Stanton M.G., Murphy-Benenato, K.E. *RNA Therapeutics. Topics in Medicinal Chemistry*, 2017, vol 27., A. Garner eds., (Springer, Cham) pp. 237-253, the content of which is incorporated by reference herein in its entirety). The literature highlights direct links between the structure of the amino lipid and the resultant delivery efficiency and tolerability of the LNP. The amino lipid MC3 (DLin-MC3-DMA) is the most clinically advanced oligonucleotide delivery system, as siRNA formulated in MC3-based LNPs has progressed to Phase III for the treatment of transthyretin-mediated amyloidosis. (See Coelho, T. *et al. N. Engl. J. Med.* 2013, 369, 819-829.; Butler, J.S. *et al. Amyloid* 2016, 23, 109-118, the contents of each of which are incorporated by reference herein in their entireties). More recently, literature reports have demonstrated the effectiveness of MC3-based LNPs to deliver mRNA. (See Nanbhan, J.F. *et al. Sci. Rep.* 2016, 6, 20019, the content of which is incorporated by reference herein in its entirety.) LNPs of this class are quickly opsonized by apolipoprotein E (ApoE) when delivered intravenously, which enables cellular uptake by the low density lipoprotein receptor (LDLr). (See Akinc, A. *et al. Mol. Ther.* 2010, 18, 1357-1364, the content

of which is incorporated by reference herein in its entirety.) However, concerns remain that MC3's long tissue half-life could contribute to unfavorable side effects hindering its use for chronic therapies. (See Maier M.A. *et al.* Mol. Ther. 2013, 21, 1570-1578, the content of which is incorporated by reference herein in its entirety). In addition, extensive literature evidence suggests that chronic dosing of lipid nanoparticles can produce several toxic side effects including complement activation-related pseudo allergy (CARPA) and liver damage (See Szebeni J. Mol. Immunol. 2014, 61, 163-173, the content of which is incorporated by reference herein in its entirety). Hence, to unleash the potential of mRNA therapies for humans, a class of LNPs with increased delivery efficiency along with a metabolic and toxicity profile that would enable chronic dosing in humans is needed.

[00520] The ability to treat a broad swath of diseases requires the flexibility to safely dose chronically at varying dose levels. Through systematic optimization of the amino lipid structure, the compounds of the disclosure were identified as compounds that balance chemical stability, improved efficiency of delivery due to improved endosomal escape, rapid *in vivo* metabolism, and a clean toxicity profile (Example 26). The combination of these features provides a drug candidate that can be dosed chronically without activation of the immune system. Initial rodent screens led to the identification of a lead lipid with good delivery efficiency and pharmacokinetics. The lead LNP was profiled further in non-human primate for efficiency of delivery after single and repeat dosing. Finally, the optimized LNPs were evaluated in one-month repeat dose toxicity studies in rat and non-human primate. Without wishing to be bound by theory, the novel ionizable lipids of the instant disclosure allow for the safe and effective use of mRNA-based therapies in acute and chronic diseases.

Methods of producing polypeptides in cells

[00521] The present disclosure provides methods of producing a polypeptide of interest in a mammalian cell. Methods of producing polypeptides involve contacting a cell with a nanoparticle composition including an mRNA encoding the polypeptide of interest. Upon contacting the cell with the nanoparticle composition, the mRNA may be taken up and translated in the cell to produce the polypeptide of interest.

[00522] In general, the step of contacting a mammalian cell with a nanoparticle composition including an mRNA encoding a polypeptide of interest may be performed *in vivo*, *ex vivo*, in culture, or *in vitro*. The amount of nanoparticle composition contacted with a cell, and/or the amount of mRNA therein, may depend on the type of cell or tissue being contacted, the means of administration, the physiochemical characteristics of the nanoparticle composition and the

mRNA (*e.g.*, size, charge, and chemical composition) therein, and other factors. In general, an effective amount of the nanoparticle composition will allow for efficient polypeptide production in the cell. Metrics for efficiency may include polypeptide translation (indicated by polypeptide expression), level of mRNA degradation, and immune response indicators.

[00523] The step of contacting a nanoparticle composition including an mRNA with a cell may involve or cause transfection. A phospholipid including in the lipid component of a nanoparticle composition may facilitate transfection and/or increase transfection efficiency, for example, by interacting and/or fusing with a cellular or intracellular membrane. Transfection may allow for the translation of the mRNA within the cell.

[00524] In some embodiments, the nanoparticle compositions described herein may be used therapeutically. For example, an mRNA included in a nanoparticle composition may encode a therapeutic polypeptide (*e.g.*, in a translatable region) and produce the therapeutic polypeptide upon contacting and/or entry (*e.g.*, transfection) into a cell. In other embodiments, an mRNA included in a nanoparticle composition may encode a polypeptide that may improve or increase the immunity of a subject. For example, an mRNA may encode a granulocyte-colony stimulating factor or trastuzumab.

[00525] In certain embodiments, an mRNA included in a nanoparticle composition may encode a recombinant polypeptide that may replace one or more polypeptides that may be substantially absent in a cell contacted with the nanoparticle composition. The one or more substantially absent polypeptides may be lacking due to a genetic mutation of the encoding gene or a regulatory pathway thereof. Alternatively, a recombinant polypeptide produced by translation of the mRNA may antagonize the activity of an endogenous protein present in, on the surface of, or secreted from the cell. An antagonistic recombinant polypeptide may be desirable to combat deleterious effects caused by activities of the endogenous protein, such as altered activities or localization caused by mutation. In another alternative, a recombinant polypeptide produced by translation of the mRNA may indirectly or directly antagonize the activity of a biological moiety present in, on the surface of, or secreted from the cell. Antagonized biological moieties may include, but are not limited to, lipids (*e.g.*, cholesterol), lipoproteins (*e.g.*, low density lipoprotein), nucleic acids, carbohydrates, and small molecule toxins. Recombinant polypeptides produced by translation of the mRNA may be engineered for localization within the cell, such as within a specific compartment such as the nucleus, or may be engineered for secretion from the cell or for translocation to the plasma membrane of the cell.

[00526] In some embodiments, contacting a cell with a nanoparticle composition including an mRNA may reduce the innate immune response of a cell to an exogenous nucleic acid. A cell

may be contacted with a first nanoparticle composition including a first amount of a first exogenous mRNA including a translatable region and the level of the innate immune response of the cell to the first exogenous mRNA may be determined. Subsequently, the cell may be contacted with a second composition including a second amount of the first exogenous mRNA, the second amount being a lesser amount of the first exogenous mRNA compared to the first amount. Alternatively, the second composition may include a first amount of a second exogenous mRNA that is different from the first exogenous mRNA. The steps of contacting the cell with the first and second compositions may be repeated one or more times. Additionally, efficiency of polypeptide production (*e.g.*, translation) in the cell may be optionally determined, and the cell may be re-contacted with the first and/or second composition repeatedly until a target protein production efficiency is achieved.

Methods of delivering therapeutic agents to cells and organs

[00527] The present disclosure provides methods of delivering a therapeutic and/or prophylactic to a mammalian cell or organ. Delivery of a therapeutic and/or prophylactic to a cell involves administering a nanoparticle composition including the therapeutic and/or prophylactic to a subject, where administration of the composition involves contacting the cell with the composition. For example, a protein, cytotoxic agent, radioactive ion, chemotherapeutic agent, or nucleic acid (such as an RNA, *e.g.*, mRNA) may be delivered to a cell or organ. In the instance that a therapeutic and/or prophylactic is an mRNA, upon contacting a cell with the nanoparticle composition, a translatable mRNA may be translated in the cell to produce a polypeptide of interest. However, mRNAs that are substantially not translatable may also be delivered to cells. Substantially non-translatable mRNAs may be useful as vaccines and/or may sequester translational components of a cell to reduce expression of other species in the cell.

[00528] In some embodiments, a nanoparticle composition may target a particular type or class of cells (*e.g.*, cells of a particular organ or system thereof). For example, a nanoparticle composition including a therapeutic and/or prophylactic of interest may be specifically delivered to a mammalian liver, kidney, spleen, femur, or lung. Specific delivery to a particular class of cells, an organ, or a system or group thereof implies that a higher proportion of nanoparticle compositions including a therapeutic and/or prophylactic are delivered to the destination (*e.g.*, tissue) of interest relative to other destinations, *e.g.*, upon administration of a nanoparticle composition to a mammal. In some embodiments, specific delivery may result in a greater than 2 fold, 5 fold, 10 fold, 15 fold, or 20 fold increase in the amount of therapeutic and/or prophylactic per 1 g of tissue of the targeted destination (*e.g.*, tissue of interest, such as a liver)

as compared to another destination (*e.g.*, the spleen). In some embodiments, the tissue of interest is selected from the group consisting of a liver, kidney, a lung, a spleen, a femur, an ocular tissue (*e.g.*, via intraocular, subretinal, or intravitreal injection), vascular endothelium in vessels (*e.g.*, intra-coronary or intra-femoral) or kidney, and tumor tissue (*e.g.*, via intratumoral injection).

[00529] As another example of targeted or specific delivery, an mRNA that encodes a protein-binding partner (*e.g.*, an antibody or functional fragment thereof, a scaffold protein, or a peptide) or a receptor on a cell surface may be included in a nanoparticle composition. An mRNA may additionally or instead be used to direct the synthesis and extracellular localization of lipids, carbohydrates, or other biological moieties. Alternatively, other therapeutic and/or prophylactics or elements (*e.g.*, lipids or ligands) of a nanoparticle composition may be selected based on their affinity for particular receptors (*e.g.*, low density lipoprotein receptors) such that a nanoparticle composition may more readily interact with a target cell population including the receptors. For example, ligands may include, but are not limited to, members of a specific binding pair, antibodies, monoclonal antibodies, Fv fragments, single chain Fv (scFv) fragments, Fab' fragments, F(ab')₂ fragments, single domain antibodies, camelized antibodies and fragments thereof, humanized antibodies and fragments thereof, and multivalent versions thereof; multivalent binding reagents including mono- or bi-specific antibodies such as disulfide stabilized Fv fragments, scFv tandems, diabodies, tribodies, or tetrabodies; and aptamers, receptors, and fusion proteins.

[00530] In some embodiments, a ligand may be a surface-bound antibody, which can permit tuning of cell targeting specificity. This is especially useful since highly specific antibodies can be raised against an epitope of interest for the desired targeting site. In some embodiments, multiple antibodies are expressed on the surface of a cell, and each antibody can have a different specificity for a desired target. Such approaches can increase the avidity and specificity of targeting interactions.

[00531] A ligand can be selected, *e.g.*, by a person skilled in the biological arts, based on the desired localization or function of the cell. For example an estrogen receptor ligand, such as tamoxifen, can target cells to estrogen-dependent breast cancer cells that have an increased number of estrogen receptors on the cell surface. Other non-limiting examples of ligand/receptor interactions include CCR1 (*e.g.*, for treatment of inflamed joint tissues or brain in rheumatoid arthritis, and/or multiple sclerosis), CCR7, CCR8 (*e.g.*, targeting to lymph node tissue), CCR6, CCR9, CCR10 (*e.g.*, to target to intestinal tissue), CCR4, CCR10 (*e.g.*, for targeting to skin), CXCR4 (*e.g.*, for general enhanced transmigration), HCELL (*e.g.*, for

treatment of inflammation and inflammatory disorders, bone marrow), Alpha4beta7 (*e.g.*, for intestinal mucosa targeting), and VLA-4NCAM-1 (*e.g.*, targeting to endothelium). In general, any receptor involved in targeting (*e.g.*, cancer metastasis) can be harnessed for use in the methods and compositions described herein.

[00532] Targeted cells may include, but are not limited to, hepatocytes, epithelial cells, hematopoietic cells, epithelial cells, endothelial cells, lung cells, bone cells, stem cells, mesenchymal cells, neural cells, cardiac cells, adipocytes, vascular smooth muscle cells, cardiomyocytes, skeletal muscle cells, beta cells, pituitary cells, synovial lining cells, ovarian cells, testicular cells, fibroblasts, B cells, T cells, reticulocytes, leukocytes, granulocytes, and tumor cells.

[00533] In some embodiments, a nanoparticle composition may target hepatocytes. Apolipoproteins such as apolipoprotein E (apoE) have been shown to associate with neutral or near neutral lipid-containing nanoparticle compositions in the body, and are known to associate with receptors such as low-density lipoprotein receptors (LDLRs) found on the surface of hepatocytes. Thus, a nanoparticle composition including a lipid component with a neutral or near neutral charge that is administered to a subject may acquire apoE in a subject's body and may subsequently deliver a therapeutic and/or prophylactic (*e.g.*, an RNA) to hepatocytes including LDLRs in a targeted manner.

Methods of treating diseases and disorders

[00534] Nanoparticle compositions may be useful for treating a disease, disorder, or condition. In particular, such compositions may be useful in treating a disease, disorder, or condition characterized by missing or aberrant protein or polypeptide activity. For example, a nanoparticle composition comprising an mRNA encoding a missing or aberrant polypeptide may be administered or delivered to a cell. Subsequent translation of the mRNA may produce the polypeptide, thereby reducing or eliminating an issue caused by the absence of or aberrant activity caused by the polypeptide. Because translation may occur rapidly, the methods and compositions may be useful in the treatment of acute diseases, disorders, or conditions such as sepsis, stroke, and myocardial infarction. A therapeutic and/or prophylactic included in a nanoparticle composition may also be capable of altering the rate of transcription of a given species, thereby affecting gene expression.

[00535] Diseases, disorders, and/or conditions characterized by dysfunctional or aberrant protein or polypeptide activity for which a composition may be administered include, but are not limited to, rare diseases, infectious diseases (as both vaccines and therapeutics), cancer and proliferative diseases, genetic diseases (*e.g.*, cystic fibrosis), autoimmune diseases, diabetes,

neurodegenerative diseases, cardio- and reno-vascular diseases, and metabolic diseases. Multiple diseases, disorders, and/or conditions may be characterized by missing (or substantially diminished such that proper protein function does not occur) protein activity. Such proteins may not be present, or they may be essentially non-functional. A specific example of a dysfunctional protein is the missense mutation variants of the cystic fibrosis transmembrane conductance regulator (CFTR) gene, which produce a dysfunctional protein variant of CFTR protein, which causes cystic fibrosis. The present disclosure provides a method for treating such diseases, disorders, and/or conditions in a subject by administering a nanoparticle composition including an RNA and a lipid component including a lipid according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId), a phospholipid (optionally unsaturated), a PEG lipid, and a structural lipid, wherein the RNA may be an mRNA encoding a polypeptide that antagonizes or otherwise overcomes an aberrant protein activity present in the cell of the subject.

[00536] The disclosure provides methods involving administering nanoparticle compositions including one or more therapeutic and/or prophylactic agents and pharmaceutical compositions including the same. The terms therapeutic and prophylactic can be used interchangeably herein with respect to features and embodiments of the present disclosure. Therapeutic compositions, or imaging, diagnostic, or prophylactic compositions thereof, may be administered to a subject using any reasonable amount and any route of administration effective for preventing, treating, diagnosing, or imaging a disease, disorder, and/or condition and/or any other purpose. The specific amount administered to a given subject may vary depending on the species, age, and general condition of the subject; the purpose of the administration; the particular composition; the mode of administration; and the like. Compositions in accordance with the present disclosure may be formulated in dosage unit form for ease of administration and uniformity of dosage. It will be understood, however, that the total daily usage of a composition of the present disclosure will be decided by an attending physician within the scope of sound medical judgment. The specific therapeutically effective, prophylactically effective, or otherwise appropriate dose level (*e.g.*, for imaging) for any particular patient will depend upon a variety of factors including the severity and identify of a disorder being treated, if any; the one or more therapeutic and/or prophylactics employed; the specific composition employed; the age, body weight, general health, sex, and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific pharmaceutical composition employed; the

duration of the treatment; drugs used in combination or coincidental with the specific pharmaceutical composition employed; and like factors well known in the medical arts.

[00537] A nanoparticle composition including one or more therapeutic and/or prophylactics may be administered by any route. In some embodiments, compositions, including prophylactic, diagnostic, or imaging compositions including one or more nanoparticle compositions described herein, are administered by one or more of a variety of routes, including oral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, intraparenchymal, subcutaneous, intraventricular, trans- or intra-dermal, interdermal, rectal, intravaginal, intraperitoneal, intraocular, subretinal, intravitreal, topical (*e.g.* by powders, ointments, creams, gels, lotions, and/or drops), mucosal, nasal, buccal, enteral, vitreal, intratumoral, sublingual, intranasal; by intratracheal instillation, bronchial instillation, and/or inhalation; as an oral spray and/or powder, nasal spray, and/or aerosol, and/or through a portal vein catheter. In some embodiments, a composition may be administered intravenously, intramuscularly, intradermally, intra-arterially, intratumorally, subcutaneously, intraocularly, subretinally, intravitreally, intraparenchymally, or by any other parenteral route of administration or by inhalation. However, the present disclosure encompasses the delivery or administration of compositions described herein by any appropriate route taking into consideration likely advances in the sciences of drug delivery. In general, the most appropriate route of administration will depend upon a variety of factors including the nature of the nanoparticle composition including one or more therapeutic and/or prophylactics (*e.g.*, its stability in various bodily environments such as the bloodstream and gastrointestinal tract), the condition of the patient (*e.g.*, whether the patient is able to tolerate particular routes of administration), etc.

[00538] In certain embodiments, compositions in accordance with the present disclosure may be administered at dosage levels sufficient to deliver from about 0.0001 mg/kg to about 10 mg/kg, from about 0.001 mg/kg to about 10 mg/kg, from about 0.005 mg/kg to about 10 mg/kg, from about 0.01 mg/kg to about 10 mg/kg, from about 0.05 mg/kg to about 10 mg/kg, from about 0.1 mg/kg to about 10 mg/kg, from about 1 mg/kg to about 10 mg/kg, from about 2 mg/kg to about 10 mg/kg, from about 5 mg/kg to about 10 mg/kg, from about 0.0001 mg/kg to about 5 mg/kg, from about 0.001 mg/kg to about 5 mg/kg, from about 0.005 mg/kg to about 5 mg/kg, from about 0.01 mg/kg to about 5 mg/kg, from about 0.05 mg/kg to about 5 mg/kg, from about 0.1 mg/kg to about 5 mg/kg, from about 1 mg/kg to about 5 mg/kg, from about 2 mg/kg to about 5 mg/kg, from about 0.0001 mg/kg to about 2.5 mg/kg, from about 0.001 mg/kg to about 2.5 mg/kg, from about 0.005 mg/kg to about 2.5 mg/kg, from about 0.01 mg/kg to about 2.5 mg/kg, from about 0.05 mg/kg to about 2.5 mg/kg, from about 0.1 mg/kg to about 2.5 mg/kg, from

about 1 mg/kg to about 2.5 mg/kg, from about 2 mg/kg to about 2.5 mg/kg, from about 0.0001 mg/kg to about 1 mg/kg, from about 0.001 mg/kg to about 1 mg/kg, from about 0.005 mg/kg to about 1 mg/kg, from about 0.01 mg/kg to about 1 mg/kg, from about 0.05 mg/kg to about 1 mg/kg, from about 0.1 mg/kg to about 1 mg/kg, from about 0.0001 mg/kg to about 0.25 mg/kg, from about 0.001 mg/kg to about 0.25 mg/kg, from about 0.005 mg/kg to about 0.25 mg/kg, from about 0.01 mg/kg to about 0.25 mg/kg, from about 0.05 mg/kg to about 0.25 mg/kg, or from about 0.1 mg/kg to about 0.25 mg/kg of a therapeutic and/or prophylactic (*e.g.*, an mRNA) in a given dose, where a dose of 1 mg/kg (mpk) provides 1 mg of a therapeutic and/or prophylactic per 1 kg of subject body weight. In some embodiments, a dose of about 0.001 mg/kg to about 10 mg/kg of a therapeutic and/or prophylactic (*e.g.*, mRNA) of a nanoparticle composition may be administered. In other embodiments, a dose of about 0.005 mg/kg to about 2.5 mg/kg of a therapeutic and/or prophylactic may be administered. In certain embodiments, a dose of about 0.1 mg/kg to about 1 mg/kg may be administered. In other embodiments, a dose of about 0.05 mg/kg to about 0.25 mg/kg may be administered. A dose may be administered one or more times per day, in the same or a different amount, to obtain a desired level of mRNA expression and/or therapeutic, diagnostic, prophylactic, or imaging effect. The desired dosage may be delivered, for example, three times a day, two times a day, once a day, every other day, every third day, every week, every two weeks, every three weeks, or every four weeks. In certain embodiments, the desired dosage may be delivered using multiple administrations (*e.g.*, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, or more administrations). In some embodiments, a single dose may be administered, for example, prior to or after a surgical procedure or in the instance of an acute disease, disorder, or condition.

[00539] Nanoparticle compositions including one or more therapeutic and/or prophylactics may be used in combination with one or more other therapeutic, prophylactic, diagnostic, or imaging agents. By “in combination with,” it is not intended to imply that the agents must be administered at the same time and/or formulated for delivery together, although these methods of delivery are within the scope of the present disclosure. For example, one or more nanoparticle compositions including one or more different therapeutic and/or prophylactics may be administered in combination. Compositions can be administered concurrently with, prior to, or subsequent to, one or more other desired therapeutics or medical procedures. In general, each agent will be administered at a dose and/or on a time schedule determined for that agent. In some embodiments, the present disclosure encompasses the delivery of compositions, or imaging, diagnostic, or prophylactic compositions thereof in combination with agents that

improve their bioavailability, reduce and/or modify their metabolism, inhibit their excretion, and/or modify their distribution within the body.

[00540] It will further be appreciated that therapeutically, prophylactically, diagnostically, or imaging active agents utilized in combination may be administered together in a single composition or administered separately in different compositions. In general, it is expected that agents utilized in combination will be utilized at levels that do not exceed the levels at which they are utilized individually. In some embodiments, the levels utilized in combination may be lower than those utilized individually.

[00541] The particular combination of therapies (therapeutics or procedures) to employ in a combination regimen will take into account compatibility of the desired therapeutics and/or procedures and the desired therapeutic effect to be achieved. It will also be appreciated that the therapies employed may achieve a desired effect for the same disorder (for example, a composition useful for treating cancer may be administered concurrently with a chemotherapeutic agent), or they may achieve different effects (*e.g.*, control of any adverse effects, such as infusion related reactions).

[00542] A nanoparticle composition may be used in combination with an agent to increase the effectiveness and/or therapeutic window of the composition. Such an agent may be, for example, an anti-inflammatory compound, a steroid (*e.g.*, a corticosteroid), a statin, an estradiol, a BTK inhibitor, an S1P1 agonist, a glucocorticoid receptor modulator (GRM), or an anti-histamine. In some embodiments, a nanoparticle composition may be used in combination with dexamethasone, methotrexate, acetaminophen, an H1 receptor blocker, or an H2 receptor blocker. In some embodiments, a method of treating a subject in need thereof or of delivering a therapeutic and/or prophylactic to a subject (*e.g.*, a mammal) may involve pre-treating the subject with one or more agents prior to administering a nanoparticle composition. For example, a subject may be pre-treated with a useful amount (*e.g.*, 10 mg, 20 mg, 30 mg, 40 mg, 50 mg, 60 mg, 70 mg, 80 mg, 90 mg, 100 mg, or any other useful amount) of dexamethasone, methotrexate, acetaminophen, an H1 receptor blocker, or an H2 receptor blocker. Pre-treatment may occur 24 or fewer hours (*e.g.*, 24 hours, 20 hours, 16 hours, 12 hours, 8 hours, 4 hours, 2 hours, 1 hour, 50 minutes, 40 minutes, 30 minutes, 20 minutes, or 10 minutes) before administration of the nanoparticle composition and may occur one, two, or more times in, for example, increasing dosage amounts.

[00543] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments in accordance with the

disclosure described herein. The scope of the present disclosure is not intended to be limited to the above Description, but rather is as set forth in the appended claims.

[0001] In the claims, articles such as “a,” “an,” and “the” may mean one or more than one unless indicated to the contrary or otherwise evident from the context. Claims or descriptions that include “or” between one or more members of a group are considered satisfied if one, more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context. The disclosure includes embodiments in which exactly one member of the group is present in, employed in, or otherwise relevant to a given product or process. The disclosure includes embodiments in which more than one, or all, of the group members are present in, employed in, or otherwise relevant to a given product or process. As used herein, the expressions “one or more of A, B, or C,” “one or more A, B, or C,” “one or more of A, B, and C,” “one or more A, B, and C,” “selected from A, B, and C,” “selected from the group consisting of A, B, and C,” and the like are used interchangeably and all refer to a selection from a group consisting of A, B, and /or C, i.e., one or more As, one or more Bs, one or more Cs, or any combination thereof, unless otherwise specified.

[0002] It is also noted that the term “comprising” is intended to be open and permits but does not require the inclusion of additional elements or steps. When the term “comprising” is used herein, the terms “consisting essentially of” and “consisting of” are thus also encompassed and disclosed. Throughout the description, where compositions are described as having, including, or comprising specific components, it is contemplated that compositions also consist essentially of, or consist of, the recited components. Similarly, where methods or processes are described as having, including, or comprising specific process steps, the processes also consist essentially of, or consist of, the recited processing steps. Further, it should be understood that the order of steps or order for performing certain actions is immaterial so long as the invention remains operable. Moreover, two or more steps or actions can be conducted simultaneously.

[0003] Where ranges are given, endpoints are included. Furthermore, it is to be understood that unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or sub-range within the stated ranges in different embodiments of the disclosure, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise.

[0004] The synthetic processes of the disclosure can tolerate a wide variety of functional groups, therefore various substituted starting materials can be used. The processes generally provide the desired final compound at or near the end of the overall process, although it may be

desirable in certain instances to further convert the compound to a pharmaceutically acceptable salt thereof.

[0005] Compounds of the present disclosure can be prepared in a variety of ways using commercially available starting materials, compounds known in the literature, or from readily prepared intermediates, by employing standard synthetic methods and procedures either known to those skilled in the art, or which will be apparent to the skilled artisan in light of the teachings herein. Standard synthetic methods and procedures for the preparation of organic molecules and functional group transformations and manipulations can be obtained from the relevant scientific literature or from standard textbooks in the field. Although not limited to any one or several sources, classic texts such as Smith, M. B., March, J., *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, 5th edition, John Wiley & Sons: New York, 2001; Greene, T.W., Wuts, P.G. M., *Protective Groups in Organic Synthesis*, 3rd edition, John Wiley & Sons: New York, 1999; R. Larock, *Comprehensive Organic Transformations*, VCH Publishers (1989); L. Fieser and M. Fieser, *Fieser and Fieser's Reagents for Organic Synthesis*, John Wiley and Sons (1994); and L. Paquette, ed., *Encyclopedia of Reagents for Organic Synthesis*, John Wiley and Sons (1995), incorporated by reference herein, are useful and recognized reference textbooks of organic synthesis known to those in the art. The following descriptions of synthetic methods are designed to illustrate, but not to limit, general procedures for the preparation of compounds of the present disclosure.

[0006] The compounds of this disclosure having any of the formulae described herein may be prepared according to the procedures illustrated in Schemes 1, 2, and 3 below, from commercially available starting materials or starting materials which can be prepared using literature procedures. The variables in the schemes (e.g., R¹, R², and R³ etc. are as defined herein). One of ordinary skill in the art will note that, during the reaction sequences and synthetic schemes described herein, the order of certain steps may be changed, such as the introduction and removal of protecting groups.

[0007] One of ordinary skill in the art will recognize that certain groups may require protection from the reaction conditions via the use of protecting groups. Protecting groups may also be used to differentiate similar functional groups in molecules. A list of protecting groups and how to introduce and remove these groups can be found in Greene, T.W., Wuts, P.G. M., *Protective Groups in Organic Synthesis*, 3rd edition, John Wiley & Sons: New York, 1999.

[0008] Preferred protecting groups include, but are not limited to:

[0009] For a hydroxyl moiety: TBS, benzyl, THP, Ac;

[0010] For carboxylic acids: benzyl ester, methyl ester, ethyl ester, allyl ester;

[0011] For amines: Fmoc, Cbz, BOC, DMB, Ac, Bn, Tr, Ts, trifluoroacetyl, phthalimide, benzylideneamine;

[0012] For diols: Ac (x2) TBS (x2), or when taken together acetones;

[0013] For thiols: Ac;

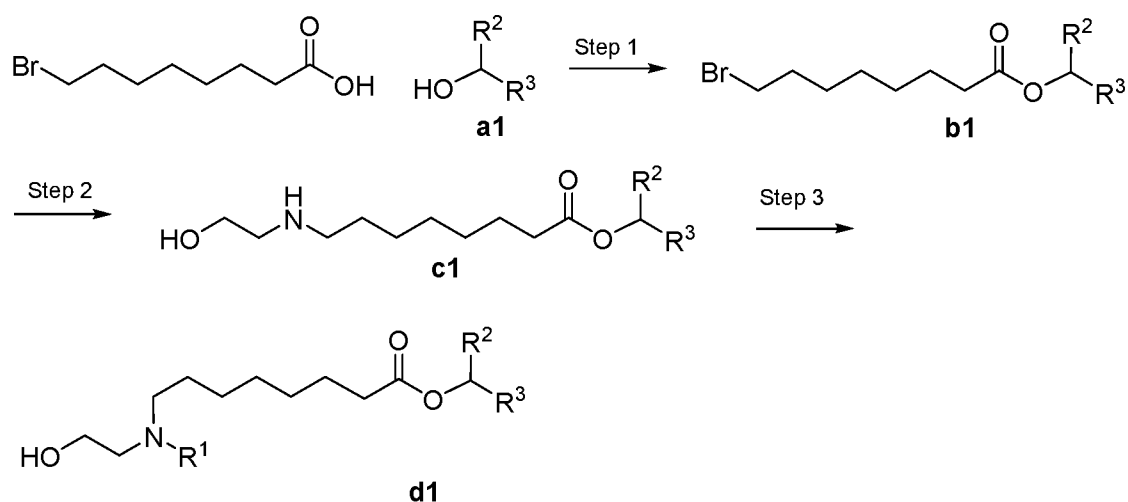
[0014] For benzimidazoles: SEM, benzyl, PMB, DMB;

[0015] For aldehydes: di-alkyl acetals such as dimethoxy acetal or diethyl acetyl.

[0016] In the reaction schemes described herein, multiple stereoisomers may be produced.

When no particular stereoisomer is indicated, it is understood to mean all possible stereoisomers that could be produced from the reaction. A person of ordinary skill in the art will recognize that the reactions can be optimized to give one isomer preferentially, or new schemes may be devised to produce a single isomer. If mixtures are produced, techniques such as preparative thin layer chromatography, preparative HPLC, preparative chiral HPLC, or preparative SFC may be used to separate the isomers.

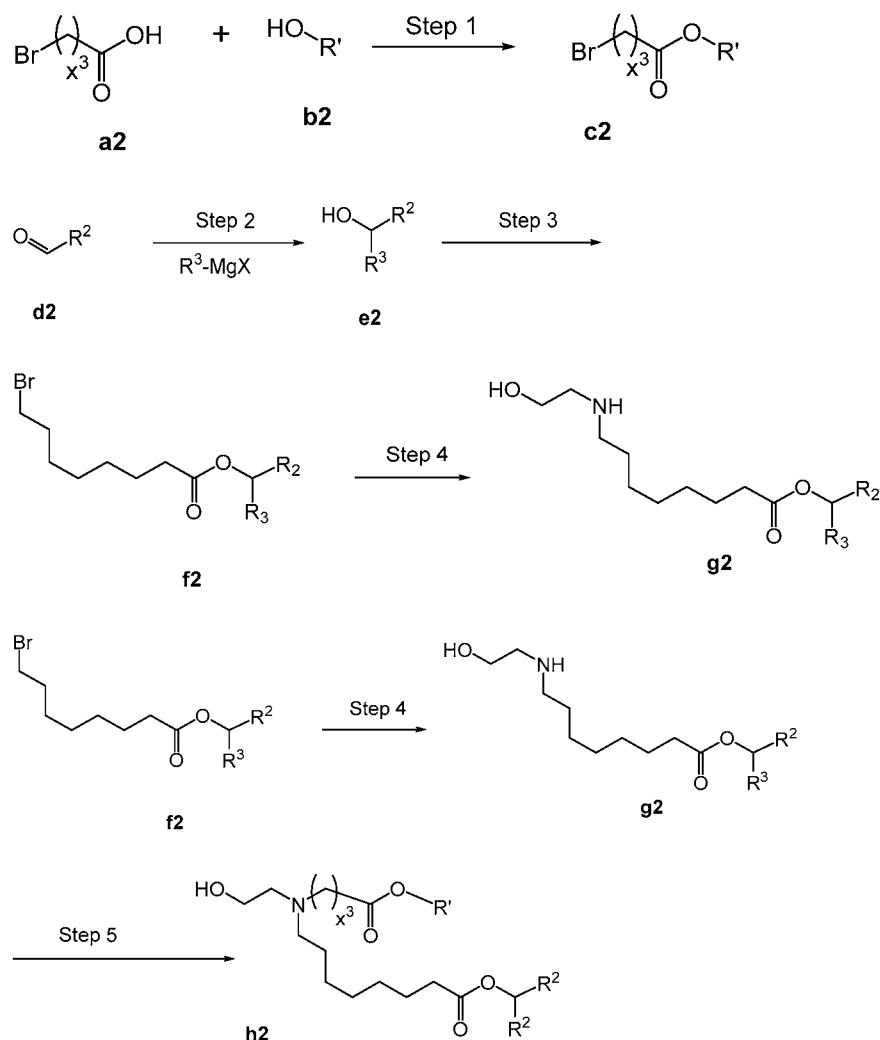
Scheme 1



[0017] As illustrated in Scheme 1 above, 8-bromooctanoic acid reacts with an alcohol **a1** (e.g., heptadecan-9-ol) to afford an ester **b1** (e.g., heptadecan-9-yl 8-bromooctanoate). Step 1 can take place in an organic solvent (e.g., dichloromethane) in the presence of, e.g., *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, *N,N*-diisopropylethylamine and DMAP. Step 1 can take place at room temperature for 18 h. Next, ester **b1** reacts with 2-aminoethan-1-ol to afford amine **c1** (e.g., heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate). Step 2 can take place in ethanol at, e.g., a temperature of about 60 °C. Then amine **c1** reacts with an bromoalkyl $\text{R}^1\text{-Br}$ (e.g., 1-bromotetradecane) to afford compound **d1** (e.g., heptadecan-

9-yl 8-((2-hydroxyethyl)(tetradecyl)amino)octanoate). Step 3 can take place in ethanol in the presence of *N,N*-diisopropylethylamine.

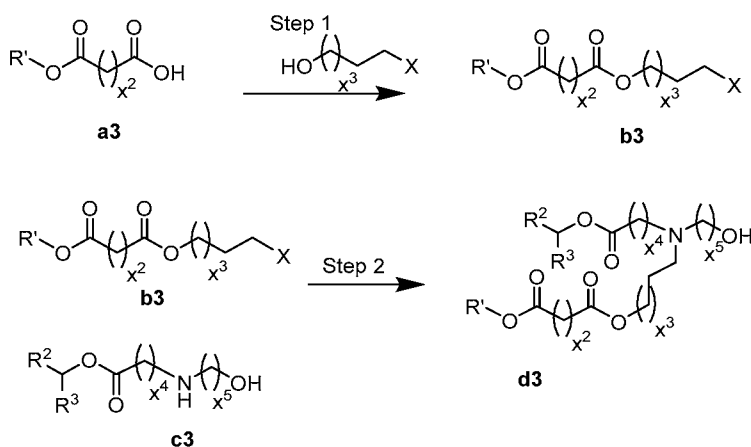
Scheme 2



[0018] As illustrated in Scheme 2 above, an acid **a2** (x^3 is an integer between 1 and 7; e.g., 8-bromooctanoic acid) reacts with an alcohol **b2** (e.g., nonan-1-ol) to afford an ester **c2** (e.g., nonyl-8-bromooctanoate). Step 1 can take place in an organic solvent (e.g., dichloromethane) in the presence of, e.g., *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, *N,N*-diisopropylethylamine and DMAP. Alcohol **e2** (e.g., heptadecan-9-ol) can be obtained from reacting aldehyde **d2** (e.g., nonanal) with a Grignard reagent R³-MgX (e.g., n-C₈H₁₇MgBr) via Step 2. Next, 8-bromooctanoic acid reacts with an alcohol **e2** (e.g., heptadecan-9-ol) to afford an ester **f2** (e.g., heptadecan-9-yl 8-bromooctanoate). Step 3 can take place in an organic solvent (e.g., dichloromethane) in the presence of, e.g., *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, *N,N*-diisopropylethylamine and DMAP. Next, ester **f2** reacts with 2-aminoethan-1-ol to afford amine **g2** (e.g., heptadecan-9-yl 8-((2-

hydroxyethyl)amino)octanoate). Step 4 can take place in ethanol in the presence of *i*-Pr₂EtN. Then amine **g2** reacts with ester **c2** (e.g., nonyl-8-bromooctanoate) to afford compound **h2** (e.g., heptadecan-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate). Step 5 can take place in an organic solvent (e.g., a mixture of CPME and MeCN), in the presence of a base (such as an inorganic base (e.g., K₂CO₃) or non-nucleophilic organic base (e.g., *i*-Pr₂EtN)) and a catalyst (e.g., an iodide such as KI or NaI) at, e.g., an elevated temperature (such as at about 70-90 °C, e.g., about 80 °C).

Scheme 3

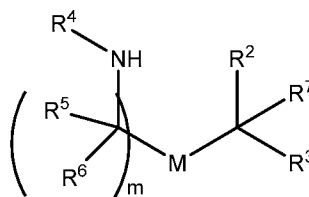


[0019] As illustrated in Scheme 3 above, a haloalkanol (x^3 is an integer between 1 and 12, e.g., 6- bromohexan-1-ol) is reacted with a starting material **a3** (x^2 is an integer between 1 and 6, e.g., 4-(hexyloxy)-4-oxobutanoic acid) to afford a halogenated diester **b3** (e.g., 6-bromohexyl hexyl succinate). Compound **a3** can be obtained by reaction of an alcohol (e.g., hexan-1-ol) with an acid anhydride (e.g. succinic anhydride, dihydro-2H-pyran-2,6(3H)-dione, 3-(tert-butoxy)-3-oxopropanoic acid, 4-(tert-butoxy)-3-methyl-4-oxobutanoic acid, or 4-(tert-butoxy)-2-methyl-4-oxobutanoic acid). Step 1 can take place in an organic solvent (e.g., dichloromethane) in the presence of, e.g., *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride, *N,N*-diisopropylethylamine and DMAP. Next, halogenated diester **b3** reacts with an amine **c3** (x^4 is an integer between 5 and 13, x^5 is an integer between 1 and 5, e.g., heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate) to afford the product **d3**. Step 2 can take place in an organic solvent (e.g., a mixture of CPME and MeCN), in the presence of a base (such as an inorganic base (e.g., K₂CO₃) and a catalyst (e.g., an iodide such as KI) and an ether solvent (e.g., cyclopentyl methyl ether), at an elevated temperature (e.g., about 90 °C).

[0020] A person of ordinary skill in the art will recognize that in the above schemes the order of certain steps may be interchangeable.

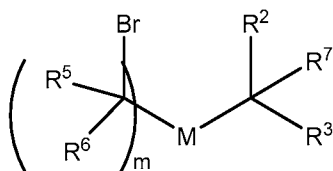
[0021] In certain aspects, the disclosure also includes methods of synthesizing a compound of any of Formulae (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIe), (IIIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIb-1), (VIIb-2), (VIIb-3), (VIIc), (VIId), (VIIIc), or (VIId) and intermediate(s) for synthesizing the compound.

[0022] In some embodiments, the method of synthesizing a compound of Formula (I)



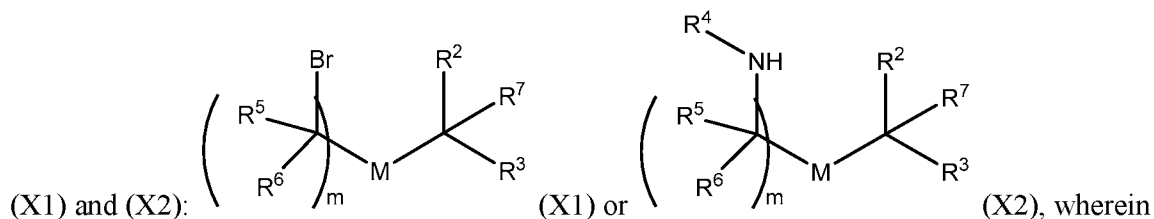
includes reacting a compound of Formula (X2): with $R^1\text{-Br}$ to afford the compound of Formula (I), wherein each variables are as defined herein. For example, m is 5, 6, 7, 8, or 9, preferably 5, 7, or 9. For example, each of R^5 , R^6 , and R^7 is H. For example, M is $-\text{C}(\text{O})\text{O}-$ or $-\text{OC}(\text{O})-$. For example, R^4 is unsubstituted C_{1-3} alkyl, or $-(\text{CH}_2)_n\text{Q}$, in which n is 2, 3, or 4 and Q is OH , $-\text{NHC}(\text{S})\text{N}(\text{R})_2$, $-\text{NHC}(\text{O})\text{N}(\text{R})_2$, $-\text{N}(\text{R})\text{C}(\text{O})\text{R}$, or $-\text{N}(\text{R})\text{S}(\text{O})_2\text{R}$. For example, the reaction of the compound of Formula (X2) with $R^1\text{-Br}$ takes place in the presence of a base (such as an inorganic base (e.g., K_2CO_3) or non-nucleophilic organic base (e.g., $i\text{-Pr}_2\text{EtN}$)). For example, the reaction takes place in the presence of an inorganic base (e.g., K_2CO_3) and a catalyst (e.g., an iodide such as KI or NaI). For example, the reaction takes place at an elevated temperature, e.g., about $50\text{-}100^\circ\text{C}$, $70\text{-}90^\circ\text{C}$, or about 80°C .

[0023] The method may also include reacting a compound of Formula (X1):



with $R^4\text{NH}_2$ to afford a compound of Formula (X2), wherein each variables are as defined herein.

[0024] In some embodiments, the intermediate(s) include those having any of Formulae



each variables are as defined herein. For example, the intermediate includes heptadecan-9-yl 8-bromooctanoate, and heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate, and morphic forms thereof (e.g., a crystalline form).

[0025] In addition, it is to be understood that any particular embodiment of the present disclosure that falls within the prior art may be explicitly excluded from any one or more of the claims. Since such embodiments are deemed to be known to one of ordinary skill in the art, they may be excluded even if the exclusion is not set forth explicitly herein.

[0026] All cited sources, for example, references, publications, databases, database entries, and art cited herein, are incorporated into this application by reference, even if not expressly stated in the citation. In case of conflicting statements of a cited source and the instant application, the statement in the instant application shall control.

Examples

Example 1: Synthesis of compounds according to Formula (I), (IA), (IB), (II), (IIa), (IIb), (IIc), (IId), (IIf), (IIg), (III), (VI), (VI-a), (VII), (VIII), (VIIa), (VIIIa), (VIIIb), (VIIIb-1), (VIIIb-2), (VIIIb-3), (VIIc), (VIId), (VIIIc), or (VIId)

A. General Considerations

[0027] All solvents and reagents used were obtained commercially and used as such unless noted otherwise. ¹H NMR spectra were recorded in CDCl₃, at 300 K using a Bruker Ultrashield 300 MHz instrument. Chemical shifts are reported as parts per million (ppm) relative to TMS (0.00) for ¹H. Silica gel chromatographies were performed on ISCO CombiFlash Rf+ Lumen Instruments using ISCO RediSep Rf Gold Flash Cartridges (particle size: 20-40 microns). Reverse phase chromatographies were performed on ISCO CombiFlash Rf+ Lumen Instruments using RediSep Rf Gold C18 High Performance columns. All final compounds were determined to be greater than 85% pure *via* analysis by reverse phase UPLC-MS (retention times, RT, in minutes) using Waters Acquity UPLC instrument with DAD and ELSD and a ZORBAX Rapid Resolution High Definition (RRHD) SB-C18 LC column, 2.1 mm, 50 mm, 1.8 μm, and a gradient of 65 to 100% acetonitrile in water with 0.1% TFA over 5 minutes at 1.2 mL/min. Injection volume was 5 μL and the column temperature was 80 °C. Detection was based on electrospray ionization (ESI) in positive mode using Waters SQD mass spectrometer (Milford, MA, USA) and evaporative light scattering detector.

[0028] The procedures described below are useful in the synthesis of Compounds 1-392.

[0029] The following abbreviations are employed herein:

THF: Tetrahydrofuran
MeCN: Acetonitrile
LAH: Lithium Aluminum Hydride
DCM: Dichloromethane
DMAP: 4-Dimethylaminopyridine

LDA: Lithium Diisopropylamide

rt: Room Temperature

DME: 1,2-Dimethoxyethane

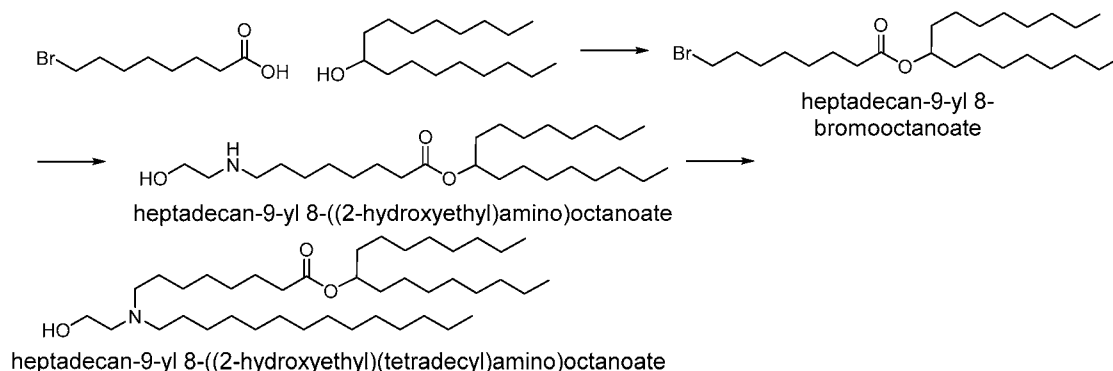
n-BuLi: *n*-Butyllithium

CPME: Cyclopentyl methyl ether

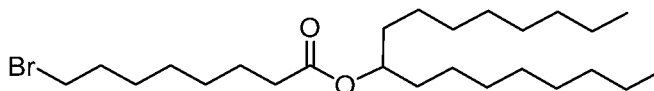
i-Pr₂EtN: *N,N*-Diisopropylethylamine

B. Compound 2: Heptadecan-9-yl 8-((2-hydroxyethyl)(tetradecyl)amino)octanoate

Representative Procedure 1

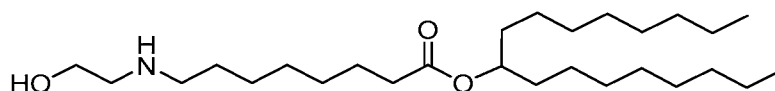


Heptadecan-9-yl 8-bromooctanoate (Method A)



[0030] To a solution of 8-bromooctanoic acid (1.04 g, 4.6 mmol) and heptadecan-9-ol (1.5 g, 5.8 mmol) in dichloromethane (20 mL) was added *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (1.1 g, 5.8 mmol), *N,N*-diisopropylethylamine (3.3 mL, 18.7 mmol) and DMAP (114 mg, 0.9 mmol). The reaction was allowed to stir at rt for 18 h. The reaction was diluted with dichloromethane and washed with saturated sodium bicarbonate. The organic layer was separated and washed with brine, and dried over MgSO₄. The organic layer was filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-10% ethyl acetate in hexanes) to obtain heptadecan-9-yl 8-bromooctanoate (875 mg, 1.9 mmol, 41%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 1H); 3.42 (m, 2H); 2.31 (m, 2H); 1.89 (m, 2H); 1.73-1.18 (br. m, 36H); 0.88 (m, 6H).

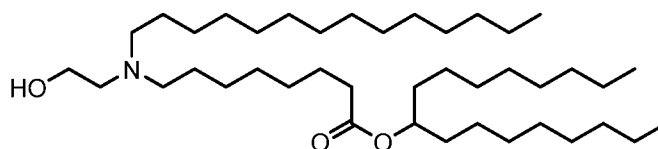
Heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (Method B)



[0031] A solution of heptadecan-9-yl 8-bromooctanoate (3.8 g, 8.2 mmol) and 2-aminoethan-1-ol (15 mL, 248 mmol) in ethanol (3 mL) was allowed to stir at 62 °C for 18 h.

The reaction mixture was concentrated *in vacuo* and the residue was taken-up in ethyl acetate and water. The organic layer was separated and washed with water, brine and dried over Na₂SO₄. The mixture was filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (3.1 g, 7 mmol, 85%). UPLC/ELSD: RT = 2.67 min. MS (ES): *m/z* (MH⁺) 442.68 for C₂₇H₅₅NO₃. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (p, 1H); 3.67 (t, 2H); 2.81 (t, 2H); 2.65 (t, 2H); 2.30 (t, 2H); 2.05 (br. m, 2H); 1.72-1.41 (br. m, 8H); 1.40-1.20 (br. m, 30H); 0.88 (m, 6H).

Heptadecan-9-yl 8-((2-hydroxyethyl)(tetradecyl)amino)octanoate (Method C)



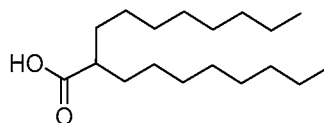
Chemical Formula: C₄₁H₈₃NO₃

Molecular Weight: 638.12

[0032] A solution of heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (125 mg, 0.28 mmol), 1-bromotetradecane (94 mg, 0.34 mmol) and *N,N*-diisopropylethylamine (44 mg, 0.34 mmol) in ethanol was allowed to stir at 65 °C for 18 h. The reaction was cooled to rt and solvents were evaporated *in vacuo*. The residue was taken-up in ethyl acetate and saturated sodium bicarbonate. The organic layer was separated, dried over Na₂SO₄ and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-((2-hydroxyethyl)(tetradecyl)amino)octanoate (89 mg, 0.14 mmol, 50%). UPLC/ELSD: RT = 3.61 min. MS (ES): *m/z* (MH⁺) 638.91 for C₄₁H₈₃NO₃. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 3.72-3.47 (br. m, 2H); 2.78-2.40 (br. m, 5H); 2.28 (t, 2H); 1.70-1.40 (m, 10H); 1.38-1.17 (br. m, 54H); 0.88 (m, 9H).

Synthesis of Intermediates:

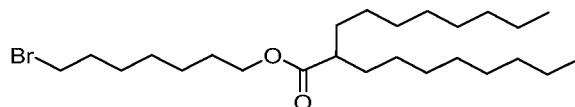
Intermediate A: 2-Octyldecanoic acid



[0033] A solution of diisopropylamine (2.92 mL, 20.8 mmol) in THF (10 mL) was cooled to -78 °C and a solution of *n*-BuLi (7.5 mL, 18.9 mmol, 2.5 M in hexanes) was added. The reaction was allowed to warm to 0 °C. To a solution of decanoic acid (2.96 g, 17.2 mmol) and NaH (754 mg, 18.9 mmol, 60%w/w) in THF (20 mL) at 0 °C was added the solution of LDA

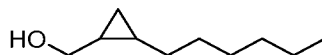
and the mixture was allowed to stir at rt for 30 min. After this time 1-iodooctane (5 g, 20.8 mmol) was added and the reaction mixture was heated at 45 °C for 6 h. The reaction was quenched with 1N HCl (10 mL). The organic layer was dried over MgSO₄, filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-20% ethyl acetate in hexanes) to yield 2-octyldecanoic acid (1.9 g, 6.6 mmol, 38%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 2.38 (br. m, 1H); 1.74-1.03 (br. m, 28H); 0.91 (m, 6H).

Intermediate B: 7-Bromoheptyl 2-octyldecanoate



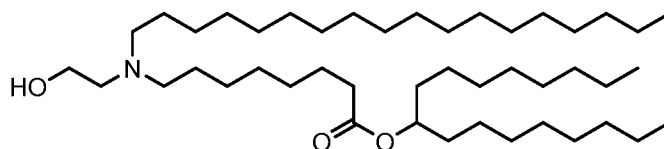
[0034] 7-bromoheptyl 2-octyldecanoate was synthesized using Method A from 2-octyldecanoic acid and 7-bromoheptan-1-ol. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.09 (br. m, 2H); 3.43 (br. m, 2H); 2.48-2.25 (br. m, 1H); 1.89 (br. m, 2H); 1.74-1.16 (br. m, 36H); 0.90 (m, 6H).

Intermediate C: (2-Hexylcyclopropyl)methanol



[0035] A solution of diethyl zinc (20 mL, 20 mmol, 1 M in hexanes), in dichloromethane (20 mL) was allowed to cool to -40 °C for 5 min. Then a solution of diiodomethane (3.22 mL, 40 mmol) in dichloromethane (10 mL) was added dropwise. After the reaction was allowed to stir for 1 h at -40 °C, a solution of trichloro-acetic acid (327 mg, 2 mmol) and DME (1 mL, 9.6 mmol) in dichloromethane (10 mL) was added. The reaction was allowed to warm to -15 °C and stir at this temperature for 1 h. A solution of (Z)-non-2-en-1-ol (1.42 g, 10 mmol) in dichloromethane (10 mL) was then added to the -15 °C solution. The reaction was then slowly allowed to warm to rt and stir for 18 h. After this time saturated NH₄Cl (200 mL) was added and the reaction was extracted with dichloromethane (3X), washed with brine, and dried over Na₂SO₄. The organic layer was filtered, evaporated *in vacuo* and the residue was purified by silica gel chromatography (0-50% ethyl acetate in hexanes) to yield (2-hexylcyclopropyl)methanol (1.43 g, 9.2 mmol, 92%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.64 (m, 2H); 1.57-1.02 (m, 12H); 0.99-0.80 (m, 4H); 0.72 (m, 1H), 0.00 (m, 1H).

C. Compound 1: Heptadecan-9-yl 8-((2-hydroxyethyl)(octadecyl)amino)octanoate

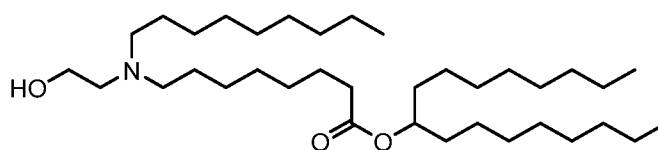


Chemical Formula: C₄₅H₉₁NO₃

Molecular Weight: 694.23

[0036] Compound 1 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.86 min. MS (ES): m/z (MH^+) 694.93 for $C_{45}H_{91}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 1H); 3.77-3.47 (br. m, 2H); 2.78-2.37 (br. m, 5H); 2.28 (t, 2H); 1.73-1.40 (br. m, 10H); 1.38-1.18 (br. m, 62H); 0.88 (m, 9H).

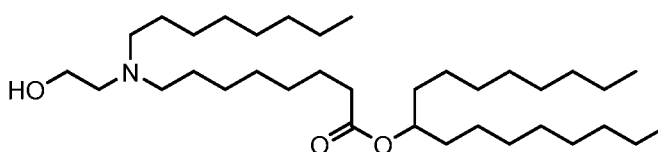
D. Compound 3: Heptadecan-9-yl 8-((2-hydroxyethyl)(nonyl)amino)octanoate

Chemical Formula: $C_{36}H_{73}NO_3$

Molecular Weight: 567.98

[0037] Compound 3 was synthesized according to the general procedure and Representative Procedure 1 and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.36 min. MS (ES): m/z (MH^+) 568.80 for $C_{36}H_{73}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 3.72-3.45 (br. m, 2H); 2.79-2.34 (br. m, 5H); 2.28 (t, 2H); 1.70-1.38 (m, 10H); 1.38-1.16 (br. m, 44H); 0.88 (m, 9H).

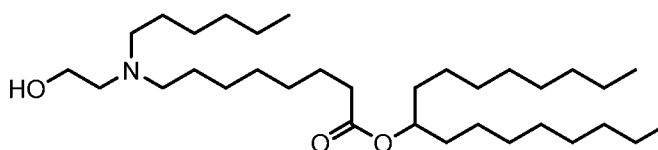
E. Compound 4: Heptadecan-9-yl 8-((2-hydroxyethyl)(octyl)amino)octanoate

Chemical Formula: $C_{35}H_{71}NO_3$

Molecular Weight: 553.96

[0038] Compound 4 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.99 min. MS (ES): m/z (MH^+) 554.777 for $C_{35}H_{71}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 3.71 (br. s, 2H); 2.70 (br. s, 5H); 2.26 (t, 2H); 1.48-1.59 (br. m., 10H); 1.24 (m, 42H); 0.86 (t, 9H).

F. Compound 5: Heptadecan-9-yl 8-(hexyl(2-hydroxyethyl)amino)octanoate

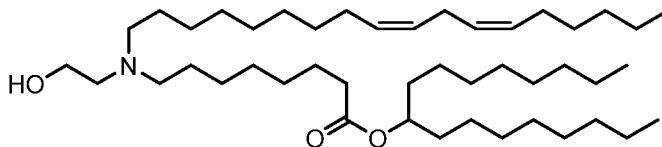
Chemical Formula: $C_{33}H_{67}NO_3$

Molecular Weight: 525.90

[0039] Compound 5 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.10 min. MS (ES): m/z (MH^+) 526.73 for

$C_{33}H_{67}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 3.67-3.48 (br. m, 2H); 2.74-2.39 (br. m, 5H); 2.28 (t, 2H); 1.68-1.39 (br. m, 10H); 1.38-1.16 (br. m, 38H); 0.88 (m, 9H).

G. Compound 6: Heptadecan-9-yl 8-((2-hydroxyethyl)((9Z,12Z)-octadeca-9,12-dien-1-yl)amino)octanoate

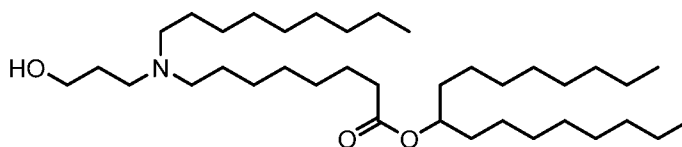


Chemical Formula: $C_{45}H_{87}NO_3$

Molecular Weight: 690.20

[0040] Compound 6 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.77 min. MS (ES): m/z (MH^+) 690.84 for $C_{45}H_{87}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.37 (m, 4H); 4.86 (br. m, 1H); 3.53 (br. m, 2H); 2.78 (br. m, 2H); 2.58 (br. m, 2H); 2.45 (br. m, 4H); 2.28 (m, 2H); 2.05 (m, 4H); 1.68-1.15 (br. m, 57H); 0.89 (m, 9H).

H. Compound 7: Heptadecan-9-yl 8-((3-hydroxypropyl)(nonyl)amino)octanoate



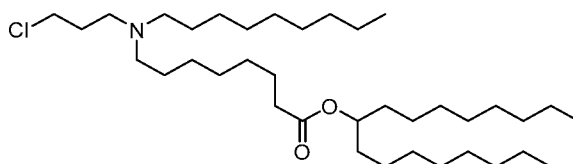
Chemical Formula: $C_{37}H_{75}NO_3$

Molecular Weight: 582.01

[0041] Compound 7 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.24 min. MS (ES): m/z (MH^+) 582.987 for $C_{37}H_{75}NO_3$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.84 (p, 1H); 3.76 (t, 2H); 2.42-2.66 (br. s, 5H); 2.25 (t, 2H); 1.47-1.68 (br. m, 12H); 1.24 (m, 42H); 0.86 (t, 9H).

I. Compound 8: Heptadecan-9-yl 8-((3-(1H-imidazol-1-yl)propyl)(nonyl)amino)octanoate

Step 1: Heptadecan-9-yl 8-((3-chloropropyl)(nonyl)amino)octanoate



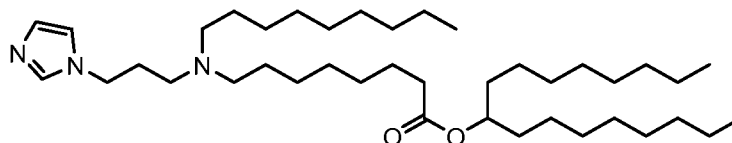
Chemical Formula: $C_{37}H_{74}ClNO_2$

Molecular Weight: 600.45

[0042] To a 0 °C solution of heptadecan-9-yl 8-((3-hydroxypropyl)(nonyl)amino)octanoate (0.53 g, 0.91 mmol) in 4 mL of DCM was added mesyl chloride (0.070 mL, 0.91 mmol) followed by triethylamine (0.13 mL, 0.91 mmol). The reaction was allowed to slowly warm to

rt and stir overnight. The reaction was quenched by the addition of water (~10 mL). The mixture was extracted with DCM three times and the pooled organics were washed with brine, dried over MgSO_4 , filtered and concentrated *in vacuo*. The crude oil was purified by silica gel chromatography to afford heptadecan-9-yl 8-((3-chloropropyl)(nonyl)amino)octanoate (0.23 g, 42%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.84 (p, 1H); 3.58 (t, 2H); 2.51 (br. s, 2H); 2.35 (br. s, 2H); 2.26 (2, 2H); 1.86 (br. s, 2H); 1.40-1.60 (br. m, 12H); 1.24 (br. m, 42H); 0.86 (t, 9H).

Step 2: Heptadecan-9-yl 8-((3-(1H-imidazol-1-yl)propyl)(nonyl)amino)octanoate

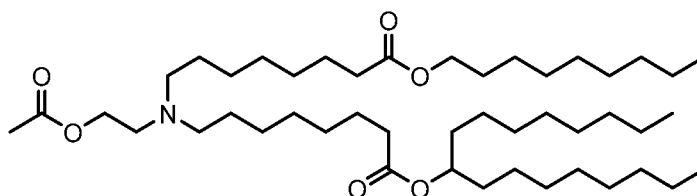


Chemical Formula: $\text{C}_{40}\text{H}_{77}\text{N}_3\text{O}_2$

Molecular Weight: 632.08

[0043] In a round bottom flask, heptadecan-9-yl 8-((3-chloropropyl)(nonyl)amino)octanoate (50 mg, 0.083 mmol) was combined with imidazole (17 mg, 0.25 mmol), K_2CO_3 (35 mg, 0.25 mmol) in MeCN (0.5 mL). The flask was fitted with a condenser and placed in an 82 °C heating mantle and was allowed to stir for 24 h. After this time, the reaction was allowed to cool to rt, was filtered and the filtrate was concentrated *in vacuo*. The crude oil was purified by silica gel chromatography (0-100% [DCM, 20% MeOH, 1% NH_4OH]/MeOH) to afford the desired product as a clear oil (39 mg, 74%). UPLC/ELSD: RT = 2.92 min. MS (ES): m/z (MH^+) 633.994 for $\text{C}_{40}\text{H}_{77}\text{N}_3\text{O}_2$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.46 (s, 1H); 7.05 (s, 1H); 6.91 (s, 1H); 4.84 (dt, 1H); 4.02 (br. s, 2H); 2.47 (br. s, 4H); 2.26 (t, 2H); 2.00 (br. s, 2H); 1.47-1.59 (br. m, 10H); 1.24 (br. m, 44H); 0.86 (t, 9H).

J. Compound 9: Heptadecan-9-yl 8-((2-acetoxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $\text{C}_{46}\text{H}_{89}\text{NO}_6$

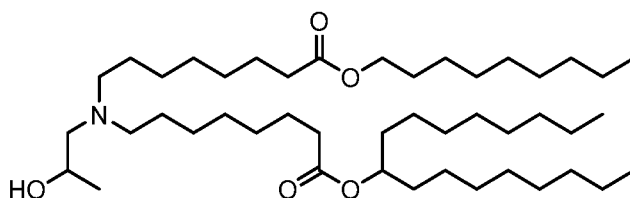
Molecular Weight: 752.22

[0044] To a solution of heptadecan-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (100 mg, 0.14 mmol) and acetic acid (8 mg, 0.13 mmol) in dichloromethane (1 mL) were added *N*-(3-Dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (31 mg, 0.16 mmol), *N,N*-diisopropylethylamine (73 mg, 0.56 mmol) and DMAP

(3 mg, 0.02 mmol). The reaction was allowed to stir at rt for 18 h. The reaction was diluted with dichloromethane and washed with saturated sodium bicarbonate. The organic layer was separated and washed with brine and dried over MgSO_4 . The organic layer was filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to yield heptadecan-9-yl 8-((2-acetoxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (63 mg, 0.08 mmol).

UPLC/ELSD: RT = 3.63 min. MS (ES): m/z (MH^+) 753.07 for $\text{C}_{46}\text{H}_{89}\text{NO}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.87 (p, 1H); 4.17-3.99 (m, 4H); 2.67 (m, 2H); 2.43 (m, 3H); 2.29 (m, 4H); 2.05 (s, 3H); 1.71-1.17 (br. m, 63H); 0.88 (m, 9H).

K. Compound 10: Heptadecan-9-yl 8-((2-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

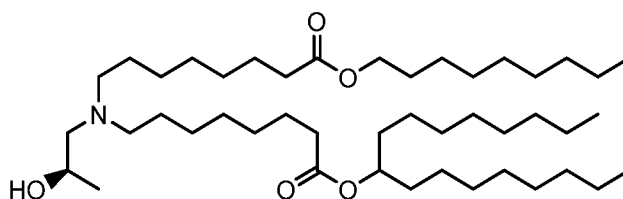


Chemical Formula: $\text{C}_{45}\text{H}_{89}\text{NO}_5$

Molecular Weight: 724.209

[0045] Compound 10 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.73 min. MS (ES): m/z (MH^+) 725.10 for $\text{C}_{45}\text{H}_{89}\text{NO}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.80-3.54 (br. m, 1H); 2.61-2.13 (br. m, 9H); 1.69-1.03 (br. m, 67H); 0.88 (m, 9H).

L. Compound 11: Heptadecan-9-yl (*R*)-8-((2-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

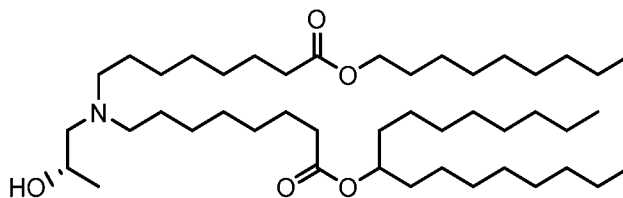


Chemical Formula: $\text{C}_{45}\text{H}_{89}\text{NO}_5$

Molecular Weight: 724.21

[0046] Compound 11 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 5.21 min. MS (ES): m/z (MH^+) 725.02 for $\text{C}_{45}\text{H}_{89}\text{NO}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.72 (br. m, 1H); 2.65-2.10 (br. m, 8H); 1.71-0.99 (br. m, 68H); 0.88 (m, 9H).

M. Compound 12: Heptadecan-9-yl (S)-8-((2-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

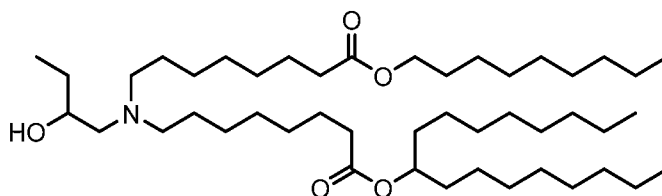


Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.21

[0047] Compound 12 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 5.30 min. MS (ES): m/z (MH^+) 725.10 for $C_{45}H_{89}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.71 (br. m, 1H); 2.64-2.10 (br. m, 8H); 1.71-1.03 (br. m, 68H); 0.88 (m, 9H).

N. Compound 13: Heptadecan-9-yl 8-((2-hydroxybutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

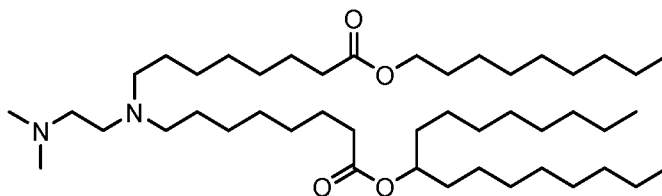


Chemical Formula: $C_{46}H_{91}NO_5$

Molecular Weight: 738.24

[0048] Compound 13 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.89 min. MS (ES): m/z (MH^+) 739.21 for $C_{46}H_{91}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.58-3.38 (br. m, 1H); 2.65-2.15 (br. m, 9H); 1.72-1.12 (br. m, 66H); 0.98 (t, 3H); 0.88 (m, 9H).

O. Compound 14: Heptadecan-9-yl 8-((2-(dimethylamino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

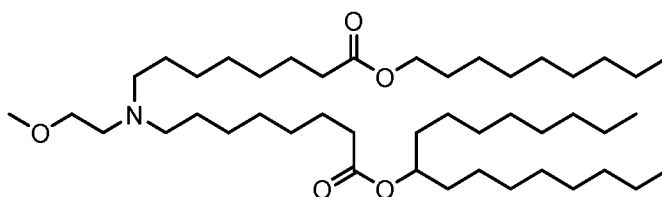


Chemical Formula: $C_{46}H_{92}N_2O_4$

Molecular Weight: 737.252

[0049] Compound 14 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.51 min. MS (ES): m/z (MH⁺) 738.23 for $C_{46}H_{92}N_2O_4$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.84 (p, 1H); 4.04 (t, 2H); 2.95 (m, 2H); 2.78 (m, 6H); 2.44 (s, 6H); 2.28 (m, 4H); 1.70-1.41 (br. m, 14H); 1.41-1.14 (br. m, 48H); 0.87 (m, 9H).

P. Compound 15: Heptadecan-9-yl 8-((2-methoxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

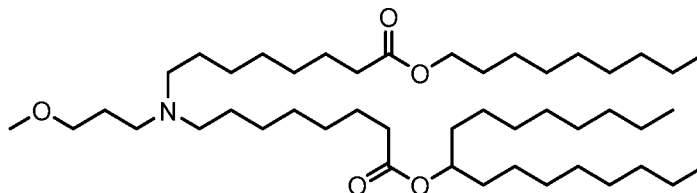


Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.21

[0050] Compound 15 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.90 min. MS (ES): m/z (MH⁺) 725.19 for $C_{45}H_{89}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.43 (m, 2H); 3.34 (s, 3H); 2.61 (m, 2H); 2.43 (m, 3H); 2.29 (m, 4H); 1.70-1.15 (br. m, 63H); 0.88 (m, 9H).

Q. Compound 16: Heptadecan-9-yl 8-((3-methoxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

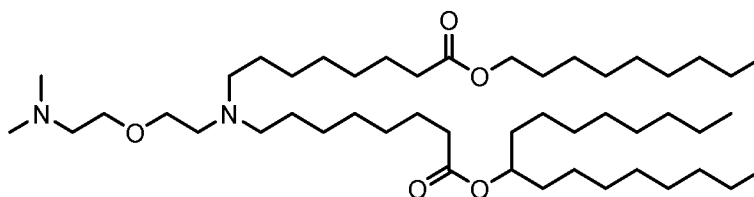


Chemical Formula: $C_{46}H_{91}NO_5$

Molecular Weight: 738.236

[0051] Compound 16 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.90 min. MS (ES): m/z (MH⁺) 739.13 for C₄₆H₉₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.42 (m, 2H); 3.35 (s, 3H); 2.55-2.21 (m, 9H); 1.81-1.18 (br. m, 65H); 0.88 (m, 9H).

R. Compound 17: Heptadecan-9-yl 8-((2-(2-(dimethylamino)ethoxy)ethyl) (8-(nonyloxy)-8-oxooctyl)amino)octanoate

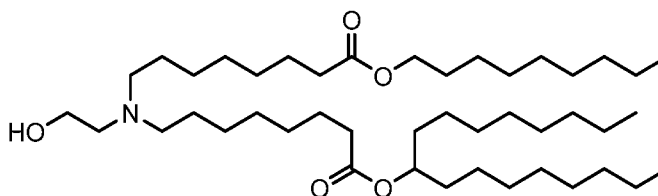


Chemical Formula: C₄₈H₉₆N₂O₅

Molecular Weight: 781.305

[0052] Compound 17 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.72 min. MS (ES): m/z (MH⁺) 782.27 for C₄₈H₉₆N₂O₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.88 (p, 1H); 4.08 (t, 2H); 3.57 (m, 4H); 2.72 (m, 2H); 2.52 (m, 5H); 2.38-2.13 (br. m, 12H); 1.73-1.19 (br. m, 61H); 0.90 (m, 9H).

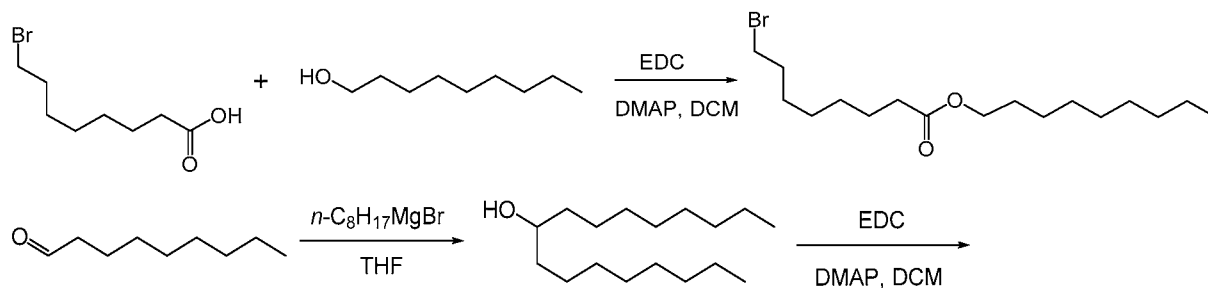
S. Compound 18: Heptadecan-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

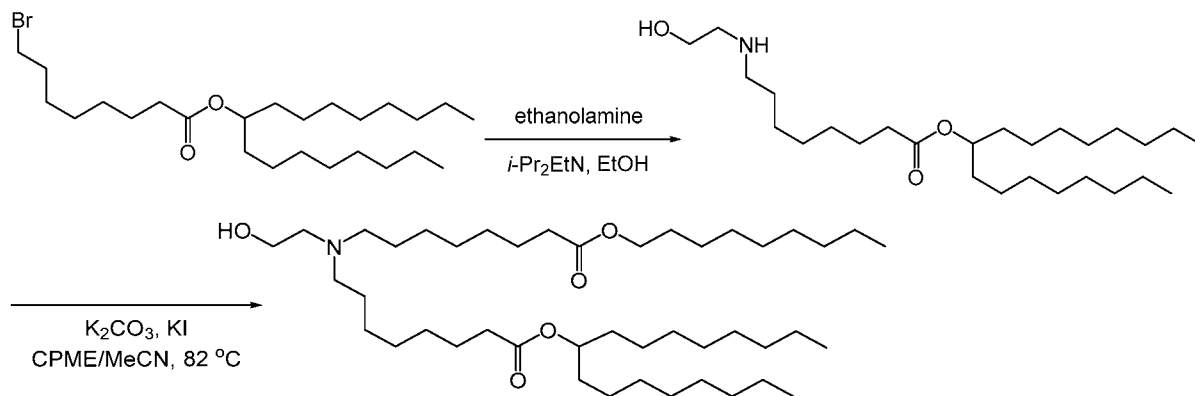


Chemical Formula: C₄₄H₈₇NO₅

Molecular Weight: 710.18

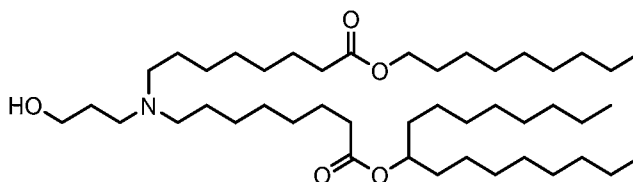
[0053] Compound 18 was synthesized according to the general procedure and Representative Procedure 1 described above or according to the scheme below:





[0054] UPLC/ELSD: RT = 3.59 min. MS (ES): m/z (MH^+) 710.89 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 1H); 4.05 (t, 2H); 3.53 (br. m, 2H); 2.83-2.36 (br. m, 5H); 2.29 (m, 4H); 0.96-1.71 (m, 64H); 0.88 (m, 9H).

T. Compound 19: Heptadecan-9-yl 8-((3-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate

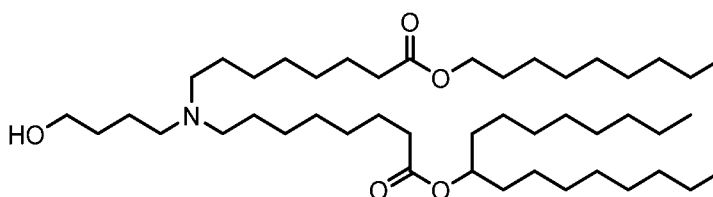


Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.21

[0055] Compound 19 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 4.51 min. MS (ES): m/z (MH^+) 725.19 for $C_{45}H_{89}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.80 (m, 2H); 2.92-2.36 (br. m, 5H); 2.29 (m, 4H); 1.89-1.42 (br. m, 16H); 1.42-1.02 (br. m, 50H); 0.88 (m, 9H).

U. Compound 20: Heptadecan-9-yl 8-((4-hydroxybutyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate



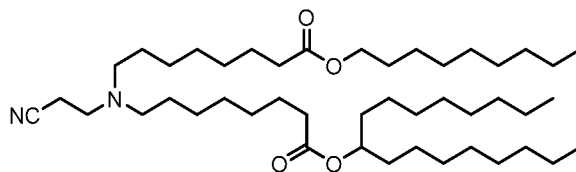
Chemical Formula: $C_{46}H_{91}NO_5$

Molecular Weight: 738.24

[0056] Compound 20 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.84 min. MS (ES): m/z

(MH⁺) 739.21 for C₄₆H₉₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.77-3.45 (br. m, 2H); 2.63-2.20 (br. m, 8H); 1.82-1.40 (br. m, 18H); 1.40-1.15 (br. m, 51H); 0.88 (m, 9H).

V. Compound 21: Heptadecan-9-yl 8-((2-cyanoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

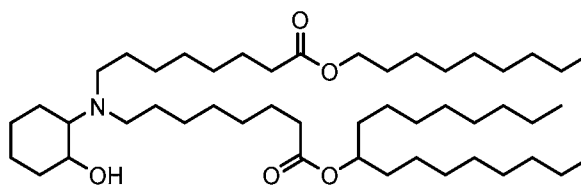


Chemical Formula: C₄₅H₈₆N₂O₄

Molecular Weight: 719.19

[0057] Compound 21 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 4.04 min. MS (ES): *m/z* (MH⁺) 720.18 for C₄₅H₈₆N₂O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.88 (p, 1H); 4.07 (t, 2H); 2.81 (m, 2H); 2.44 (m, 5H); 2.30 (m, 4H); 1.73-1.18 (br. m, 63H); 0.89 (m, 9H).

W. Compound 22: Heptadecan-9-yl 8-((2-hydroxycyclohexyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

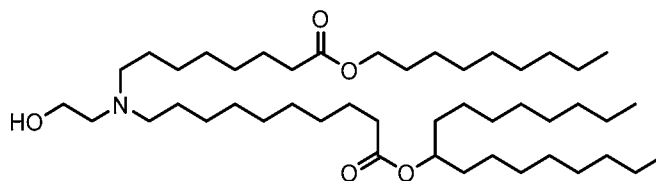


Chemical Formula: C₄₈H₉₃NO₅

Molecular Weight: 764.27

[0058] Compound 22 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 4.54 min. MS (ES): *m/z* (MH⁺) 765.21 for C₄₈H₉₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 4.05 (t, 2H); 2.89-2.34 (br. m, 4H); 2.28 (m, 4H); 2.00 (m, 1H); 1.86-0.99 (br. m, 72H); 0.88 (m, 9H).

X. Compound 23: Heptadecan-9-yl 10-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)decanoate

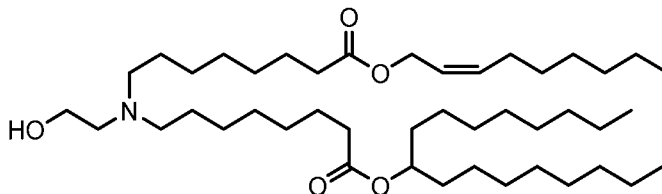


Chemical Formula: C₄₆H₉₁NO₅

Molecular Weight: 738.24

[0059] Compound 23 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.75 min. MS (ES): m/z (MH^+) 739.13 for $C_{46}H_{91}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 1H); 4.05 (m, 2H); 3.72-3.46 (br. m, 2H); 2.81-2.35 (br. m, 5H); 2.29 (m, 4H); 1.71-1.40 (br. m, 13H); 1.40-1.15 (br. m, 55H); 0.88 (m, 9H).

Y. Compound 24: Heptadecan-9-yl (Z)-8-((2-hydroxyethyl) (8-(non-2-en-1-yloxy)-8-oxooctyl)amino)octanoate

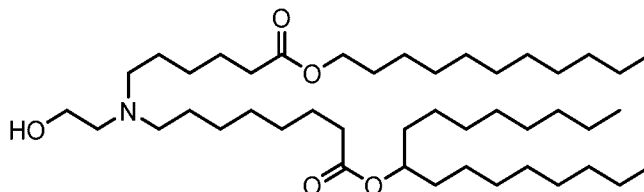


Chemical Formula: $C_{44}H_{85}NO_5$

Molecular Weight: 708.17

[0060] Compound 24 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.54 min. MS (ES): m/z (MH^+) 708.95 for $C_{44}H_{85}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.74-5.44 (br. m, 2H); 4.86 (m, 1H); 4.62 (m, 2H); 3.71-3.40 (br. m, 2H); 2.81-2.37 (br. m, 5H); 2.29 (m, 4H); 2.09 (m, 2H); 1.70-1.14 (br. m, 58H); 0.88 (m, 9H).

Z. Compound 25: Heptadecan-9-yl 8-((2-hydroxyethyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

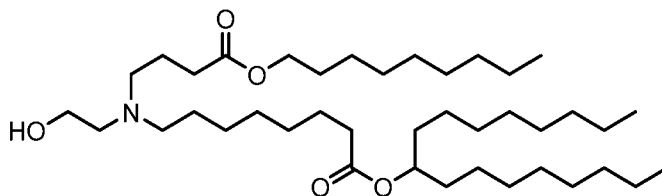


Chemical Formula: $C_{44}H_{87}NO_5$

Molecular Weight: 710.182

[0061] Compound 25 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.66 min. MS (ES): m/z (MH^+) 711.00 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 1H); 4.05 (t, 2H); 3.68-3.46 (br. m, 2H); 2.77-2.37 (br. m, 5H); 2.29 (m, 4H); 1.74-1.41 (br. m, 14H); 1.39-1.18 (m, 50H); 0.88 (m, 9H).

AA. Compound 26: Heptadecan-9-yl 8-((2-hydroxyethyl)(4-(nonyloxy)-4-oxobutyl)amino) octanoate

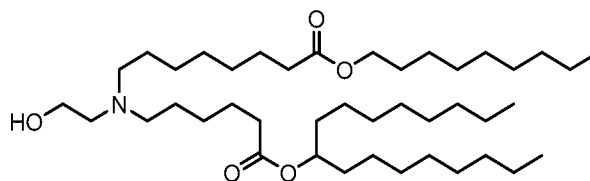


Chemical Formula: C₄₀H₇₉NO₅

Molecular Weight: 654.07

[0062] Compound 26 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 4.29 min. MS (ES): *m/z* (MH⁺) 655.07 for C₄₀H₇₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 4.06 (t, 2H); 3.79 (br. m, 2H); 2.91-2.20 (br. m, 10H); 1.98-1.03 (br. m, 55H); 0.88 (m, 9H).

AB. Compound 27: Nonyl 8-((6-(heptadecan-9-yloxy)-6-oxohexyl)(2-hydroxyethyl)amino) octanoate

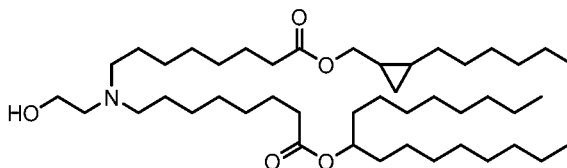


Chemical Formula: C₄₂H₈₃NO₅

Molecular Weight: 682.13

[0063] Compound 27 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.57 min. MS (ES): *m/z* (MH⁺) 683.12 for C₄₂H₈₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (m, 1H); 4.05 (m, 2H); 3.70-3.45 (br. m, 2H); 2.78-2.35 (br. m, 5H); 2.29 (m, 4H); 1.73-1.41 (m, 13H); 1.41-1.16 (m, 47H); 0.88 (m, 9H).

AC. Compound 28: Heptadecan-9-yl 8-((8-((2-hexylcyclopropyl)methoxy)-8-oxooctyl)(2-hydroxyethyl)amino) octanoate



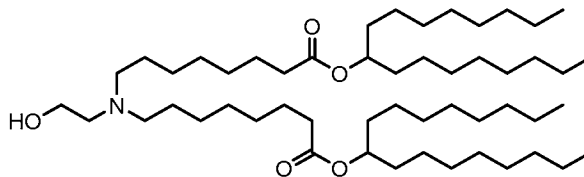
Chemical Formula: C₄₅H₈₇NO₅

Molecular Weight: 722.19

[0064] Compound 28 was synthesized according to the general procedure and Representative Procedure 1 described above using Intermediate C. UPLC/ELSD: RT = 5.17

min. MS (ES): m/z (MH^+) 722.97 for $C_{45}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 4.17 (m, 1H); 3.93 (m, 1H); 3.61 (br. m, 2H); 2.97-2.37 (br. m, 6H); 2.35-2.21 (m, 4H); 1.74-0.97 (br. m, 60H); 0.94-0.79 (m, 10H); 0.74 (m, 1H); 0.01 (m, 1H).

AD. Compound 29: Di(heptadecan-9-yl) 8,8'-((2-hydroxyethyl)azanediyl)dioctanoate

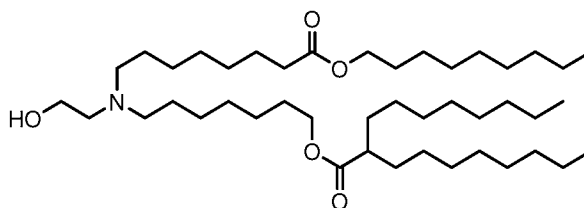


Chemical Formula: $C_{52}H_{103}NO_5$

Molecular Weight: 822.40

[0065] Compound 29 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.98 min. MS (ES): m/z (MH^+) 823.19 for $C_{52}H_{103}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 2H); 3.72-3.44 (br. m, 2H); 2.83- 2.34 (br. m, 5H); 2.28 (m, 4H); 1.69-1.39 (br. m, 16H); 1.39-1.16 (br. m, 62H); 0.88 (m, 12H).

AE. Compound 30: 7-((2-Hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)heptyl 2-octyldecanoate

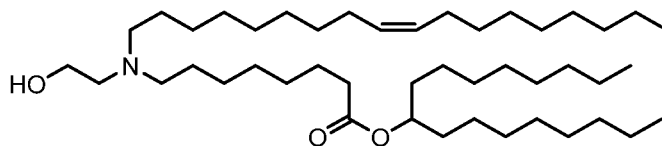


Chemical Formula: $C_{44}H_{87}NO_5$

Molecular Weight: 710.18

[0066] Compound 30 was synthesized according to the general procedure and Representative Procedure 1 described above using Intermediate B. UPLC/ELSD: RT = 3.55 min. MS (ES): m/z (MH^+) 711.16 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.06 (m, 4H); 3.69-3.44 (br. m, 2H); 2.71-2.39 (br. m, 5H); 2.29 (m, 3H); 1.70-1.16 (br. m, 64H); 0.88 (m, 9H).

AF. Compound 31: heptadecan-9-yl (Z)-8-((2-hydroxyethyl)(octadec-9-en-1-yl)amino) octanoate

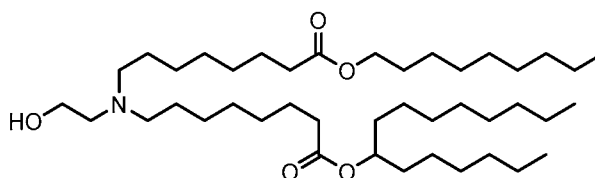


Chemical Formula: $C_{45}H_{89}NO_3$

Molecular Weight: 692.21

[0067] Compound 31 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.83 min. MS (ES): m/z (MH⁺) 693.20 for C₄₅H₈₉NO₃. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.37 (m, 2H); 4.89 (p, 1H); 3.58 (br. m, 2H); 2.72-2.43 (br. m, 5H); 2.30 (m, 2H), 2.05 (m, 4H); 1.71-1.03 (br. m, 63H), 0.90 (m, 9H).

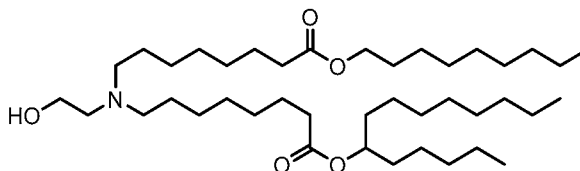
AG. Compound 32: nonyl 8-((2-hydroxyethyl)(8-oxo-8-(pentadecan-7-yloxy)octyl)amino) octanoate

Chemical Formula: C₄₂H₈₃NO₅

Molecular Weight: 682.13

[0068] Compound 32 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.45 min. MS (ES): m/z (MH⁺) 683.20 for C₄₂H₈₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.60 (br. m, 2H); 2.85-2.40 (br. m, 5H); 2.31 (m, 4H), 1.78-1.01 (m, 59H), 0.90 (m, 9H).

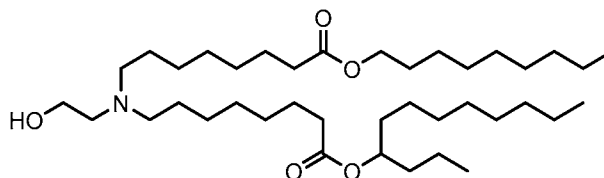
AH. Compound 33: nonyl 8-((2-hydroxyethyl)(8-oxo-8-(tetradecan-6-yloxy)octyl)amino) octanoate

Chemical Formula: C₄₁H₈₁NO₅

Molecular Weight: 668.10

[0069] Compound 33 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.39 min. MS (ES): m/z (MH⁺) 669.09 for C₄₁H₈₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.84 - 3.54 (br. m, 2H); 2.99-2.41 (br. m, 5H); 2.31 (m, 4H), 1.76-1.02 (br. m, 57H), 0.90 (m, 9H).

AI. Compound 34: dodecan-4-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate

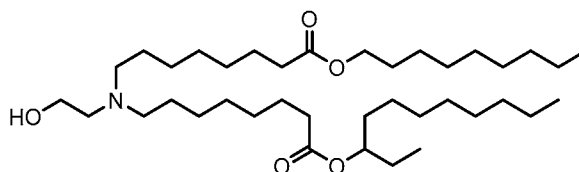


Chemical Formula: $C_{39}H_{77}NO_5$

Molecular Weight: 640.05

[0070] Compound 34 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.21 min. MS (ES): m/z (MH^+) 641.05 for $C_{39}H_{77}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.91 (p, 1H); 4.08 (t, 2H); 3.67 (br. m, 2H); 3.03-2.44 (br. m, 5H); 2.30 (m, 4H), 1.75-1.00 (br. m, 53H), 0.90 (m, 9H).

AJ. Compound 35: nonyl 8-((2-hydroxyethyl)(8-oxo-8-(undecan-3-yloxy)octyl)amino) octanoate

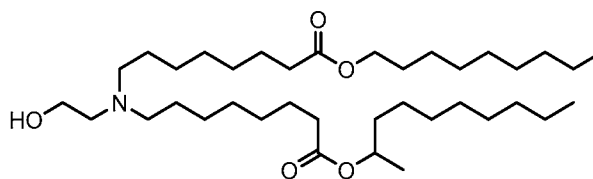


Chemical Formula: $C_{38}H_{75}NO_5$

Molecular Weight: 626.02

[0071] Compound 35 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.16 min. MS (ES): m/z (MH^+) 627.11 for $C_{38}H_{75}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.83 (p, 1H); 4.08 (t, 2H); 3.63 (br. m, 2H); 2.81-2.39 (br. m, 5H); 2.31 (m, 4H), 1.74-1.01 (br. m, 51H), 0.90 (m, 9H).

AK. Compound 36: decan-2-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate



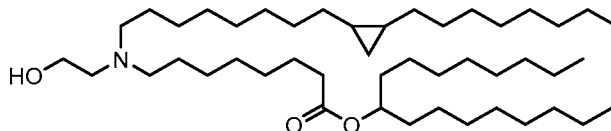
Chemical Formula: $C_{37}H_{73}NO_5$

Molecular Weight: 611.99

[0072] Compound 36 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.05 min. MS (ES): m/z

(MH⁺) 613.00 for C₃₇H₇₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (p, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.60 (m, 2H); 2.47 (m, 4H); 2.29 (m, 4H), 1.731-1.01 (m, 51H), 0.90 (m, 6H).

AL. Compound 47: heptadecan-9-yl 8-((2-hydroxyethyl)(8-(2-octylcyclopropyl)octyl)amino)octanoate

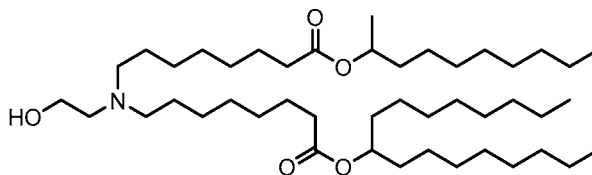


Chemical Formula: C₄₆H₉₁NO₃

Molecular Weight: 706.24

[0073] Compound 47 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.92 min. MS (ES): *m/z* (MH⁺) 707.39 for C₄₆H₉₁NO₃. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 3.56 (br. m, 2H); 2.72-2.38 (br. m, 5H); 2.28 (t, 2H); 1.70-1.02 (br. m, 67H), 0.88 (m, 9H); 0.71-0.49 (m, 4H); -0.33 (m, 1H).

AM. Compound 48: decan-2-yl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

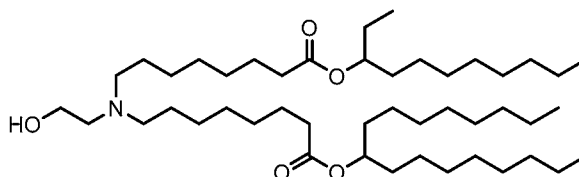


Chemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.21

[0074] Compound 48 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.60 min. MS (ES): *m/z* (MH⁺) 725.10 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 2H); 3.59 (br. m, 2H); 2.79-2.37 (br. m, 5H); 2.29 (m, 4H); 1.74-1.13 (m, 66H); 0.90 (m, 9H).

AN. Compound 49: heptadecan-9-yl 8-((2-hydroxyethyl)(8-oxo-8-(undecan-3-yloxy)octyl)amino)octanoate

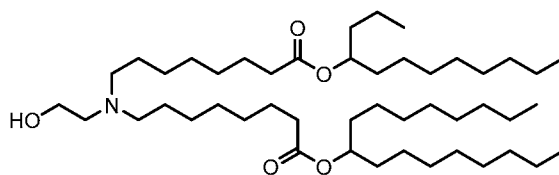


Chemical Formula: C₄₆H₉₁NO₅

Molecular Weight: 738.24

[0075] Compound 49 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.68 min. MS (ES): m/z (MH⁺) 739.21 for C₄₆H₉₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (m, 2H); 3.56 (br. m, 2H); 2.68-2.39 (br. m, 5H); 2.30 (m, 4H); 1.71-1.19 (m, 66H); 0.90 (m, 12H).

AO. Compound 50: dodecan-4-yl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

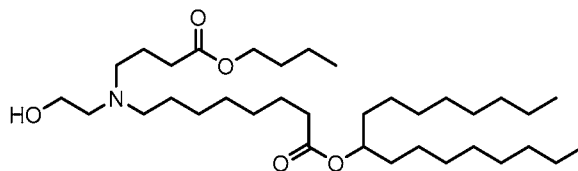


Chemical Formula: C₄₇H₉₃NO₅

Molecular Weight: 752.26

[0076] Compound 50 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.73 min. MS (ES): m/z (MH⁺) 753.23 for C₄₇H₉₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (m, 2H); 3.60 (br. m, 2H); 2.75-2.43 (br. m, 5H); 2.30 (m, 4H); 1.71-1.44 (m, 16H); 1.28 (m, 51H); 0.90 (m, 12H).

AP. Compound 51: heptadecan-9-yl 8-((4-butoxy-4-oxobutyl)(2-hydroxyethyl)amino)octanoate

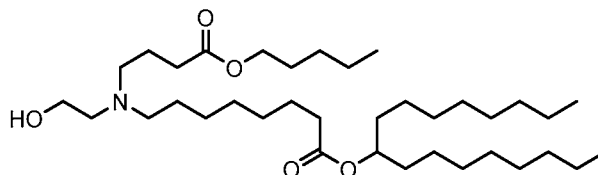


Chemical Formula: C₃₅H₆₉NO₅

Molecular Weight: 583.94

[0077] Compound 51 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.05 min. MS (ES): m/z (MH⁺) 584.87 for C₃₅H₆₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 1H); 4.10 (t, 2H); 3.61 (br. m, 2H); 2.81-2.21 (br. m, 9H); 1.87 (br. m, 2H); 1.70-1.04 (m, 43H); 0.98-0.82 (m, 9H).

AQ. Compound 52: heptadecan-9-yl 8-((2-hydroxyethyl)(4-oxo-4-(pentyloxy)butyl)amino)octanoate

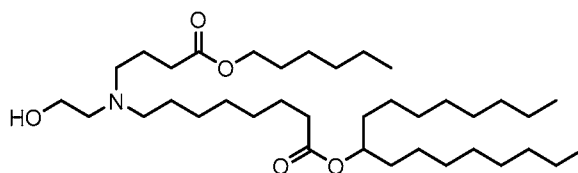


Chemical Formula: $C_{36}H_{71}NO_5$

Molecular Weight: 597.97

[0078] Compound 52 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.11 min. MS (ES): m/z (MH^+) 598.90 for $C_{36}H_{71}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (p, 1H); 4.09 (t, 2H); 3.61 (br. m, 2H); 2.89-2.22 (br. m, 9H); 1.87 (br. m, 2H); 1.73-1.43 (m, 11H); 1.28 (m, 34H); 0.90 (m, 9H).

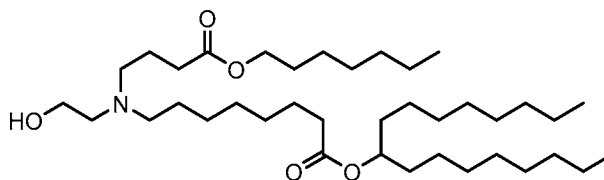
AR. Compound 53: heptadecan-9-yl 8-((4-(hexyloxy)-4-oxobutyl)(2-hydroxyethyl)amino) octanoate

Chemical Formula: $C_{37}H_{73}NO_5$

Molecular Weight: 611.99

[0079] Compound 53 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.22 min. MS (ES): m/z (MH^+) 612.92 for $C_{37}H_{73}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H); 4.06 (t, 2H); 3.55 (br. m, 2H); 2.68-2.38 (br. m, 5H); 2.28 (m, 4H); 1.79 (br. m, 2H); 1.71-0.96 (m, 48H); 0.88 (m, 9H).

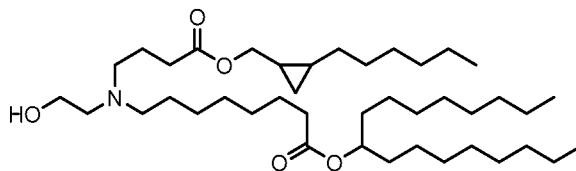
AS. Compound 54: heptadecan-9-yl 8-((4-(heptyloxy)-4-oxobutyl)(2-hydroxyethyl)amino) octanoate

Chemical Formula: $C_{38}H_{75}NO_5$

Molecular Weight: 626.02

[0080] Compound 54 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.28 min. MS (ES): m/z (MH^+) 626.94 for $C_{38}H_{75}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (p, 1H); 4.09 (t, 2H); 3.60 (br. m, 2H); 2.77-2.42 (br. m, 5H); 2.32 (m, 4H); 1.84 (br. m, 2H); 1.75-1.03 (m, 49H); 0.90 (m, 9H).

AT. Compound 55: heptadecan-9-yl 8-((4-((2-hexylcyclopropyl)methoxy)-4-oxobutyl)(2-hydroxyethyl) amino)octanoate

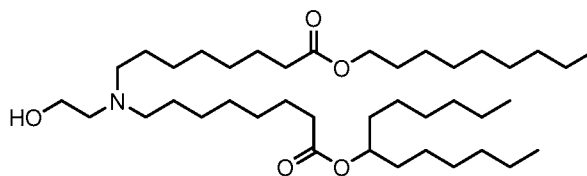


Chemical Formula: $C_{41}H_{79}NO_5$

Molecular Weight: 666.09

[0081] Compound 55 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.37 min. MS (ES): m/z (MH⁺) 667.04 for $C_{41}H_{79}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.83 (p, 1H); 4.15 (m, 1H); 3.95 (m, 1H); 3.53 (br. m, 2H); 2.66-2.39 (br. m, 5H); 2.34-2.19 (m, 4H); 1.78 (br. m, 2H); 1.66-0.98 (m, 50H); 0.85 (m, 10H); 0.70 (m, 1H); 0.00 (m, 1H).

AU. Compound 56: nonyl 8-((2-hydroxyethyl)(8-oxo-8-(tridecan-7-yloxy)octyl)amino) octanoate

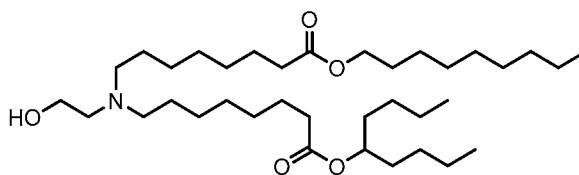


Chemical Formula: $C_{40}H_{79}NO_5$

Molecular Weight: 654.07

[0082] Compound 56 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.28 min. MS (ES): m/z (MH⁺) 654.99 for $C_{40}H_{79}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.60 (br. m, 2H); 2.77-2.40 (br. m, 5H); 2.30 (m, 4H); 1.78-0.99 (m, 55H); 0.90 (m, 9H).

AV. Compound 57: nonan-5-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate



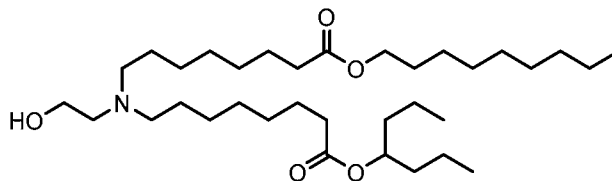
Chemical Formula: $C_{36}H_{71}NO_5$

Molecular Weight: 597.97

[0083] Compound 57 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.88 min. MS (ES): m/z

(MH⁺) 598.98 for C₃₆H₇₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.59 (br. m, 2H); 2.82-2.37 (br. m, 5H); 2.31 (m, 4H); 1.73-1.03 (m, 47H); 0.91 (m, 9H).

AW. Compound 58: heptan-4-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino) octanoate

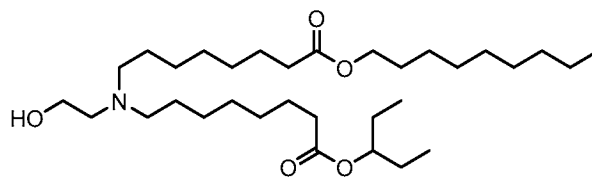


Chemical Formula: C₃₄H₆₇NO₅

Molecular Weight: 569.91

[0084] Compound 58 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.67 min. MS (ES): *m/z* (MH⁺) 570.93 for C₃₄H₆₇NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.93 (p, 1H); 4.08 (t, 2H); 3.57 (br. m, 2H); 2.69-2.42 (br. m, 5H); 2.30 (m, 4H); 1.72-1.04 (m, 43H); 0.93 (m, 9H).

AX. Compound 59: nonyl 8-((2-hydroxyethyl)(8-oxo-8-(pentan-3-yloxy)octyl)amino) octanoate

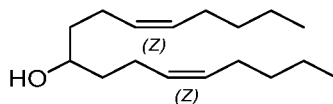


Chemical Formula: C₃₂H₆₃NO₅

Molecular Weight: 541.86

[0085] Compound 59 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.39 min. MS (ES): *m/z* (MH⁺) 542.80 for C₃₂H₆₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.78 (p, 1H); 4.08 (t, 2H); 3.57 (br. m, 2H); 2.71-2.39 (br. m, 5H); 2.31 (m, 4H); 1.77-1.05 (m, 39H); 0.90 (m, 9H).

AY. Compound 60: (5Z,12Z)-Heptadeca-5,12-dien-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
(5Z,12Z)-Heptadeca-5,12-dien-9-ol

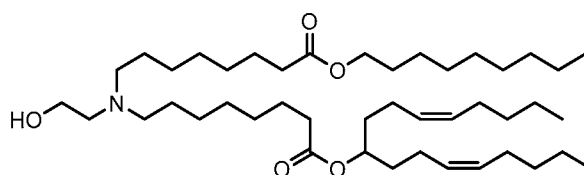


Chemical Formula: C₁₇H₃₂O

Molecular Weight: 252.44

[0086] To a solution of (Z)-1-bromooct-3-ene (6.2 g, 32.4 mmol) in THF (45 mL) Mg turnings were added (0.843 g, 34.7 mmol). The reaction was heated to 45 °C for 3 h. The reaction was cooled to 0 °C and ethyl formate (2.4 g, 32.4 mmol) in THF (5 mL) was added dropwise. The reaction was allowed to warm to rt and stir for 30 min. The reaction was cooled to 0 °C and quenched with water (15 mL) and 6N HCl (15 mL). The reaction was stirred until all the Mg was dissolved. Water (25 mL) was added and the mixture was extracted with hexanes (3X25 mL). The combined organic layer was washed with brine, separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was dissolved in EtOH (20 mL), a solution of KOH in water (1.76 g in 8 mL of water) was added and allowed to stir for 15 min. EtOH was evaporated under vacuum. The residue was diluted with water (20 mL), acidified with 6N HCl (20 mL) and extracted with hexanes (3x). The combined organic layers were washed with brine, separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-5%) EtOAc in hexanes to obtain (5Z,12Z)-heptadeca-5,12-dien-9-ol (2.3 g, 9.1 mmol, 28%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.41 (m, 4); 3.66 (m, 1H); 2.13 (m, 8H); 1.51 (m, 5H); 1.36 (m, 8H); 0.92 (m, 6H).

(5Z,12Z)-Heptadeca-5,12-dien-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

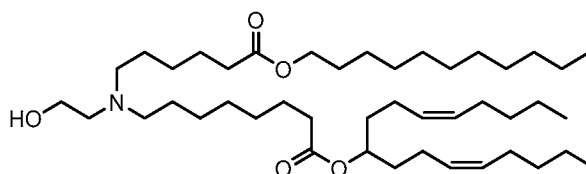


Chemical Formula: C₄₄H₈₃NO₅

Molecular Weight: 706.15

[0087] Compound 60 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.36 min. MS (ES): *m/z* (MH⁺) 707.10 for C₄₄H₈₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.37 (m, 4H); 4.92 (p, 1H); 4.08 (t, 2H); 3.57 (br. m, 2H); 2.73-2.38 (br. m, 5H); 2.31 (m, 4H); 2.04 (m, 8H); 1.73-1.01 (m, 47H); 0.92 (m, 9H).

AZ. Compound 61: (5Z,12Z)-heptadeca-5,12-dien-9-yl 8-((2-hydroxyethyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

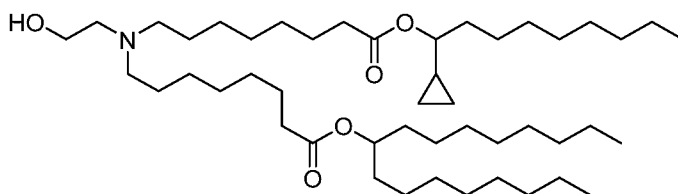


Chemical Formula: C₄₄H₈₃NO₅

Molecular Weight: 706.15

[0088] Compound 61 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.39 min. MS (ES): m/z (MH⁺) 707.10 for C₄₄H₈₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.37 (m, 4H); 4.92 (p, 1H); 4.08 (t, 2H); 3.58 (br. m, 2H); 2.70-2.41 (br. m, 5H); 2.32 (m, 4H); 2.04 (m, 8H); 1.77-1.03 (m, 47H); 0.92 (m, 9H).

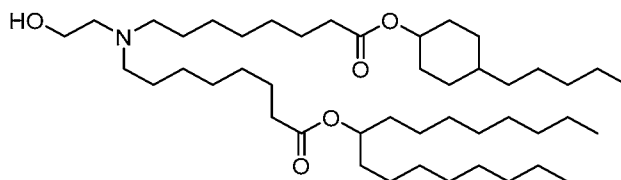
BA. Compound 65: 1-Cyclopropylnonyl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

Chemical Formula: C₄₇H₉₁NO₅

Molecular Weight: 750.247

[0089] Compound 65 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.72 min. MS (ES): m/z (MH⁺) 750.9 for C₄₇H₉₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (m, 1H); 4.28 (m, 1H); 3.54 (m, 2H); 2.59 (m, 2H); 2.46 (m, 4H); 2.29 (m, 4H); 1.73-1.18 (m, 61H); 0.90 (m, 10H); 0.62-0.33 (m, 3H); 0.28 (m, 1H).

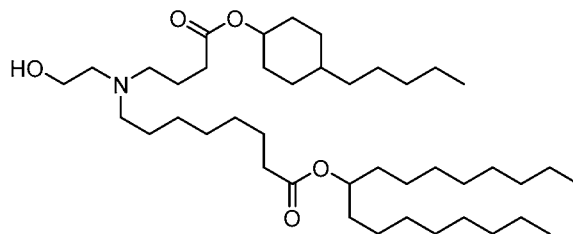
BB. Compound 66: Heptadecan-9-yl 8-((2-hydroxyethyl)(8-oxo-8-((4-pentylcyclohexyl)oxy)octyl)amino)octanoate

Chemical Formula: C₄₆H₈₉NO₅

Molecular Weight: 736.220

[0090] Compound 66 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.72 min. MS (ES): m/z (MH⁺) 736.9 for C₄₆H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.00 (m, 0.5H); 4.89 (m, 1H); 4.68 (m, 0.6H); 3.56 (m, 2H); 2.61 (br. m, 2H); 2.48 (m, 4H); 2.30 (m, 4H); 1.98 (m, 1H); 1.82 (m, 2H); 1.73-1.14 (m, 61H); 1.04 (m, 1H); 0.90 (m, 9H).

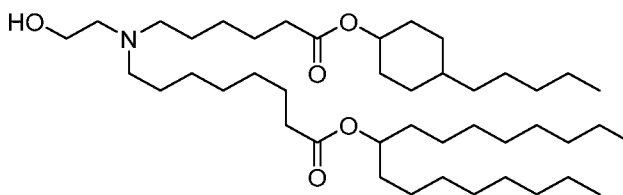
BC. Compound 67: Heptadecan-9-yl 8-((2-hydroxyethyl)(4-oxo-4-((4-pentylcyclohexyl)oxy)butyl)amino)octanoate

Chemical Formula: $C_{42}H_{81}NO_5$

Molecular Weight: 680.112

[0091] Compound 67 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.56 min. MS (ES): m/z (MH⁺) 680.8 for $C_{42}H_{81}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.01 (m, 0.4H); 4.89 (m, 1H); 4.68 (m, 0.6H); 3.59 (m, 2H), 2.72-2.43 (br. m, 6H); 2.30 (m, 4H); 1.98 (m, 1H); 1.83 (m, 4H); 1.69-1.44 (m, 10H); 1.28 (m, 41H); 1.03 (m, 1H); 0.90 (m, 9H).

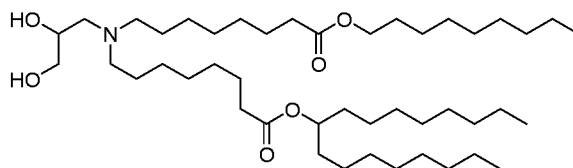
BD. Compound 68: Heptadecan-9-yl 8-((2-hydroxyethyl)(6-oxo-6-((4-pentylcyclohexyl)oxy)hexyl)amino)octanoate

Chemical Formula: $C_{44}H_{85}NO_5$

Molecular Weight: 708.166

[0092] Compound 68 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.66 min. MS (ES): m/z (MH⁺) 708.9 for $C_{44}H_{85}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.00 (m, 0.5H); 4.89 (m, 1H); 4.68 (m, 0.6H); 3.55 (m, 2H), 2.66-2.39 (br. m, 6H); 2.30 (m, 4H); 1.97 (m, 1H); 1.83 (m, 2H); 1.73-1.41 (m, 15H); 1.41-1.17 (m, 42H); 1.04 (m, 1H); 0.90 (m, 9H).

BE. Compound 69: Heptadecan-9-yl 8-((2,3-dihydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

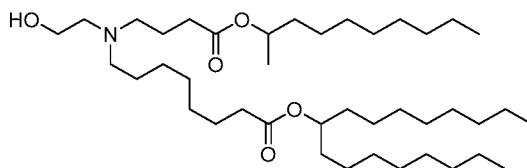
Chemical Formula: $C_{45}H_{89}NO_6$

Molecular Weight: 740.21

[0093] Compound 69 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.60 min. MS (ES): m/z

(MH⁺) 741.0 for C₄₅H₈₉NO₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.76 (br. m, 2H); 3.51 (m, 1H); 2.57 (m, 6H); 2.31 (m, 4H); 1.71-1.41 (m, 14H); 1.41- 1.12 (m, 48H); 0.90 (m, 9H).

BF. Compound 70: Heptadecan-9-yl 8-((4-(decan-2-yloxy)-4-oxobutyl)(2-hydroxyethyl)amino)octanoate

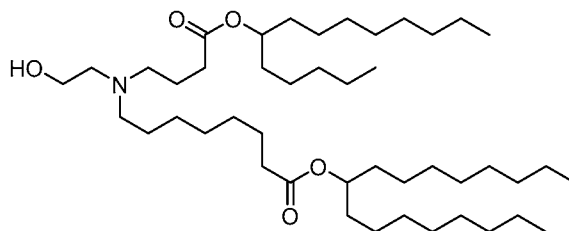


Chemical Formula: C₄₁H₈₁NO₅

Molecular Weight: 667.61

[0094] Compound 70 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.44 min. MS (ES): *m/z* (MH⁺) 668.9 for C₄₁H₈₁NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 2H); 3.57 (m, 2H); 2.71-2.40 (m, 5H); 2.30 (m, 4H), 1.80 (m, 2H); 1.71-1.40 (m, 11H); 1.39-1.05 (m, 45H); 0.90 (m, 9H).

BG. Compound 71: Heptadecan-9-yl 8-((2-hydroxyethyl)(4-oxo-4-(tetradecan-6-yloxy)butyl)amino)octanoate

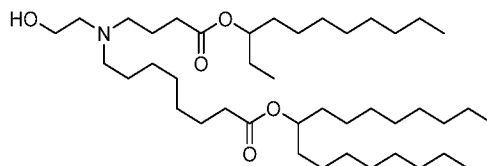


Chemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.209

[0095] Compound 71 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.72 min. MS (ES): *m/z* (MH⁺) 724.9 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 2H); 3.56 (m, 2H); 2.70-2.41 (m, 6H); 2.33 (m, 4H), 1.80 (m, 2H); 1.69-1.41 (m, 13H); 1.28 (m, 48H); 0.90 (m, 12H).

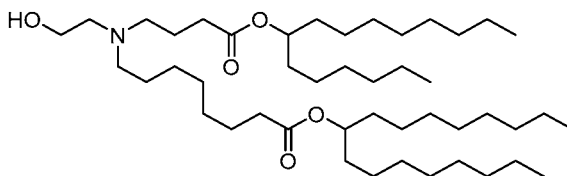
BH. Compound 72: Heptadecan-9-yl 8-((2-hydroxyethyl)(4-oxo-4-(undecan-3-yloxy)butyl)amino)octanoate

Chemical Formula: $C_{42}H_{83}NO_5$

Molecular Weight: 682.13

[0096] Compound 72 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.57 min. MS (ES): m/z (MH^+) 683.0 for $C_{42}H_{83}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (m, 2H); 3.58 (br. m, 2H); 2.75-2.41 (br. m, 5H); 2.30 (m, 4H); 1.81 (br. m, 2H); 1.70-1.42 (m, 13H); 1.40-1.18 (m, 42H); 0.90 (m, 12H).

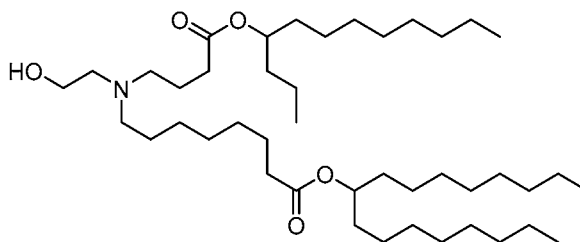
BI. Compound 73: Heptadecan-9-yl 8-((2-hydroxyethyl)(4-oxo-4-(pentadecan-7-yloxy)butyl)amino)octanoate

Chemical Formula: $C_{46}H_{91}NO_5$

Molecular Weight: 738.236

[0097] Compound 73 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.80 min. MS (ES): m/z (MH^+) 739.09 for $C_{46}H_{91}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 2H); 3.59 (br. m, 2H); 2.81-2.43 (br. m, 6H); 2.31 (m, 4H); 1.83 (m, 2H); 1.69-1.42 (m, 12H); 1.28 (m, 50H); 0.90 (m, 12H).

BJ. Compound 74: Heptadecan-9-yl 8-((4-(dodecan-4-yloxy)-4-oxobutyl)(2-hydroxyethyl)amino)octanoate

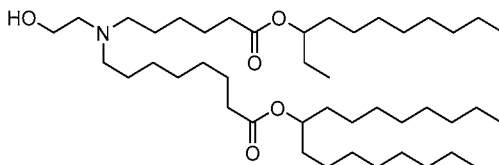
Chemical Formula: $C_{43}H_{85}NO_5$

Molecular Weight: 696.155

[0098] Compound 74 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.68 min. MS (ES): m/z

(MH⁺) 696.9 for C₄₃H₈₅NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 2H); 3.56 (m, 2H); 2.70-2.41 (m, 6H); 2.30 (m, 4H); 1.80 (m, 2H); 1.70-1.40 (m, 12H); 1.28 (m, 44H); 0.90 (m, 12H).

BK. Compound 75: Heptadecan-9-yl 8-((2-hydroxyethyl)(6-oxo-6-(undecan-3-yloxy)hexyl)amino)octanoate

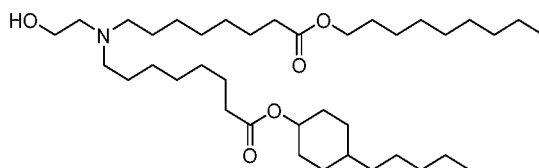


Chemical Formula: C₄₄H₈₇NO₅

Molecular Weight: 710.18

[0099] Compound 75 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.67 min. MS (ES): *m/z* (MH⁺) 711.1 for C₄₄H₈₇NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (m, 2H); 3.57 (m, 2H); 2.72-2.40 (br. m, 5H); 2.30 (m, 4H); 1.70-1.42 (m, 16H); 1.28 (m, 45H); 0.90 (m, 12H).

BL. Compound 79: Nonyl 8-((2-hydroxyethyl)(8-oxo-8-((4-pentylcyclohexyl)oxy)octyl)amino)octanoate

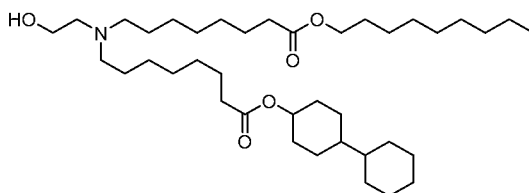


Chemical Formula: C₃₈H₇₃NO₅

Molecular Weight: 624.00

[00100] Compound 79 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.10 min. MS (ES): *m/z* (MH⁺) 624.8 for C₃₈H₇₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.00 (br. m, 0.5H); 4.68 (m, 0.5H); 4.08 (t, 2H); 3.56 (m, 2H); 2.72-2.38 (m, 6H); 2.31 (m, 4H); 1.97 (m, 1H); 1.82 (m, 2H); 1.73-0.95 (m, 48H); 0.90 (m, 6H).

BM. Compound 80: [1,1'-Bi(cyclohexan)]-4-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

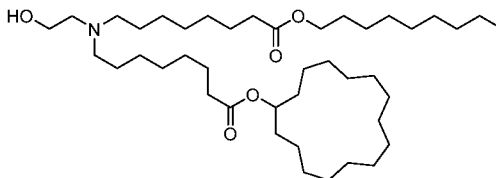


Chemical Formula: C₃₉H₇₃NO₅

Molecular Weight: 636.02

[00101] Compound 80 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.10 min. MS (ES): m/z (MH^+) 636.9 for $C_{39}H_{73}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.01 (br. m, 0.5H); 4.65 (m, 0.5H); 4.08 (t, 2H); 3.56 (m, 2H); 2.69-2.36 (m, 6H); 2.31 (m, 4H); 2.07-0.84 (m, 57H).

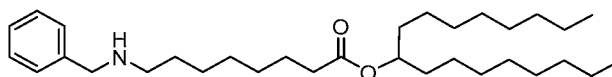
BN. Compound 81: Cyclopentadecyl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{42}H_{81}NO_5$

Molecular Weight: 680.11

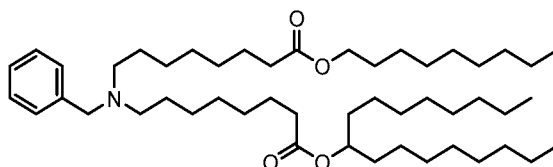
[00102] Compound 81 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.36 min. MS (ES): m/z (MH^+) 681.0 for $C_{42}H_{81}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.91 (p, 1H); 4.08 (t, 2H); 3.57 (br. m, 2H); 2.74-2.39 (m, 6H); 2.30 (m, 4H); 1.73-1.03 (m, 62H); 0.90 (m, 3H).

BO. Compound 94: Heptadecan-9-yl 8-(benzyl(8-nonyloxy)-8-oxooctyl)amino)octanoate
Heptadecan-9-yl 8-(benzylamino)octanoate

Chemical Formula: $C_{32}H_{57}NO_2$

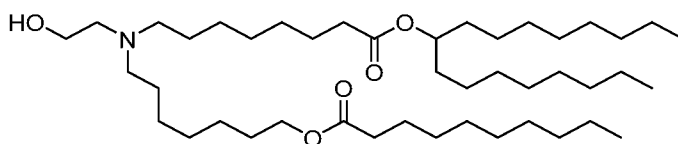
Molecular Weight: 487.81

[00103] A solution of heptadecan-9-yl 8-bromooctanoate (250 mg, 0.542 mmol) in phenylmethanamine (1.2 mL, 10.83 mmol) was allowed to stir at rt for 6 h. The reaction was cooled to rt and solvents were evaporated *in vacuo*. The residue was taken-up in ethyl acetate and washed with saturated aqueous sodium bicarbonate. The organic layer was separated and washed with brine, dried over Na_2SO_4 and evaporated *in vacuo*. The residue was purified by silica gel chromatography (20-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-(benzylamino)octanoate (200 mg, 0.41 mmol, 76%). UPLC/ELSD: RT = 2.87 min. MS (ES): m/z (MH^+) 488.4 for $C_{32}H_{57}NO_2$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.35-7.25 (br. m, 5H); 4.89 (p, 1H); 3.81 (s, 2H); 2.65 (t, 2H); 2.29 (t, 2H); 1.65-1.51 (br. m, 8H); 1.28 (m, 30H); 0.90 (m, 6H).

Heptadecan-9-yl 8-(benzyl(8-(nonyloxy)-8-oxooctyl)amino)octanoateChemical Formula: $C_{49}H_{89}NO_4$

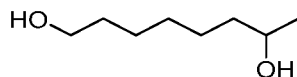
Molecular Weight: 756.25

[00104] A solution of heptadecan-9-yl 8-(benzylamino)octanoate (200 mg, 0.41 mmol), nonyl 8-bromooctanoate (172 mg, 0.49 mmol) and *N,N*-diisopropylethylamine (100 μ L, 0.57 mmol) were dissolved in ethanol and was allowed to stir at 62 °C for 48 h. The reaction was cooled to rt and solvents were evaporated *in vacuo*. The residue was taken-up in ethyl acetate and washed with saturated aqueous sodium bicarbonate. The organic layer was separated and washed with brine, dried over Na_2SO_4 and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-(benzyl(8-(nonyloxy)-8-oxooctyl)amino)octanoate (138 mg, 0.18 mmol, 45%). UPLC/ELSD: RT = 3.78 min. MS (ES): m/z (MH^+) 757.0 for $C_{49}H_{89}NO_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.33-7.23 (br. m, 5H); 4.89 (p, 1H); 4.08 (t, 2H); 3.55 (s, 2H); 2.40 (m, 4H); 2.30 (m, 4H); 1.64-1.28 (br. m, 62H); 0.90 (m, 9H).

BP. Compound 96: 7-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl decanoateChemical Formula: $C_{44}H_{87}NO_5$

Molecular Weight: 710.182

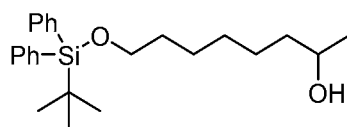
[00105] Compound 96 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.74 min. MS (ES): m/z (MH^+) 711.0 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.61 (m, 2H); 2.88-2.37 (br. m, 6H); 2.31 (m, 4H), 1.79-1.04 (m, 62H); 0.90 (m, 9H).

BQ. Compound 98: 8-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octan-2-yl decanoate**Octane-1,7-diol**

Chemical Formula: C₈H₁₈O₂

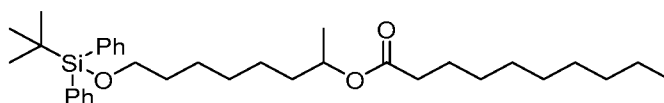
Molecular Weight: 146.230

[00106] A solution of 7-oxooctanoic acid (4 g, 25.29 mmol) in THF (10 mL) was added to a stirred solution of LAH in THF (70 mL) under N₂ at 0 °C. The mixture was allowed to warm to rt and stir at rt for 4 h, after which time 10 mL of sat. Na₂SO₄·10H₂O (aq) was added to the solution slowly. White solid crashed out. Additional solid Na₂SO₄·10H₂O was added and the mixture was filtered through a plug of celite. The filtrate was diluted with EtOAc and washed with brine. The organic layer was separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain octane-1,7-diol (2.97 g, 20.31 mmol, 80%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.81 (m, 1H); 3.66 (t, 2H); 1.66-1.31 (m, 12H); 1.22 (d, 3H).

8-((*tert*-Butyldiphenylsilyl)oxy)octan-2-olChemical Formula: C₂₄H₃₆O₂Si

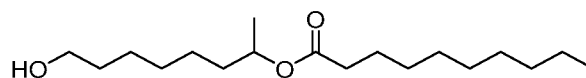
Molecular Weight: 384.635

[00107] To a solution of octane-1,7-diol (1 g, 6.84 mmol) in DCM (75 mL) at 0 °C imidazole (0.94 g, 13.81 mmol) was added followed by slow addition of a solution of *tert*-butyl(chloro)diphenylsilane (2.14 mL, 8.21 mmol) in DCM (using dropping funnel). The reaction allowed stir at 0 °C for 1.5 h. The reaction was quenched with saturated NH₄Cl(aq). The aqueous layer was extracted 3 times with a DCM (3 × 50 mL). The organic layer was dried over anhydrous MgSO₄ and filtered, and the solvent was evaporated. The crude product was purified by flash silica gel column chromatography 0-10% EtOAc in hexanes to obtain 8-((*tert*-butyldiphenylsilyl)oxy)octan-2-ol (2.29 g, 5.95 mmol, 87%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.69 (m, 4H); 7.42 (m, 6H); 3.80 (m, 1H); 3.68 (t, 2H); 1.59 (m, 2H); 1.50-1.26 (m, 9H); 1.21 (d, 3H); 1.07 (s, 9H).

8-((*tert*-Butyldiphenylsilyl)oxy)octan-2-yl decanoateChemical Formula: C₃₄H₅₄O₃Si

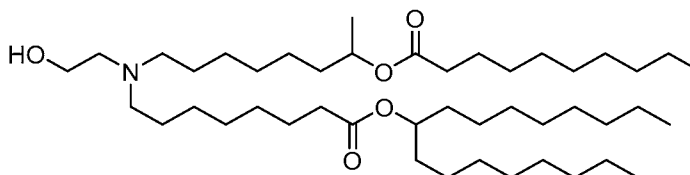
Molecular Weight: 538.888

[00108] 8-((*tert*-Butyldiphenylsilyl)oxy)octan-2-yl decanoate was synthesized according to Method A. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.69 (m, 4H); 7.42 (m, 6H); 4.92 (m, 1H); 3.67 (t, 2H); 2.29(t, 2H); 1.67-1.42 (m, 6H); 1.41-1.17 (m, 21H); 1.07 (s, 9H); 0.90 (m, 3H).

8-Hydroxyoctan-2-yl decanoateChemical Formula: C₁₈H₃₆O₃

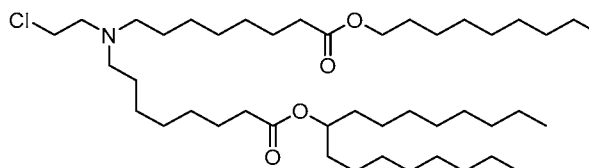
Molecular Weight: 300.483

[00109] To a solution of 8-[(*tert*-butyldiphenylsilyl)oxy]octan-2-yl decanoate (1.08 g, 2 mmol) in THF was added TBAF (8.02 mL 1 M solution in THF, 8.02 mmol) and the mixture was allowed to stir at rt for 3h. The organic solvents were evaporated under vacuum. The residue was diluted with EtOAc and washed with sat. NaHCO₃, followed by brine. The organic layer was separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain 8-hydroxyoctan-2-yl decanoate (0.55g, 1.82 mmol, 91%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 1H); 3.66 (t, 2H); 2.29 (t, 2H); 1.72-1.17 (m, 28H); 0.90 (m, 3H).

8-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octan-2-yl decanoateChemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.209

[00110] Compound 98 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.55 min. MS (ES): *m/z* (MH⁺) 725.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 2H); 3.58 (br. m, 2H); 2.77-2.40 (m, 6H); 2.29 (m, 4H); 1.72-1.41 (m, 14H); 1.28 (m, 51H); 0.90 (m, 9H).

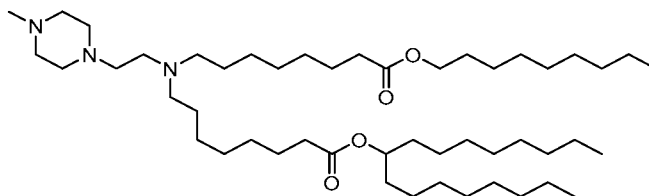
BR. Compound 101: Heptadecan-9-yl 8-((2-(4-methylpiperazin-1-yl)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate**Heptadecan-9-yl 8-((2-chloroethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate**Chemical Formula: C₄₄H₈₆ClNO₄

Molecular Weight: 728.63

[00111] A solution of heptadecan-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1100 mg, 1.55 mmol) in dichloromethane (25 mL) at 0 °C was added *N*-Chlorosuccinimide in one portion. The reaction was allowed to stir at 0 °C for 1 h followed

by 1 h at room temperature. Added 90 mL of hexanes and allowed the reaction to stir at room temperature for 20 min. Filtered off white solid through a silica gel plug and washed three times with hexanes. Organic layers were concentrated *in vacuo*. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.57 (m, 2H); 2.85 (m, 2H); 2.54 (m, 4H); 2.33-2.27 (m, 4H); 1.66-1.28 (br. m, 62H); 0.90 (m, 9H).

Heptadecan-9-yl 8-((2-(4-methylpiperazin-1-yl)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



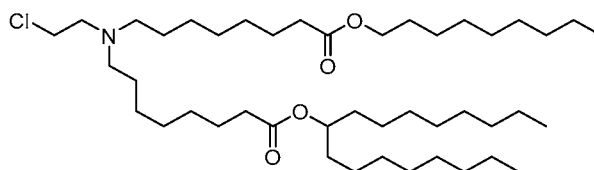
Chemical Formula: $\text{C}_{49}\text{H}_{97}\text{N}_3\text{O}_4$

Molecular Weight: 792.33

[00112] A solution of 1-methylpiperazine (15 mg, 0.151 mmol), heptadecan-9-yl 8-((2-chloroethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (110 mg, 0.151 mmol), K_2CO_3 (42 mg, 0.302 mmol) and KI (3 mg, 0.0151 mmol) were dissolved in 1:1 THF:MeCN (1 mL:1 mL). The reaction was allowed to stir at 65 °C for 18 hours. The reaction was cooled to room temperature, filtered and washed with hexanes and EtOAc. The organic filtrate was transferred to separatory funnel and washed with water and brine. Dried organic layers over Na_2SO_4 , filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography [0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane] to obtain heptadecan-9-yl 8-((2-(4-methylpiperazin-1-yl)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (36 mg, 0.045 mmol, 30%). UPLC/ELSD: RT = 3.25 min. MS (ES): m/z (MH^+) 792.8 for $\text{C}_{49}\text{H}_{97}\text{N}_3\text{O}_4$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.88 (p, 1H); 4.08 (t, 2H); 2.57-2.45 (br. m, 20H); 2.31 (m, 3H); 1.64-1.28 (br. m, 62H); 0.90 (m, 9H).

BS. Compound 103: Heptadecan-9-yl 8-((2-(4-methylpiperazin-1-yl)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Heptadecan-9-yl 8-((2-chloroethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

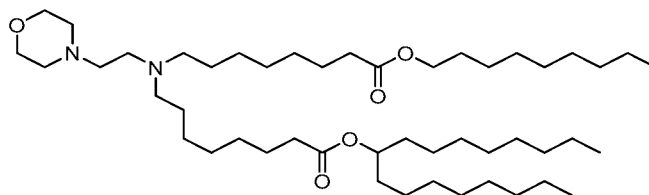


Chemical Formula: C₄₄H₈₆ClNO₄

Molecular Weight: 728.63

[00113] To a stirred solution of heptadecan-9-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1100 mg, 1.55 mmol) in dichloromethane (25 mL) at 0 °C was added *N*-Chlorosuccinimide in one portion. The reaction was allowed to stir at 0 °C for 1 h followed by 1h at room temperature. Added 90 mL of hexanes and allowed the reaction to stir at room temperature for 20 min. Filtered off white solid through a silica gel plug and washed three times with hexanes. Organic layers were concentrated *in vacuo*. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (p, 1H); 4.08 (t, 2H); 3.57 (m, 2H); 2.85 (m, 2H); 2.54 (m, 4H); 2.33-2.27 (m, 4H); 1.66-1.28 (br. m, 62H); 0.90 (m, 9H).

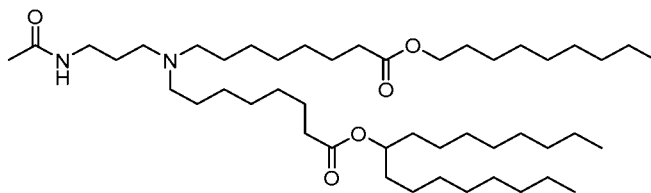
Heptadecan-9-yl 8-((2-morpholinoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₄₈H₉₄N₂O₅

Molecular Weight: 779.29

[00114] A solution of morpholine (13 mg, 0.151 mmol), heptadecan-9-yl 8-((2-chloroethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (110 mg, 0.151 mmol), K₂CO₃ (42 mg, 0.302 mmol) and KI (3 mg, 0.0151 mmol) were dissolved in 1:1 THF:MeCN (1 mL:1 mL). The reaction was allowed to stir at 65 °C for 18 hours. The reaction was cooled to room temperature, filtered and washed with hexanes and EtOAc. The organic filtrate was transferred to separatory funnel and washed with water and brine. Dried organic layers over Na₂SO₄, filtered and concentrated *in vacuo*. The residue was purified by silica gel chromatography [0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane] to obtain heptadecan-9-yl 8-((2-(4-methylpiperazin-1-yl)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (58 mg, 0.074 mmol, 49%). UPLC/ELSD: RT = 3.53 min. MS (ES): *m/z* (MH⁺) 779.8 for C₄₈H₉₄N₂O₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (p, 1H); 4.05 (t, 2H); 3.70 (m, 4H); 2.59-2.54 (m, 2H); 2.48-2.38 (m, 10H); 2.31-2.25 (m, 4H); 1.64-1.26 (br. m, 62H); 0.88 (m, 9H).

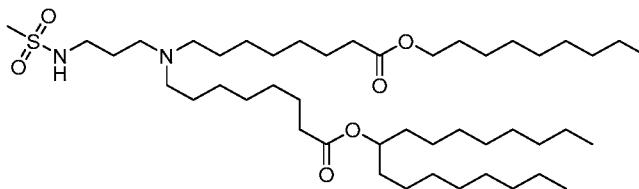
BT. Compound 108: Heptadecan-9-yl 8-((3-acetamidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₄₇H₉₂N₂O₅

Molecular Weight: 765.26

[00115] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol) and triethylamine (0.15 mL, 1.10 mmol) in 10 mL dichloromethane was added dropwise at 0 °C acetyl chloride (47 µL, 0.66 mmol), and the reaction mixture was allowed to warm to room temperature for 16 h. MS showed the product, and the mixture was diluted with dichloromethane and washed with saturated sodium bicarbonate and brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to provide the product as a colorless oil (300 mg, 71%). LC/UV (202 nm): RT = 9.14 min. MS (APCI): *m/z* (MH⁺) 765.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.41 (bs, 1H); 4.85 (p, 1H, *J* = 6.0 Hz); 4.04 (t, 2H, *J* = 6.6 Hz); 3.40-3.25 (m, 2H); 2.53-2.23 (m, 10H); 1.91 (s, 3H); 1.65-1.16 (m, 64H); 0.86 (m, 9H).

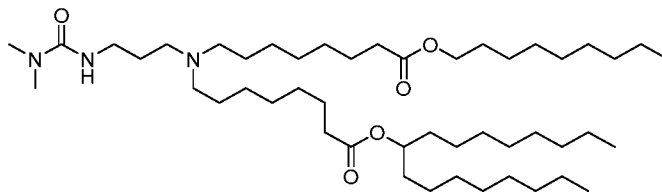
BU. Compound 109: Heptadecan-9-yl 8-((3-(methanesulfonylamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₄₆H₉₂N₂O₆S

Molecular Weight: 801.31

[00116] Methanesulfonyl chloride (51 µL, 0.66 mmol) was added dropwise to a 0 °C solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol) and triethylamine (0.15 mL, 1.10 mmol) in 10 mL dichloromethane, and the reaction mixture was allowed to warm to room temperature for 16 h. MS showed the product, and the mixture was diluted with dichloromethane and washed with saturated sodium bicarbonate and brine. After drying over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to provide the product as a colorless oil (296 mg, 88%). LC/UV (214 nm): RT = 11.51 min. MS (APCI): *m/z* (MH⁺) 801.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.85 (p, 1H, *J* = 6.0 Hz); 4.04 (t, 2H, *J* = 6.6 Hz); 3.22 (t, 2H, *J* = 5.8 Hz); 2.88 (s, 3H); 2.53-2.23 (m, 10H); 1.73-1.16 (m, 64H); 0.87 (m, 9H).

BV. Compound 110: Heptadecan-9-yl 8-((3-(3,3-dimethylureido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

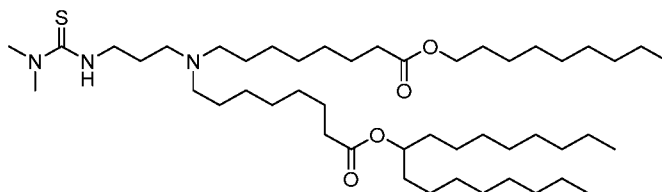


Chemical Formula: $C_{48}H_{95}N_3O_5$

Molecular Weight: 794.30

[00117] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol), dimethylaminopyridine (7 mg, 0.0553 mmol) and triethylamine (0.15 mL, 1.10 mmol) in 10 mL dichloromethane, dimethylcarbamic chloride (56 μ L, 0.61 mmol) was added dropwise at 0 °C, and the reaction mixture was allowed to stir at room temperature for 16 h. MS showed the product. The mixture was diluted with dichloromethane and washed with saturated sodium bicarbonate and brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a colorless oil (267 mg, 60%). LC/UV (202 nm): RT = 9.81 min. MS (APCI): m/z (MH⁺) 794.7. ¹H NMR (300 MHz, CDCl₃) δ : ppm 6.13 (t, 1H, J = 4.5 Hz); 4.85 (p, 1H, J = 6.0 Hz); 4.04 (t, 2H, J = 6.6 Hz); 3.32-3.26 (m, 2H); 2.85 (s, 6H); 2.52-2.23 (m, 10H); 1.67-1.18 (m, 64H); 0.87 (m, 9H).

BW. Compound 111: Heptadecan-9-yl 8-((3-(3,3-dimethylthioureido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



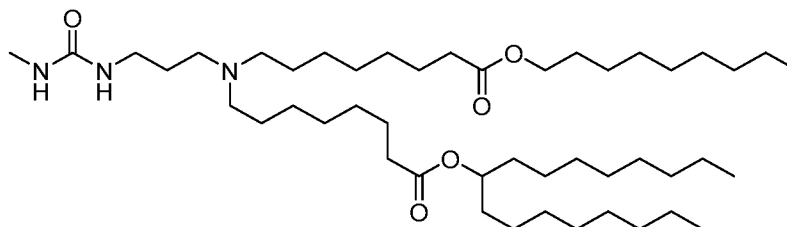
Chemical Formula: $C_{48}H_{95}N_3O_4S$

Molecular Weight: 810.37

[00118] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol) and triethylamine (0.15 mL, 1.10 mmol) in 10 mL dichloromethane was added dropwise at 0 °C thiophosgene (51 μ L, 0.664 mmol), and the reaction mixture was allowed to stir at room temperature for 6 h. After this time, the reaction was cooled to 0 °C, and a solution of dimethylamine in THF (2.0 M, 0.55 mL, 1.10 mmol) was added. The reaction was then allowed to stir at room temperature for 16 h. MS showed the product, and the mixture was diluted with dichloromethane and washed with saturated sodium

bicarbonate and brine. After drying over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a brown oil (346 mg, 77%). LC/UV (202 nm): RT = 9.89 min. MS (APCI): *m/z* (MH⁺) 810.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 8.12 (bs, 1H); 4.85 (p, 1H, *J* = 6.0 Hz); 4.04 (t, 2H, *J* = 6.6 Hz); 3.74-3.64 (m, 2H); 3.20 (s, 6H); 2.62-2.23 (m, 10H); 1.77-1.17 (m, 64H); 0.87 (m, 9H).

BX. Compound 112: Heptadecan-9-yl 8-((3-(3-methylureido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

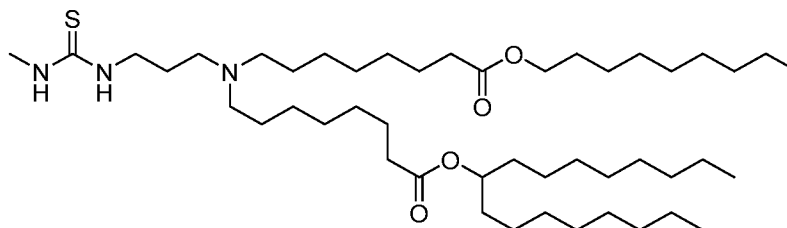


Chemical Formula: C₄₇H₉₃N₃O₅

Molecular Weight: 780.28

[00119] To a 0 °C solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol) in 10 mL dichloromethane was methyl isocyanate (38 mg, 0.664 mmol), and the reaction mixture was allowed to stir at room temperature for 16 h. MS showed the product. The mixture was diluted with dichloromethane and washed with saturated sodium bicarbonate and brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a colorless oil (320 mg, 70%). LC/UV (202 nm): RT = 9.63 min. MS (APCI): *m/z* (MH⁺) 780.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.54 (bs, 1H); 4.85 (p, 1H, *J* = 6.0 Hz); 4.76 (bs, 1H); 4.04 (t, 2H, *J* = 6.6 Hz); 3.23 (t, 2H, *J* = 5.8 Hz); 2.74 (d, 3H, *J* = 2.0 Hz); 2.47 (t, 2H, *J* = 6.0 Hz); 2.37 (t, 4H, *J* = 7.4 Hz); 2.31-2.23 (m, 4H); 1.68-1.17 (m, 64H); 0.87 (m, 9H).

BY. Compound 113: Heptadecan-9-yl 8-((3-(3-methylthioureido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

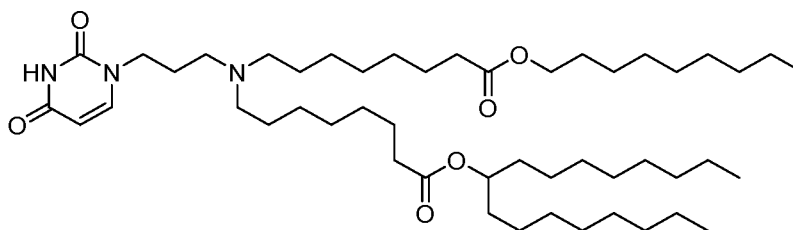


Chemical Formula: C₄₉H₉₃N₃O₄S

Molecular Weight: 795.69

[00120] To a 0 °C solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.553 mmol) in 10 mL dichloromethane was added methyl isothiocyanate (45 μ L, 0.664 mmol), and the reaction mixture was allowed to stir at room temperature for 16 h. MS showed the product. The mixture was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a colorless oil (312 mg, 70%). LC/UV (202 nm): RT = 9.96 min. MS (APCI): m/z (MH⁺) 796.7. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.85 (p, 1H, J = 6.0 Hz); 4.04 (t, 2H, J = 6.6 Hz); 3.51 (bs, 2H); 2.93 (bs, 3H); 2.52 (t, 2H, J = 6.0 Hz); 2.41 (t, 4H, J = 7.8 Hz); 2.31-2.23 (m, 4H); 1.68-1.17 (m, 66H); 0.86 (m, 9H).

BZ. Compound 114: Heptadecan-9-yl 8-((3-(2,4-dioxo-3,4-dihydropyrimidin-1(2H)-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

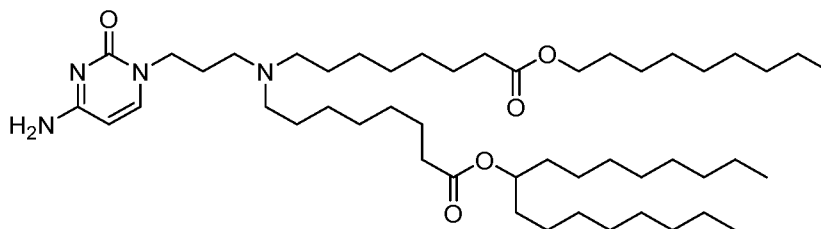


Chemical Formula: C₄₉H₉₁N₃O₆

Molecular Weight: 818.28

[00121] A mixture of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.67 mmol), uracil (300 mg, 2.67 mmol) and 1,8-diazabicycloundec-7-ene (150 μ L, 1.07 mmol) in 3 mL DMF was heated at 100 °C in a sealed tube for 16 h. The reaction mixture was concentrated to dryness and partitioned between dichloromethane and water. The organic layer was washed with brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a yellow oil (268 mg, 49%). LC/UV (202 nm): RT = 8.91 min. MS (APCI): m/z (MH⁺) 818.7. ¹H NMR (300 MHz, CDCl₃) δ : ppm 8.19 (bs, 1H); 7.24 (d, 1H, J = 7.7 Hz); 5.64 (d, 1H, J = 7.7 Hz); 4.85 (p, 1H, J = 6.0 Hz); 4.04 (t, 2H, J = 6.6 Hz); 3.76 (t, 2H, J = 7.0 Hz); 2.45-2.24 (m, 10H); 1.81 (p, 2H, J = 6.6 Hz); 1.68-1.17 (m, 62H); 0.87 (m, 9H).

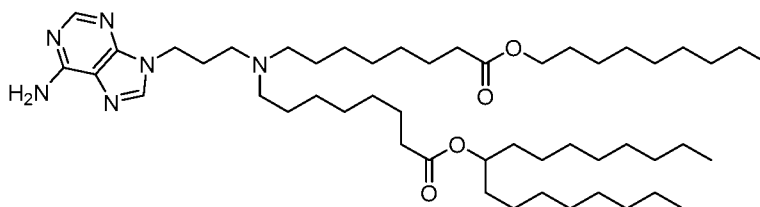
CA. Compound 115: Heptadecan-9-yl 8-((3-(4-amino-2-oxopyrimidin-1(2H)-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₄₉H₉₂N₄O₅

Molecular Weight: 817.30

[00122] To a suspension of cytosine (82 mg, 0.74 mmol) in 1 mL DMF was added NaH (30 mg, 0.74 mmol) and the reaction mixture was stirred at room temperature for 30 min. A solution of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.67 mmol) in 2 mL DMF was then added and the mixture was heated at 100 °C in a sealed tube for 16 h. MS showed product. The reaction was quenched with saturated sodium bicarbonate and extracted with hexanes (2X). The combined organic layer was washed with water and brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a yellow oil (310 mg, 56%). LC/UV (202 nm): RT = 8.32 min. MS (APCI): *m/z* (MH⁺) 817.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.34 (d, 1H, *J* = 7.1 Hz); 5.61 (d, 1H, *J* = 7.1 Hz); 5.44 (bs, 2H); 4.85 (p, 1H, *J* = 6.0 Hz); 4.04 (t, 2H, *J* = 6.6 Hz); 3.79 (t, 2H, *J* = 7.0 Hz); 2.42-2.22 (m, 9H); 1.84 (t, 2H, *J* = 6.6 Hz); 1.68-1.17 (m, 63H); 0.86 (m, 9H).

CB. Compound 116: Heptadecan-9-yl 8-((3-(6-amino-9H-purin-9-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₅₀H₉₂N₆O₄

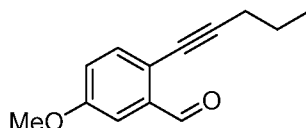
Molecular Weight: 841.32

[00123] A mixture of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.67 mmol), adenine (135 mg, 1.0 mmol) and 1,8-diazabicycloundec-7-ene (137 μL, 1.0 mmol) in 2 mL DMF was heated at 90 °C in a sealed tube for 16 h. The reaction mixture was concentrated to dryness and partitioned between dichloromethane and water. The organic layer was washed with brine. After it was dried over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to afford the product as a yellow oil (325 mg, 57%). LC/UV (202 nm): RT =

8.47 min. MS (APCI): m/z (MH^+) 841.7. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 8.36 (s, 1H); 7.80 (s, 1H); 5.51 (bs, 2H); 4.85 (p, 1H, $J = 6.0$ Hz); 4.24 (t, 2H, $J = 7.0$ Hz); 4.04 (t, 2H, $J = 6.6$ Hz); 2.45-2.24 (m, 10H); 2.01 (p, 2H, $J = 6.9$ Hz); 1.68-1.17 (m, 62H); 0.86 (m, 9H).

CC. Compound 118: 3,4-Dipentylphenyl 8-((2-hydroxyethyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate

5-Methoxy-2-(pent-1-yn-1-yl)benzaldehyde (see e.g., *Bioorg. Med. Chem. Lett.* **2013**, 23, 1365)

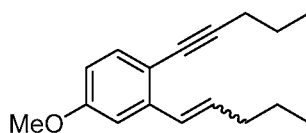


Chemical Formula: $C_{13}H_{14}O_2$

Molecular Weight: 202.25

[00124] A mixture of 2-bromo-5-methoxybenzaldehyde (4.30 g, 20 mmol), 1-pentyne (3.0 mL, 30 mmol), bis(triphenylphosphino)palladium chloride (702 mg, 1 mmol), CuI (380 mg, 2.0 mmol) and triethylamine (5.6 mL, 40 mmol) in 60 mL THF was heated to 50 °C for 16 h under nitrogen. TLC showed the disappearance of starting material. The reaction mixture was concentrated to dryness. The residue was dissolved in dichloromethane and washed with water and brine. After drying over sodium sulfate, the filtrate was concentrated and the residue was purified by ISCO (SiO_2 : EtOAc/Hexanes 0 to 5%) to afford the product as a dark brown oil (3.00 g, 74%). ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 10.49 (s, 1H); 7.42 (d, 1H, $J = 8.5$ Hz); 7.36 (d, 1H, $J = 2.8$ Hz); 7.07 (dd, 1H, $J = 8.5$ Hz, 2.8 Hz); 3.84 (s, 3H); 2.44 (t, 2H, $J = 7.0$ Hz); 1.62 (m, 2H); 1.05 (t, 3H, $J = 7.2$ Hz).

4-Methoxy-2-(pent-1-en-1-yl)-1-(pent-1-yn-1-yl)benzene



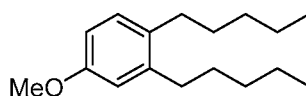
Chemical Formula: $C_{17}H_{22}O$

Molecular Weight: 242.36

[00125] To a suspension of butyl triphenylphosphonium bromide (8.88 g, 22.2 mmol) in 75 mL THF was added at 0 °C potassium tert-butoxide (2.50 g, 22.2 mmol). After 30 min, a solution of 5-methoxy-2-(pent-1-yn-1-yl)benzaldehyde (3.00 g, 14.8 mmol) in 25 mL THF was then added slowly into the orange suspension. The reaction mixture was allowed to warm up to room temperature and stir for 60 h. Saturated ammonium chloride solution was added and the mixture was extracted with ether (2X), and the combined organic layer was washed with brine. After drying over sodium sulfate, the filtrate was concentrated and the residue was purified by

ISCO (SiO₂: EtOAc/Hexanes 0 to 5%) to afford the product as a brown oil (3.46 g, 96%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.33 (d, 0.5H, *J* = 8.5 Hz); 7.26 (d, 0.5H, *J* = 8.5 Hz); 6.99 (d, 0.5H, *J* = 2.8 Hz); 6.88-6.80 (m, 1H); 6.73-6.61 (m, 1.5H); 6.25 (dt, 0.5H, *J* = 15.9 Hz, 6.9 Hz); 5.73 (dt, 0.5H, *J* = 11.5 Hz, 7.4 Hz); 3.80 (s, 3H); 2.45-2.37 (m, 2H); 2.31-2.18 (m, 2H); 1.71-1.41 (m, 4H); 1.09-0.90 (m, 6H).

4-Methoxy-1,2-dipentylbenzene

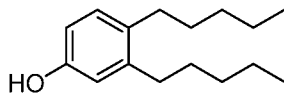


Chemical Formula: C₁₇H₂₈O

Molecular Weight: 248.41

[00126] A mixture of 4-methoxy-2-(pent-1-en-1-yl)-1-(pent-1-yn-1-yl)benzene (3.46 g, 14.3 mmol) and Pd/C (10%, 300 mg) in 60 mL EtOH was stirred for 60 h under a hydrogen balloon. TLC showed complete reaction. The reaction mixture was filtered through Celite and concentrated to afford the product as a yellow oil (3.70 g, quant.), which was used for the next step without purification. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.05 (d, 1H, *J* = 8.2 Hz); 6.72-6.55 (m, 2H); 3.78 (s, 3H); 2.59-2.50 (m, 4H); 1.62-1.48 (m, 4H); 1.39-1.28 (m, 8H); 0.93-0.86 (m, 6H).

3,4-Dipentylphenol

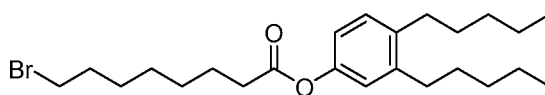


Chemical Formula: C₁₆H₂₆O

Molecular Weight: 234.38

[00127] To a solution of 4-methoxy-1,2-dipentylbenzene (3.40 g, 13.7 mmol) in 75 mL dichloromethane was added dropwise at -78 °C BBr₃ (1.65 mL, 17.1 mmol), and then the reaction was allowed to warm to room temperature over 3 h. TLC showed complete reaction. The reaction was quenched by addition of saturated sodium bicarbonate, and then it was extracted with dichloromethane (2X). The combined organic layer was washed with brine and dried over sodium sulfate. After concentration, the residue was purified by ISCO (SiO₂: EtOAc/Hexanes 0 to 30%) to afford the product as a brown oil (3.35 g, 97%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.99 (d, 1H, *J* = 8.0 Hz); 6.64-6.59 (m, 2H); 4.45 (bs, 1H); 2.55-2.47 (m, 4H); 1.66-1.43 (m, 4H); 1.39-1.28 (m, 8H); 0.93-0.86 (m, 6H).

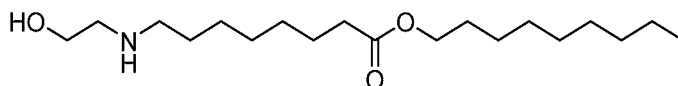
3,4-Dipentylphenyl 8-bromooctanoate



Chemical Formula: $C_{24}H_{39}BrO_2$

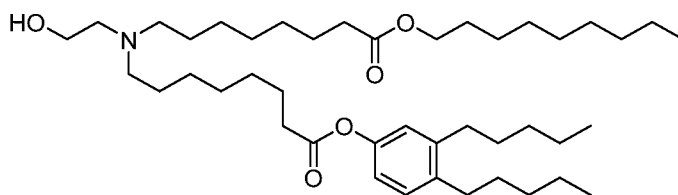
Molecular Weight: 439.48

[00128] To a solution of 8-bromooctanoic acid (2.23g, 10 mmol) and 3,4-dipentylphenol (2.34 g, 10 mmol) in dichloromethane (50 mL) were added *N*-(3-Dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (1.92 g, 10 mmol) and DMAP (244 mg, 2 mmol). The reaction was allowed to stir at room temperature for 18 h. The reaction was diluted with dichloromethane and extracted with saturated sodium bicarbonate. The organic layer was separated and washed with brine, dried over sodium sulfate. The organic layer was filtered and evaporated under vacuum. The residue was purified by ISCO (SiO_2 : EtOAc/Hexanes 0 to 10%) to afford the product as a brown oil (4.30 g, 98%). ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.11 (d, 1H, $J = 7.7$ Hz); 6.84-6.77 (m, 2H); 3.41 (t, 2H, $J = 6.9$ Hz); 2.60-2.49 (m, 6H); 1.92-1.69 (m, 4H); 1.62-1.29 (m, 18H); 0.90 (m, 6H).

Nonyl 8-((2-hydroxyethyl)amino)octanoateChemical Formula: $C_{19}H_{39}NO_3$

Molecular Weight: 329.53

[00129] A mixture of nonyl 8-bromooctanoate (2.50 g, 7.15 mmol) and 2-aminoethanol (4.3 mL, 71.5 mmol) in 10 mL EtOH was stirred at room temperature for 60 h. The reaction mixture was partitioned with hexanes and water, and the organic layer was washed with brine. After drying over sodium sulfate, the filtrate was concentrated and purified by ISCO (SiO_2 : MeOH/ CH_2Cl_2 /1% NH_4OH 0 to 20%) to afford the product as white solid (1.57 g, 66%). MS (APCI): m/z (MH^+) 330.3. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.04 (t, 2H, $J = 6.6$ Hz); 3.63 (t, 2H, $J = 5.2$ Hz); 2.77 (t, 2H, $J = 5.1$ Hz); 2.61 (t, 2H, $J = 7.1$ Hz); 2.28 (t, 2H, $J = 7.4$ Hz); 1.99 (bs, 2H); 1.67-1.20 (m, 4H); 1.62-1.29 (m, 17H); 0.87 (m, 6H).

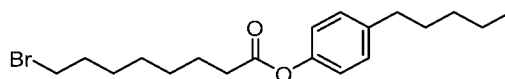
3,4-Dipentylphenyl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoateChemical Formula: $C_{43}H_{77}NO_5$

Molecular Weight: 688.09

[00130] A solution of nonyl 8-((2-hydroxyethyl)amino)octanoate (500 mg, 1.52 mmol), 3,4-dipentylphenyl 8-bromooctanoate (1.00 g, 2.27 mmol) and *N,N*-diisopropylethylamine (0.40

mL, 2.27 mmol) in *tert*-butanol (3 mL) was heated to 60 °C in a sealed tube for 60 h. The reaction was cooled to room temperature and solvents were evaporated under vacuum. The residue was purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to obtain mixture (365 mg), and then the mixture was purified by ISCO (EtOAc/Hexanes/0.5% Et₃N 0 to 50%) to afford product as a colorless oil (80 mg). LC/UV (214 nm): RT = 10.23 min. MS (APCI): *m/z* (MH⁺) 688.6. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.11 (d, 1H, *J* = 8.0 Hz); 6.84-6.77 (m, 2H); 4.04 (t, 2H, *J* = 6.6 Hz); 3.51 (t, 2H, *J* = 5.5 Hz); 2.60-2.38 (m, 12H); 2.28 (t, 2H, *J* = 7.4 Hz); 1.79-1.19 (m, 37H); 0.92-0.82 (m, 9H).

CD. Compound 119: Nonyl 8-((2-hydroxyethyl)(8-oxo-8-(4-pentylphenoxy)octyl)amino)octanoate
4-Pentylphenyl 8-bromooctanoate

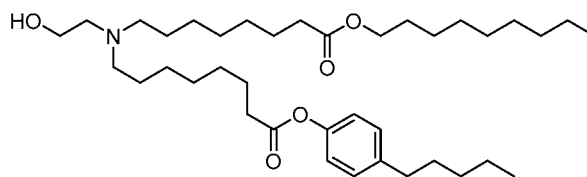


Chemical Formula: C₁₉H₂₉BrO₂

Molecular Weight: 369.34

[00131] To a solution of 8-bromooctanoic acid (2.00 g, 8.96 mmol) and 4-pentylphenol (3.07 mL, 17.9 mmol) in dichloromethane (50 mL) were added *N*-(3-Dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (1.72 g, 8.96 mmol) and DMAP (220 mg, 1.79 mmol). The reaction was allowed to stir at room temperature for 60 h. The reaction was diluted with dichloromethane and extracted with saturated sodium bicarbonate. The organic layer was separated and washed with brine, and dried over sodium sulfate. The organic layer was filtered and evaporated under vacuum. The residue was purified by ISCO (SiO₂: EtOAc/Hexanes 0 to 10%) to afford the product as a colorless oil (3.12 g, 94%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.16 (d, 2H, *J* = 8.5 Hz); 6.96 (d, 2H, *J* = 8.5 Hz); 3.41 (t, 2H, *J* = 6.9 Hz); 2.61-2.49 (m, 4H); 1.92-1.69 (m, 4H); 1.65-1.25 (m, 10H); 0.88 (m, 3H).

Nonyl 8-((2-hydroxyethyl)(8-oxo-8-(4-pentylphenoxy)octyl)amino)octanoate



Chemical Formula: C₃₈H₆₇NO₅

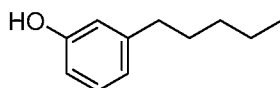
Molecular Weight: 617.96

[00132] A solution of nonyl 8-((2-hydroxyethyl)amino)octanoate (500 mg, 1.52 mmol), 4-pentylphenyl 8-bromooctanoate (840 mg, 2.28 mmol) and *N,N*-diisopropylethylamine (0.40 mL, 2.28 mmol) in *tert*-butanol (3 mL) was heated to 60 °C in a sealed tube for 48 h. The

reaction was cooled to room temperature and solvents were evaporated under vacuum. The residue was purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to obtain mixture (360 mg), and then the mixture was purified by ISCO (EtOAc/Hexanes/0.5% Et₃N 0 to 50%) to afford the product as a colorless oil (95 mg). LC/UV (214 nm): RT = 9.63 min. MS (APCI): *m/z* (MH⁺) 618.5. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.11 (d, 1H, *J* = 8.0 Hz); 6.84-6.77 (m, 2H); 4.04 (t, 2H, *J* = 6.6 Hz); 3.51 (t, 2H, *J* = 5.5 Hz); 2.60-2.38 (m, 12H); 2.28 (t, 2H, *J* = 7.4 Hz); 1.79-1.19 (m, 37H); 0.92-0.82 (m, 9H).

CE. Compound 120: Nonyl 8-((2-hydroxyethyl)(8-oxo-8-(3-pentylphenoxy)octyl)amino)octanoate

3-Pentylphenol (Ref: *Tetrahedron Lett.* **2013**, 54, 52)

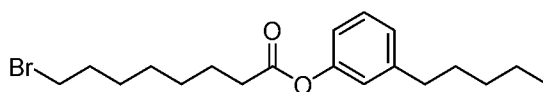


Chemical Formula: C₁₁H₁₆O

Molecular Weight: 164.25

[00133] At -78 °C, to a suspension of potassium tert-butoxide (6.73 g, 60 mmol) in 15 mL pentane were added sequentially tetramethylethylenediamine (9.0 mL, 60 mmol) and BuLi (2.5 M in hexane, 24 mL, 60 mmol), and a solution of m-cresol (2.6 mL, 25 mmol) in 10 mL pentane was added slowly. The reaction mixture was warmed up to -20 °C for 3 h. 30 mL THF was added and the reaction was cooled to -60 °C. Butyl bromide (4.8 mL, 45 mmol) was added slowly, and the mixture was allowed warm to room temperature and stir for 16 h. After cooled to 0 °C, the reaction mixture was acidified with 4 M HCl to pH~3, and then extracted with ether. The combined organic layer was washed with brine and dried over sodium sulfate. After concentration, the residue was purified by ISCO (EtOAc/Hexanes 0 to 5%) to provide a mixture of product with starting material, which was distilled under vacuum to provide the product as a colorless oil (1.23 g, 65%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.14 (t, 1H, *J* = 7.7 Hz); 6.75 (d, 1H, *J* = 7.7 Hz); 6.67-6.61 (m, 2H); 4.62 (s, 1H); 2.55 (t, 2H, *J* = 7.7 Hz); 1.67-1.52 (m, 2H); 1.38-1.24 (m, 4H); 0.88 (t, 3H, *J* = 6.9 Hz).

3-Pentylphenyl 8-bromooctanoate



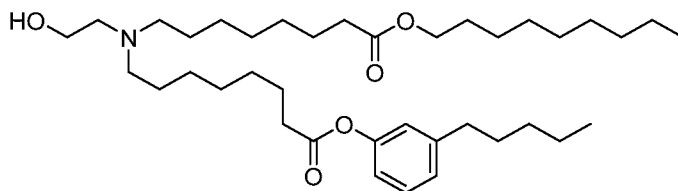
Chemical Formula: C₁₉H₂₉BrO₂

Molecular Weight: 369.34

[00134] To a solution of 8-bromooctanoic acid (1.84 g, 8.20 mmol) and 3-pentylphenol (1.23 g, 7.49 mmol) in dichloromethane (40 mL) were added *N*-(3-Dimethylaminopropyl)-*N'*-

ethylcarbodiimide hydrochloride (1.58 g, 8.20 mmol) and DMAP (183 mg, 1.50 mmol). The reaction was allowed to stir at room temperature for 16 h. The reaction was diluted with dichloromethane and extracted with saturated sodium bicarbonate. The organic layer was separated and washed with brine, dried over sodium sulfate. The organic layer was filtered and evaporated under vacuum. The residue was purified by ISCO (SiO₂: EtOAc/Hexanes 0 to 10%) to provide the product as a colorless oil (2.23 g, 80%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.26 (t, 1H, *J* = 8.5 Hz); 7.03 (d, 1H, *J* = 7.6 Hz); 6.91-6.84 (m, 2H); 3.41 (t, 2H, *J* = 6.9 Hz); 2.61-2.49 (m, 4H); 1.92-1.69 (m, 4H); 1.65-1.25 (m, 12H); 0.88 (t, 3H, *J* = 6.9 Hz).

Nonyl 8-((2-hydroxyethyl)(8-oxo-8-(3-pentylphenoxy)octyl)amino)octanoate

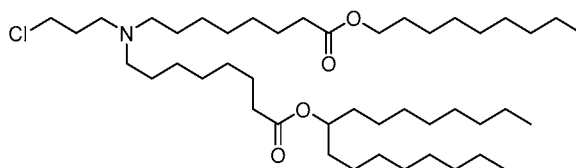


Chemical Formula: C₃₈H₆₇NO₅

Molecular Weight: 617.96

[00135] A solution of nonyl 8-((2-hydroxyethyl)amino)octanoate (500 mg, 1.52 mmol), 3-pentylphenyl 8-bromooctanoate (840 mg, 2.28 mmol) and *N,N*-diisopropylethylamine (0.40 mL, 2.28 mmol) in tert-butanol (3 mL) was stirred at 60 °C in a sealed tube for 16 h. The reaction was cooled to room temperature and solvents were evaporated under vacuum. The residue was purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 5%) to obtain a mixture (247 mg), and then the mixture was purified by ISCO (EtOAc/Hexanes/0.5% Et₃N 0 to 50%) to afford the product as a colorless oil (150 mg). LC/UV (202 nm): RT = 7.45 min. MS (APCI): *m/z* (MH⁺) 618.5. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.26 (t, 1H, *J* = 8.5 Hz); 7.03 (d, 1H, *J* = 7.6 Hz); 6.91-6.84 (m, 2H); 4.05 (t, 2H, *J* = 6.6 Hz); 3.51 (t, 2H, *J* = 5.5 Hz); 2.64-2.38 (m, 10H); 2.28 (t, 2H, *J* = 7.8 Hz); 1.79-1.19 (m, 41H); 0.91-0.82 (m, 6H).

CF. Compound 121: Heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
Heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

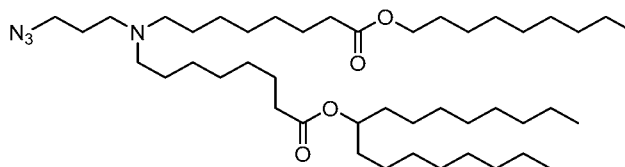


Chemical Formula: C₄₅H₈₈ClNO₄

Molecular Weight: 742.65

[00136] To a solution of heptadecan-9-yl 8-((3-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (8.00 g, 11.0 mmol) and triethylamine (2.0 mL, 14.4 mmol) in dichloromethane (200 mL) was added dropwise methanesulfonyl chloride (1.07 mL, 13.8 mmol) at 0 °C, and the reaction mixture was allowed to room temperature for 16 h. TLC and MS showed complete reaction. The reaction mixture was diluted with dichloromethane and washed with saturated sodium bicarbonate and brine. After drying over sodium sulfate, the solvent was removed under vacuum to give the product as a brown oil (7.30 g, 89%). NMR showed the crude contained a small amount of mesylate and desired chloride. This was used for the next step without purification. MS (APCI): m/z (MH^+) 742.6. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (p, 1H, $J = 6.0$ Hz); 4.05 (t, 2H, $J = 6.9$ Hz); 3.58 (t, 2H, $J = 6.6$ Hz); 2.58-2.22 (m, 9H); 1.92-1.16 (m, 65H); 0.87 (m, 9H).

Heptadecan-9-yl 8-((3-azidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

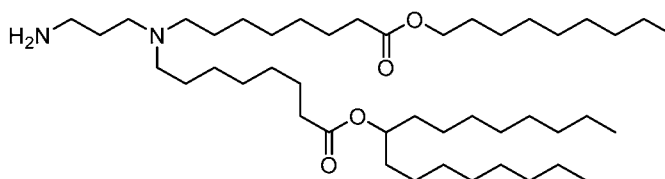


Chemical Formula: $C_{45}H_{88}N_4O_4$

Molecular Weight: 749.22

[00137] A mixture of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (4.20 g, 5.66 mmol) and sodium azide (1.75 g, 28.28 mmol) in 20 mL DMF in a sealed tube was heated to 100 °C for 16 h. After it was cooled to room temperature, the reaction mixture was diluted with water and extracted with hexanes. The combined organic layer was washed with water and brine, and then dried over sodium sulfate. After filtration and concentration, the residue was purified by ISCO (SiO_2 : MeOH/ CH_2Cl_2 /1% NH_4OH 0 to 5%) to provide the product as a brown oil (3.66 g, 86%). MS (APCI): m/z (MH^+) 749.7. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.85 (p, 1H, $J = 6.0$ Hz); 4.04 (t, 2H, $J = 6.7$ Hz); 3.32 (t, 2H, $J = 6.9$ Hz); 2.58-2.22 (m, 10H); 1.72-1.19 (m, 64H); 0.87 (m, 9H).

Heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

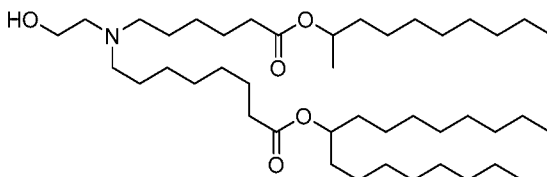


Chemical Formula: $C_{45}H_{90}N_2O_4$

Molecular Weight: 723.23

[00138] A mixture of heptadecan-9-yl 8-((3-azidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (3.66 g, 4.89 mmol) and Pd/C (10%, 400 mg) in 150 mL EtOH was stirred under hydrogen balloon for 16 h. MS showed complete reaction. The reaction mixture was filtered through Celite, and the filtrate was concentrated and purified by ISCO (SiO₂: MeOH/CH₂Cl₂/1% NH₄OH 0 to 20%) to afford the product as a brown oil (3.08 g, 87%). LC/UV (202 nm): RT = 8.39 min. MS (APCI): *m/z* (MH⁺) 723.7. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.85 (p, 1H, *J* = 6.0 Hz); 4.04 (t, 2H, *J* = 6.6 Hz); 2.70 (t, 2H, *J* = 6.9 Hz); 2.46-2.24 (m, 10H); 1.65-1.16 (m, 66H); 0.87 (m, 9H).

CG. Compound 122: Heptadecan-9-yl 8-((6-(decan-2-yloxy)-6-oxohexyl)(2-hydroxyethyl)amino)octanoate

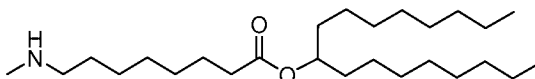


Chemical Formula: C₄₃H₈₅NO₅

Molecular Weight: 696.16

[00139] Compound 122 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.58 min. MS (ES): *m/z* (MH⁺) 697.1 for C₄₃H₈₅NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 2H); 3.62 (m, 2H); 2.81-2.42 (br. m, 5H); 2.30 (m, 4H); 1.73-1.43 (m, 14H); 1.28 (m, 48H); 0.90 (m, 9H).

CH. Compound 123: Heptadecan-9-yl 8-(methyl(8-nonyloxy)-8-oxooctyl)amino)octanoate

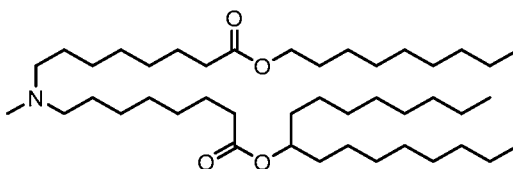


Chemical Formula: C₂₆H₅₃NO₂

Molecular Weight: 411.72

[00140] A solution of heptadecan-9-yl 8-bromooctanoate (200 mg, 0.433 mmol) in methanamine (10 mL, 19.92 mmol, 2M in THF) was allowed to stir at rt for 18 h. The reaction mixture was concentrated *in vacuo*. The residue was purified by silica gel chromatography (10-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-(methylamino)octanoate (113 mg, 0.27 mmol, 63%). UPLC/ELSD: RT = 2.76 min. MS (ES): *m/z* (MH⁺) 412.4 for C₂₆H₅₃NO₂. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.92 (p, 1H); 2.62 (t, 2H); 2.48 (s, 3H); 2.32-2.27 (m, 2H); 1.66-1.52 (br. m, 8H); 1.28 (m, 30H); 0.90 (m, 6H).

Heptadecan-9-yl 8-(methyl(8-(nonyloxy)-8-oxooctyl)amino)octanoate

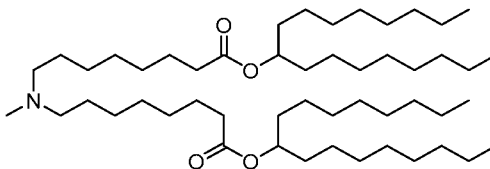


Chemical Formula: C₄₃H₈₅NO₄

Molecular Weight: 680.16

[00141] A solution of heptadecan-9-yl 8-(methylamino)octanoate (113 mg, 0.27 mmol), nonyl 8-bromooctanoate (115 mg, 0.33 mmol) and *N,N*-diisopropylethylamine (67 μ L, 0.38 mmol) and potassium iodide (5 mg, 0.027 mmol) were dissolved in ethanol and was allowed to stir at 62 °C for 48 h. The reaction was cooled to rt and solvents were evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-(methyl(8-(nonyloxy)-8-oxooctyl)amino)octanoate (75 mg, 0.11 mmol, 41%). UPLC/ELSD: RT = 3.84 min. MS (ES): *m/z* (MH⁺) 681.0 for C₄₃H₈₅NO₄. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.88 (p, 1H); 4.08 (t, 2H); 2.88-2.67 (br. m, 7H); 2.34-2.27 (m, 4H); 1.80 (m, 4H); 1.63-1.52 (br. m, 10H); 1.37-1.28 (br. m, 48H); 0.90 (m, 9H).

CI. Compound 124: Di(heptadecan-9-yl) 8,8'-(methylazanediyl)diocanoate



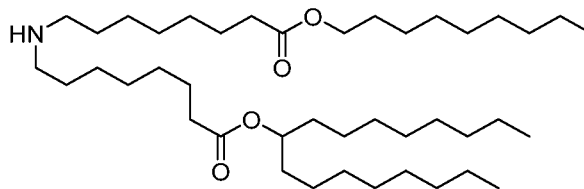
Chemical Formula: C₅₁H₁₀₁NO₄

Molecular Weight: 792.37

[00142] A solution of heptadecan-9-yl 8-bromooctanoate (500 mg, 1.08 mmol) in methanamine (11 mL, 21.67 mmol, 2M in THF) was allowed to stir at rt for 6 h. The reaction mixture was concentrated *in vacuo*. The residue was purified by silica gel chromatography (20-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain di(heptadecan-9-yl) 8,8'-(methylazanediyl)diocanoate (26 mg, 0.03 mmol, 3%). UPLC/ELSD: RT = 4.03 min. MS (ES): *m/z* (MH⁺) 793.3 for C₅₁H₁₀₁NO₄. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (p, 2H); 2.32-2.24 (m, 11H); 1.66-1.28 (br. m, 76H); 0.90 (m, 12H).

CJ. Compound 125: 3-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)propanoic acid

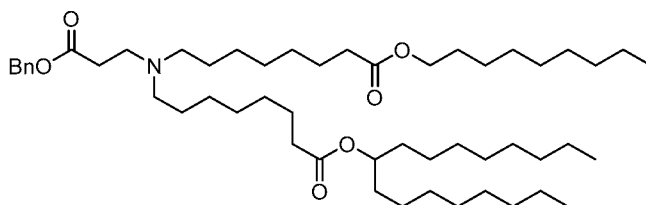
Heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{42}H_{83}NO_4$

Molecular Weight: 666.13

[00143] At $-78\text{ }^{\circ}\text{C}$, to a solution of oxalyl chloride (0.25 mL, 3.0 mmol) in 3 mL dichloromethane was added dropwise a solution of DMSO (0.43 mL, 6.0 mmol) in 2 mL dichloromethane, and then a solution of heptadecan-9-yl 8-((3-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.45 g, 2.0 mmol) in dichloromethane (10 mL) was added immediately. After it was stirred for 30 min at this temperature, triethylamine (1.45 mL, 10.4 mmol) was added and the reaction mixture was warmed up to room temperature. TLC and MS showed complete reaction ($M+1$: 722.7), and the reaction mixture was diluted with water and extracted with hexanes (2X). The combined organic layer was washed with brine. After drying over sodium sulfate, the filtrate was concentrated and the residue was purified by ISCO (SiO_2 : EtOAc/Hexanes/0.5% Et_3N 0 to 50%) to afford the product as a brown oil (810 mg, 61%). MS (APCI): m/z (MH^+) 666.7. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.85 (p, 1H, $J = 6.0$ Hz); 4.05 (t, 2H, $J = 6.9$ Hz); 2.56 (t, 4H, $J = 7.1$ Hz); 2.31-2.24 (m, 4H); 1.67-1.19 (m, 63H); 0.87 (m, 9H).

Heptadecan-9-yl 8-((3-(benzyloxy)-3-oxopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

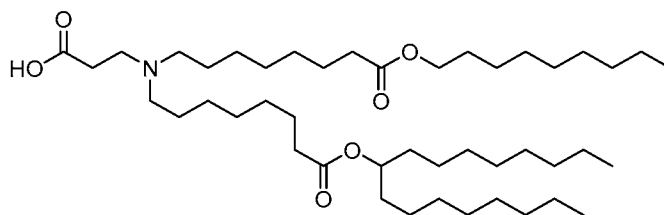
Chemical Formula: $C_{52}H_{93}NO_6$

Molecular Weight: 828.32

[00144] A solution of heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (798 mg, 1.2 mmol) and benzyl acrylate (293 mg, 1.8 mmol) in dichloromethane (20 mL) was stirred at room temperature for 16 h. TLC and MS showed almost no reaction, 10 mL MeOH was added and the reaction mixture was stirred at room temperature for 16 h. MS showed the product with a small amount of methyl ester ($M+1$: 829.8, 752.7). The reaction mixture was concentrated to dryness and purified by ISCO (SiO_2 : EtOAc/hexanes 0 to 35%) to afford the product as a colorless oil (280 mg, 28%). MS (APCI): m/z (MH^+) 829.8. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.36-7.32 (m, 5H); 5.10 (s, 2H); 4.85 (p, 1H, $J = 6.0$ Hz); 4.04 (t, 2H, $J = 6.9$

Hz); 2.78 (t, 2H, $J = 6.9$ Hz); 2.46 (t, 2H, $J = 7.0$ Hz); 2.36 (t, 4H, $J = 6.9$ Hz); 2.30-2.24 (m, 4H); 1.67-1.19 (m, 62H); 0.87 (m, 9H).

3-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)propanoic acid

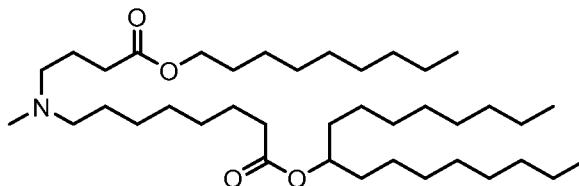


Chemical Formula: $C_{45}H_{87}NO_6$

Molecular Weight: 738.19

[00145] A mixture of heptadecan-9-yl 8-((3-(benzyloxy)-3-oxopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (280 mg, 0.34 mmol) and Pd/C (10%, 28 mg) in 20 mL EtOAc was stirred under hydrogen balloon for 1 h. MS showed complete reaction. The reaction mixture was filtered and the filtrate was concentrated. The residue was purified by ISCO (SiO₂: MeOH/CH₂Cl₂ 0 to 10%) to afford the product as a colorless oil (230 mg, 91%). LC/UV (214 nm): RT = 12.38 min. MS (APCI): m/z (MH^+) 838.7. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.85 (p, 1H, $J = 6.0$ Hz); 4.04 (t, 2H, $J = 6.6$ Hz); 2.85 (t, 2H, $J = 6.0$ Hz); 2.65 (t, 4H, $J = 7.7$ Hz); 2.48 (t, 2H, $J = 6.0$ Hz); 2.32-2.24 (m, 4H); 1.67-1.17 (m, 63H); 0.87 (m, 9H).

CK. Compound 126: Heptadecan-9-yl 8-(methyl(4-(nonyloxy)-4-oxobutyl)amino)octanoate



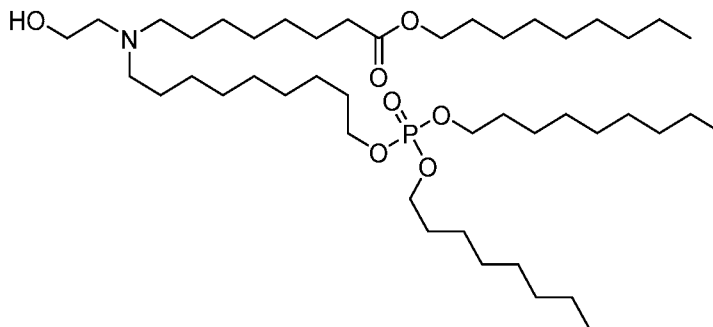
Chemical Formula: $C_{39}H_{77}NO_4$

Molecular Weight: 624.05

[00146] A solution of heptadecan-9-yl 8-(methylamino)octanoate (103 mg, 0.25 mmol), nonyl 4-bromobutanoate (88 mg, 0.30 mmol) and *N,N*-diisopropylethylamine (61 μ L, 0.35 mmol) were dissolved in ethanol and was allowed to stir at 62 °C for 48 h. The reaction was cooled to rt and solvents were evaporated *in vacuo*. The residue was taken-up in ethyl acetate and washed with saturated aqueous sodium bicarbonate. The organic layer was separated and washed with brine, dried over Na₂SO₄ and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain heptadecan-9-yl 8-(methyl(4-(nonyloxy)-4-oxobutyl)amino)octanoate (90 mg, 0.14 mmol, 58%). UPLC/ELSD: RT = 3.58 min. MS (ES):

m/z (MH^+) 624.8 for $C_{39}H_{77}NO_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (p, 1H); 4.08 (t, 2H); 2.38-2.24 (br. m, 11H); 1.82 (m, 2H); 1.64-1.28 (br. m, 52H); 0.90 (m, 9H).

CL. Compound 127: Nonyl 8-((9-((bis(nonyloxy)phosphoryl)oxy)nonyl)(2-hydroxyethyl)amino)octanoate



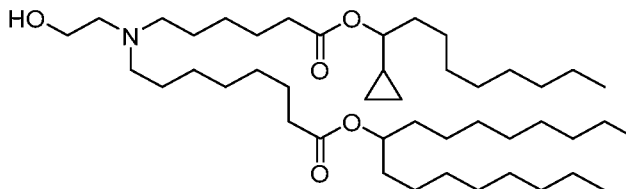
Chemical Formula: $C_{46}H_{94}NO_7P$

Molecular Weight: 804.232

[00147] Compound 127 was synthesized in the same manner as Compound 131 and according to the general procedure and Representative Procedure 1 described above.

UPLC/ELSD: RT = 3.58 min. MS (ES): m/z (MH^+) 805.1 for $C_{46}H_{94}NO_7P$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.05 (m, 8H); 3.55 (m, 2H); 2.59 (m, 2H); 2.46 (m, 4H); 2.31 (t, 2H), 1.67 (m, 11H); 1.29 (m, 55H); 0.90 (m, 9H).

CM. Compound 128: Heptadecan-9-yl 8-((6-((1-cyclopropylnonyl)oxy)-6-oxohexyl)(2-hydroxyethyl)amino)octanoate

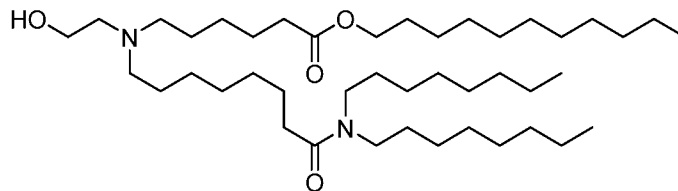


Chemical Formula: $C_{45}H_{87}NO_5$

Molecular Weight: 722.193

[00148] Compound 128 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.67 min. MS (ES): m/z (MH^+) 722.9 for $C_{45}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.30 (m, 1H); 3.56 (m, 2H); 2.72-2.39 (m, 6H); 2.30 (m, 4H), 1.76-1.17 (m, 58H); 0.90 (m, 10H); 0.61-0.35 (m, 3H); 0.28 (m, 1H).

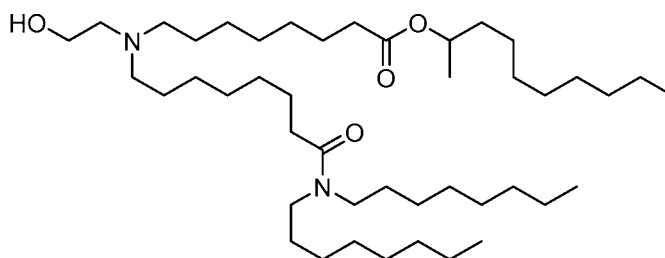
CN. Compound 129: Undecyl 6-((8-(dioctylamino)-8-oxooctyl)(2-hydroxyethyl)amino)hexanoate

Chemical Formula: $C_{43}H_{86}N_2O_4$

Molecular Weight: 695.171

[00149] Compound 129 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.45 min. MS (ES): m/z (MH^+) 695.9 for $C_{43}H_{86}N_2O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.08 (t, 2H); 3.54 (m, 2H), 3.28 (m, 4H); 2.59 (m, 2H); 2.47 (m, 4H); 2.32 (q, 4H); 1.73-1.19 (m, 58H); 0.90 (m, 9H).

CO. Compound 130: Decan-2-yl 8-((8-(di-octylamino)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

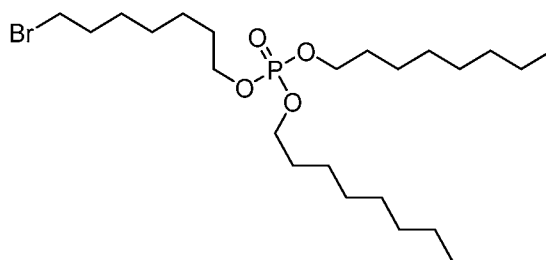
Chemical Formula: $C_{44}H_{88}N_2O_4$

Molecular Weight: 709.198

[00150] Compound 130 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.46 min. MS (ES): m/z (MH^+) 709.9 for $C_{44}H_{88}N_2O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.90 (m, 1H); 3.70 (br. m, 2H), 3.35-3.15 (m, 4H); 2.96-2.41 (br. m, 6H); 2.29 (m, 4H); 1.74-1.43 (m, 14H); 1.41-1.115 (m, 47H); 0.90 (m, 9H).

CP. Compound 131: Nonyl 8-((7-((bis(octyloxy)phosphoryl)oxy)heptyl)(2-hydroxyethyl)amino)octanoate

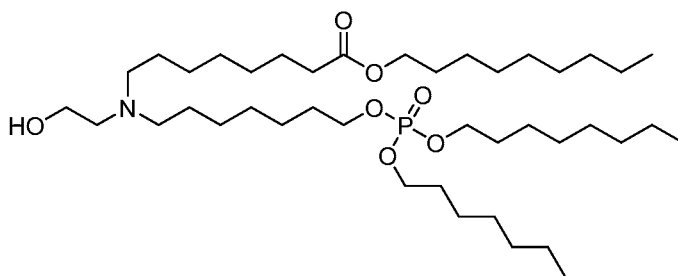
7-Bromoheptyl dioctyl phosphate

Chemical Formula: $C_{23}H_{48}BrO_4P$

Molecular Weight: 499.511

[00151] To a solution of POCl_3 (1.91 mL, 20.5 mmol) in DCM (20 mL) at 0 °C, Et_3N (2.85 mL, 20.4 mmol) was slowly added followed by 7-bromoheptan-1-ol (4.0 g, 20.5 mmol). The reaction was allowed to stir for 4 h at 0 °C. A solution of octan-1-ol (7.10 mL, 45.11 mmol) and Et_3N (8.9 mL, 63.8 mmol) in DCM were added and the reaction was allowed to stir at rt for 16 h. The reaction was diluted with DCM and washed with saturated NaHCO_3 . The organic layer was separated, dried over Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by ISCO with (0-30%) EtOAc in hexanes to obtain 7-bromoheptyl dioctyl phosphate (0.58 g, 1.16 mmol, 6%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.03 (m, 6H); 3.43 (t, 2H); 1.88 (m, 2H); 1.70 (m, 6H); 1.54-1.23 (m, 26H); 0.90 (m, 6H).

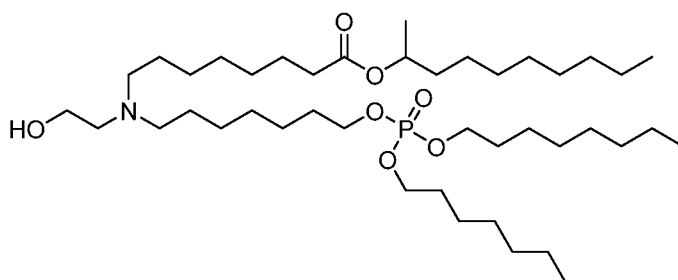
Nonyl 8-((7-((bis(octyloxy)phosphoryl)oxy)heptyl)(2-hydroxyethyl)amino)octanoate

Chemical Formula: $\text{C}_{42}\text{H}_{86}\text{NO}_7\text{P}$

Molecular Weight: 748.124

[00152] Compound 131 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.22 min. MS (ES): m/z (MH^+) 750.0 for $\text{C}_{42}\text{H}_{86}\text{NO}_7\text{P}$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.05 (m, 8H); 3.51 (m, 2H); 2.60 (br. m, 2H); 2.46 (m, 4H); 2.31 (t, 2H); 1.76 - 1.15 (m, 58H); 0.90 (m, 9H).

CQ. Compound 132: Decan-2-yl 8-((7-((bis(octyloxy)phosphoryl)oxy)heptyl)(2-hydroxyethyl)amino)octanoate

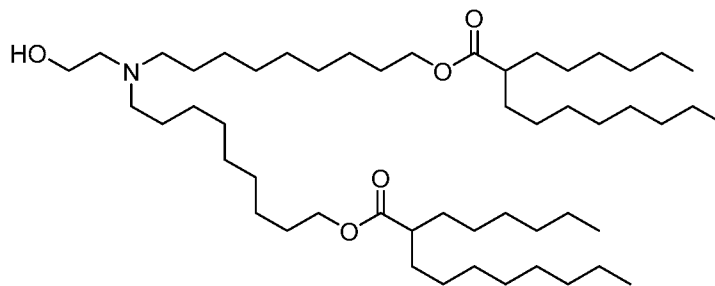
Chemical Formula: $\text{C}_{43}\text{H}_{88}\text{NO}_7\text{P}$

Molecular Weight: 762.15

[00153] Compound 132 was synthesized in the same manner as Compound 131 and according to the general procedure and Representative Procedure 1 described above.

UPLC/ELSD: RT = 3.27 min. MS (ES): m/z (MH^+) 764.00 for $C_{43}H_{88}NO_7P$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.91 (m, 1H); 4.03 (m, 6H); 3.56 (m, 2H); 2.73-2.38 (br. m, 6H); 2.29 (t, 2H); 1.79 - 1.16 (m, 61H); 0.90 (m, 9H).

CR. Compound 133: ((2-Hydroxyethyl)azanediyl)bis(nonane-9,1-diyl) bis(2-hexyldecanoate)

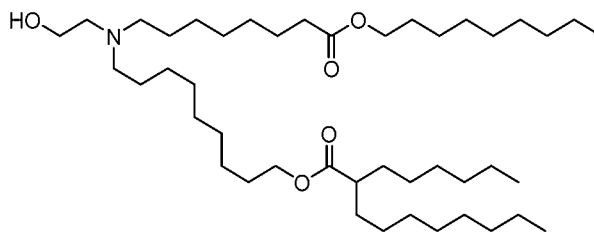


Chemical Formula: $C_{52}H_{103}NO_5$

Molecular Weight: 822.398

[00154] Compound 133 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.91 min. MS (ES): m/z (MH^+) 824.0 for $C_{52}H_{103}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.09 (t, 4H); 3.60 (m, 2H); 2.74 - 2.42 (br. m, 6H); 2.33 (m, 3H); 1.72 - 1.17 (m, 76H); 0.90 (m, 12H).

CS. Compound 134: 9-((2-Hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)nonyl 2-hexyldecanoate

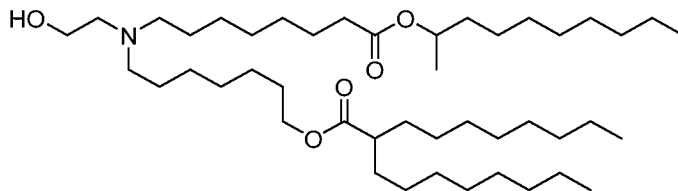


Chemical Formula: $C_{44}H_{87}NO_5$

Molecular Weight: 710.182

[00155] Compound 134 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.48 min. MS (ES): m/z (MH^+) 712.0 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.08 (m, 4H); 3.55 (m, 2H); 2.67 - 2.39 (br. m, 6H); 2.31 (m, 3H); 1.71 - 1.19 (m, 62H); 0.90 (m, 12H).

CT. Compound 135: 7-((8-(Decan-2-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl 2-octyldecanoate

Chemical Formula: C₄₅H₈₉NO₅

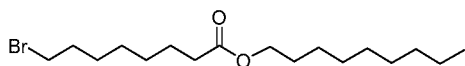
Molecular Weight: 724.209

[00156] Compound 135 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.63 min. MS (ES): *m/z* (MH⁺) 726.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 1H); 4.08 (t, 2H); 3.57 (m, 2H); 2.73 – 2.40 (br. m, 6H); 2.29 (m, 3H); 1.71 -1.16 (m, 66H); 0.90 (m, 9H).

CU. Compound 136: Nonyl 8-((2-hydroxyethyl)((9Z,12Z)-octadeca-9,12-dien-1-yl)amino)octanoate

Representative Procedure 2:

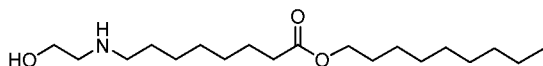
Nonyl 8-bromooctanoate (Method A)



[00157] To a solution of 8-bromooctanoic acid (5 g, 22 mmol) and nonan-1-ol (6.46 g, 45 mmol) in dichloromethane (100 mL) were added *N*-(3-Dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (4.3 g, 22 mmol) and DMAP (547 mg, 4.5 mmol). The reaction was allowed to stir at rt for 18 h. The reaction was diluted with dichloromethane and washed with saturated sodium bicarbonate. The organic layer was separated and washed with brine, dried over MgSO₄. The organic layer was filtered and evaporated under vacuum. The residue was purified by silica gel chromatography (0-10% ethyl acetate in hexanes) to obtain nonyl 8-bromooctanoate (6.1 g, 17 mmol, 77%).

[00158] ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.06 (t, 2H); 3.40 (t, 2H); 2.29 (t, 2H); 1.85 (m, 2H); 1.72-0.97 (m, 22H); 0.88 (m, 3H).

Nonyl 8-((2-hydroxyethyl)amino)octanoate



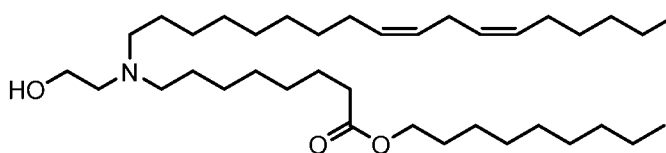
[00159] A solution of nonyl 8-bromooctanoate (1.2 g, 3.4 mmol) and 2-aminoethan-1-ol (5 mL, 83 mmol) in ethanol (2 mL) was allowed to stir at 62 °C for 18 h. The reaction mixture was concentrated in vacuum and the residue was extracted with ethyl acetate and water. The organic layer was separated and washed with water, brine and dried over Na₂SO₄. The organic layer was filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-

100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to obtain nonyl 8-((2-hydroxyethyl)amino)octanoate (295 mg, 0.9 mmol, 26%).

[00160] UPLC/ELSD: RT = 1.29 min. MS (ES): m/z (MH⁺) 330.42 for C₁₉H₃₉NO₃

[00161] ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.07 (t, 2H); 3.65 (t, 2H); 2.78 (t, 2H); 2.63 (t, 2H); 2.32-2.19 (m, 4H); 1.73-1.20 (m, 24H); 0.89 (m, 3H)

Nonyl 8-((2-hydroxyethyl)((9Z,12Z)-octadeca-9,12-dien-1-yl)amino)octanoate



Chemical Formula: C₃₇H₇₁NO₃

Molecular Weight: 577.98

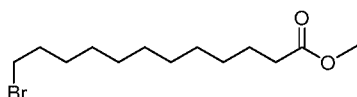
[00162] A solution of nonyl 8-((2-hydroxyethyl)amino)octanoate (150 mg, 0.46 mmol), (6Z,9Z)-18-bromooctadeca-6,9-diene (165 mg, 0.5 mmol) and *N,N*-diisopropylethylamine (65 mg, 0.5 mmol) in ethanol (2 mL) was allowed to stir at reflux for 48 h. The reaction was allowed to cool to rt and solvents were evaporated under vacuum. The residue was purified by silica gel chromatography (0-10% MeOH in dichloromethane) to obtain nonyl 8-((2-hydroxyethyl)((9Z,12Z)-octadeca-9,12-dien-1-yl)amino)octanoate (81 mg, 0.14 mmol, 30%) as a HBr salt.

[00163] UPLC/ELSD: RT = 3.24 min. MS (ES): m/z (MH⁺) 578.64 for C₃₇H₇₁NO₃

[00164] ¹H NMR (300 MHz, CDCl₃) δ : ppm 10.71 (br., 1H); 5.36 (br. m, 4H); 4.04 (m, 4H); 3.22-2.96 (br. m, 5H); 2.77 (m, 2H); 2.29 (m, 2H); 2.04 (br. m, 4H); 1.86 (br. m, 4H); 1.66-1.17 (br. m, 40H); 0.89 (m, 6H)

CV. Compound 137: Methyl 12-(dodecyl(2-hydroxyethyl)amino)dodecanoate

Methyl 12-bromododecanoate



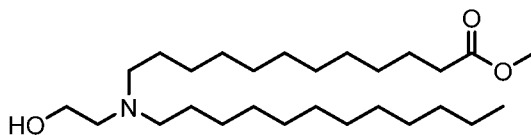
Chemical Formula: C₁₃H₂₅BrO₂

Molecular Weight: 293.25

[00165] To a solution of 12-bromododecanoic acid (2.5 g, 8.95 mmol) in THF (7 mL) was added methanol (7.2 mL, 179 mmol). Sulfuric acid (0.50 mL, 8.95 mmol) was added dropwise and the reaction was allowed to stir at 65 °C for two hours. The reaction mixture was washed with 5% NaHCO₃ and brine. The organic layer was dried over anhydrous Na₂SO₄, filtered, and concentrated *in vacuo*. Purification by silica gel chromatography (0-20% EtOAc/hexanes) provided methyl 12-bromododecanoate (2.40 g, 92%).

[00166] ^1H NMR (300 MHz, CDCl_3) δ : ppm 3.69 (s, 3H); 3.44 (t, 2H); 2.33 (t, 2H); 1.88 (br. m, 2H); 1.64 (br. m, 2H); 1.45 (br. m, 2H); 1.31 (br. m, 12H).

Methyl 12-(dodecyl(2-hydroxyethyl)amino)dodecanoate



Chemical Formula: $\text{C}_{27}\text{H}_{55}\text{NO}_3$

Molecular Weight: 441.74

[00167] To a solution of methyl 12-((2-hydroxyethyl)amino)dodecanoate (413 mg, 1.51 mmol) (isolated from the synthesis of 12,12'-((2-Hydroxyethyl)azanediyl)didodecanoate) in MeCN (5 mL) was added 1-bromododecane (452 mg, 1.81 mmol), K_2CO_3 (418 mg, 3.02 mmol), and KI (25 mg, 0.151 mmol). The reaction was allowed to stir at 82 °C for 16 hours. The reaction mixture was cooled to room temperature, diluted with H_2O , and extracted with EtOAc. The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 , filtered, and concentrated *in vacuo*. Purification by silica gel chromatography (0-100% [DCM, 20% MeOH, 1% NH_4OH]/MeOH) provided methyl 12-(dodecyl(2-hydroxyethyl)amino)dodecanoate (409 mg, 61%).

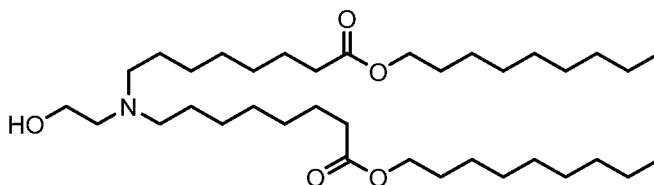
[00168] UPLC/ELSD: RT = 2.39 min. MS (ES): m/z (MH^+) 442.60 for $\text{C}_{27}\text{H}_{55}\text{NO}_3$

[00169] ^1H NMR (300 MHz, CDCl_3) δ : ppm 3.69 (s, 3H); 3.61 (t, 2H); 2.68 (t, 2H); 2.54 (t, 4H); 2.32 (t, 2H); 1.64 (m, 2H); 1.50 (br. m, 4H); 1.28 (br. m, 32H); 0.90 (t, 3H).

CW. Compound 138: Dinonyl 8,8'-((2-hydroxyethyl)azanediyl)dioctanoate

Representative Procedure 3:

Dinonyl 8,8'-((2-hydroxyethyl)azanediyl)dioctanoate



Chemical Formula: $\text{C}_{36}\text{H}_{71}\text{NO}_5$

Molecular Weight: 597.97

[00170] A solution of nonyl 8-bromooctanoate (200 mg, 0.6 mmol) and 2-aminoethan-1-ol (16 mg, 0.3 mmol) and *N,N*-diisopropylethylamine (74 mg, 0.6 mmol) in THF/ CH_3CN (1:1) (3 mL) was allowed to stir at 63 °C for 72 h. The reaction was cooled to rt and solvents were evaporated under vacuum. The residue was extracted with ethyl acetate and saturated sodium

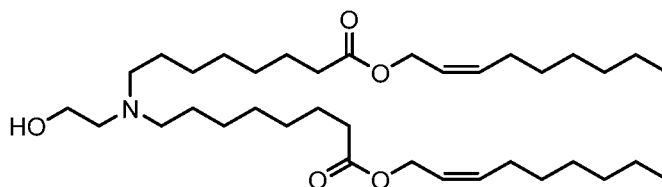
bicarbonate. The organic layer was separated, dried over Na₂SO₄ and evaporated under vacuum. The residue was purified by silica gel chromatography (0-10% MeOH in dichloromethane) to obtain dinonyl 8,8'-((2-hydroxyethyl)azanediyl)diocanoate (80 mg, 0.13 mmol, 43%).

[00171] UPLC/ELSD: RT = 3.09 min. MS (ES): m/z (MH⁺) 598.85 for C₃₆H₇₁NO₅

[00172] ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.05 (m, 4H); 3.57 (br. m, 2H); 2.71-2.38 (br. m, 6H); 2.29 (m, 4H), 1.71-1.01 (br. m, 49H), 0.88 (m, 6H).

CX. Compound 139: Di((Z)-non-2-en-1-yl) 8,8'-((2-hydroxyethyl)azanediyl)diocanoate

[00173] Compound 139 was synthesized following the Representative Procedure 3.



Chemical Formula: C₃₆H₆₇NO₅

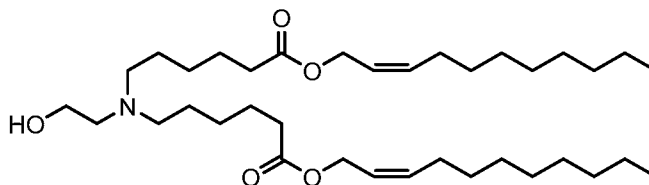
Molecular Weight: 593.93

[00174] UPLC/ELSD: RT = 2.88 min. MS (ES): m/z (MH⁺) 594.78 for C₃₆H₆₇NO₅

[00175] ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.60 (m, 2H); 5.50 (m, 2H); 4.59 (m, 4H); 3.96 (br. m, 2H); 3.20-2.94 (br. m, 5H); 2.28 (m, 4H); 2.07 (m, 4H); 1.80 (br. m, 4H); 1.59 (br. m, 6H); 1.43-1.14 (br. m, 28H), 0.85 (m, 6H).

CY. Compound 140: Di((Z)-undec-2-en-1-yl) 6,6'-((2-hydroxyethyl)azanediyl)dihexanoate

[00176] Compound 140 was synthesized following the Representative Procedure 3.



Chemical Formula: C₃₆H₆₇NO₅

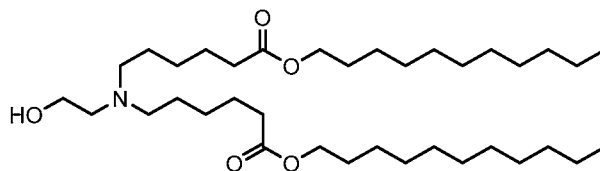
Molecular Weight: 593.93

[00177] UPLC/ELSD: RT = 2.87 min. MS (ES): m/z (MH⁺) 594.74 for C₃₆H₆₇NO₅

[00178] ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.73-5.44 (m, 4H); 4.62 (m, 4H); 3.55 (m, 2H); 2.73-2.39 (br. m, 6H); 2.39 (m, 4H); 2.09 (m, 4H); 1.64 (m, 4H); 1.55-1.14 (br. m, 33H); 0.88 (m, 6H).

CZ. Compound 141: Diundecyl 6,6'-((2-hydroxyethyl)azanediyl)dihexanoate

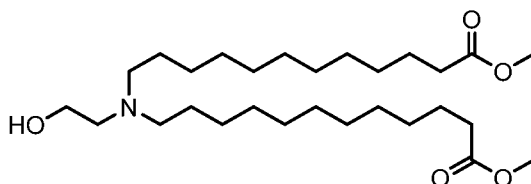
[00179] Compound 141 was synthesized following Representative Procedure 3.

Chemical Formula: C₃₆H₇₁NO₅

Molecular Weight: 597.97

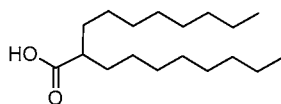
[00180] UPLC/ELSD: RT = 3.03 min. MS (ES): *m/z* (MH⁺) 598.63 for C₃₆H₇₁NO₅[00181] ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.05 (m, 4H); 3.53 (m, 2H); 2.95 (br. m, 1H); 2.65-2.35 (m, 6H); 2.30 (m, 4H); 1.73-1.54 (m, 8H); 1.54-1.15 (m, 40H); 0.88 (m, 6H).**DA. Compound 142: 12,12'-((2-Hydroxyethyl)azanediyl)didodecanoate**

12,12'-((2-Hydroxyethyl)azanediyl)didodecanoate

Chemical Formula: C₂₈H₅₅NO₅

Molecular Weight: 485.75

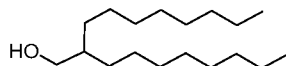
[00182] To a solution of methyl 12-bromododecanoate (1.5 g, 5.12 mmol) in MeCN (11 mL) was added ethanolamine (0.310 mL, 5.12 mmol), K₂CO₃ (1.42 g, 10.2 mmol), and KI (85 mg, 0.512 mmol). The reaction was allowed to stir at 82 °C for 16 hours. The reaction mixture was cooled to room temperature, filtered, and the solids were washed with hexanes. The filtrate was extracted with hexanes, and the combined extracts were concentrated *in vacuo*. Purification by silica gel chromatography (0-100% [DCM, 20% MeOH, 1% NH₄OH]/MeOH) provided 12,12'-((2-hydroxyethyl)azanediyl)didecanoate (563 mg, 45%).

[00183] UPLC/ELSD: RT = 1.81 min. MS (ES): *m/z* (MH⁺) 486.63 for C₂₈H₅₅NO₅[00184] ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.69 (s, 6H); 3.59 (br. m, 2H); 2.75-2.40 (br. m, 6H); 2.32 (t, 4H); 1.64 (m, 4H); 1.48 (br. m, 4H); 1.29 (br. m, 28H).**DB. Compound 143: Nonyl 8-((2-hydroxyethyl)(7-((2-octyldecyl)oxy)-7-oxoheptyl)amino)octanoate****2-Octyldecanoic acid**Chemical Formula: C₁₈H₃₆O₂

Molecular Weight: 284.48

[00185] A solution of diisopropylamine (2.92 mL, 20.8 mmol) in THF (10 mL) was cooled to -78 °C and a solution of *n*-BuLi (7.5 mL, 18.9 mmol, 2.5 M in hexanes) was added. The reaction was allowed to warm to 0 °C. To a solution of decanoic acid (2.96 g, 17.2 mmol) and NaH (754 mg, 18.9 mmol, 60% w/w) in THF (20 mL) at 0 °C was added the solution of LDA and the mixture was allowed to stir at rt for 30 min. After this time 1-iodooctane (5 g, 20.8 mmol) was added and the reaction mixture was heated at 45 °C for 6 h. The reaction was quenched with 1N HCl (10 mL). The organic layer was dried over MgSO₄, filtered and evaporated under vacuum. The residue was purified by silica gel chromatography (0-20% ethyl acetate in hexanes) to yield 2-octyldecanoic acid (1.9 g, 6.6 mmol).

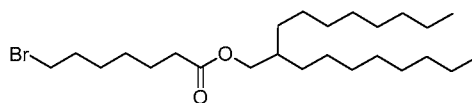
[00186] ¹H NMR (300 MHz, CDCl₃) δ: ppm 2.38 (br. m, 1H); 1.74-1.03 (br. m, 28H); 0.91 (m, 6H).

2-Octyldecan-1-olChemical Formula: C₁₈H₃₈O

Molecular Weight: 270.50

[00187] A solution of 2-octyldecanoic acid (746 mg, 2.6 mmol) in dry THF (12 mL) was added to a stirred solution of LAH (5.2 mL, 5.2 mmol, 1M solution in THF) in dry THF (6 mL) under nitrogen at 0 °C. The reaction was allowed to warm to rt and stirred at rt for 12 h. A solution of saturated Na₂SO₄·10H₂O solution (10 mL) was added. The solids were filtered through a plug of Celite. The filtrate was evaporated under vacuum and the residue was purified by silica gel chromatography (0-20% ethyl acetate in hexanes) to yield 2-octyldecan-1-ol (635 mg, 2.3 mmol).

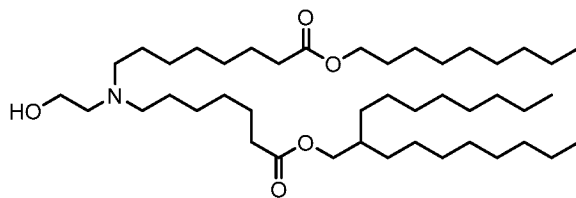
[00188] ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.54 (d, 2H); 1.56-1.21 (br. m, 30H); 0.91 (t, 6H).

2-Octyldecyl 7-bromoheptanoate

[00189] 2-Octyldecyl 7-bromoheptanoate was synthesized according to Method A.

[00190] ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.96 (d, 2H); 3.40 (t, 2H); 2.31 (t, 2H); 1.86 (m, 2H); 1.71-1.19 (m, 35H); 0.88 (m, 6H).

[00191] Nonyl 8-((2-hydroxyethyl)(7-((2-octyldecyl)oxy)-7-oxoheptyl)amino)octanoate was synthesized using Representative Procedure 2.



Chemical Formula: $C_{44}H_{87}NO_5$

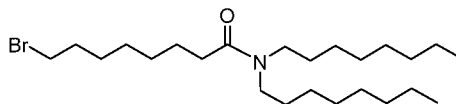
Molecular Weight: 710.182

[00192] UPLC/ELSD: RT = 5.23 min. MS (ES): m/z (MH^+) 711.08 for $C_{44}H_{87}NO_5$

[00193] ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.05 (t, 2H); 3.96 (d, 2H); 3.58 (br. m, 2H); 2.79-2.36 (br. m, 5H); 2.30 (m, 4H); 1.72-1.01 (br. m, 63H); 0.88 (m, 9H).

DC. Compound 144: Nonyl 8-((8-(di-octylamino)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

8-Bromo-*N,N*-dioctyloctanamide



Chemical Formula: $C_{24}H_{48}BrNO$

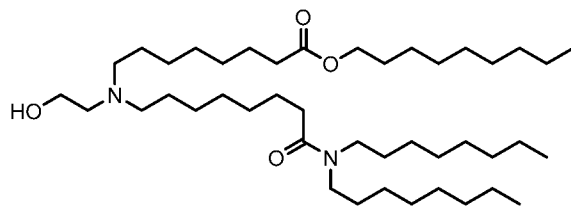
Molecular Weight: 446.56

[00194] To a solution of 8-bromooctanoic acid (1 g, 2.2 mmol) and DMF (1 drop) in dichloromethane was added oxalyl chloride (0.416 mL, 2.5 mmol) dropwise. The reaction was allowed to stir for 1 h at room temperature. Solvents were evaporated and the residue was added to a solution of dioctylamine (1.14 g, 4.8 mmol) and DMAP (100 mg, 0.8 mmol). Triethylamine was added to the reaction dropwise and the reaction was allowed to stir for 18 h. The solvents were evaporated and the residue was taken up in ethyl acetate and saturated $NaHCO_3$. The organic layer was separated and washed with water and brine. The organic layer was dried over Na_2SO_4 , filtered and evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane to yield a mixture of 8-bromo-*N,N*-dioctyloctanamide and chloro-*N,N*-dioctyloctanamide (736 mg, 1.6 mmol).

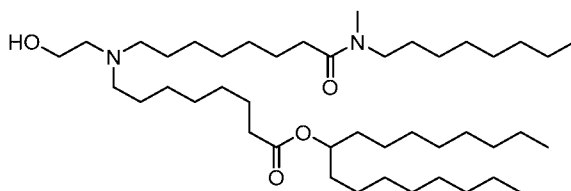
[00195] UPLC/ELSD: RT = 4.02 min. MS (ES): m/z (MH^+) 446.53 for $C_{24}H_{48}BrNO$

[00196] ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 3.55 (t, 0.6H); 3.42 (t, 1.4H); 3.36-3.15 (m, 4H); 2.31 (t, 2H); 1.96-1.18 (m, 34H); 0.91 (m, 6H).

[00197] Nonyl 8-((8-(di-octylamino)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate was synthesized utilizing Representative Procedure 2.

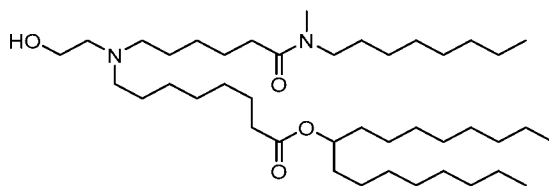
Chemical Formula: $C_{43}H_{86}N_2O_4$

Molecular Weight: 695.17

[00198] UPLC/ELSD: RT = 4.24 min. MS (ES): m/z (MH^+) 696.16 for $C_{43}H_{86}N_2O_4$ [00199] ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.05 (t, 2H); 3.57 (br. m, 2H); 3.35-3.14 (m, 4H); 2.80-2.20 (m, 10H); 1.74-1.00 (br. m, 59H); 0.88 (m, 9H).**DD. Compound 145: Heptadecan-9-yl 8-((2-hydroxyethyl)(8-(methyl(octyl)amino)-8-oxooctyl)amino)octanoate**Chemical Formula: $C_{44}H_{88}N_2O_4$

Molecular Weight: 709.198

[00200] Compound 145 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.17 min. MS (ES): m/z (MH^+) 710.0 for $C_{44}H_{88}N_2O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 3.55 (m, 2H); 3.37 (t, 1H); 3.27 (t, 1H); 2.98 (s, 1.5H); 2.93 (s, 1.5H); 2.59 (m, 2H); 2.47 (m, 4H); 2.30 (m, 4H); 1.75-1.20 (m, 60H); 0.90 (m, 9H).

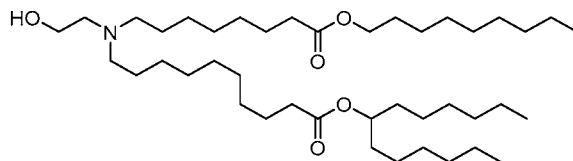
DE. Compound 146: Heptadecan-9-yl 8-((2-hydroxyethyl)(6-(methyl(octyl)amino)-6-oxohexyl)amino)octanoateChemical Formula: $C_{42}H_{84}N_2O_4$

Molecular Weight: 681.144

[00201] Compound 146 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.01 min. MS (ES): m/z (MH^+) 682.0 for $C_{42}H_{84}N_2O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.88 (m, 1H); 3.55 (m, 2H);

3.37 (t, 1H); 3.26 (t, 1H); 2.98 (s, 1.5H); 2.93 (s, 1.5H); 2.59 (m, 2H); 2.48 (m, 4H); 2.31 (m, 4H), 1.76-1.18 (m, 56H); 0.90 (m, 9H).

DF. Compound 147: Tridecan-7-yl 10-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)decanoate



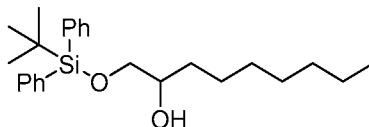
Chemical Formula: $C_{42}H_{83}NO_5$

Molecular Weight: 682.128

[00202] Compound 147 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.16 min. MS (ES): m/z (MH^+) 683.0 for $C_{42}H_{83}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.08 (m, 2H); 3.55 (m, 2H); 2.59 (m, 2H); 2.46 (m, 4H); 2.30 (m, 4H), 1.72-1.18 (m, 58H); 0.90 (m, 9H).

DG. Compound 148: Heptadecan-9-yl 8-((2-hydroxyethyl)(8-((2-methoxynonyl)oxy)-8-oxooctyl)amino)octanoate

1-((*tert*-Butyldiphenylsilyl)oxy)nonan-2-ol

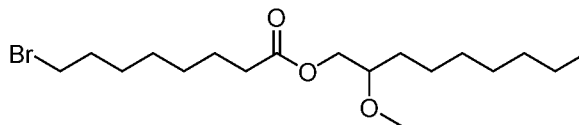


Chemical Formula: $C_{25}H_{38}O_2Si$

Molecular Weight: 398.662

[00203] TBDPSCl (8.58 g, 31.2 mmol) was added to a mixture of nonane-1,2-diol (5.0 g, 31.2 mmol) and imidazole (4.24 g, 62.4 mmol) in DMF at RT. The reaction was stirred at RT overnight. The reaction was diluted with water (150 mL) and extracted with EtOAc/hexanes (1:1) (4X). The combined organic layer was washed with brine, separated, dried with Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by ISCO with (0-10%) EtOAc in hexanes to obtain 1-((*tert*-butyldiphenylsilyl)oxy)nonan-2-ol (7.75 g, 19.4 mmol). ^1H NMR (300 MHz, DMSO) δ : ppm 7.63 (m, 4H); 7.43 (m, 6H); 4.51 (d, 1H); 3.54 (m, 2H); 3.43 (m, 1H); 1.57 (m, 1H); 1.24 (m, 11H); 1.00 (s, 9H); 0.85 (m, 3H).

2-Methoxynonyl 8-bromooctanoate

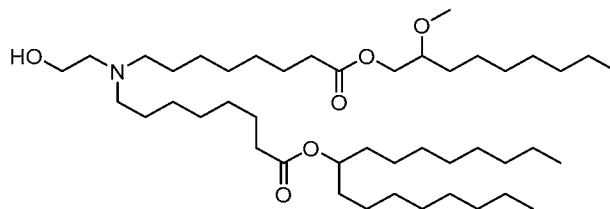


Chemical Formula: $C_{18}H_{35}BrO_3$

Molecular Weight: 379.379

[00204] 2-Methoxynonyl 8-bromooctanoate was synthesized following Method A in Representative Procedure 1. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.19 (m, 1H); 4.04 (m, 1H); 3.42 (m, 6H); 2.36 (t, 2H); 1.87 (m, 2H); 1.73-1.22 (m, 20H); 0.93 (m, 3H).

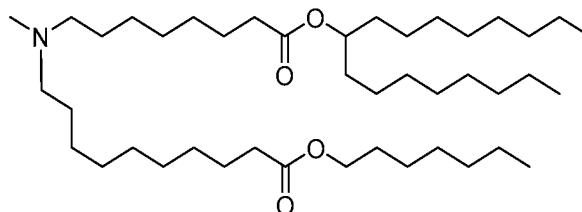
Heptadecan-9-yl 8-((2-hydroxyethyl)(8-((2-methoxynonyl)oxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $\text{C}_{45}\text{H}_{89}\text{NO}_6$

Molecular Weight: 740.208

[00205] Compound 148 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.48 min. MS (ES): m/z (MH^+) 741.0 for $\text{C}_{45}\text{H}_{89}\text{NO}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.89 (m, 1H); 4.19 (m, 1H); 4.04 (m, 1H); 3.57 (m, 2H); 3.42 (s, 3H); 3.37 (m, 1H); 2.73-2.41 (m, 6H); 2.33 (m, 4H); 1.73-1.19 (m, 61H); 0.90 (m, 9H).

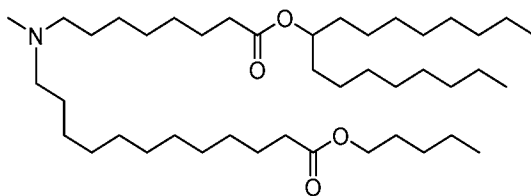
DH. Compound 149: Heptyl 10-((8-(heptadecan-9-yloxy)-8-oxooctyl)(methyl)amino)decanoate

Chemical Formula: $\text{C}_{43}\text{H}_{85}\text{NO}_4$

Molecular Weight: 680.156

[00206] Compound 149 was synthesized similarly to Compound 123 and according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.55 min. MS (ES): m/z (MH^+) 681.0 for $\text{C}_{43}\text{H}_{85}\text{NO}_4$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 2.42-2.14 (m, 11H); 1.73-1.17 (m, 62H); 0.90 (m, 9H).

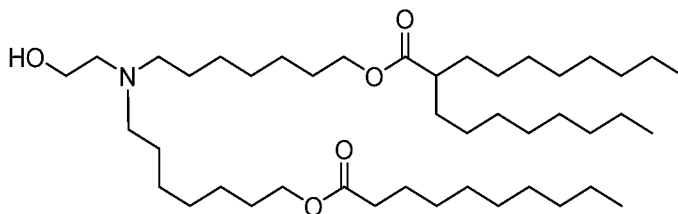
DI. Compound 150: Pentyl 12-((8-(heptadecan-9-yloxy)-8-oxooctyl)(methyl)amino)dodecanoate

Chemical Formula: C₄₃H₈₅NO₄

Molecular Weight: 680.156

[00207] Compound 150 was synthesized similarly to Compound 123 and according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.47 min. MS (ES): *m/z* (MH⁺) 681.0 for C₄₃H₈₅NO₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 1H); 4.08 (t, 2H); 2.42-2.16 (m, 10H); 1.73-1.20 (m, 63H); 0.90 (m, 9H).

DJ. Compound 151: 7-((7-(Decanoyloxy)heptyl)(2-hydroxyethyl)amino)heptyl 2-octyldecanoate

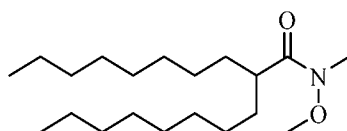
Chemical Formula: C₄₄H₈₇NO₅

Molecular Weight: 710.182

[00208] Compound 151 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.83 min. MS (ES): *m/z* (MH⁺) 711.0 for C₄₄H₈₇NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.07 (m, 4H); 3.57 (m, 2H); 2.63 (br. m, 2H); 2.50 (m, 4H); 2.31 (m, 3H); 1.71-1.19 (m, 62H); 0.90 (m, 9H).

DK. Compound 152: Nonyl (Z)-8-((2-hydroxyethyl)(10-octyloctadec-8-en-1-yl)amino)octanoate

N-Methoxy-N-methyl-2-octyldecanamide

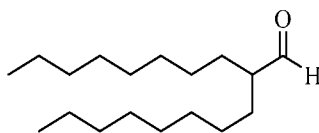
Chemical Formula: C₂₀H₄₁NO₂

Molecular Weight: 327.553

[00209] To a solution of 2-octyl-decanoic acid (11.1 g, 39.02 mmol) and DMF (0.05 mL, 3.9 mmol) in DCM (100 mL) oxalyl chloride (3.63 mL, 42.92 mmol) was added dropwise. The reaction was allowed to stir for 2 h at rt. Solvents and volatiles were evaporated under vacuum. The resulting residue (crude 2-octyldecanoyl chloride) (11.82 g, 39.02 mmol) was taken up in

DCM (100 mL) and *N,O*-dimethylhydroxylamine hydrochloride (4 g, 40.97 mmol) and 4-dimethylaminopyridine (0.48 g, 3.9 mmol) were added. The mixture was allowed to cool to 0 °C and triethylamine (19.04 mL, 136.57 mmol) was slowly added. The reaction was allowed to warm to rt and stir for 1 h. Solvents were evaporated under vacuum. The residue was diluted with EtOAc and washed with sat. NaHCO₃, followed by brine. The organic layer was separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain *N*-methoxy-*N*-methyl-2-octyldecanamide (7.10 g, 21.68 mmol, 56%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.70 (s, 3H); 3.22 (s, 3H); 2.82 (br. m, 1H); 1.62 (m, 2H); 1.51-1.19 (m, 26H); 0.90 (m, 6H).

2-Octyldecanal

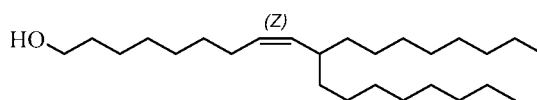


Chemical Formula: C₁₈H₃₆O

Molecular Weight: 268.485

[00210] A solution of *N*-methoxy-*N*-methyl-2-octyldecanamide (7.1 g, 21.68 mmol) in dry THF (2 mL) was added to a suspension of LAH (27.53 mL 1 M in THF, 27.53 mmol) in dry THF (5 mL) at -45 °C. The resulting suspension was stirred for 1 h at -45 °C, after which time it was allowed to warm to room temperature and stir for 0.5 h. The reaction was cooled back to -45 °C and quenched with a sat. aqueous solution of sodium sulfate decahydrate (2 mL). The mixture was stirred for 20 min at room temperature and filtered through plug of Celite. The filtrate was washed with brine. The organic layer was separated, dried over sodium sulfate, filtered and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-10 %) EtOAc in hexanes to obtain 2-octyldecanal (4.45 g, 16.57 mmol, 76%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 9.58 (d, 1H); 2.23 (m, 1H); 1.63 (m, 2H); 1.53-1.19 (m, 26H); 0.90 (m, 6H).

(*Z*)-10-Octyloctadec-8-en-1-ol



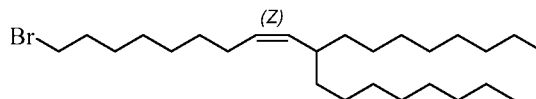
Chemical Formula: C₂₆H₅₂O

Molecular Weight: 380.701

[00211] A solution of (8-hydroxyoctyl)triphenylphosphonium bromide (3.68 g, 7.81 mmol) in THF (16 mL) and HMPA was cooled in an ice bath and NaHMDS (19.52 mL 1 M, 19.52 mmol) was added. 2-Octyldecanal (1.05 g, 3.9 mmol) in THF (5 mL) was slowly added and the reaction was warmed to 30 °C. After 16 h the reaction was diluted with 20 mL of water and

acidified with 2N HCl. The reaction was extracted with EtOAc (3 x 50 mL). The combined organic extracts were dried over sodium sulfate, filtered and concentrated under reduce pressure. The residue was purified by silica gel chromatography (0-50%) EtOAc in hexanes to obtain (Z)-10-octyloctadec-8-en-1-ol (0.5 g, 1.30 mmol, 33%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.24 (m, 1H); 4.90 (m, 1H); 3.53 (t, 2H); 2.14 (m, 1H); 1.89 (m, 2H); 1.45 (m, 3H); 1.33-0.95 (m, 36H); 0.77 (m, 6H).

(Z)-1-Bromo-10-octyloctadec-8-ene

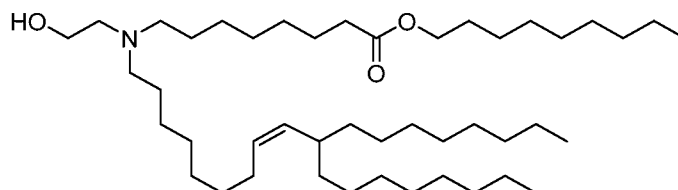


Chemical Formula: C₂₆H₅₁Br

Molecular Weight: 443.598

[00212] To a solution of PPh₃ (0.29 g, 1.11 mmol) and (8Z)-10-octyloctadec-8-en-1-ol (0.4 g, 1.05 mmol) in DCM (10 mL) at 0 °C, NBS (0.22 g, 1.22 mmol) was added in one portion. The reaction was allowed to stir at 0 °C for 1 h and then warm to rt and stir for 1 h. 300 mL of hexanes were added and the mixture was filtered through a silica plug and evaporated under vacuum. 200 mL of hexanes were added and the mixture was filtered through a silica plug and evaporated under vacuum to obtain (Z)-1-bromo-10-octyloctadec-8-ene (0.39 g, 0.88 mmol, 83%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.24 (m, 1H); 4.90 (m, 1H); 3.53 (t, 2H); 2.14 (m, 1H); 1.89 (m, 2H); 1.45 (m, 3H); 1.33-0.95 (m, 36H); 0.77 (m, 6H).

Nonyl (Z)-8-((2-hydroxyethyl)(10-octyloctadec-8-en-1-yl)amino)octanoate

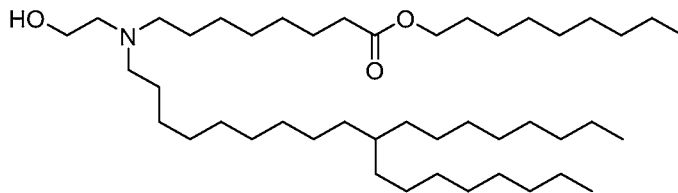


Chemical Formula: C₄₅H₈₉NO₃

Molecular Weight: 693.211

[00213] Compound 152 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.00 min. MS (ES): *m/z* (MH⁺) 694.0 for C₄₅H₈₉NO₃. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.36 (m, 1H); 5.03 (m, 1H); 4.07 (t, 2H); 3.54 (t, 2H); 2.59 (t, 2H); 2.46 (m, 4H); 2.30 (m, 3H); 2.01 (m, 2H); 1.63 (m, 4H); 1.53-1.03 (m, 58H); 0.90 (m, 9H).

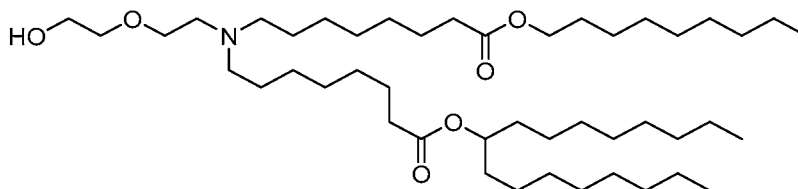
DL. Compound 153: Nonyl 8-((2-hydroxyethyl)(10-octyloctadecyl)amino)octanoate

Chemical Formula: C₄₅H₉₁NO₃

Molecular Weight: 694.227

[00214] A flask was charged with Pd(OH)₂ (20 mg) and purged with N₂. A solution of nonyl 8-[(2-hydroxyethyl)[(8Z)-10-octyloctadec-8-en-1-yl]amino]octanoate (100 mg, 0.14 mmol) in EtOH (1 mL) was added. The reaction was purged with H₂ and was kept under H₂ (balloon) with stirring for 16h at rt. After this time the reaction was purged with N₂. The reaction was filtered through a plug of Celite and washed with EtOH (50 mL). The filtrate was evaporated under vacuum. The residue was dissolved in EtOAc and washed with water. The organic layer was separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-50%) (1%, 20% MeOH in DCM) in DCM to obtain nonyl 8-((2-hydroxyethyl)(10-octyloctadecyl)amino)octanoate (0.069 g, 0.099 mmol, 69%). UPLC/ELSD: RT = 3.21 min. MS (ES): *m/z* (MH⁺) 695.08 for C₄₅H₉₁NO₃. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.08 (t, 2H); 3.56 (t, 2H); 2.62 (m, 2H); 2.48 (m, 4H); 2.31 (m, 2H); 1.64 (m, 4H); 1.54-1.16 (m, 66H); 0.90 (m, 9H).

DM. Compound 154: Heptadecan-9-yl 8-((2-(2-hydroxyethoxy)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

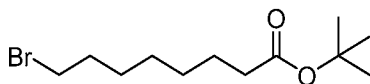
Chemical Formula: C₄₆H₉₁NO₆

Molecular Weight: 754.235

[00215] Compound 154 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.54 min. MS (ES): *m/z* (MH⁺) 755.0 for C₄₆H₉₁NO₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.88 (m, 1H); 4.62 (m, 1H); 4.08 (t, 2H); 3.79-3.56 (m, 6H); 2.64 (m, 2H); 2.47 (m, 4H); 2.31 (m, 4H); 1.73-1.20 (m, 61H); 0.90 (m, 9H).

DN. Compound 155: *tert*-Butyl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

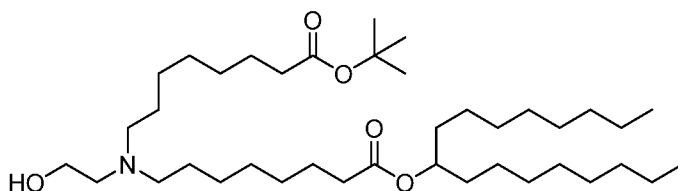
***tert*-Butyl 8-bromooctanoate**

Chemical Formula: $C_{12}H_{23}BrO_2$

Molecular Weight: 279.218

[00216] To a solution of 8-bromooctanoic acid (2 g, 8.96 mmol) in DCM (20 mL) at 0 °C trifluoroacetic anhydride (2.77 mL, 19.9 mmol) was added dropwise. After 2.5 h. *t*-BuOH (3.1 mL, 32.27 mmol) was slowly added. After 1 h the reaction was warmed to rt and allowed to stir for 2.5 h. The reaction was quenched with water and extracted with diethylether. The organic layer was separated, dried over $MgSO_4$, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-10%) EtOAc in hexanes to obtain *tert*-butyl 8-bromooctanoate (1.5 g, 5.37 mmol, 60%). ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 3.42 (t, 2H); 2.23 (t, 2H); 1.87 (m, 2H); 1.60 (m, 2H); 1.47 (s, 11H); 1.35(m, 4H).

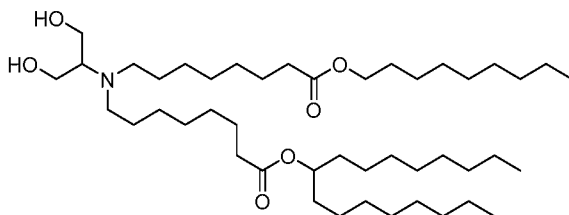
***tert*-Butyl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate**

Chemical Formula: $C_{39}H_{77}NO_5$

Molecular Weight: 640.047

[00217] Compound 155 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.18 min. MS (ES): m/z (MH^+) 641.0 for $C_{39}H_{77}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 3.58 (br. m, 2H); 2.75-2.36 (br. m, 6H); 2.26 (m, 4H); 1.71-1.40 (m, 22H); 1.28 (m, 35H); 0.90 (m, 6H).

DO. Compound 156: Heptadecan-9-yl 8-((1,3-dihydroxypropan-2-yl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

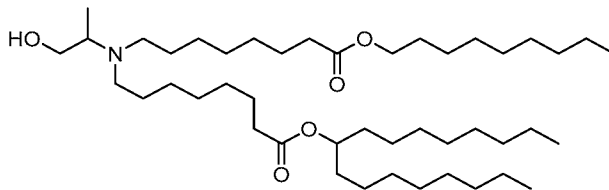
Chemical Formula: $C_{45}H_{89}NO_6$

Molecular Weight: 740.208

[00218] Compound 156 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.53 min. MS (ES): m/z (MH^+) 741.0 for $C_{45}H_{89}NO_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.88 (m, 1H); 4.08 (t, 2H);

3.67 (br. m, 4H); 3.04 (m, 1H); 2.65 (m, 4H); 2.32 (m, 4H), 1.72-1.44 (m, 15H); 1.28 (m, 48H); 0.90 (m, 9H).

DP. Compound 157: Heptadecan-9-yl 8-((1-hydroxypropan-2-yl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

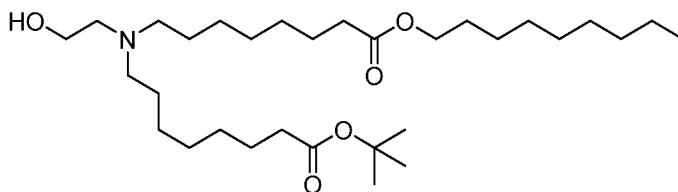


Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.209

[00219] Compound 157 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.56 min. MS (ES): m/z (MH⁺) 725.0 for $C_{45}H_{89}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.45-3.17 (br. m, 2H); 2.94 (br. m, 1H); 2.55-2.22 (m, 8H); 1.70-1.17 (m, 62H); 0.90 (m, 12H).

DQ. Compound 158: *tert*-Butyl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

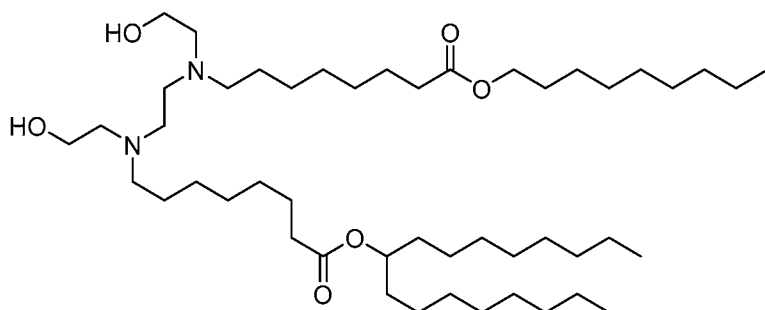


Chemical Formula: $C_{31}H_{61}NO_5$

Molecular Weight: 527.831

[00220] Compound 158 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.23 min. MS (ES): m/z (MH⁺) 528.0 for $C_{31}H_{61}NO_5$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.08 (t, 2H); 3.55 (br. m, 2H); 2.60 (br. m, 2H); 2.47 (m, 4H); 2.31 (t, 2H); 2.22 (t, 2H); 1.64 (br. m, 6H); 1.53-1.23 (m, 37H); 0.90 (m, 3H).

DR. Compound 159: Heptadecan-9-yl 8-((2-hydroxyethyl)(2-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)ethyl)amino)octanoate

Chemical Formula: $C_{48}H_{96}N_2O_6$

Molecular Weight: 797.304

[00221] Compound 159 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.15 min. MS (ES): m/z (MH^+) 798.0 for $C_{48}H_{96}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.88 (m, 1H); 4.07 (t, 2H); 3.62 (br. m, 4H); 2.72 – 2.47 (br. m, 12H); 2.31 (m, 4H); 1.72-1.42 (m, 14H); 1.28 (m, 47H); 0.90 (m, 12H).

DS. Compound 160: 1,5-Bis(2-butylcyclopropyl)pentan-3-yl 8-((2-hydroxyethyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate

2-(2-Butylcyclopropyl)ethan-1-ol

Chemical Formula: $C_9H_{18}O$

Molecular Weight: 142.242

[00222] 2-(2-Butylcyclopropyl)ethan-1-ol was synthesized in the same manner as Intermediate C. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm: 3.94 (t, 2H); 1.93 (m, 1H); 1.59 (m, 7H); 1.39 (m, 1H); 1.12 (m, 3H); 0.90 (m, 3H); 0.00 (m, 1H).

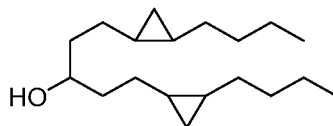
1-(2-Bromoethyl)-2-butylcyclopropane

Chemical Formula: $C_9H_{17}Br$

Molecular Weight: 205.139

[00223] 1-(2-Bromoethyl)-2-butylcyclopropane was synthesized in the same manner as (Z)-1-Bromo-10-octyloctadec-8-ene. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm: 3.64 (t, 2H); 2.18 (m, 1H); 1.92 (m, 1H); 1.47 (m, 6H); 0.96 (m, 6H); 0.00 (m, 1H).

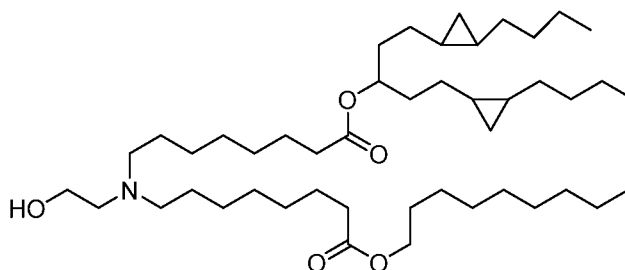
1,5-Bis(2-butylcyclopropyl)pentan-3-ol

Chemical Formula: C₁₉H₃₆O

Molecular Weight: 280.496

[00224] 1,5-Bis(2-butylcyclopropyl)pentan-3-ol was synthesized in the same manner as (5Z,12Z)-heptadeca-5,12-dien-9-ol. ¹H NMR (300 MHz, CDCl₃) δ: ppm: 3.96 (t, 1H); 1.64 (m, 21H); 1.16 (m, 6H); 0.91 (m, 6H); 0.03 (m, 2H).

1,5-Bis(2-butylcyclopropyl)pentan-3-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

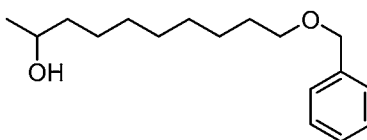
Chemical Formula: C₄₆H₈₇NO₅

Molecular Weight: 734.204

[00225] Compound 160 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.51 min. MS (ES): *m/z* (MH⁺) 735.0 for C₄₆H₈₇NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.97 (m, 1H); 4.08 (t, 2H); 3.56 (br. m, 2H); 2.75-2.37 (br. m, 6H); 2.31 (m, 4H); 1.74-1.05 (m, 54H); 0.92 (m, 9H); 0.67 (m, 6H); 0.31 (m, 2H).

DT. Compound 161: Heptadecan-9-yl 8-((2-hydroxyethyl)(10-(octanoyloxy)decan-2-yl)amino)octanoate

10-(Benzyloxy)decan-2-ol

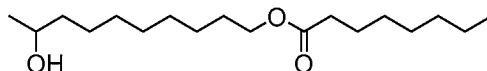
Chemical Formula: C₁₇H₂₈O₂

Molecular Weight: 264.409

[00226] A solution of 10-(benzyloxy)decan-2-one (3.5 g, 13.34 mmol) in THF (10 mL) was added to a stirred solution of LAH in THF (10 mL) under N₂ at 0 °C. The mixture was allowed to warm to rt and stir for 2 h after which time 10 mL of sat. Na₂SO₄·10H₂O (aq) solution was slowly added. White solid precipitated. Additional solid Na₂SO₄·10H₂O was

added and the mixture was filtered through a plug of Celite. The filtrate was diluted with EtOAc and washed with brine. The organic layer was separated, dried over Na₂SO₄, filtered, and concentrated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain 10-(benzyloxy)decan-2-ol (3.2 g, 12.1 mmol, 91%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.32 (m, 5H); 4.53 (s, 2H); 3.80 (m, 1H); 3.49 (t, 2H); 1.64 (m, 2H); 1.55-1.25 (m, 132H); 1.21 (d, 3H).

9-Hydroxydecyl octanoate

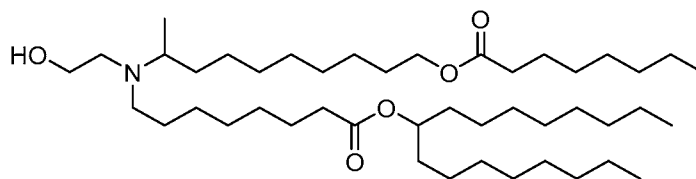


Chemical Formula: C₁₈H₃₆O₃

Molecular Weight: 300.483

[00227] 9-Hydroxydecyl octanoate was synthesized following Method A. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.08 (t, 2H); 3.80 (m, 1H); 2.30 (t, 2H); 1.64 (m, 4H); 1.52-1.17 (m, 23H); 0.90 (m, 3H).

Heptadecan-9-yl 8-((2-hydroxyethyl)(10-(octanoyloxy)decan-2-yl)amino)octanoate

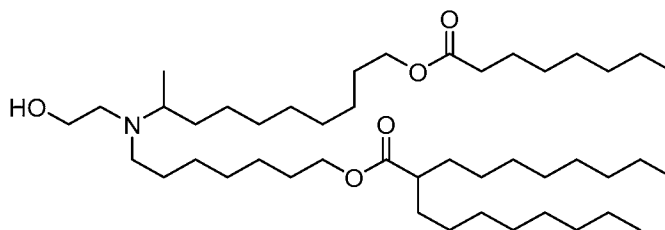


Chemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.209

[00228] Compound 161 was synthesized in a manner similar to Compound 152 and according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.46 min. MS (ES): *m/z* (MH⁺) 725.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.49 (br. m, 2H); 2.77-2.55 (m, 2H); 2.54-2.23 (m, 7H); 1.71-1.20 (m, 63H); 0.91 (m, 12H).

DU. Compound 162: 7-((2-Hydroxyethyl)(10-(octanoyloxy)decan-2-yl)amino)heptyl 2-octyldecanoate



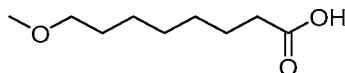
Chemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.209

[00229] Compound 162 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.49 min. MS (ES): m/z (MH⁺) 725.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 3.99 (m, 4H); 2.72-2.48 (m, 2H); 2.48-2.17 (m, 6H); 1.55 (m, 8H); 1.44-1.10 (m, 56H); 0.92-0.75 (m, 12H).

DV. Compound 163: 7-((2-Hydroxyethyl)(7-methyl-8-(nonyloxy)-8-oxooctyl)amino)heptyl 2-octyldecanoate

8-Methoxyoctanoic acid

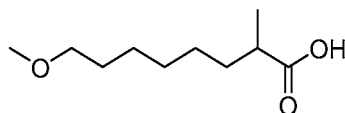


Chemical Formula: C₉H₁₈O₃

Molecular Weight: 174.240

[00230] To anhydrous MeOH (80 mL) at 0 °C KOH was added (7.54 g, 134.46 mmol) and stirred for 30 min. A solution of 8-bromooctanoic acid (10 g, 44.82 mmol) in anhydrous MeOH (70 mL) was added and the resulting solution was refluxed for 18 h. MeOH was removed under vacuum and the residue was acidified with 1N HCl and extracted with diethylether. The organic layer was washed with brine, separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-50%) EtOAc in hexanes to obtain 8-methoxyoctanoic acid (6.3 g, 36.16 mmol, 81%). ¹H NMR (300 MHz, CDCl₃) δ : ppm 3.35 (m, 5H); 2.37 (t, 2H); 1.61 (m, 4H); 1.36 (m, 6H).

8-Methoxy-2-methyloctanoic acid



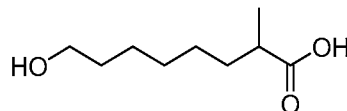
Chemical Formula: C₁₀H₂₀O₃

Molecular Weight: 188.267

[00231] To a suspension of NaH in THF (100 mL) at 0 °C, 8-methoxyoctanoic acid (5.6 g, 32.14 mmol) in THF (30 mL) was added dropwise. The reaction was allowed to stir at rt for 30 min. The reaction was cooled to 0 °C and LDA (17.86 mL, 2M in THF, 35.71 mmol) was added dropwise. After complete addition, the reaction was allowed to stir at 45 °C for 2 h. The reaction was cooled to rt and methyl iodide (2.45 mL, 39.28 mmol) in THF (15 mL) was slowly added. The reaction was stirred at 45 °C for 16 h. The reaction was quenched with 1N HCl (20 mL). The quenched reaction was evaporated under vacuum to remove volatiles. The residue was dissolved in hexanes/EtOAc (1:1) and washed with 1N HCl (100 mL X 2) followed by brine. The organic layer was separated, dried over sodium sulfate, filtered and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-15%) EtOAc in

hexanes to obtain 8-methoxy-2-methyloctanoic acid (3.25 g, 17.26 mmol, 54%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 3.35 (m, 5H); 2.49 (m, 1H); 1.70 (m, 1H); 1.59 (m, 2H); 1.36 (m, 7H); 1.21 (d, 3H).

8-Hydroxy-2-methyloctanoic acid

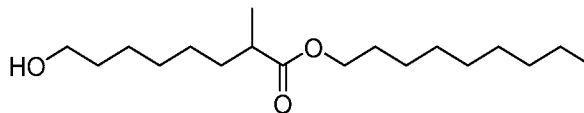


Chemical Formula: $\text{C}_9\text{H}_{18}\text{O}_3$

Molecular Weight: 174.240

[00232] To a solution of 8-methoxy-2-methyloctanoic acid (1 g, 5.31 mmol) in DCM (20 mL) at -78°C , boron tribromide (13.28 mL 1 M in DCM, 13.28 mmol) was added dropwise. The reaction was allowed to warm to rt and stir at rt for 2 h. The reaction was poured into ice and extracted with DCM. The organic layer was separated, dried over Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain 8-hydroxy-2-methyloctanoic acid (0.77 g, 4.41 mmol, 83%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 3.43 (t, 2H); 2.50 (m, 1H); 1.94-1.64 (m, 4H); 1.56-1.26 (m, 7H); 1.20 (d, 3H).

Nonyl 8-hydroxy-2-methyloctanoate

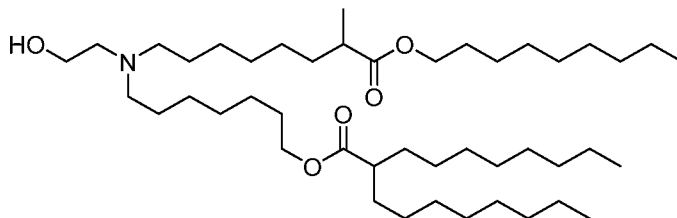


Chemical Formula: $\text{C}_{18}\text{H}_{36}\text{O}_3$

Molecular Weight: 300.483

[00233] A solution of 8-hydroxy-2-methyloctanoic acid (0.75 g, 4.31 mmol), nonan-1-ol (6.22 g, 43.1 mmol), 4-dimethylaminopyridine (0.11 g, 0.86 mmol) in DCM (20 mL) under N_2 was added to (3-[(ethylimino)methylidene]amino)propyl)dimethylamine hydrochloride (0.83 g, 4.31 mmol). The reaction allowed to stir at rt for 16 h. The reaction was diluted with DCM and washed with sat. NaHCO_3 , followed by brine. The organic layer was separated, dried over Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-20%) EtOAc in hexanes to obtain nonyl 8-hydroxy-2-methyloctanoate (0.68 g, 2.26 mmol, 53%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.08 (t, 2H); 3.42 (t, 2H); 2.45 (m, 1H); 1.87 (m, 2H); 1.75-1.57 (m, 4H); 1.52-1.22 (m, 19H); 1.15 (d, 3H); 0.91 (m, 3H).

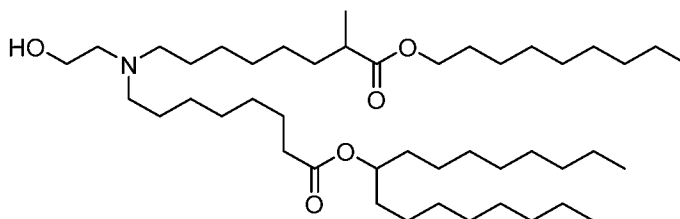
7-((2-Hydroxyethyl)(7-methyl-8-(nonyloxy)-8-oxooctyl)amino)heptyl 2-octyldecanoate

Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.209

[00234] Compound 163 was synthesized in a manner similar to Compound 152 according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.50 min. MS (ES): m/z (MH^+) 725.0 for $C_{45}H_{89}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.08 (t, 4H); 3.55 (m, 2H); 2.67 (m, 2H); 2.53-2.24 (m, 6H); 1.72-1.10 (m, 65H); 0.90 (m, 9H).

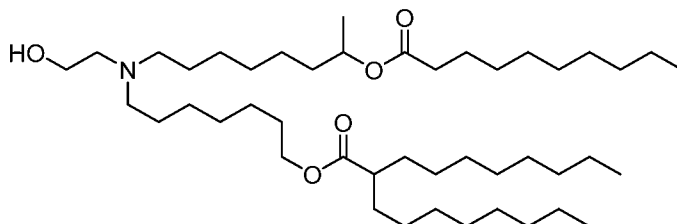
DW. Compound 164: Nonyl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)-2-methyloctanoate

Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.209

[00235] Compound 164 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.51 min. MS (ES): m/z (MH^+) 725.0 for $C_{45}H_{89}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.69-2.38 (m, 8H); 2.30 (t, 2H); 1.74-1.09 (m, 65H); 0.90 (m, 9H).

DX. Compound 165: 7-((7-(Decanoyloxy)octyl)(2-hydroxyethyl)amino)heptyl 2-octyldecanoate

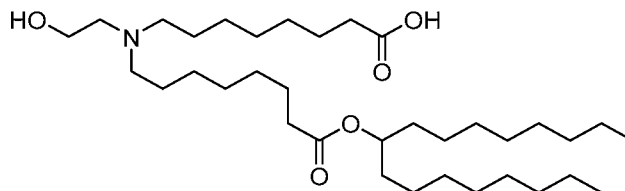
Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.209

[00236] Compound 165 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.55 min. MS (ES): m/z

(MH⁺) 725.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.68-2.39 (m, 8H); 2.29 (m, 3H); 1.72-1.15 (m, 64H); 0.90 (m, 9H).

DY. Compound 166: 8-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoic acid

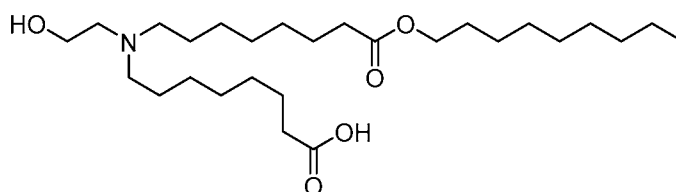


Chemical Formula: C₃₅H₆₉NO₅

Molecular Weight: 583.939

[00237] To a solution of heptadecan-9-yl 8-[[8-(*tert*-butoxy)-8-oxooctyl](2-hydroxyethyl)amino}octanoate (0.11 g, 0.17 mmol) in DCM was added trifluoroacetic acid (0.06 mL, 0.69 mmol) and the reaction was allowed to stir at rt for 40 h. Volatiles were evaporated under vacuum. The residue was dissolved in ethylacetate and water and extracted with ethylacetate. The organic layer was separated, dried with Na₂SO₄, filtered and concentrated under vacuum. The residue was purified by silica gel chromatography (0-50%) (1%, 20% MeOH in DCM) in DCM to obtain 8-[[8-(heptadecan-9-yloxy)-8-oxooctyl](2-hydroxyethyl)amino}octanoic acid (0.023 g, 0.04 mmol) as a colorless liquid. UPLC/ELSD: RT = 2.72 min. MS (ES): m/z (MH⁺) 585.0 for C₃₅H₆₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.87 (m, 1H); 3.98 (m, 2H); 3.25-3.05 (m, 6H); 2.32 (m, 4H); 1.82-1.45 (m, 12H); 1.45-1.19 (m, 37H); 0.89 (m, 6H).

DZ. Compound 167: 8-((2-Hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoic acid

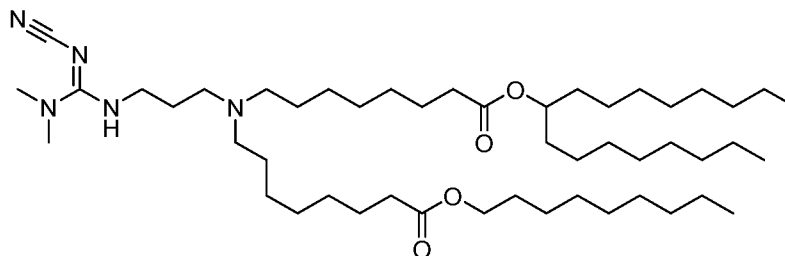


Chemical Formula: C₂₇H₅₃NO₅

Molecular Weight: 471.723

[00238] Compound 167 was synthesized following the same procedure as Compound 166. UPLC/ELSD: RT = 1.57 min. MS (ES): m/z (MH⁺) 472.0 for C₂₇H₅₃NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.08 (m, 2H); 4.00 (m, 2H); 3.44-2.98 (m, 10H); 2.35 (t, 4H); 1.85-1.55 (m, 10H); 1.33 (m, 23H); 0.90 (m, 3H).

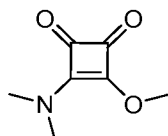
EA. Compound 168: Heptadecan-9-yl (Z)-8-((3-(2-cyano-3,3-dimethylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: C₄₉H₉₅N₅O₄

Molecular Weight: 818.33

[00239] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.3 mmol) in 5 mL 2-propanol was added triethylamine (0.04 mL, 0.3 mmol) followed by diphenyl cyanocarbonimidate (72 mg, 0.3 mmol) and the mixture stirred at rt for two hours. To the reaction mixture was added a 2M dimethylamine solution in THF (0.75 mL, 1.5 mmol) and the resulting solution heated to 75 °C for 18 hours. Additional 2M dimethylamine/THF solution (0.75 mL, 1.5 mmol) was added and the temperature increased to 85 °C. After six hours the reaction was complete by LC/MS so the solution was reduced under vacuum, diluted with DCM and washed once with a saturated aqueous sodium bicarbonate solution. The organic phase was dried (MgSO₄), filtered and the filtrate evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((3-(2-cyano-3,3-dimethylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (119.2 mg, 0.14 mmol, 49%) as a colorless syrup. UPLC/ELSD: RT = 3.52 min. MS (ES): *m/z* (MH⁺) 819.0 for C₄₉H₉₅N₅O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.62 (br. s., 1H); 4.86 (quint., 1H, *J* = 6 Hz); 4.05 (t, 2H, *J* = 7.5 Hz); 3.68 (d, 2H, *J* = 3 Hz); 2.99 (s, 6H); 2.59 (br. s, 2H); 2.43 (br. s, 3H); 2.28 (m, 4H); 1.71 (br. s, 2H); 1.62 (m, 8H); 1.49 (m, 5H); 1.26 (br. m, 50H); 0.88 (t, 9H, *J* = 7.5 Hz).

EB. Compound 169: Heptadecan-9-yl 8-((3-((2-(dimethylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
3-(Dimethylamino)-4-methoxycyclobut-3-ene-1,2-dione

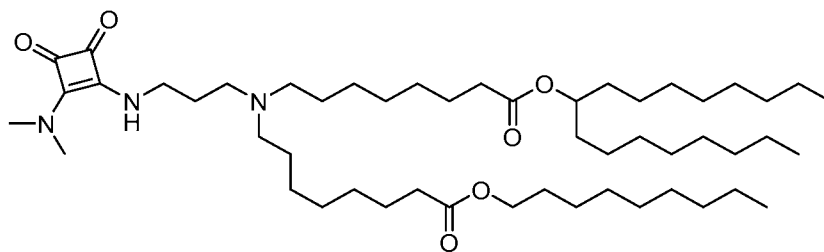
Chemical Formula: C₇H₉NO₃

Molecular Weight: 155.15

[00240] To a solution of 3,4-dimethoxy-3-cyclobutene-1,2-dione (1 g, 7 mmol) in 100 mL diethyl ether was added a 2M dimethylamine solution in THF (3.8 mL, 7.6 mmol) and a ppt.

formed almost immediately. The mixture was stirred at rt for 24 hours and then filtered. The filter solids were washed with diethyl ether and air-dried. The filter solids were dissolved in hot MeOH, filtered, the filtrate allowed to cool to room temp., then cooled to 0 °C to give a ppt. This was isolated via filtration, washed with cold MeOH, air-dried, then dried under vacuum to give 3-(dimethylamino)-4-methoxycyclobut-3-ene-1,2-dione (0.42 g, 2.7 mmol, 39%) as a pale yellow solid. ¹H NMR (300 MHz, DMSO-*d*₆) δ: ppm 4.28 (s, 3H); 3.21 (s, 3H); 3.05 (s, 3H).

Heptadecan-9-yl 8-((3-((2-(dimethylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

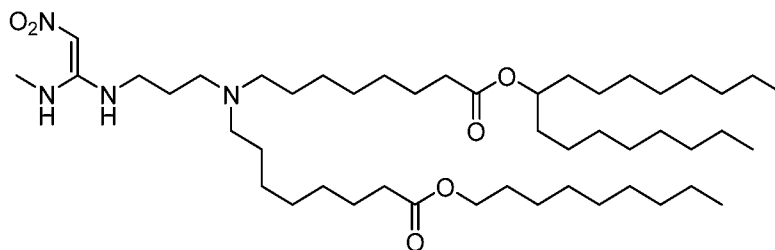


Chemical Formula: C₅₁H₉₅N₃O₆

Molecular Weight: 846.34

[00241] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.3 mmol) in 10 mL ethanol was added 3-(dimethylamino)-4-methoxycyclobut-3-ene-1,2-dione (47 mg, 0.3 mmol) and the resulting colorless solution stirred at rt for 20 hours after which no starting amine remained by LC/MS. The solution was concentrated *in vacuo* and the residue purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-((2-(dimethylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (135 mg, 0.16 mmol, 53%) as a colorless syrup. UPLC/ELSD: RT = 3.51 min. MS (ES): *m/z* (MH⁺) 847.3 for C₅₁H₉₅N₃O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.86 (br. s., 1H); 4.86 (quint., 1H, *J* = 6 Hz); 4.05 (t, 2H, *J* = 6 Hz); 3.92 (d, 2H, *J* = 3 Hz); 3.20 (s, 6H); 2.63 (br. s., 2H); 2.42 (br. s., 3H); 2.28 (m, 4H); 1.74 (br. s., 2H); 1.61 (m, 8H); 1.50 (m, 5H); 1.41 (m, 3H); 1.25 (br. m, 47H); 0.88 (t, 9H, *J* = 7.5 Hz).

EC. Compound 170: Heptadecan-9-yl (E)-8-((3-((1-(methylamino)-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

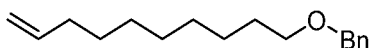


Chemical Formula: $C_{48}H_{94}N_4O_6$

Molecular Weight: 823.30

[00242] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.3 mmol) in 5 mL methanol was added 1-methylthio-1-methylamino-2-nitroethene (45 mg, 0.3 mmol), the resulting solution heated to 70 °C and stirred for 24 hours after which no starting amine remained by LC/MS. The solution was diluted with DCM and washed once with a saturated aqueous sodium bicarbonate solution. The organic phase was dried ($MgSO_4$), filtered and the filtrate evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (E)-8-((3-((1-(methylamino)-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (90 mg, 0.11 mmol, 36%) as a pale yellow syrup. UPLC/ELSD: RT = 3.33 min. MS (ES): m/z (MH^+) 824.3 for $C_{48}H_{94}N_4O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 10.15 (d, 1H, J = 9 Hz); 8.26 (d, 1H, J = 27 Hz); 6.55 (d, 1H, J = 9 Hz); 4.86 (quint., 1H, J = 6 Hz); 4.05 (t, 2H, J = 6 Hz); 3.32 (br. s, 1H); 3.24 (br. s, 1H); 2.81 (dd, 3H, J = 3 Hz, 12 Hz); 2.63 (br. s, 1H); 2.47 (br. s, 4H); 2.28 (m, 4H); 1.77 (br. s, 2H); 1.62 (m, 5H); 1.59 (m, 6H); 1.49 (m, 3H); 1.43 (m, 3H); 1.26 (br. m, 46H); 0.88 (t, 9H, J = 7.5 Hz).

ED. Compound 171: Heptadecan-9-yl 8-((9-hydroxy-9-methyloctadecyl)(2-hydroxyethyl)amino)octanoate ((Dec-9-en-1-yloxy)methyl)benzene



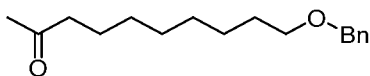
Chemical Formula: $C_{17}H_{26}O$

Molecular Weight: 246.394

[00243] To a suspension of sodium hydride (3.88 g, 96.99 mmol) in THF (100 mL) was added 9-decen-1-ol (10 g, 63.99 mmol) slowly. After 30 min. benzyl bromide (10.57 mL, 88.9 mmol) was added. The reaction was allowed to stir at rt for 18 h. The reaction was quenched with water. Solvents were evaporated under vacuum. The residue was diluted with EtOAc and

washed with sat. NaHCO_3 , followed by brine. The organic layer was separated, dried with Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-20%) EtOAc in hexanes to obtain ((dec-9-en-1-yloxy)methyl)benzene (8.5 g, 34.5 mmol, 54%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.32 (m, 5H); 5.83 (m, 1H); 4.98 (m, 2H); 4.53 (s, 2H); 3.49 (t, 2H); 2.06 (m, 2H); 1.64 (m, 2H); 1.46-1.26 (br. m, 10H).

10-(Benzyloxy)decan-2-one

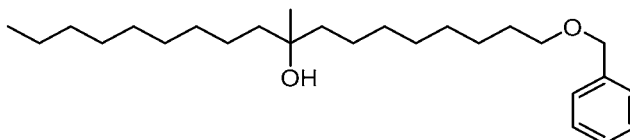


Chemical Formula: $\text{C}_{17}\text{H}_{26}\text{O}_2$

Molecular Weight: 262.393

[00244] To a solution of palladium chloride (0.09 g, 0.52 mmol) and benzoquinone (3.09 g, 28.57 mmol) in DMF/Water (7:1, 12.8 mL), [(dec-9-en-1-yloxy)methyl]benzene (6.4 g, 25.98 mmol) was slowly added and the dark brown solution was allowed to stir for 3 days at rt. The mixture was dissolved in 2N HCl (50 mL) and extracted with ether (3 x 50 mL). The combined organic phase was washed with 2N NaOH (3 x 50 mL) and dried over MgSO_4 . Solvents were removed under vacuum and the residue was purified by silica gel chromatography (0-40%) ethyl acetate in hexanes to obtain 10-(benzyloxy)decan-2-one (3.44 g, 13.11 mmol, 50%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.36 (m, 5H); 4.52 (s, 2H); 3.48 (t, 2H); 2.43 (t, 2H); 2.15 (s, 3H); 1.61 (m, 4H); 1.45-1.24 (br. m, 8H).

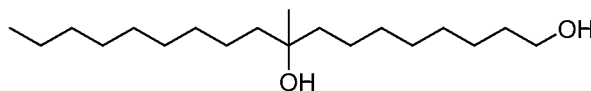
1-(Benzyloxy)-9-methyloctadecan-9-ol



Chemical Formula: $\text{C}_{26}\text{H}_{46}\text{O}_2$

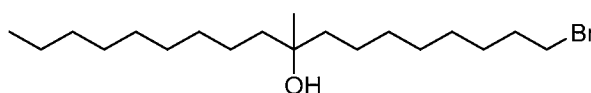
Molecular Weight: 390.652

[00245] To a solution of 10-(benzyloxy)decan-2-one (1 g, 3.81 mmol) in THF (30 mL) at 0 °C, bromo(nonyl)magnesium (4.57 mL 1 M in diethylether, 4.57 mmol) was added dropwise. The reaction was allowed to warm to rt and stir for 4 h. The reaction was quenched with water (2mL), diethylether was added (200 mL) and the resulting white solid was filtered through a silica plug. The filtrate was extracted with ether. The organic layer was washed with water, followed by brine. The organic layer was separated, dried over Na_2SO_4 , filtered, and concentrated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain 1-(benzyloxy)-9-methyloctadecan-9-ol (0.99 g). The product was impure but taken to the next step without further purification.

9-Methyloctadecane-1,9-diolChemical Formula: C₁₉H₄₀O₂

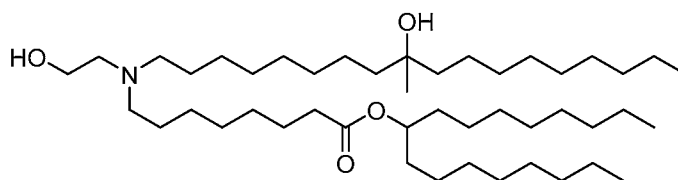
Molecular Weight: 300.527

[00246] Under N₂ a flask was charged with 1-(benzyloxy)-9-methyloctadecan-9-ol (1 g, 2.56 mmol), Pd(OH)₂ (100 mg) and EtOH. The reaction was purged with H₂ and was kept under H₂ (balloon) with stirring for 16 h at rt. The reaction was purged with N₂. The reaction was filtered through a plug of Celite and the Celite was washed with EtOAc (200 mL). The filtrate was evaporated under vacuum. The residue was dissolved in EtOAc and was washed with water. The organic layer was separated, dried over Na₂SO₄, filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with EtOAc in hexanes (0-40%) to obtain 9-methyloctadecane-1,9-diol (0.65g, 2.16 mmol, 84%). ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.66 (t, 2H); 1.59 (m, 2H); 1.49-1.22 (br. m, 29H); 1.17 (s, 3H); 0.90 (m, 3H).

1-Bromo-9-methyloctadecan-9-olChemical Formula: C₁₉H₃₉BrO

Molecular Weight: 363.42

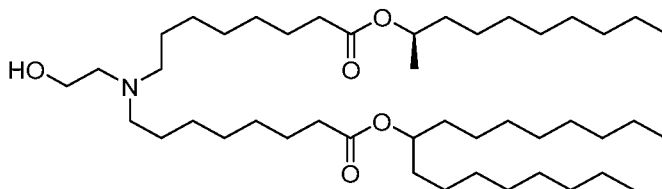
[00247] 1-Bromo-9-methyloctadecan-9-ol was synthesized in the same manner as (Z)-1-bromo-10-octyloctadec-8-ene. ¹H NMR (300 MHz, CDCl₃) δ: ppm 3.43 (t, 2H); 1.88 (m, 2H); 1.53-1.23 (br. m, 28H); 1.17 (s, 3H); 0.91 (m, 3H).

Heptadecan-9-yl 8-((9-hydroxy-9-methyloctadecyl)(2-hydroxyethyl)amino)octanoateChemical Formula: C₄₆H₉₃NO₄

Molecular Weight: 724.253

[00248] Compound 171 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.56 min. MS (ES): m/z (MH⁺) 725.0 for C₄₆H₉₃NO₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.89 (m, 1H); 3.55 (m, 2H); 2.60 (m, 2H); 2.47 (m, 4H); 2.30 (t, 2H); 1.74-1.21(m, 69H); 1.17 (s, 3H); 0.90 (m, 9H).

EE. Compound 172: (*R*)-Decan-2-yl 8-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)octanoate

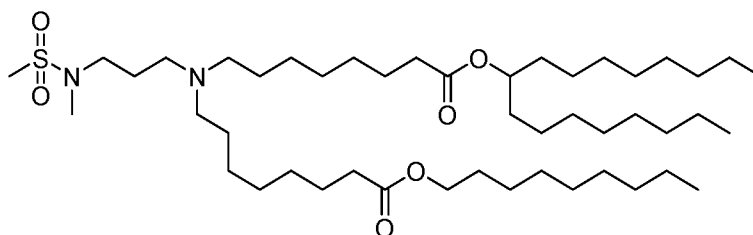


Chemical Formula: C₄₅H₈₉NO₅

Molecular Weight: 724.209

[00249] Compound 172 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.53 min. MS (ES): *m/z* (MH⁺) 725.0 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.91 (m, 2H); 3.54 (m, 2H); 2.59 (m, 2H); 2.46 (m, 4H); 2.30 (m, 4H); 1.70-1.19 (m, 66H); 0.90 (m, 9H).

EF. Compound 173: Heptadecan-9-yl 8-((3-(*N*-methylmethanesulfonamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



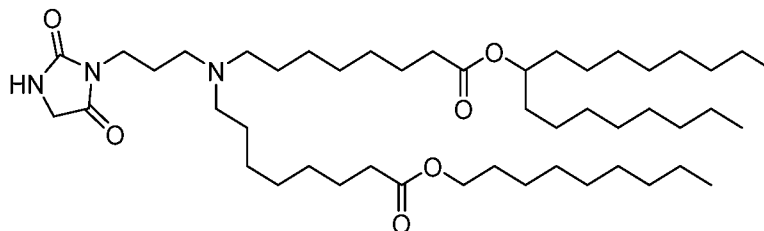
Chemical Formula: C₄₇H₉₄N₂O₆S

Molecular Weight: 815.34

[00250] To a solution of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and *N*-methyl methanesulfonamide (50 μ L, 0.54 mmol) in 4 mL dry DMF was added cesium carbonate (130 mg, 0.40 mmol), the resulting mixture heated to 60 °C and stirred for 24 hours, after which no starting chloride remained by LC/MS. The mixture was allowed to cool to rt, diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried (MgSO₄), filtered and conc. to a yellow oil. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(*N*-methylmethanesulfonamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (85 mg, 0.11 mmol, 39%) as a pale yellow oil. UPLC/ELSD: RT = 3.57 min. MS (ES): *m/z* (MH⁺) 816.1 for C₄₇H₉₄N₂O₆S. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (quint., 1H, *J* = 6 Hz); 4.05 (t, 2H, *J* = 6 Hz); 3.15 (t, 2H, *J* = 7.5 Hz);

2.85 (s, 3H); 2.79 (3, 3H); 2.40 (br. m, 5H); 2.28 (m, 4H); 1.72 (br. m, 2H); 1.64 - 1.49 (m, 13H); 1.26 (br. m, 50H); 0.88 (t, 9H, $J = 7.5$ Hz).

EG. Compound 174: Heptadecan-9-yl 8-((3-(2,5-dioxoimidazolidin-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

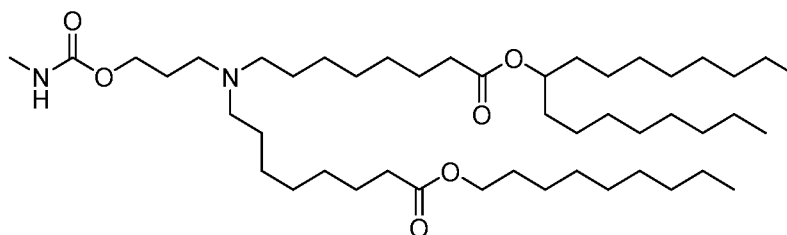


Chemical Formula: $C_{48}H_{91}N_3O_6$

Molecular Weight: 806.27

[00251] To a solution of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and hydantoin (50 mg, 0.54 mmol) in 4 mL dry DMF was added cesium carbonate (130 mg, 0.40 mmol), the resulting mixture heated to 60 °C and stirred for 24 hours, after which no starting chloride remained by LC/MS. The mixture was allowed to cool to rt, diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried ($MgSO_4$), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2,5-dioxoimidazolidin-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (35 mg, 0.05 mmol, 18%) as a pale yellow oil. UPLC/ELSD: RT = 3.52 min. MS (ES): m/z (MH^+) 807.2 for $C_{48}H_{91}N_3O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.27 (br. s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.95 (s, 2H); 3.55 (t, 2H, $J = 7.5$ Hz); 2.50 – 2.34 (br. m, 5H); 2.26 (m, 4H); 1.77 (br. s, 2H); 1.64 - 1.49 (m, 15H); 1.26 (br. m, 48H); 0.88 (t, 9H, $J = 7.5$ Hz).

EH. Compound 175: Heptadecan-9-yl 8-((3-((methylcarbamoyl)oxy)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

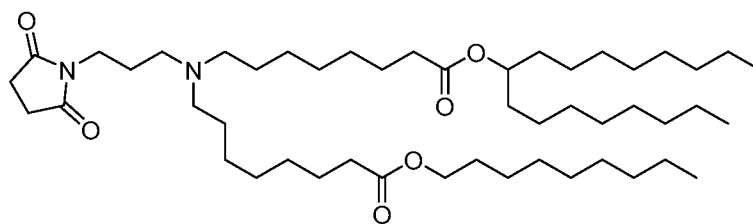


Chemical Formula: $C_{47}H_{92}N_2O_6$

Molecular Weight: 781.26

[00252] To a solution of heptadecan-9-yl 8-((3-hydroxypropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and triethylamine (60 μ L, 0.41 mmol) in 5 mL dry DCM at 0 °C was added methyl isocyanate (22 μ L, 0.35 mmol) dropwise. The cooling bath was removed and the solution stirred at rt for 2 hours, after which no starting alcohol remained by LC/MS. The reaction was quenched with three drops of methanol, the mixture reduced in a stream of nitrogen and the residue purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-((methylcarbamoyl)oxy)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (115 mg, 0.15 mmol, 53%) as a colorless oil. UPLC/ELSD: RT = 3.54 min. MS (ES): m/z (MH^+) 782.3 for $\text{C}_{47}\text{H}_{92}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (quint., 1H, $J = 6$ Hz); 4.62 (br. s, 1H); 4.05 (m, 4H); 2.79 (d, 3H, $J = 3$ Hz); 2.47 (br. s, 2H); 2.37 (br. m, 3H); 2.27 (m, 4H); 1.73 (br. s, 2H); 1.61 (m, 7H); 1.50 (br. m, 4H); 1.40 (br. m, 4H); 1.25 (br. m, 48H); 0.87 (t, 9H, $J = 7.5$ Hz).

EI. Compound 176: Heptadecan-9-yl 8-((3-(2,5-dioxopyrrolidin-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



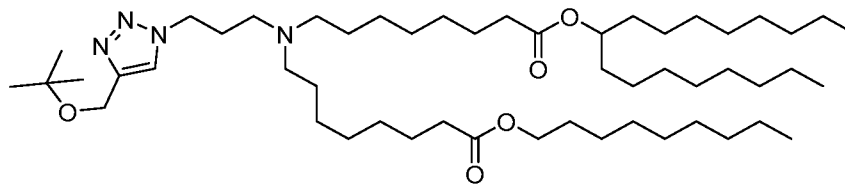
Chemical Formula: $\text{C}_{49}\text{H}_{92}\text{N}_2\text{O}_6$

Molecular Weight: 805.28

[00253] To a solution of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and succinimide (50 mg, 0.54 mmol) in 4 mL dry DMSO was added cesium carbonate (130 mg, 0.40 mmol), the resulting mixture heated to 80 °C and stirred for 48 hours, after which no starting chloride remained by LC/MS. The mixture was allowed to cool to rt, diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted three times with DCM. The organics were combined, washed once with water, dried (MgSO_4), filtered and conc. The residue was purified twice by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2,5-dioxopyrrolidin-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (44 mg, 0.05 mmol, 19%) as a slightly yellow oil. UPLC/ELSD: RT = 3.56 min. MS (ES): m/z (MH^+) 806.1 for $\text{C}_{49}\text{H}_{92}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.52 (t, 2H, $J = 7.5$ Hz); 2.69 (s, 4H);

2.42 – 2.25 (br. m, 9H); 1.71 – 1.58 (m, 10H); 1.50 (br. d, 4H, $J = 3$ Hz); 1.26 (br. m, 51H); 0.88 (t, 9H, $J = 7.5$ Hz).

EJ. Compound 177: Heptadecan-9-yl 8-((3-(4-(tert-butoxymethyl)-1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

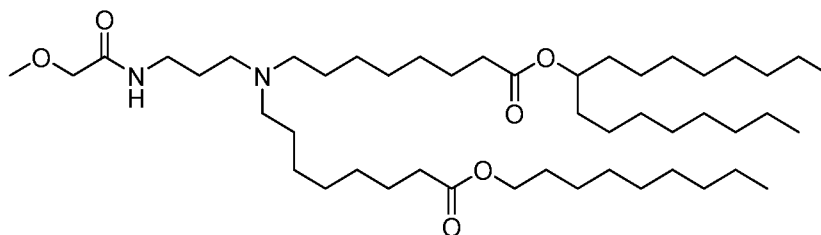


Chemical Formula: $C_{52}H_{100}N_4O_5$

Molecular Weight: 861.40

[00254] To a solution of heptadecan-9-yl 8-((3-azidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.67 mmol) and *tert*-butyl propargyl ether (100 μ L, 0.73 mmol) in 4 mL THF was added a suspension of anhydrous copper(II) sulfate (5 mg, 0.03 mmol) and sodium ascorbate (14 mg, 0.07 mmol) in 1 mL water and the mixture stirred at rt for 24 hours, after which no starting azide remained by LC/MS. The mixture was diluted with a saturated aqueous sodium bicarbonate solution and extracted three times with DCM. The organics were combined, dried ($MgSO_4$), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(4-(tert-butoxymethyl)-1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (485 mg, 0.56 mmol, 84%) as a slightly yellow oil. UPLC/ELSD: RT = 3.63 min. MS (ES): m/z (MH^+) 862.2 for $C_{52}H_{100}N_4O_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.50 (s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.59 (s, 2H); 4.36 (t, 2H, $J = 7.5$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 2.36 (br. m, 5H); 2.28 (m, 4H); 2.02 (br. m, 2H); 1.62 (br. m, 8H); 1.50 (br. d, 4H, $J = 3$ Hz); 1.28 (br. m, 60H); 0.88 (t, 9H, $J = 7.5$ Hz).

EK. Compound 178: Heptadecan-9-yl 8-((3-(2-methoxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_{48}H_{94}N_2O_6$

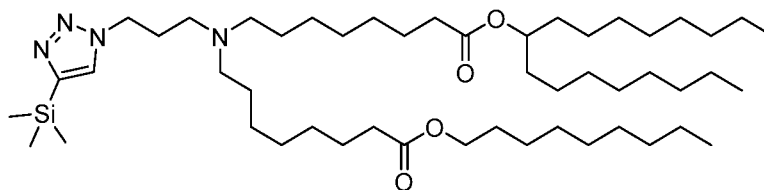
Molecular Weight: 795.29

[00255] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and triethylamine (60 μ L, 0.41 mmol) in 5 mL

dry DCM at 0 °C was added methoxyacetyl chloride (30 μ L, 0.33 mmol) dropwise. The cooling bath was removed and the solution stirred at rt for 24 hours, after which no starting amine remained by LC/MS. The mixture was diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried (MgSO_4), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-methoxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (50 mg, 0.06 mmol, 23%) as a colorless oil. UPLC/ELSD: RT = 3.56 min. MS (ES): m/z (MH^+) 796.2 for $\text{C}_{48}\text{H}_{94}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.53 (s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.87 (s, 2H); 3.39 (m, 5H); 2.47 (br. s, 2H); 2.36 (br. m, 3H); 2.27 (m, 4H); 1.61 (m, 8H); 1.46 (br. m, 9H); 1.26 (br. m, 48H); 0.88 (t, 9H, $J = 7.5$ Hz).

EL. Compound 179: Heptadecan-9-yl 8-((3-(1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)(3-(4-(trimethylsilyl)-1H-1,2,3-triazol-1-yl)propyl)amino)octanoate



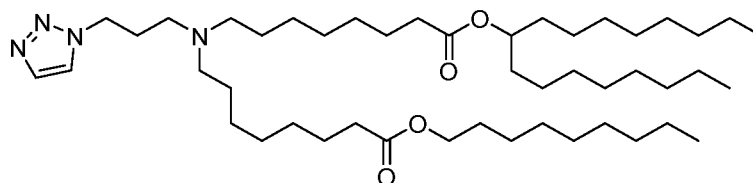
Chemical Formula: $\text{C}_{50}\text{H}_{98}\text{N}_4\text{O}_4\text{Si}$

Molecular Weight: 847.44

[00256] To a solution of heptadecan-9-yl 8-((3-azidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and ethynyltrimethylsilane (41 μ L, 0.29 mmol) in 2 mL THF was added a suspension of anhydrous copper(II) sulfate (2 mg, 0.01 mmol) and sodium ascorbate (5 mg, 0.02 mmol) in 0.5 mL water and the mixture stirred at rt for 20 hours, after which no starting azide remained by LC/MS. The mixture was diluted with a saturated aqueous sodium bicarbonate solution and extracted three times with DCM. The organics were combined, dried (MgSO_4), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)(3-(4-(trimethylsilyl)-1H-1,2,3-triazol-1-yl)propyl)amino)octanoate (150 mg, 0.18 mmol, 66%) as a slightly yellow oil which is a 2:1 mixture of TMS / des-TMS product by ^1H -NMR. Carried through as is. UPLC/ELSD: RT = 3.63 min. MS (ES): m/z (MH^+) 848.3 for $\text{C}_{50}\text{H}_{98}\text{N}_4\text{O}_4\text{Si}$. ^1H NMR (300

MHz, CDCl₃) δ : ppm 7.55 (s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.45 (t, 2H, $J = 7.5$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.42 (br. s, 1H); 2.28 (m, 5H); 1.65 – 1.45 (br. m, 14H); 1.25 (br. m, 48H); 0.87 (t, 9H, $J = 7.5$ Hz); 0.33 (s, 6H).

Heptadecan-9-yl 8-((3-(1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

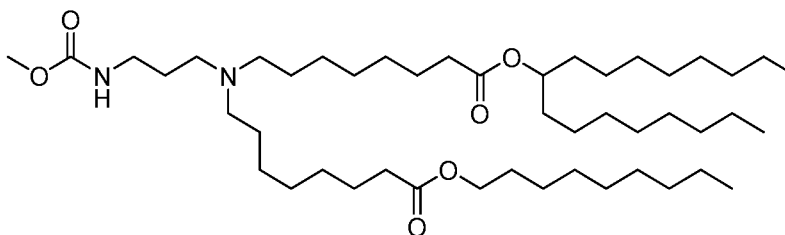


Chemical Formula: C₄₇H₉₀N₄O₄

Molecular Weight: 775.26

[00257] To a solution of (150 mg, 0.18 mmol) in 5 mL THF was added a 1M tetrabutylammonium fluoride solution in THF (0.21 mL, 0.21 mmol) and the solution stirred at rt for 24 hours after which the reaction had progressed ca. 25%. The solution was heated to 55 °C and stirred for 24 hours, after which the reaction was complete by LC/MS. The solution was diluted with a saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, dried (MgSO₄), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (53 mg, 0.07 mmol, 39%) as a colorless oil. UPLC/ELSD: RT = 3.55 min. MS (ES): m/z (MH⁺) 776.2 for C₄₇H₉₀N₄O₄. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.69 (s, 1H); 7.55 (s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.44 (t, 2H, $J = 7.5$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 2.37 (br. m, 5H); 2.28 (m, 4H); 2.05 (br. m, 2H); 1.61 (br. m, 8H); 1.49 (br. m, 4H); 1.26 (br. m, 51H); 0.88 (t, 9H, $J = 7.5$ Hz).

EM. Compound 181: Heptadecan-9-yl 8-((3-((methoxycarbonyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₇H₉₂N₂O₆

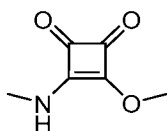
Molecular Weight: 781.26

[00258] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.27 mmol) and triethylamine (60 μ L, 0.41 mmol) in 5 mL

dry DCM at 0 °C was added methyl chloroformate (27 uL, 0.33 mmol) dropwise. The cooling bath was removed and the solution stirred at rt for 24 hours, after which no starting amine remained by LC/MS. The mixture was diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried (MgSO₄), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(((methoxycarbonyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (120 mg, 0.15 mmol, 54%) as a colorless oil.

UPLC/ELSD: RT = 3.55 min. MS (ES): m/z (MH⁺) 782.1 for C₄₇H₉₂N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ : ppm 6.11 (br. s, 1H); 4.86 (quint., 1H, J = 6 Hz); 4.05 (t, 2H, J = 6 Hz); 3.64 (s, 3H); 3.25 (br. d, 2H, J = 6 Hz); 2.46 (br. s, 2H); 2.38 – 2.24 (m, 7H); 1.61 (br. t, 9H, J = 7.5 Hz); 1.50 (m, 4H); 1.42 (br. m, 3H); 1.26 (br. m, 49H); 0.88 (t, 9H, J = 7.5 Hz).

EN. Compound 182: Heptadecan-9-yl 8-((3-((2-(methylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
3-Methoxy-4-(methylamino)cyclobut-3-ene-1,2-dione

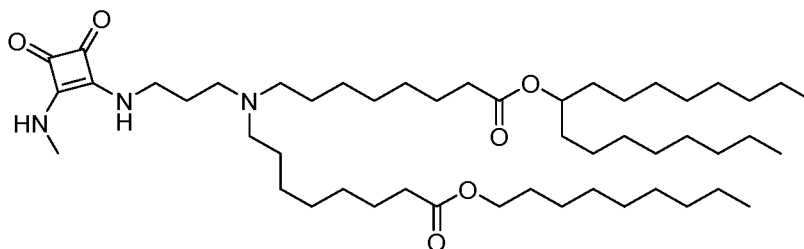


Chemical Formula: C₆H₇NO₃

Molecular Weight: 141.13

[00259] To a solution of 3,4-dimethoxy-3-cyclobutene-1,2-dione (1 g, 7 mmol) in 100 mL diethyl ether was added a 2M methylamine solution in THF (3.8 mL, 7.6 mmol) and a ppt. formed almost immediately. The mixture was stirred at rt for 24 hours, then filtered, the filter solids washed with diethyl ether and air-dried. The filter solids were dissolved in hot EtOAc, filtered, the filtrate allowed to cool to room temp., then cooled to 0 °C to give a ppt. This was isolated via filtration, washed with cold EtOAc, air-dried, then dried under vacuum to give 3-methoxy-4-(methylamino)cyclobut-3-ene-1,2-dione (0.70 g, 5 mmol, 73%) as a white solid. ¹H NMR (300 MHz, DMSO-*d*₆) δ : ppm 8.50 (br. d, 1H, J = 69 Hz); 4.27 (s, 3H); 3.02 (sdd, 3H, J = 42 Hz, 4.5 Hz).

Heptadecan-9-yl 8-((3-((2-(methylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

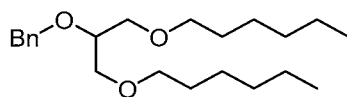
Chemical Formula: $C_{50}H_{93}N_3O_6$

Molecular Weight: 832.31

[00260] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.28 mmol) in 10 mL ethanol was added 3-methoxy-4-(methylamino)cyclobut-3-ene-1,2-dione (39 mg, 0.28 mmol) and the resulting colorless solution stirred at rt for 20 hours after which no starting amine remained by LC/MS. The solution was concentrated *in vacuo* and the residue purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-((2-(methylamino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (138 mg, 0.17 mmol, 60%) as a gummy white solid. UPLC/ELSD: RT = 3. min. MS (ES): m/z (MH^+) 833.4 for $C_{51}H_{95}N_3O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.86 (br. s., 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.92 (d, 2H, $J = 3$ Hz); 3.20 (s, 6H); 2.63 (br. s., 2H); 2.42 (br. s., 3H); 2.28 (m, 4H); 1.74 (br. s., 2H); 1.61 (m, 8H); 1.50 (m, 5H); 1.41 (m, 3H); 1.25 (br. m, 47H); 0.88 (t, 9H, $J = 7.5$ Hz).

EO. Compound 183: 1,3-Bis(hexyloxy)propan-2-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

((((1,3-Bis(hexyloxy)propan-2-yl)oxy)methyl)benzene

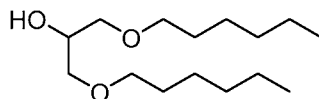
Chemical Formula: $C_{22}H_{38}O_3$

Molecular Weight: 350.543

[00261] To a slurry of NaH (1.76 g, 43.9 mmol) in THF (40 mL) under N_2 was added 2-(benzyloxy)propane-1,3-diol (2 g, 10.98 mmol) and the mixture was allowed to stir at 40 °C for 2 h. After this time 1-bromohexane (4.35 g, 26.34 mmol) in DMF (2ml) and a catalytic amount of KI were added. The reaction was refluxed for 16 h. Solvents were evaporated under vacuum. The residue was diluted with EtOAc and washed with sat. $NaHCO_3$, followed by brine. The organic layer was separated, dried over Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-40%) EtOAc in hexanes to obtain ((1,3-bis(hexyloxy)propan-2-yl)oxy)methylbenzene (1.7 g, 4.75 mmol, 43%). ^1H NMR (300

MHz, CDCl₃) δ : ppm 7.34 (m, 5H); 4.73 (s, 2H); 3.75 (m, 1H); 3.61-3.40 (m, 8H); 1.59 (m, 4H); 1.32 (m, 12H); 0.91 (m, 6H).

1,3-Bis(hexyloxy)propan-2-ol

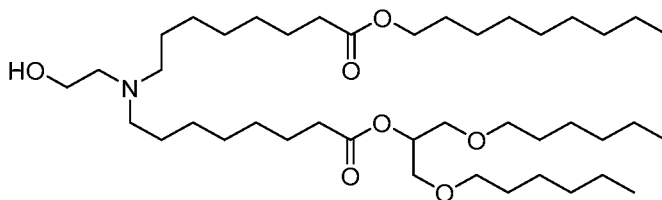


Chemical Formula: C₁₅H₃₂O₃

Molecular Weight: 260.418

[00262] 1,3-Bis(hexyloxy)propan-2-ol was synthesized using the same manner as 9-Methyloctadecane-1,9-diol. ¹H NMR (300 MHz, CDCl₃) δ : ppm 3.96 (m, 1H); 3.48 (m, 8H); 2.37 (br. s, 1H); 1.64 (m, 2H); 1.60 (m, 4H); 1.32 (m, 12H); 0.91 (m, 6H).

1,3-Bis(hexyloxy)propan-2-yl 8-((2-hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



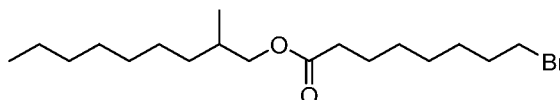
Chemical Formula: C₄₂H₈₃NO₇

Molecular Weight: 714.126

[00263] Compound 183 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.17 min. MS (ES): m/z (MH⁺) 715.0 for C₄₂H₈₃NO₇. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.15 (m, 1H); 4.08 (t, 2H); 3.66-3.34 (m, 10H); 2.71-2.41 (m, 6H); 2.34 (m, 4H); 1.74-1.20 (m, 50H); 0.91 (m, 9H).

EP. Compound 184: Heptadecan-9-yl 8-((2-hydroxyethyl)(8-((2-methylnonyl)oxy)-8-oxooctyl)amino)octanoate

2-Methylnonyl 8-bromooctanoate



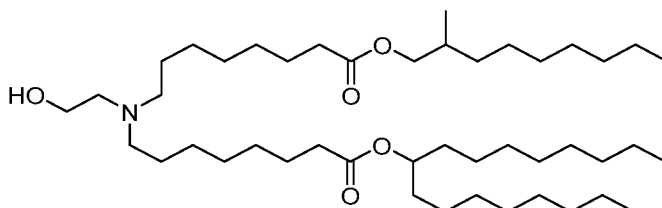
Chemical Formula: C₁₈H₃₅BrO₂

Molecular Weight: 363.380

[00264] To a solution of 8-bromooctanoic acid (3.83 g, 17.18 mmol), 2-methylnonan-1-ol (2.72 g, 17.18 mmol), 4-dimethylaminopyridine (0.42 g, 3.44 mmol) in DCM (25 mL) under N₂ was added (3-{[(ethylimino)methylidene]amino}propyl)dimethylamine hydrochloride (3.29 g, 17.18 mmol). The reaction was allowed to stir at rt for 16 h. The reaction was diluted with

DCM and washed with sat. NaHCO_3 , followed by brine. The organic layer was separated, dried over Na_2SO_4 , filtered, and evaporated under vacuum. The residue was purified by silica gel chromatography with (0-20%) EtOAc in hexanes to obtain 2-methylnonyl 8-bromooctanoate (5.1 g, 14.04 mmol, 82%). ^1H NMR (300 MHz, CDCl_3) δ : ppm 3.98 (m, 2H); 3.43 (t, 2H); 2.33 (t, 2H); 1.93-1.74 (m, 3H); 1.72-1.09 (m, 20H); 0.93 (m, 6H).

Heptadecan-9-yl 8-((2-hydroxyethyl)(8-((2-methylnonyl)oxy)-8-oxooctyl)amino)octanoate

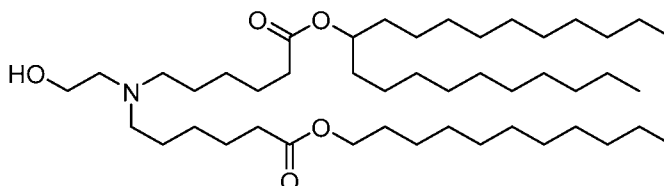


Chemical Formula: $\text{C}_{45}\text{H}_{89}\text{NO}_5$

Molecular Weight: 724.209

[00265] Compound 184 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.60 min. MS (ES): m/z (MH^+) 725.0 for $\text{C}_{45}\text{H}_{89}\text{NO}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.89 (m, 1H); 3.92 (m, 2H); 3.57 (m, 2H); 2.70-2.41 (m, 6H); 2.31 (m, 4H); 1.79 (m, 1H); 1.70-1.07 (m, 60H); 0.93 (m, 12H).

EQ. Compound 185: Henicosan-11-yl 6-((2-hydroxyethyl)(6-oxo-6-(undecyloxy)hexyl)amino)hexanoate

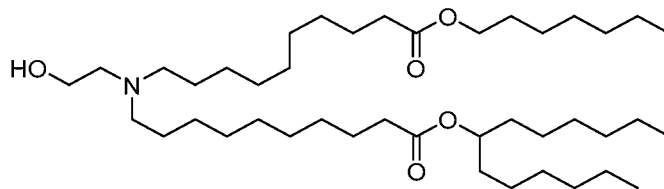


Chemical Formula: $\text{C}_{46}\text{H}_{91}\text{NO}_5$

Molecular Weight: 738.236

[00266] Compound 185 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.72 min. MS (ES): m/z (MH^+) 739.0 for $\text{C}_{46}\text{H}_{91}\text{NO}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.88 (m, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.60 (m, 2H); 2.48 (m, 4H); 2.32 (m, 4H); 1.72-1.41 (m, 15H); 1.28 (m, 52H); 0.90 (m, 9H).

ER. Compound 186: Heptyl 10-((2-hydroxyethyl)(10-oxo-10-(tridecan-7-yloxy)decyl)amino)decanoate

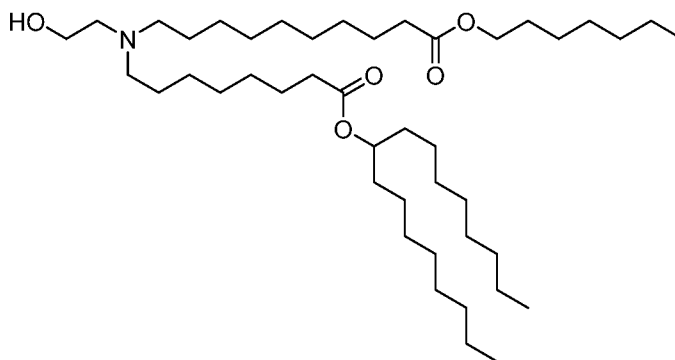


Chemical Formula: $C_{42}H_{83}NO_5$

Molecular Weight: 682.128

[00267] Compound 186 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.31min. MS (ES): m/z (MH^+) 739.0 for $C_{42}H_{83}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.58 (m, 2H); 2.47 (m, 4H); 2.30 (m, 4H); 1.71-1.18 (m, 58H); 0.90 (m, 9H).

ES. Compound 189: Heptyl 10-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)decanoate

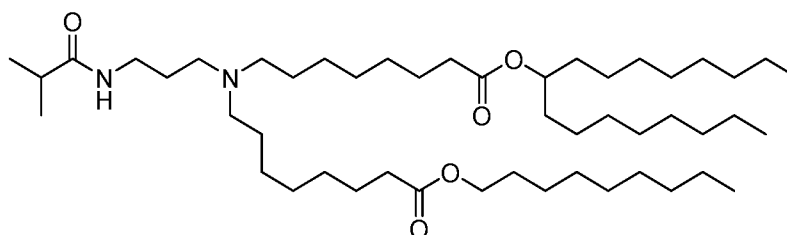


Chemical Formula: $C_{44}H_{87}NO_5$

Molecular Weight: 710.182

[00268] Compound 189 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.47min. MS (ES): m/z (MH^+) 710.98 for $C_{44}H_{87}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.89 (m, 1H); 4.08 (t, 2H); 3.55 (m, 2H); 2.61 (m, 2H); 2.47 (m, 4H); 2.31 (m, 4H); 1.70-1.20 (m, 62H); 0.90 (m, 9H).

ET. Compound 194: Heptadecan-9-yl 8-((3-isobutyramidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

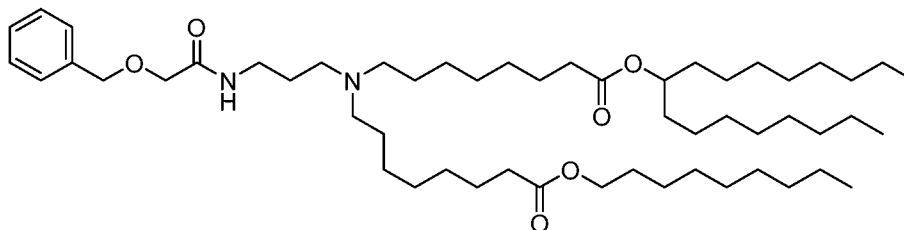


Chemical Formula: $C_{49}H_{96}N_2O_5$

Molecular Weight: 793.32

[00269] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (150 mg, 0.21 mmol) and triethylamine (90 μ L, 0.62 mmol) in 5 mL dry DCM at 0 °C was added isobutyryl chloride (35 μ L, 0.31 mmol) dropwise. After 30 minutes the cooling bath was removed and the solution stirred at rt for 90 minutes, after which no starting amine remained by LC/MS. The mixture was diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried (MgSO_4), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-isobutyramidopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (65 mg, 0.08 mmol, 39%) as a colorless oil. UPLC/ELSD: RT = 3.65 min. MS (ES): m/z (MH^+) 794.3 for $\text{C}_{49}\text{H}_{96}\text{N}_2\text{O}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.53 (s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (t, 2H, $J = 6$ Hz); 3.87 (s, 2H); 3.39 (m, 5H); 2.47 (br. s, 2H); 2.36 (br. m, 3H); 2.27 (m, 4H); 1.61 (m, 8H); 1.46 (br. m, 9H); 1.26 (br. m, 48H); 0.88 (t, 9H, $J = 7.5$ Hz).

EU. Compound 197: Heptadecan-9-yl 8-((3-(2-(benzyloxy)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



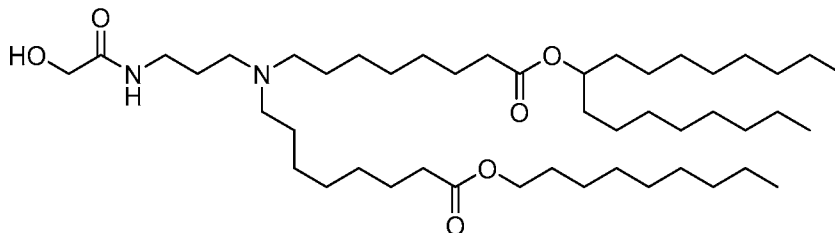
Chemical Formula: $\text{C}_{54}\text{H}_{98}\text{N}_2\text{O}_6$

Molecular Weight: 871.39

[00270] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (300 mg, 0.41 mmol) and triethylamine (145 μ L, 1 mmol) in 10 mL dry DCM at 0 °C was added benzyloxyacetyl chloride (82 μ L, 0.52 mmol) dropwise. The cooling bath was removed and the solution stirred at rt for 24 hours, after which no starting amine remained by LC/MS. The mixture was diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried (MgSO_4), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-(benzyloxy)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (179 mg, 0.21 mmol, 50%) as a colorless oil. UPLC/ELSD: RT = 3.66 min. MS (ES): m/z (MH^+) 872.4 for $\text{C}_{54}\text{H}_{98}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.55 (s, 1H); 7.33 (m, 5H); 4.86 (quint., 1H, $J = 6$ Hz); 4.55 (s, 2H); 4.05 (t, 2H, $J = 6$ Hz); 3.97

(s, 2H); 3.35 (quart., 2H, $J = 6$ Hz); 2.46 (br. m, 2H); 2.28 (m, 7H); 1.65 - 1.48 (m, 15H); 1.26 (br. m, 50H); 0.88 (t, 9H, $J = 7.5$ Hz).

EV. Compound 198: Heptadecan-9-yl 8-((3-(2-hydroxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



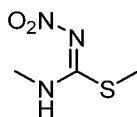
Chemical Formula: $C_{47}H_{92}N_2O_6$

Molecular Weight: 781.26

[00271] To a solution of heptadecan-9-yl 8-((3-(2-(benzyloxy)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (130 mg, 0.15 mmol) in 5 mL ethanol under nitrogen was added palladium 10 wt.% on carbon (approx. 20, cat.) added, the sides of the flask washed down with ethanol and the flask fitted with a hydrogen balloon. The flask was evacuated and back-filled with hydrogen three times, then stirred at rt for 24 hours after which no starting ether remained by LC/MS. The flask was flushed with nitrogen, the mixture filtered through diatomaceous earth, the filter solids washed with ethanol and the filtrate conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-hydroxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (55 mg, 0.07 mmol, 47%) as a colorless oil. UPLC/ELSD: RT = 3.46 min. MS (ES): m/z (MH^+) 782.2 for $C_{47}H_{92}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.73 (br. s, 1H); 4.86 (quint., 1H, $J = 6$ Hz); 4.05 (m, 4H); 3.40 (quart., 2H, $J = 6$ Hz); 2.50 (m, 2H); 2.37 (t, 4H, $J = 6$ Hz); 2.28 (m, 4H); 1.63 (m, 8H); 1.46 (br. m, 8H); 1.26 (br. m, 49H); 0.88 (t, 9H, $J = 7.5$ Hz).

EW. Compound 200: Heptadecan-9-yl (*E*)-8-((3-(3-methyl-2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Methyl (*E/Z*)-*N*-methyl-*N'*-nitrocarbamimidothioate

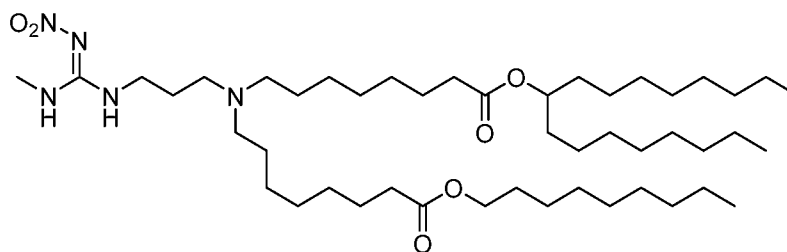


Chemical Formula: $C_3H_7N_3O_2S$

Molecular Weight: 149.17

[00272] To a suspension of 2-methyl-1-nitro-2-thiopseudourea (1.0 g, 7.4 mmol) and cesium carbonate (2.5 g, 7.8 mmol) in 8 mL dry DMF was added iodomethane (0.69 mL, 11.1 mmol)

and the mixture stirred at room temp for 24 hours. The yellow mixture was diluted with water and extracted twice with EtOAc. The organics were combined, washed three times with a 50% saturated aqueous sodium bicarbonate solution, once with brine, dried (MgSO₄), filtered and conc. to a yellow solid. This was dissolved in hot water, the solution filtered and the filtrate cooled to 4 °C for three days. The resulting solids were isolated *via* filtration, washed with water, air-dried, then dried under vacuum to give methyl (*E/Z*)-*N*-methyl-*N'*-nitrocarbamiimidothioate (85 mg, 0.57 mmol, 8%) as a pale yellow solid. ¹H NMR (300 MHz, CDCl₃) δ: ppm 10.02 (br. s, 1H); 3.12 (d, 1H, *J* = 6 Hz); 2.53 (s, 3H).



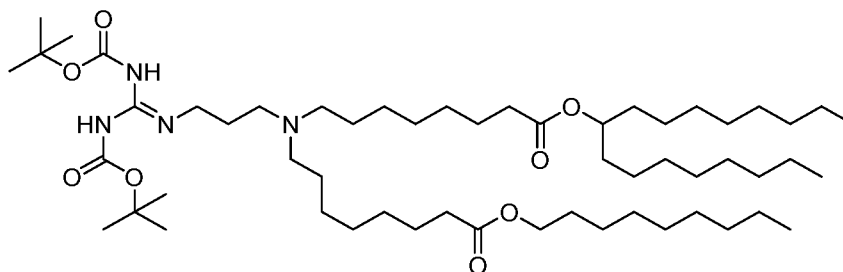
Chemical Formula: C₄₇H₉₃N₅O₆

Molecular Weight: 824.29

[00273] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.28 mmol) in 5 mL methanol was added methyl (*E/Z*)-*N*-methyl-*N'*-nitrocarbamiimidothioate (45 mg, 0.3 mmol), the resulting solution heated to 70 °C and stirred for 24 hours after which no starting amine remained by LC/MS. The solution was diluted with DCM and washed once with a saturated aqueous sodium bicarbonate solution. The organic phase was dried (MgSO₄), filtered and the filtrate evaporated *in vacuo*. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (*E*)-8-((3-(3-methyl-2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (75 mg, 0.09 mmol, 33%) as a pale yellow syrup. UPLC/ELSD: RT = 3.55 min. MS (ES): *m/z* (MH⁺) 825.3 for C₄₇H₉₃N₅O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 9.26 (br. s, 1H); 8.27 (br. s, 1H); 4.86 (quint., 1H, *J* = 6 Hz); 4.05 (t, 2H, *J* = 6 Hz); 3.42 (br. s, 2H); 2.86 (d, 3H, *J* = 6 Hz); 2.60 - 2.40 (br. m, 5H); 2.28 (m, 4H); 1.73 (br. s, 2H); 1.65 - 1.40 (m, 16H); 1.26 (br. m, 47H); 0.88 (t, 9H, *J* = 7.5 Hz).

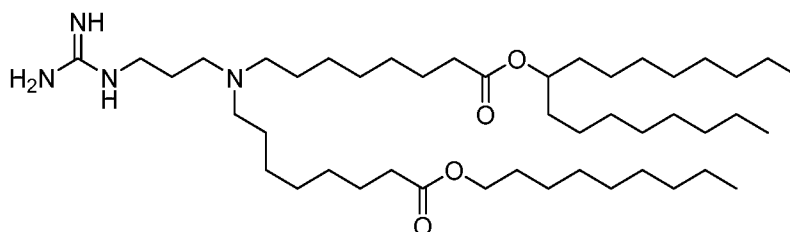
EX. Compound 207: Heptadecan-9-yl 8-((3-guanidinopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Heptadecan-9-yl 6-((tert-butoxycarbonyl)amino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-6-en-19-oate

Chemical Formula: $C_{56}H_{108}N_4O_8$

Molecular Weight: 965.50

[00274] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (300 mg, 0.41 mmol) and triethylamine (230 μ L, 1.66 mmol) in 10 mL dry DCM at 0 $^{\circ}$ C was added 1,3-bis(*tert*-butoxycarbonyl)-2-(trifluoromethylsulfonyl)guanidine (325 mg, 0.83 mmol) in one portion and the resulting solution allowed to gradually warm to rt with stirring overnight. LC/MS showed no starting material remained so the solution was diluted with DCM, washed with a 50% saturated aqueous sodium bicarbonate solution, the organic layer dried ($MgSO_4$), filtered and conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 6-((*tert*-butoxycarbonyl)amino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-6-en-19-oate (310 mg, 0.32 mmol, 77%) as a colorless oil in ca. 95% purity. Largest single impurity has mass corresponding to product with loss of one Boc group. Carried through as is. UPLC/ELSD: RT = 3.90 min. MS (ES): m/z (MH^+) 966.0 for $C_{56}H_{108}N_4O_8$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 11.49 (s, 1H); 8.55 (br. s., 1H); 4.86 (quint., 1H, J = 6 Hz); 4.05 (t, 2H, J = 7.5 Hz); 3.45 (quart., 2H, J = 6 Hz); 2.46 (m, 2H); 2.36 (m, 4H); 2.27 (m, 4H); 1.61 (m, 8H); 1.50 (m, 22H); 1.40 (m, 4H); 1.25 (br. m, 48H); 0.88 (t, 9H, J = 7.5 Hz).

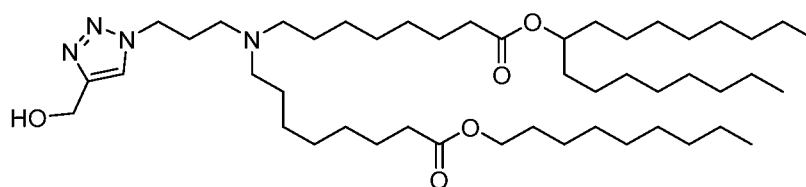
Chemical Formula: $C_{46}H_{92}N_4O_4$

Molecular Weight: 765.27

[00275] To a solution of heptadecan-9-yl 6-((*tert*-butoxycarbonyl)amino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-6-en-19-oate (310 mg, 0.32 mmol) in 10 mL DCM was added trifluoroacetic acid (500 μ L, excess) and the solution stirred at rt for 48 hours after which no starting material remained by LC/MS. The solution was conc., the residue

codistilled with DCM twice and purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-guanidinopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (210 mg, 0.27 mmol, 84%) as a colorless oil. UPLC/ELSD: RT = 3.16 min. MS (ES): m/z (MH⁺) 766.3 for C₄₆H₉₂N₄O₄. ¹H NMR (300 MHz, CDCl₃) δ : ppm 10.92 (br. s, 1H); 8.82 (br. s, 1H); 7.25 (br. s, 2H); 4.85 (quint., 1H, J = 6 Hz); 4.05 (t, 2H, J = 6 Hz); 3.38 (br. s, 2H); 3.15 (br. s, 2H); 3.00 (br. s, 4H); 2.29 (m, 4H); 2.05 (br. s, 2H); 1.91 (br. s, 3H); 1.70 – 1.45 (br. m, 12H); 1.26 (br. m, 47H); 0.88 (t, 9H, J = 7.5 Hz).

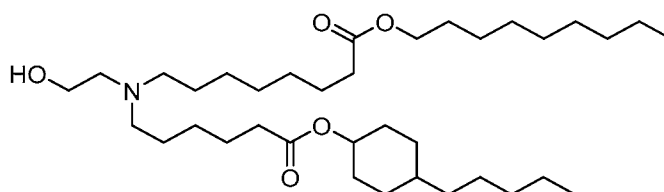
EY. Compound 218: Heptadecan-9-yl 8-((3-(4-(hydroxymethyl)-1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₈H₉₂N₄O₅
Molecular Weight: 805.29

[00276] To a solution of heptadecan-9-yl 8-((3-(4-(tert-butoxymethyl)-1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (190 mg, 0.22 mmol) in 4 mL DCM was added trifluoroacetic acid (675 μ L, excess) and the solution stirred at rt for 72 hours after which no starting material remained by LC/MS. The solution was conc., the residue codistilled with DCM twice and purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(4-(hydroxymethyl)-1H-1,2,3-triazol-1-yl)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (113 mg, 0.14 mmol, 64%) as a colorless oil. UPLC/ELSD: RT = 3.41 min. MS (ES): m/z (MH⁺) 806.1 for C₄₈H₉₂N₄O₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.54 (s, 1H); 4.86 (quint., 1H, J = 6 Hz); 4.80 (s, 2H); 4.40 (t, 2H, J = 7.5 Hz); 4.05 (t, 2H, J = 6 Hz); 2.38 (br. m, 5H); 2.28 (m, 5H); 2.04 (br. m, 2H); 1.61 (br. m, 7H); 1.50 (br. d, 4H, J = 3 Hz); 1.26 (br. m, 51H); 0.88 (t, 9H, J = 7.5 Hz) (hydroxyl proton not observed).

EZ. Compound 232: Nonyl 8-((2-hydroxyethyl)(6-oxo-6-((4-pentylcyclohexyl)oxy)hexyl)amino)octanoate

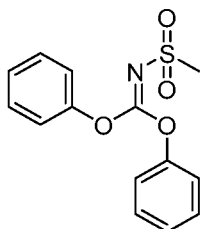


Chemical Formula: C₃₆H₆₉NO₅

Molecular Weight: 595.950

[00277] Compound 232 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 2.84 min. MS (ES): m/z (MH⁺) 596.84 for C₃₆H₆₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 5.01 (m, 0.5H); 4.68 (m, 0.5H); 4.08 (t, 2H); 3.56 (m, 2H); 2.67-2.55 (br. m, 2H); 2.55-2.40 (br. m, 4H); 2.31 (m, 4H); 1.97 (m, 1H); 1.82 (m, 2H); 1.73-1.15 (m, 43H); 1.02 (m, 1H); 0.90 (m, 6H).

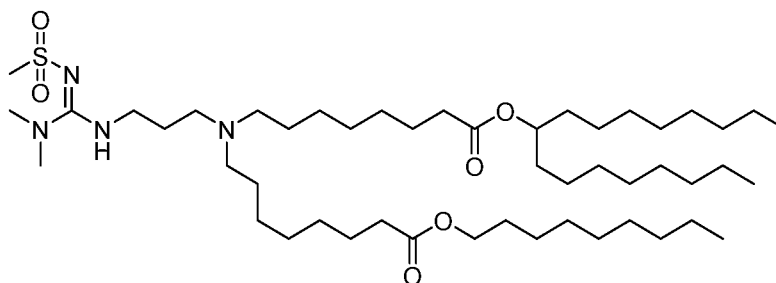
FA. Compound 233: Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-(methylsulfonyl)guanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate Diphenyl (methylsulfonyl)carbonimidate



Chemical Formula: C₁₄H₁₃NO₄S
Molecular Weight: 291.32

[00278] In a 100 mL RBF were suspended 2.0 g (7.4 mmol) dichlorodiphenoxymethane and 1.56 g (16.4 mmol) methanesulfonamide in 15 mL ethyl acetate with stirring to give a white mixture. This was heated to reflux (85 °C) and stirred for 24 hours, after which only product was seen by LC/MS. The mixture was allowed to cool to room temp., conc., the residue suspended in DCM and filtered. The filter solids were washed with DCM, the filtrates combined and conc. The residue was purified by silica gel chromatography (0-40% EtOAc in hexanes), the product-containing fractions pooled and conc. to a slightly yellow solid. This was triturated with hexanes, filtered, the filter solids washed with hexanes and air-dried to give diphenyl (methylsulfonyl)carbonimidate (0.84 g, 2.88 mmol, 39%) as a white solid. UPLC/ELSD: RT = 0.50 min. MS (ES): m/z (MH⁺) 292.2 for C₁₄H₁₃NO₄S. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.45-7.37 (m, 4H); 7.30 (m, 2H); 7.21 (m, 4H); 3.01 (s, 3H).

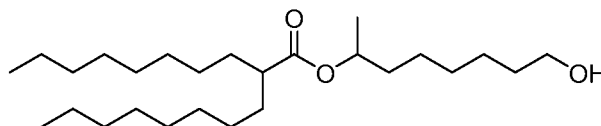
Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-(methylsulfonyl)guanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₉H₉₈N₄O₆S
Molecular Weight: 871.41

[00279] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (200 mg, 0.28 mmol) in 5 mL 2-propanol was added triethylamine (40 μ L, 0.28 mmol) followed by diphenyl (methylsulfonyl)carbonimidate (81 mg, 0.28 mmol) and the white mixture stirred at room temp. for three hours after which no starting amine remained by LC/MS. To the solution was added a 2.0M dimethylamine solution in THF (0.75 mL, 1.5 mmol), the slightly yellow solution heated to 80 °C and stirred for 24 hours. No starting material remained by LC/MS so the solution was allowed to cool to room temp., conc. in a stream of nitrogen and the residue dissolved in DCM. The solution was washed once with a saturated aqueous sodium bicarbonate solution, then dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-(methylsulfonyl)guanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (80 mg, 0.09 mmol, 33%) as a colorless oil. UPLC/ELSD: RT = 3.53 min. MS (ES): m/z (MH⁺) 872.1 for C₄₉H₉₈N₄O₆S. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.22 (br. s, 1H); 4.86 (quint., 1H, J = 12.3 Hz, 5.9 Hz,); 4.05 (t, 2H, J = 6.7 Hz); 3.40 (br. d, 2H, J = 5.4 Hz); 2.97 (s, 9H); 2.52 (br. s, 2H); 2.39 (br. s, 3H); 2.29 (m, 4H); 1.69-1.49 (m, 15H); 1.45-1.15 (m, 50H); 0.87 (t, 9H, J = 5.8 Hz)

FB. Compound 234: 8-((2-Hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octan-2-yl 2-octyldecanoate
8-Hydroxyoctan-2-yl 2-octyldecanoate

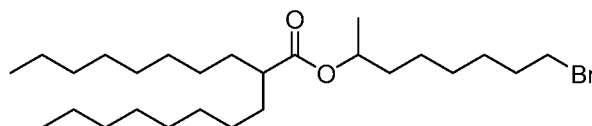


Chemical Formula: $C_{26}H_{52}O_3$

Molecular Weight: 412.699

[00280] Compound 8-Hydroxyoctan-2-yl 2-octyldecanoate was synthesized according to the general procedure as of 8-Hydroxyoctan-2-yl decanoate. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.93 (m, 1H); 3.66 (t, 2H); 2.29 (m, 1H); 1.69-1.16 (m, 42H); 0.90 (m, 6H).

8-Bromooctan-2-yl 2-octyldecanoate

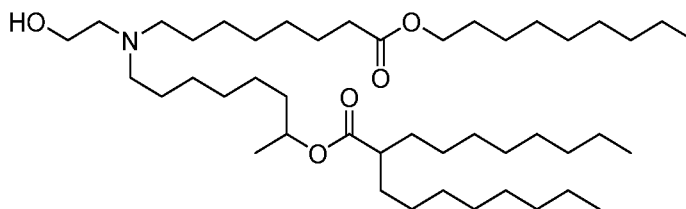


Chemical Formula: $C_{26}H_{51}BrO_2$

Molecular Weight: 475.596

[00281] Compound 8-Bromooctan-2-yl 2-octyldecanoate was synthesized according to the general procedure as of (Z)-1-Bromo-10-octyloctadec-8-ene. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.94 (m, 1H); 3.42 (t, 2H); 2.30 (m, 1H); 1.87 (m, 2H); 1.69-1.16 (m, 39H); 0.90 (m, 6H).

8-((2-Hydroxyethyl)(8-(nonyloxy)-8-oxooctyl)amino)octan-2-yl 2-octyldecanoate

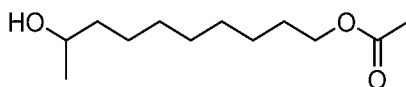


Chemical Formula: $C_{45}H_{89}NO_5$

Molecular Weight: 724.209

[00282] Compound 234 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.61 min. MS (ES): m/z (MH^+) 725.08 for $C_{45}H_{89}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.93 (m, 1H); 4.08 (t, 2H); 3.71 (br. m, 2H); 3.00-2.50 (br. m, 6H); 2.32 (m, 3H); 1.73-1.15 (m, 65H); 0.90 (m, 9H).

FC. Compound 235: Heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)(3-propionamidopropyl)amino)octanoate
9-Hydroxydecyl acetate

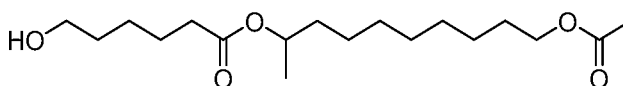


Chemical Formula: C₁₂H₂₄O₃

Molecular Weight: 216.321

[00283] 9-Hydroxydecyl acetate was synthesized according to the general procedure as of 8-Hydroxyoctan-2-yl decanoate. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.07 (t, 2H); 3.80 (m, 1H); 2.07 (s, 3H); 1.76 (m, 2H); 1.54-1.16 (m, 16H).

10-Acetoxydecan-2-yl 6-hydroxyhexanoate

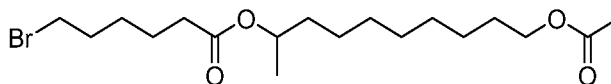


Chemical Formula: C₁₈H₃₄O₅

Molecular Weight: 330.465

[00284] 10-Acetoxydecan-2-yl 6-hydroxyhexanoate was synthesized according to the general procedure as of 8-Hydroxyoctan-2-yl decanoate. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.07 (t, 2H); 3.80 (m, 1H); 2.07 (s, 3H); 1.76 (m, 2H); 1.76 (m, 2H); 1.54-1.42 (m, 8H); 1.41-1.17 (m, 16H).

10-Acetoxydecan-2-yl 6-bromohexanoate

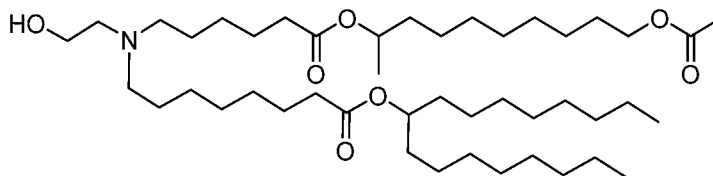


Chemical Formula: C₁₈H₃₃BrO₄

Molecular Weight: 393.362

[00285] 10-Acetoxydecan-2-yl 6-bromohexanoate was synthesized according to the general procedure as of (Z)-1-Bromo-10-octyloctadec-8-ene. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.93 (m, 1H); 4.07 (t, 2H); 3.43 (t, 2H); 2.32 (t, 2H); 2.07 (s, 3H); 1.90 (m, 2H); 1.76-1.42 (m, 8H); 1.41-1.17 (m, 13H).

Heptadecan-9-yl 8-(((10-acetoxydecan-2-yl)oxy)-6-oxohexyl)(2-hydroxyethyl)amino)octanoate

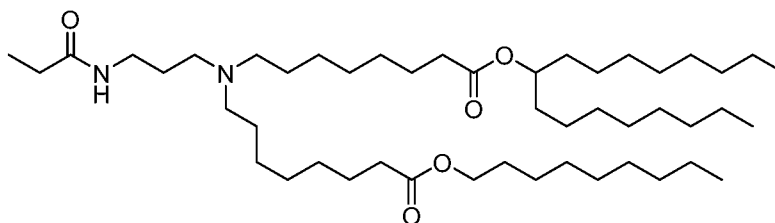


Chemical Formula: $C_{45}H_{87}NO_7$

Molecular Weight: 754.191

[00286] Compound 235 was synthesized according to the general procedure and Representative Procedure 1 described above. UPLC/ELSD: RT = 3.33min. MS (ES): m/z (MH^+) 755.10 for $C_{45}H_{87}NO_7$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.91 (m, 2H); 4.07 (t, 2H); 3.56 (m, 2H); 2.67-2.41 (m, 6H); 2.30 (t, 4H); 2.07 (s, 3H); 1.73-1.08(m, 61H); 0.90 (m, 6H).

FD. Compound 236: Heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)(3-propionamidopropyl)amino)octanoate

Chemical Formula: $C_{48}H_{94}N_2O_5$

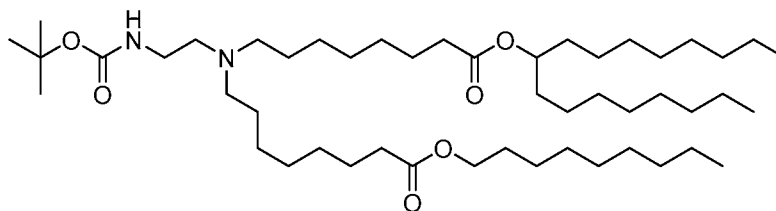
Molecular Weight: 779.29

[00287] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (160 mg, 0.22 mmol) and triethylamine (95 μ L, 0.66 mmol) in 5 mL dry DCM at 0 $^{\circ}$ C was added propionyl chloride (30 μ L, 0.33 mmol) dropwise. After 30 minutes the cooling bath was removed and the solution stirred at rt for 30 minutes, after which no starting amine remained by LC/MS. The mixture was diluted with a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, washed once with water, dried ($MgSO_4$), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)(3-propionamidopropyl)amino)octanoate (90 mg, 0.12 mmol, 52%) as a colorless oil.

UPLC/ELSD: RT = 3.59 min. MS (ES): m/z (MH^+) 780.1 for $C_{48}H_{94}N_2O_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.29 (br. s, 1H); 4.86 (quint., 1H, J = 12.4 Hz, 5.2 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.34 (quart., 2H, J = 11.3 Hz, 5.9 Hz); 2.63-2.33 (m, 6H); 2.31-2.25 (m, 4H); 2.16 (quart., 2H, J = 15.1 Hz, 7.6 Hz); 1.61 (br. t, 8H, J = 6.8 Hz); 1.55-1.38 (br. m, 9H); 1.35-1.20 (br. m, 47H); 1.14 (t, 3H, J = 7.6 Hz); 0.87 (t, 9H, J = 6.4 Hz).

FE. Compound 244: Heptadecan-9-yl 8-((2-(acetamidoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

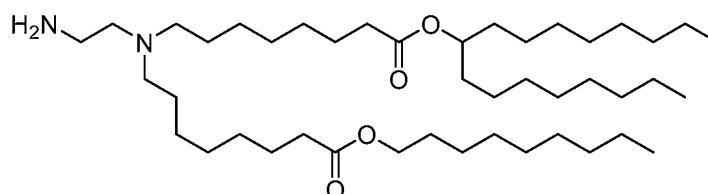
Heptadecan-9-yl 8-(((tert-butoxycarbonyl)amino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{49}H_{96}N_2O_6$

Molecular Weight: 809.32

[00288] To a solution of heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.0 g, 1.5 mmol) and N-Boc-glycinal (0.36 g, 2.25 mmol) in 10 mL dry THF was added $MgSO_4$ (ca. 0.5 g, excess) and the white mixture stirred at room temp. for 30 minutes. To the mixture was added sodium triacetoxyborohydride (0.67 g, 3.0 mmol) in portions over five minutes and the resulting white mixture stirred at rt overnight. No starting material remained by LC/MS so the reaction was quenched with the addition of ca. 5 mL of a saturated aqueous sodium bicarbonate solution. The resulting mixture was diluted with water, extracted three times with DCM, the organics combined, washed once with water, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((2-((tert-butoxycarbonyl)amino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (930 mg, 1.15 mmol, 77%) as a pale yellow oil. UPLC/ELSD: RT = 3.66 min. MS (ES): m/z (MH^+) 809.6 for $C_{49}H_{96}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.88 (quint. 1H, $J = 11.9$ Hz, 6.0 Hz); 4.07 (t, 2H, $J = 6.7$ Hz); 2.60-2.25 (m, 8H); 1.70-1.55 (m, 6H); 1.53-1.43 (m, 22H); 1.37-1.22 (m, 48H); 0.90 (t, 9H, $J = 6.8$ Hz)

Heptadecan-9-yl 8-((2-aminoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

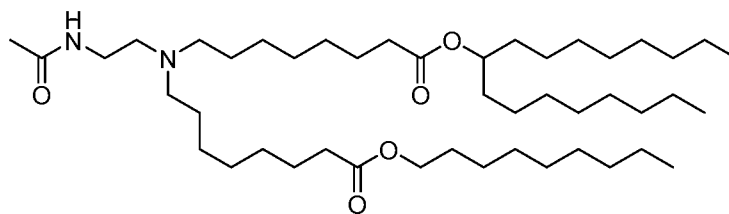
Chemical Formula: $C_{44}H_{88}N_2O_4$

Molecular Weight: 709.20

[00289] To a solution of heptadecan-9-yl 8-((2-((tert-butoxycarbonyl)amino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (820 mg, 1.0 mmol) in 20 mL DCM at 0 °C was added a 4N HCl solution in 1,4-dioxane (2.5 mL, 10 mmol), the resulting yellow solution allowed to warm to rt and stirred for three hours after which no starting material remained by LC/MS. The red/brown solution was diluted with DCM and washed with a 1:1 mixture of a saturated aqueous sodium bicarbonate solution and brine. The phases were separated and the aqueous extracted

twice with DCM. The organics were combined, dried (MgSO_4), filtered and the filtrate conc. to a brown oil. This was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((2-aminoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (520 mg, 0.73 mmol, 72%) as a brown oil. UPLC/ELSD: RT = 3.15 min. MS (ES): m/z (MH^+) 709.5 for $\text{C}_{44}\text{H}_{88}\text{N}_2\text{O}_4$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (quint., 1H, $J = 12.4$ Hz, 5.9 Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 2.74 (t, 2H, $J = 6.0$ Hz); 2.52-2.35 (m, 5H); 2.31-2.25 (m, 4H); 1.75-1.67 (br. s, 5H); 1.61 (br. t, 6H, $J = 6.8$ Hz); 1.55-1.37 (br. m, 8H); 1.36-1.16 (br. m, 46H); 0.88 (t, 9H, $J = 6.1$ Hz).

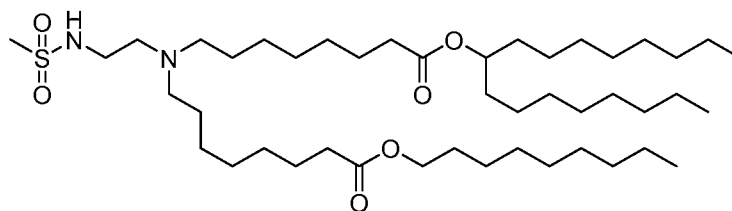
Heptadecan-9-yl 8-((2-acetamidoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $\text{C}_{46}\text{H}_{90}\text{N}_2\text{O}_5$
Molecular Weight: 751.24

[00290] To a solution of heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.0 g, 1.5 mmol) and N-Boc-glycinal (0.36 g, 2.25 mmol) in 10 mL dry THF was added MgSO_4 (ca. 0.5 g, excess) and the white mixture stirred at room temp. for 30 minutes. To the mixture was added sodium triacetoxymethylborohydride (0.67 g, 3.0 mmol) in portions over five minutes and the resulting white mixture stirred at rt overnight. No starting material remained by LC/MS so the reaction was quenched with the addition of ca. 5 mL of a saturated aqueous sodium bicarbonate solution. The resulting mixture was diluted with water, extracted three times with DCM, the organics combined, washed once with water, dried (MgSO_4), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-(((tert-butoxycarbonyl)amino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (930 mg, 1.15 mmol, 77%) as a pale yellow oil. UPLC/ELSD: RT = 3.66 min. MS (ES): m/z (MH^+) 809.6 for $\text{C}_{49}\text{H}_{96}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.88 (quint. 1H, $J = 11.9$ Hz, 6.0 Hz); 4.07 (t, 2H, $J = 6.7$ Hz); 2.60-2.25 (m, 8H); 1.70-1.55 (m, 6H); 1.53-1.43 (m, 22H); 1.37-1.22 (m, 48H); 0.90 (t, 9H, $J = 6.8$ Hz).

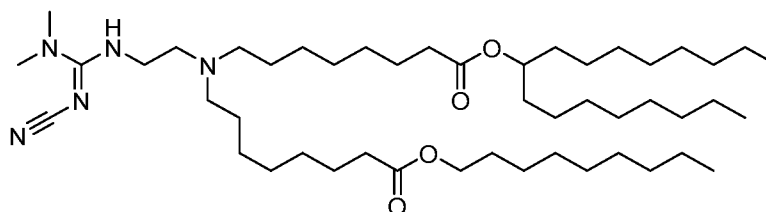
FF. Compound 246: Heptadecan-9-yl 8-((2-(methylsulfonamido)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_{45}H_{90}N_2O_6S$
Molecular Weight: 787.28

[00291] To a solution of heptadecan-9-yl 8-((2-aminoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (160 mg, 0.23 mmol) in 4 mL dry DCM was added triethylamine (63 μ L, 0.45 mmol) and the solution cooled to 0 $^{\circ}$ C. To this was added methanesulfonyl chloride (24 μ L, 0.32 mmol), the solution allowed to warm to rt and stirred for four hours. No starting material remained by LC/MS so the solution was diluted with DCM, washed once with a 50% saturated aqueous sodium bicarbonate solution, dried ($MgSO_4$), filtered, and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((2-(methylsulfonylamido)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (130 mg, 0.165 mmol, 73%) as a yellow oil. UPLC/ELSD: RT = 3.48 min. MS (ES): m/z (MH^+) 787.6 for $C_{45}H_{90}N_2O_6S$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (quint. 1H, $J = 12.4$ Hz, 5.2 Hz); 4.05 (t, 2H, $J = 6.8$ Hz); 3.14 (br. s, 2H); 2.95 (s, 3H); 2.61 (br. s, 2H); 2.42 (br. s, 3H); 2.32-2.25 (m, 4H); 1.61 (br. t, 6H, $J = 7.0$ Hz); 1.55-1.38 (m, 8H); 1.37-1.14 (m, 50H); 0.88 (t, 9H, $J = 6.1$ Hz).

FG. Compound 247: Heptadecan-9-yl (Z)-8-((2-(2-cyano-3,3-dimethylguanidino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



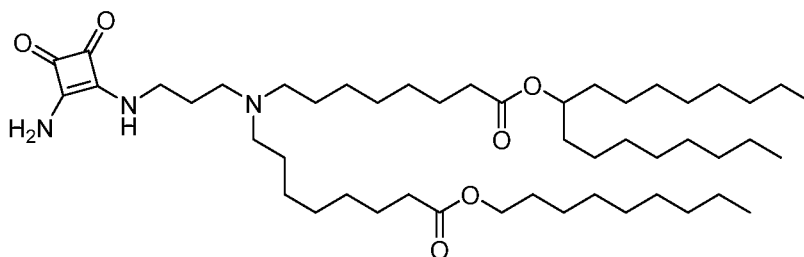
Chemical Formula: $C_{48}H_{93}N_5O_4$
Molecular Weight: 804.30

[00292] To a solution of heptadecan-9-yl 8-((2-aminoethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (160 mg, 0.23 mmol) in 4 mL 2-propanol was added triethylamine (31 μ L, 0.23 mmol) followed by diphenyl cyanocarbonimidate (54 mg, 0.23 mmol) and the white mixture stirred at rt for two hours after which it had become a colorless solution. No starting material remained by LC/MS and only the monophenyl carbamimidate was observed (MW = 853.3). To this was added a 2M dimethylamine solution in methanol (1.1 mL, 2.2

mmol), the resulting pale yellow solution heated to 55 °C and stirred for 20 hours, after which no carbamimidate intermediate remained by LC/MS. The reaction was allowed to cool to rt, conc., the residue dissolved in DCM, washed twice with a saturated aqueous sodium bicarbonate solution, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((2-(2-cyano-3,3-dimethylguanidino)ethyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (75 mg, 0.09 mmol, 41%) as a colorless oil.

UPLC/ELSD: RT = 3.46 min. MS (ES): m/z (MH⁺) 804.6 for C₄₈H₉₃N₅O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.80 (br. s, 1H); 4.86 (quint. 1H, J = 12.5 Hz, 6.2 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.60 (br. s, 2H); 3.01 (s, 6H); 2.59 (br. s, 2H); 2.40 (br. s, 3H); 2.32-2.25 (m, 4H); 1.68-1.45 (m, 12H); 1.38-1.12 (m, 51H); 0.88 (t, 9H, J = 6.0 Hz).

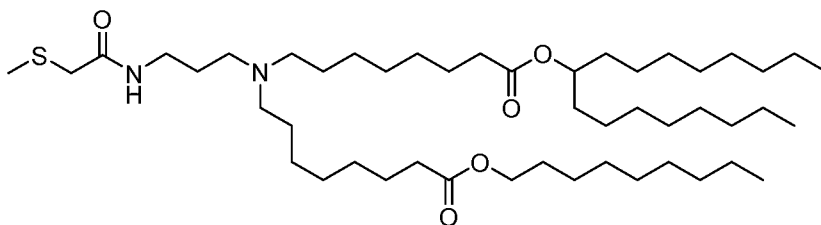
FH. Compound 251: Heptadecan-9-yl 8-((3-((2-amino-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₉H₉₁N₃O₆
Molecular Weight: 818.28

[00293] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.28 mmol) in 8 mL ethanol was added 3-amino-4-methoxycyclobut-3-ene-1,2-dione [JACS, 88(7), 1533-1536 (1966)] (35 mg, 0.28 mmol), the resulting colorless solution heated to 40 °C and stirred for 20 hours after which no starting amine remained by LC/MS. The solution was concentrated in vacuo and the residue purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-((2-amino-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (175 mg, 0.21 mmol, 77%) as a gummy white solid. UPLC/ELSD: RT = 3.38 min. MS (ES): m/z (MH⁺) 818.6 for C₄₉H₉₁N₃O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.43 (br. s., 1H); 4.85 (quint., 1H, J = 12.6 Hz, 5.8 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.65 (br. s, 2H); 2.78-2.38 (m, 5H); 2.29 (m, 4H); 1.84 (br. s, 2H); 1.68-1.41 (m, 14H); 1.40-1.14 (m, 51H); 0.88 (t, 9H, J = 6.0 Hz).

FI. Compound 252: Heptadecan-9-yl 8-((3-(2-(methylthio)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

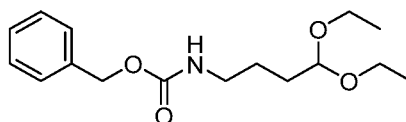
Chemical Formula: $C_{48}H_{94}N_2O_5S$

Molecular Weight: 811.35

[00294] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.0 g, 1.38 mmol) and (methylthio)acetic acid (Matrix Scientific, Columbia, SC) (150 μ L, 1.66 mmol) in 20 mL dry DCM was added 4-(dimethylamino)pyridine (42 mg, 0.35 mmol) followed by 1-[bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 3-oxide hexafluorophosphate (HATU; 790 mg, 2.1 mmol) and finally N,N-diisopropylethylamine (740 μ L, 4.1 mmol) and the resulting mixture stirred at rt overnight. No starting amine remained by LC/MS so the yellow solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution, once with brine, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-50% methanol in DCM) to give heptadecan-9-yl 8-((3-(2-(methylthio)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.0 g, 1.23 mmol, 89%) as a yellow oil. UPLC/ELSD: RT = 3.54 min. MS (ES): m/z (MH^+) 811.56 for $C_{48}H_{94}N_2O_5S$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.79 (br. s, 1H); 4.86 (quint., 1H, $J = 12.5$ Hz, 6.2 Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 3.40 (br. s, 2H); 3.17 (s, 2H); 2.96 (br. s, 2H); 2.66-2.34 (br. m, 3H); 2.28 (m, 4H); 2.15 (s, 3H); 1.88-1.41 (m, 16H); 1.39-1.18 (br. m, 49H); 0.88 (t, 9H, $J = 5.8$ Hz).

FJ. Compound 255: Heptadecan-9-yl 8-((4-acetamidobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Benzyl (4,4-diethoxybutyl)carbamate

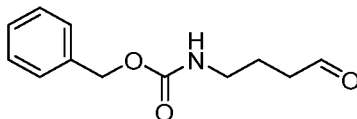
Chemical Formula: $C_{16}H_{25}NO_4$

Molecular Weight: 295.38

[00295] To a solution of 4-aminobutanal diethyl acetal (Aldrich, St. Louis, MO) (1 g, 6.2 mmol) in 25 mL ether was added 25 mL water followed by potassium carbonate (2.6 g, 18.6 mmol) and the resulting colorless biphasic mixture cooled to 0 $^{\circ}C$ with vigorous stirring. To this was added benzyl chloroformate (0.88 mL, 6.2 mmol) dropwise over ten minutes and the resulting mixture allowed to slowly warm to rt overnight. The phases were separated and the aqueous extracted with ether. The organics were combined, washed twice with an aqueous 10% citric

acid solution, then brine, dried (MgSO₄), filtered, and the filtrate conc. to a colorless oil. This was purified by silica gel chromatography (0-50% EtOAc in hexanes) to give benzyl (4,4-diethoxybutyl)carbamate (1.56 g, 5.3 mmol, 85%) as a colorless oil. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.32 (m, 5H); 5.09 (s, 2H); 4.88 (s, 1H); 4.48 (t, 2H, J = 5.3 Hz); 3.70-3.55 (m, 2H); 3.54-3.40 (m, 2H); 3.22 (quart.; 2H, J = 12.5 Hz, 6.2 Hz); 1.71-1.51 (m, 4H); 1.20 (t, 6H, J = 7.0 Hz).

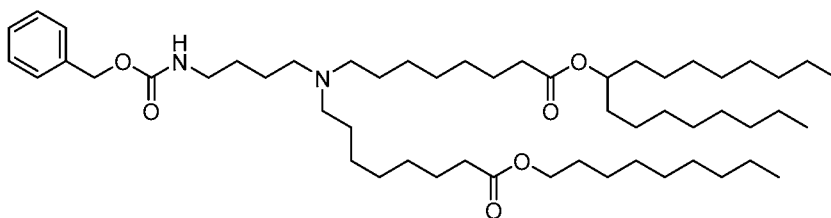
Benzyl (4-oxobutyl)carbamate



Chemical Formula: C₁₂H₁₅NO₃
Molecular Weight: 221.26

[00296] To a solution of benzyl (4,4-diethoxybutyl)carbamate (1.56 g, 5.3 mmol) in 25 mL acetone was added an aqueous 1N HCl solution (25 mL, 25 mmol) to give a cloudy mixture which quickly became a clear solution. This was stirred at rt overnight, after which no starting acetal remained by TLC. The solution was extracted twice with Et₂O, the organics combined, washed once with a saturated aqueous sodium bicarbonate solution, once with brine, dried (MgSO₄), filtered and the filtrate conc. to a colorless oil. This was purified by silica gel chromatography (0-50% EtOAc in hexanes) to give benzyl (4-oxobutyl)carbamate (0.82 g, 5.3 mmol, 70%) as a colorless liquid. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.36 (m, 5H); 5.52 (br. d, 1H, J = 12.0 Hz); 5.15 (s, 2H); 3.68-3.52 (m, 1H); 3.44-3.30 (m, 1H); 2.18-1.79 (m, 4H) (aldehyde proton not observed).

Heptadecan-9-yl 8-(((benzyloxy)carbonyl)amino)butyl)-(8-(nonyloxy)-8-oxooctyl)amino)octanoate

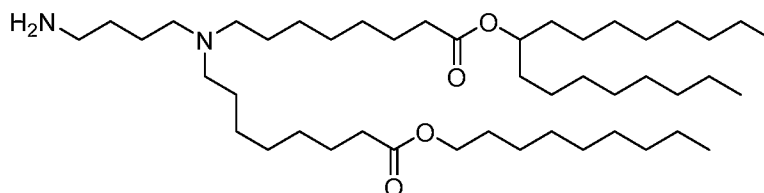


Chemical Formula: C₅₄H₉₈N₂O₆
Molecular Weight: 871.39

[00297] To a solution of heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.65 g, 2.5 mmol) and benzyl (4-oxobutyl)carbamate (0.82 g, 3.71 mmol) in 15 mL dry THF was added anhydrous MgSO₄ (ca. 0.5 g, excess) and the white mixture stirred at rt for 30 minutes. To the mixture was added sodium triacetoxymethylborohydride (1.1 g, 4.9 mmol) in portions over five minutes and the resulting white mixture stirred at rt overnight. No starting material remained by

LC/MS so the reaction was quenched with the addition of ca. 5 mL of a saturated aqueous sodium bicarbonate solution. The resulting mixture was diluted with water, extracted three times with DCM, the organics combined, washed once with water, dried (MgSO_4), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((4-(((benzyloxy)carbonyl)amino)butyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.43 g, 1.64 mmol, 66%) as a pale yellow oil. UPLC/ELSD: RT = 3.54 min. MS (ES): m/z (MH^+) 871.52 for $\text{C}_{54}\text{H}_{98}\text{N}_2\text{O}_6$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 7.34 (m, 5H); 5.51 (m, 1H); 5.15 (m, 2H); 5.09 (s, 2H); 4.86 (quint., 1H, $J = 12.3$ Hz, 6.2 Hz); 4.05 (t, 2H, $J = 6.8$ Hz); 3.60 (m, 1H); 3.38 (m, 1H); 3.20 (br. d, 2H, $J = 3.8$ Hz); 2.40 (br. s, 4H); 2.27 (m, 4H); 2.15-1.75 (m, 4H); 1.61 (br. t, 6H, $J = 6.3$ Hz); 1.55-1.43 (m, 8H); 1.37-1.15 (m, 46H); 0.88 (t, 9H, $J = 5.8$ Hz).

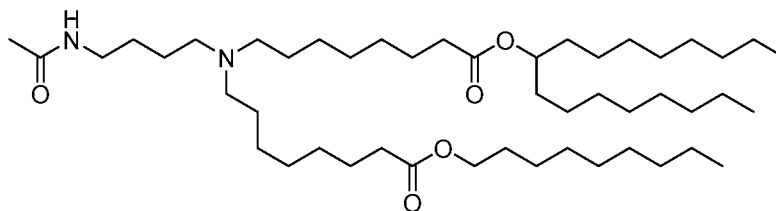
Heptadecan-9-yl 8-((4-aminobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $\text{C}_{46}\text{H}_{92}\text{N}_2\text{O}_4$
Molecular Weight: 737.25

[00298] Heptadecan-9-yl 8-((4-(((benzyloxy)carbonyl)amino)butyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (1.42 g, 1.63 mmol) was dissolved in 20 mL ethanol with stirring to give a pale yellow solution. The reaction vessel was flushed with nitrogen and palladium 10 wt.% on carbon (ca. 200 mg, cat.) added, the sides of the vessel washed with 5 mL ethanol and the vessel again flushed with nitrogen. The flask was fitted with a hydrogen balloon, evacuated and back-filled with hydrogen three times. The resulting dark mixture was stirred at rt for five hours after which no starting material remained by LC/MS. The flask was flushed with nitrogen, the mixture filtered through Celite, the filter solids washed with ethanol and the filtrate conc. to a cloudy white oil. This was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((4-aminobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (706 mg, 0.96 mmol, 59%) as a colorless oil. UPLC/ELSD: RT = 3.09 min. MS (ES): m/z (MH^+) 737.43 for $\text{C}_{46}\text{H}_{92}\text{N}_2\text{O}_4$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.86 (quint., 1H, $J = 12.2$ Hz, 6.2 Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 2.71 (t, 1H, $J = 6.4$ Hz); 2.48-2.34 (m, 6H); 2.33-2.23 (m, 4H); 1.95 (br. s, 2H); 1.61 (br. t, 6H, $J = 6.6$ Hz); 1.55-1.38 (m, 12H); 1.37-1.17 (m, 49H); 0.88 (t, 9H, $J = 5.9$ Hz).

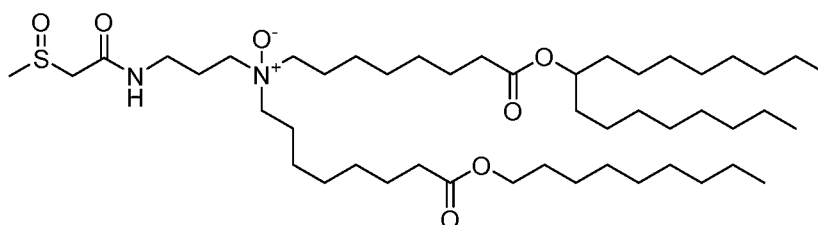
Heptadecan-9-yl 8-((4-acetamidobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{48}H_{94}N_2O_5$

Molecular Weight: 779.29

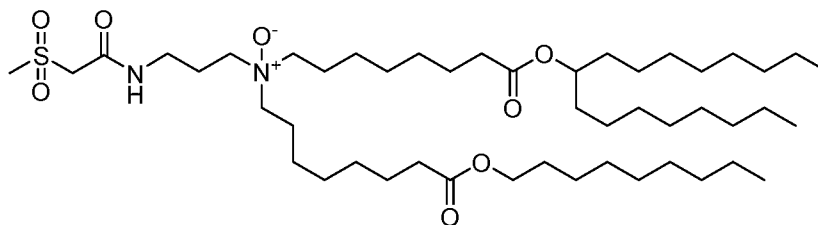
[00299] To a solution of heptadecan-9-yl 8-((4-aminobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.3 mmol) in 4 mL dry DCM was added triethylamine (125 μ L, 0.9 mmol) and the solution cooled to 0 $^{\circ}$ C. To this was added acetic anhydride (42 μ L, 0.45 mmol) and the solution allowed to warm to rt with stirring overnight. No starting material remained by LC/MS so the solution was diluted with DCM, washed once with a 50% saturated aqueous sodium bicarbonate solution, dried ($MgSO_4$), filtered, and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((4-acetamidobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (160 mg, 0.20 mmol, 69%) as a colorless oil. UPLC/ELSD: RT = 3.50 min. MS (ES): m/z (MH^+) 779.66 for $C_{48}H_{94}N_2O_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 6.33 (br. s, 1H); 4.86 (quint., 1H, $J = 12.3$ Hz, 6.2 Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 3.23 (quart., 2H, $J = 11.9$ Hz, 6.1 Hz); 2.46-2.33(m, 5H); 2.32-2.22 (m, 4H); 1.95 (s, 3H); 1.68-1.56 (m, 6H); 1.54-1.36 (m, 12H); 1.35-1.15 (m, 49H); 0.87 (t, 9H, $J = 5.8$ Hz).

FK. Compound 256: 8-(Heptadecan-9-yloxy)-N-(3-(2-(methylsulfinyl)acetamido)propyl)-N-(8-(nonyloxy)-8-oxooctyl)-8-oxooctan-1-amine oxide

Chemical Formula: $C_{48}H_{94}N_2O_7S$

Molecular Weight: 843.35

FL. Compound 257: 8-(Heptadecan-9-yloxy)-N-(3-(2-(methylsulfonyl)acetamido)propyl)-N-(8-(nonyloxy)-8-oxooctyl)-8-oxooctan-1-amine oxide

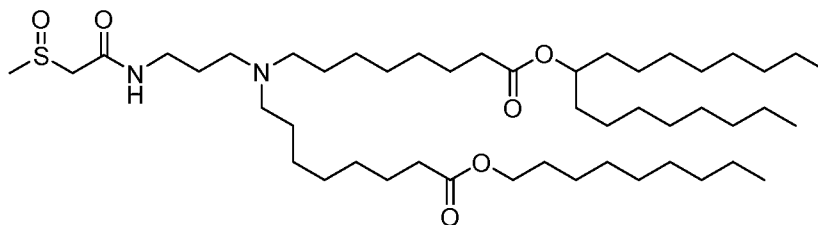
Chemical Formula: C₄₈H₉₄N₂O₈S

Molecular Weight: 859.35

[00300] To a solution of heptadecan-9-yl 8-((3-(2-(methylthio)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (350 mg, 0.43 mmol) in 5 mL DCM at 0 °C was added m-chloroperoxybenzoic acid (50% by weight; 300 mg, 0.84 mmol) in one portion. The ice bath was removed and the resulting yellow solution stirred at rt for 24 hours after which no starting material remained by LC/MS. The solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution, dried (MgSO₄), filtered and the filtrate conc. to a pale yellow oil. This was purified by silica gel chromatography (0-75% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give two sets of fractions. The first set to elute was conc. to give 8-(heptadecan-9-yloxy)-N-(3-(2-(methylsulfonyl)acetamido)propyl)-N-(8-(nonyloxy)-8-oxooctyl)-8-oxooctan-1-amine oxide (60 mg, 0.07 mmol, 16%) as a colorless oil. UPLC/ELSD: RT = 3.44 min. MS (ES): m/z (MH⁺) 859.62 for C₄₈H₉₄N₂O₈S (Compound 257). ¹H NMR (300 MHz, CDCl₃) δ: ppm 10.95 (br. s, 1H); 4.86 (quint., 1H, J = 12.3 Hz, 5.9 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.93 (s, 2H); 3.38 (br. d, 3H, J = 5.2 Hz); 3.15 (m, 6H); 2.62-2.36 (m, 1H); 2.34-2.21 (m, 4H); 2.02 (t, 2H, J = 6.1 Hz); 1.86-1.55 (m, 10H); 1.54-1.43 (m, 5H); 1.41-1.14 (m, 48H); 0.88 (t, 9H, J = 6.0 Hz).

[00301] The second set of fractions to elute was conc. to give 8-(heptadecan-9-yloxy)-N-(3-(2-(methylsulfinyl)acetamido)propyl)-N-(8-(nonyloxy)-8-oxooctyl)-8-oxooctan-1-amine oxide (75 mg, 0.09 mmol, 20%) as a waxy white solid. UPLC/ELSD: RT = 3.42 min. MS (ES): m/z (MH⁺) 843.71 for C₄₈H₉₄N₂O₇S (Compound 256). ¹H NMR (300 MHz, CDCl₃) δ: ppm 10.15 (br. s, 1H); 4.86 (quint., 1H, J = 12.5 Hz, 6.3 Hz); 4.05 (t, 2H, J = 6.6 Hz); 3.57 (m, 2H); 3.44-3.25 (m, 3H); 3.14 (t, 3H, J = 8.2 Hz); 2.72 (s, 3H); 2.54-2.34 (m, 1H); 2.33-2.24 (m, 4H); 2.04 (t, 2H, J = 5.6 Hz); 1.88-1.71 (m, 2H); 1.69-1.55 (m, 8H); 1.54-1.43 (m, 4H); 1.41-1.14 (m, 49H); 0.88 (t, 9H, J = 6.0 Hz).

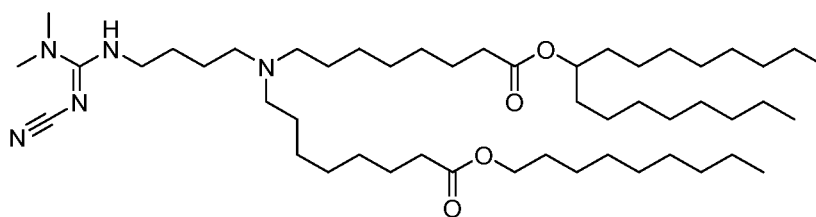
FM. Compound 258: Heptadecan-9-yl 8-((3-(2-(methylsulfinyl)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{48}H_{94}N_2O_6S$

Molecular Weight: 827.35

[00302] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.55 mmol) and methanesulfinylacetic acid [J. Med. Chem., 38(3), 508-525 (1995)] (81 mg, 0.66 mmol) in 10 mL dry DCM was added 4-(dimethylamino)pyridine (17 mg, 0.14 mmol) followed by 1-[bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 3-oxide hexafluorophosphate (HATU; 315 mg, 0.83 mmol) and finally N,N-diisopropylethylamine (300 μ L, 1.66 mmol) and the resulting mixture stirred at rt overnight. No starting amine remained by LC/MS so the dark orange solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution, once with brine, dried ($MgSO_4$), filtered and the filtrate conc. to a dark yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-(methylsulfinyl)acetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (190 mg, 0.23 mmol, 41%) as a yellow oil. UPLC/ELSD: RT = 3.44 min. MS (ES): m/z (MH^+) 827.56 for $C_{48}H_{94}N_2O_6S$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.74 (br. s, 1H); 4.86 (quint., 1H, $J = 12.5$ Hz, 6.1 Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 3.60 (d, 1H, $J = 13.7$ Hz); 3.36 (m, 3H); 2.71 (s, 3H); 2.60-2.48 (br. s, 2H); 2.47-2.34 (br. s, 3H); 2.28 (m, 4H); 1.76-1.55 (m, 8H); 1.54-1.38 (m, 8H); 1.37-1.15 (br. m, 49H); 0.88 (t, 9H, $J = 5.9$ Hz).

FN. Compound 259: Heptadecan-9-yl (Z)-8-((4-(2-cyano-3,3-dimethylguanidino)butyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

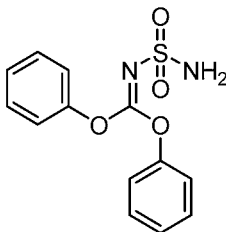
Chemical Formula: $C_{50}H_{97}N_5O_4$

Molecular Weight: 832.36

[00303] To a solution of heptadecan-9-yl 8-((4-aminobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (235 mg, 0.32 mmol) in 4 mL 2-propanol was added triethylamine

(44 uL, 0.32 mmol) followed by diphenyl cyanocarbonimidate (76 mg, 0.32 mmol) and the white mixture stirred at rt for ninety minutes after which it had become a colorless solution. No starting material remained by LC/MS and only the monophenyl carbamimidate was observed (MW = 881.4). To this was added a 2M dimethylamine solution in methanol (1.6 mL, 3.2 mmol), the resulting pale yellow solution heated to 55 °C and stirred for 20 hours, after which no carbamimidate intermediate remained by LC/MS. The reaction was allowed to cool to rt, conc., the residue dissolved in DCM, washed twice with a saturated aqueous sodium bicarbonate solution, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-60% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((4-(2-cyano-3,3-dimethylguanidino)butyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (130 mg, 0.16 mmol, 49%) as a colorless oil. UPLC/ELSD: RT = 3.43 min. MS (ES): m/z (MH⁺) 832.48 for C₅₀H₉₇N₅O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.50 (br. s, 1H); 4.86 (quint., 1H, J = 12.2 Hz, 6.2 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.48 (quart., 2H, J = 11.4 Hz, 5.7 Hz); 3.02 (s, 6H); 2.49 (br. s, 6H); 2.32-2.22 (m, 4H); 1.70-1.55 (m, 8H); 1.54-1.45 (m, 6H); 1.44-1.15 (m, 52H); 0.87 (t, 9H, J = 5.8 Hz).

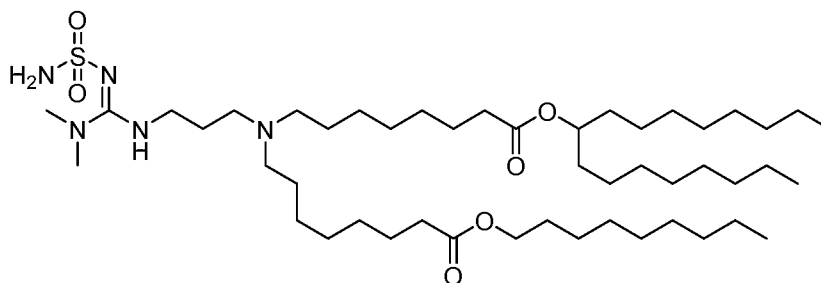
FO. Compound 260: Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-sulfamoylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
Diphenyl sulfamoylcarbonimidate



Chemical Formula: C₁₃H₁₂N₂O₄S
Molecular Weight: 292.31

[00304] To a solution of dichlorodiphenoxymethane (1 g, 3.7 mmol) in 10 mL dry acetonitrile under dry nitrogen was added sulfamide (0.72 g, 7.4 mmol) and the pale yellow mixture stirred at rt for 72 hours. The resulting mixture was conc., the residue triturated with DCM, filtered, and the filtrate conc. The residue was purified by silica gel chromatography on silica (0-60% EtOAc in hexanes) to give diphenyl sulfamoylcarbonimidate (295 mg, 1.01 mmol, 27%) as a colorless oil which solidified to a translucent white solid on standing. UPLC/ELSD: RT = 0.31 min. MS (ES): m/z (M-SO₂NH₂) 213.97 for C₁₃H₁₂N₂O₄S. ¹H NMR (300 MHz, DMSO-d₆) δ: ppm 7.54-7.29 (dt, 10H, J = 44.5 Hz, 7.5 Hz); 7.19 (s, 2H).

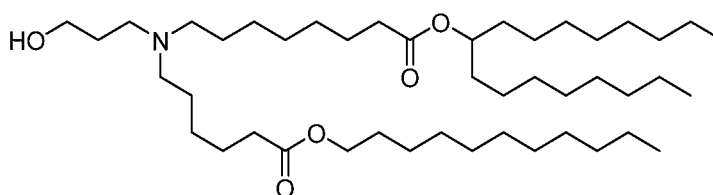
Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-sulfamoylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_{48}H_{97}N_5O_6S$
Molecular Weight: 872.39

[00305] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) in 5 mL 2-propanol was added triethylamine (48 μ L, 0.35 mmol) followed by diphenyl sulfamoylcarbonimide (101 mg, 0.35 mmol) and the mixture stirred at rt for two hours, after which no starting material was seen by LC/MS and the only peak observed corresponded with the monophenyl carbamimide intermediate (MW = 921.4). To the reaction mixture was added a 2M dimethylamine solution in methanol (1 mL, 2 mmol) and the resulting pale yellow solution heated to 55 $^{\circ}$ C for 18 hours. The reaction was complete by LC/MS so the solution was reduced under vacuum, diluted with DCM and washed once with a saturated aqueous sodium bicarbonate solution. The organic phase was dried ($MgSO_4$), filtered and the filtrate conc. to a cloudy pale yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-sulfamoylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (155 mg, 0.18 mmol, 51%) as a slightly yellow syrup. UPLC/ELSD: RT = 3.34 min. MS (ES): m/z (MH^+) 872.58 for $C_{48}H_{97}N_5O_6S$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.02 (br. s, 1H); 4.86 (quint., 1H, J = 12.4 Hz, 6.4 Hz,); 4.48 (br. s, 2H); 4.05 (t, 2H, J = 6.7 Hz); 3.36 (quart., 2H, J = 11.5 Hz, 5.5 Hz); 2.97 (s, 6H); 2.54 (br. s, 2H); 2.41 (br. s, 3H); 2.28 (m, 4H); 1.79-1.68 (m, 2H); 1.67-1.55 (m, 6H); 1.54-1.45 (m, 4H); 1.44-1.37 (m, 2H); 1.36-1.14 (m, 51H); 0.87 (t, 9H, J = 5.8 Hz).

FP. Compound 261: Heptadecan-9-yl 8-((3-hydroxypropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

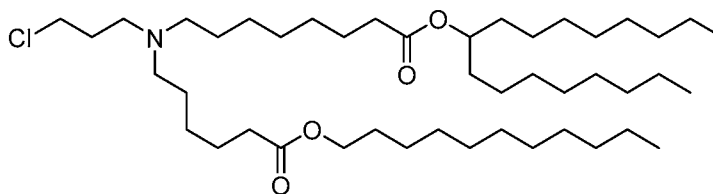


Chemical Formula: $C_{45}H_{89}NO_5$
Molecular Weight: 724.21

[00306] To a solution of heptadecan-9-yl 8-((3-hydroxypropyl)amino)octanoate (740 mg, 1.62 mmol) and undecyl 6-bromohexanoate (570 mg (1.62 mmol) in 16 mL dry acetonitrile under dry nitrogen was added potassium iodide (300 mg, 1.79 mmol) followed by powdered potassium carbonate (900 mg, 6.5 mmol) and the mixture diluted with 4 mL dry cyclopentyl methyl ether. The resulting white mixture was heated to 90 °C and stirred for 24 hours, then allowed to cool to rt, filtered, the filter solids washed with DCM and the filtrate conc. The residue was suspended in a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-hydroxypropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (780 mg, 1.08 mmol, 66%) as a slightly yellow oil. UPLC/ELSD: RT = 3.55 min. MS (ES): m/z (MH⁺) 724.39 for C₄₅H₈₉NO₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 5.60 (br. s, 1H); 4.86 (quint., 1H, J = 12.2 Hz, 6.2 Hz,); 4.05 (t, 2H, J = 6.7 Hz); 3.78 (t, 2H, J = 4.9 Hz); 2.62 (t, 2H, J = 5.2 Hz); 2.40 (quint., 4H, J = 8.3 Hz, 5.2 Hz); 2.28 (quart., 4H, J = 15.0 Hz, 7.7 Hz); 1.73-1.55 (m, 8H); 1.54-1.39 (m, 8H); 1.38-1.12 (m, 48H); 0.87 (t, 9H, J = 5.9 Hz).

FQ. Compound 263: Heptadecan-9-yl 8-((3-(2-methoxyacetamido)propyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

Heptadecan-9-yl 8-((3-chloropropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate



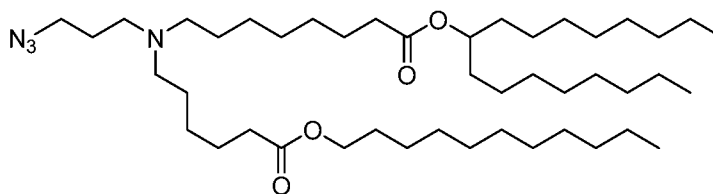
Chemical Formula: C₄₅H₈₈ClNO₄

Molecular Weight: 742.65

[00307] To a solution of heptadecan-9-yl 8-((3-hydroxypropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (700 mg, 0.97 mmol) and triethylamine (202 uL, 1.45 mmol) in dry DCM at 0 °C was added methanesulfonyl chloride (90 uL, 1.16 mmol) and the resulting solution allowed to warm to rt overnight after which no starting material remained by LC/MS. The solution was diluted with DCM, washed once with a saturated aqueous sodium bicarbonate solution, once with brine, dried (MgSO₄), filtered and the filtrate conc. to give heptadecan-9-yl 8-((3-chloropropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (720 mg ~quant.) as a pale yellow oil/solid mixture which contained some of the corresponding mesylate by ¹H-NMR. The material was carried through without further purification. UPLC/ELSD: RT

= 3.61 min. MS (ES): m/z (M-Cl) 706.68 for $C_{45}H_{88}ClNO_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (quint., 1H, $J = 12.1$ Hz, 5.9 Hz,); 4.05 (t, 2H, $J = 6.7$ Hz); 3.59 (t, 2H, $J = 6.5$ Hz); 2.51 (t, 2H, $J = 6.8$ Hz); 2.40-2.23 (m, 7H); 1.86 (t, 2H, $J = 6.0$ Hz); 1.70-1.45 (m, 12H); 1.44-1.37 (m, 4H); 1.36-1.15 (m, 47H); 0.88 (t, 9H, $J = 5.9$ Hz).

Heptadecan-9-yl 8-((3-azidopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

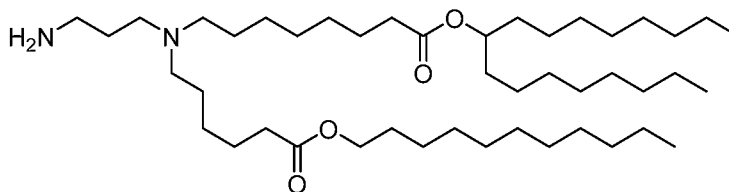


Chemical Formula: $C_{45}H_{88}N_4O_4$

Molecular Weight: 749.22

[00308] To a solution of heptadecan-9-yl 8-((3-chloropropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (720 mg, 0.97 mmol) in 10 mL dry DMF in a high-pressure Pyrex vessel was added sodium azide (250 mg, 3.9 mmol), the vessel flushed with nitrogen and sealed with a teflon screw-top cap. The reaction was heated to 100 °C and stirred overnight after which no starting chloride remained by TLC. The reaction was allowed to cool to rt, the solution diluted with water and extracted 3x with hexanes. The organics were combined, washed once with water, once with brine, dried ($MgSO_4$), filtered, and the filtrate conc. to a pale yellow oil. This was purified by silica gel chromatography (0-20% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-azidopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (550 mg, 0.73 mmol, 75%) as a yellow oil. UPLC/ELSD: RT = 3.61 min. MS (ES): m/z (MH^+) 749.32 for $C_{45}H_{88}N_4O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (quint., 1H, $J = 12.5$ Hz, 6.2 Hz,); 4.06 (t, 2H, $J = 6.7$ Hz); 3.33 (t, 2H, $J = 6.4$ Hz); 2.46 (t, 2H, $J = 6.3$ Hz); 2.42-2.34 (m, 3H); 2.28 (quart., 4H, $J = 14.3$ Hz, 7.1 Hz); 1.77-1.55 (m, 8H); 1.54-1.38 (m, 8H); 1.37-1.14 (m, 49H); 0.88 (t, 9H, $J = 5.7$ Hz).

Heptadecan-9-yl 8-((3-aminopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate



Chemical Formula: $C_{45}H_{90}N_2O_4$

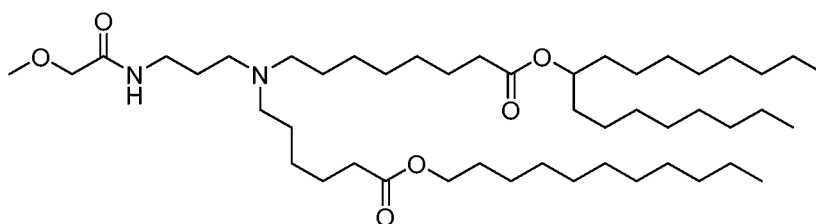
Molecular Weight: 723.23

[00309] A flask containing a stirring dispersion of heptadecan-9-yl 8-((3-azidopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (550 mg, 0.73 mmol) in 8 mL ethanol was flushed with

nitrogen and palladium 10 wt.% on carbon (ca. 50 mg, cat.) added to give a black mixture. The sides of the vessel were washed down with 2 mL ethanol and the flask again flushed with nitrogen. The flask was fitted with a hydrogen balloon, evacuated and back-filled with hydrogen three times and stirred at rt for two hours, after which no starting azide remained by LC/MS. The flask was flushed with nitrogen, the mixture filtered through Celite, the filter solids washed with ethanol and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-aminopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (375 mg, 0.52 mmol, 71%) as a colorless oil.

UPLC/ELSD: RT = 3.17 min. MS (ES): m/z (MH⁺) 723.57 for C₄₅H₉₀N₂O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.91 (br. s, 2H); 4.86 (quint., 1H, J = 12.3 Hz, 6.1 Hz,); 4.05 (t, 2H, J = 6.8 Hz); 3.06 (t, 2H, J = 5.5 Hz); 2.65 (t, 2H, J = 5.8 Hz); 2.48 (quint., 4H, J = 9.7 Hz, 5.3 Hz); 2.29 (quart., 4H, J = 17.1 Hz, 9.6 Hz); 1.89-1.72 (m, 2H); 1.70-1.55 (m, 6H); 1.54-1.39 (m, 8H); 1.38-1.13 (m, 48H); 0.87 (t, 9H, J = 5.8 Hz).

Heptadecan-9-yl 8-((3-(2-methoxyacetamido)propyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate

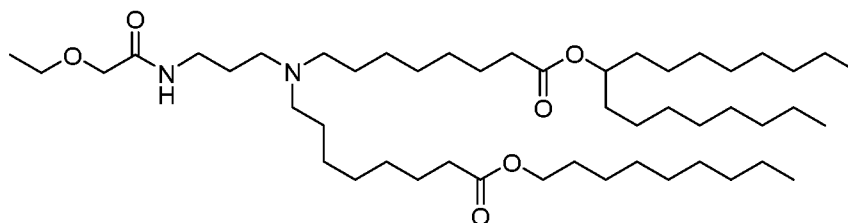


Chemical Formula: C₄₈H₉₄N₂O₆
Molecular Weight: 795.29

[00310] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (170 mg, 0.23 mmol) and triethylamine (100 uL, 0.7 mmol) in 4 mL dry DCM at 0 °C and was added methoxyacetyl chloride (32 uL, 0.35 mmol) dropwise, the resulting mixture stirred and allowed to warm to rt overnight. No starting amine remained by LC/MS so the yellow solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution, once with brine, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-methoxyacetamido)propyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (42 mg, 0.05 mmol, 22%) as a yellow oil. UPLC/ELSD: RT = 3.44 min. MS (ES): m/z (MH⁺) 795.25 for C₄₈H₉₄N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.50 (s, 1H); 4.86 (quint., 1H, J = 12.0 Hz,

6.2 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.87 (s, 2H); 3.40 (m, 5H); 2.98 (br. s, 1H); 2.54-2.34 (m, 4H); 2.28 (quart., 4H, J = 14.7 Hz, 7.4 Hz); 1.69-1.39 (m, 14H); 1.38-1.13 (m, 51H); 0.88 (t, 9H, J = 5.9 Hz).

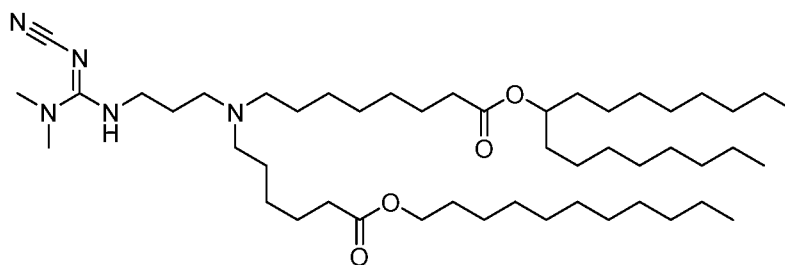
FR. Compound 264: Heptadecan-9-yl 8-((3-(2-ethoxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_{49}H_{96}N_2O_6$
Molecular Weight: 809.32

[00311] Compound 264 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.55 mmol) analogously to Compound 178 except that ethoxyacetyl chloride (Alfa Aesar, Tewksbury, MA) (92 μ L, 0.83 mmol) was used in place of methoxyacetyl chloride. Following an aqueous workup the residue was purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-ethoxyacetamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (140 mg, 0.55 mmol, 31%) as a yellow oil. UPLC/ELSD: RT = 3.51 min. MS (ES): m/z (MH^+) 809.43 for $C_{49}H_{96}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.48 (s, 1H); 4.86 (quint., 1H, J = 12.6 Hz, 6.1 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.91 (s, 2H); 3.55 (quart., 2H, J = 13.8 Hz, 7.0 Hz); 3.36 (d, 2H, J = 5.8 Hz); 2.53-2.43 (m, 2H); 2.41-2.32 (br. m, 3H); 2.31-2.23 (m, 4H); 1.70-1.56 (m, 8H); 1.55-1.37 (m, 8H); 1.36-1.14 (m, 52H); 0.88 (t, 9H, J = 7.5 Hz).

FS. Compound 265: Heptadecan-9-yl (Z)-8-((3-(2-cyano-3,3-dimethylguanidino)propyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate



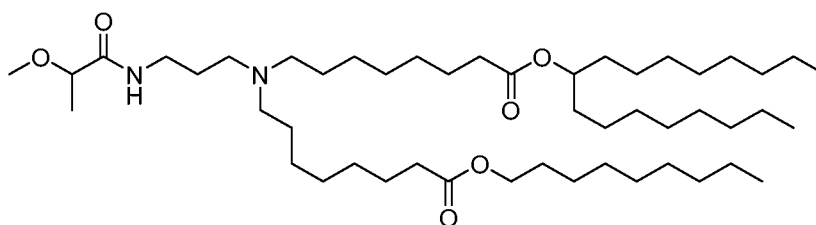
Chemical Formula: $C_{49}H_{95}N_5O_4$
Molecular Weight: 818.33

[00312] Compound 265 was prepared analogously to Compound 168 except that heptadecan-9-yl 8-((3-aminopropyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (170 mg, 0.23 mmol) was

used. Following an aqueous workup the residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((3-(2-cyano-3,3-dimethylguanidino)propyl)(6-oxo-6-(undecyloxy)hexyl)amino)octanoate (40 mg, 0.05 mmol, 21%) as a colorless syrup.

UPLC/ELSD: RT = 3.52 min. MS (ES): m/z (MH⁺) 818.78 for C₄₉H₉₅N₅O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.52 (br. s., 1H); 4.86 (quint., 1H, J = 12.6 Hz, 6.3 Hz); 4.06 (t, 2H, J = 6.7 Hz); 3.68 (d, 2H, J = 4.3 Hz); 3.00 (s, 6H); 2.59 (br. s, 2H); 2.44 (br. s, 3H); 2.29 (quart., 4H, J = 13.4 Hz, 7.1 Hz); 1.80-1.58 (m, 8H); 1.56-1.38 (m, 6H); 1.37-1.13 (m, 51H); 0.88 (t, 9H, J = 5.9 Hz).

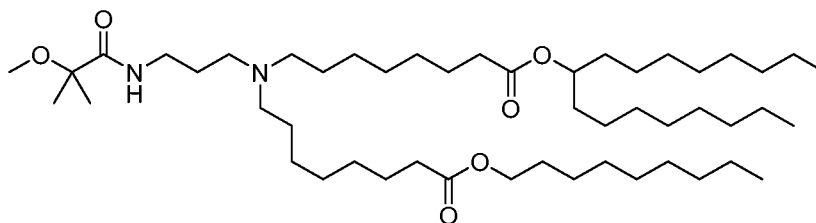
FT. Compound 267: Heptadecan-9-yl 8-((3-(2-methoxypropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₉H₉₆N₂O₆
Molecular Weight: 809.32

[00313] Compound 267 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (300 mg, 0.42 mmol) analogously to Compound 252 except that 2-methoxypropanoic acid (Ark Pharm, Arlington Heights, IL)(66 mg, 0.62 mmol) was used instead of (methylthio)acetic acid. Following an aqueous workup the residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-methoxypropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (45 mg, 0.06 mmol, 54%) as a slightly yellow oil. UPLC/ELSD: RT = 3.48 min. MS (ES): m/z (MH⁺) 809.60 for C₄₉H₉₆N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.43 (s, 1H); 4.86 (quint., 1H, J = 12.2 Hz, 6.2 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.71 (quart., 1H, J = 13.4 Hz, 6.7 Hz); 3.36 (m, 5H); 2.58-2.47 (m, 2H); 2.45-2.35 (m, 3H); 2.34-2.24 (m, 4H); 1.76-1.41 (m, 16H); 1.40-1.15 (m, 52H); 0.87 (t, 9H, J = 5.7 Hz).

FU. Compound 268: Heptadecan-9-yl 8-((3-(2-methoxy-2-methylpropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

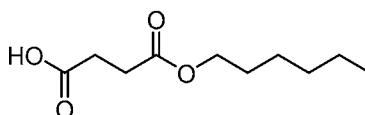
Chemical Formula: C₅₀H₉₈N₂O₆

Molecular Weight: 823.34

[00314] Compound 268 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) analogously to Compound 252 except that 2-methoxy-2-methylpropanoic acid (Enamine, Monmouth Jct., NJ) (63 mg, 0.52 mmol) was used instead of (methylthio)acetic acid. Following an aqueous workup the residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(2-methoxy-2-methylpropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (35 mg, 0.04 mmol, 12%) as a slightly yellow oil. UPLC/ELSD: RT = 3.58 min. MS (ES): m/z (MH⁺) 823.62 for C₅₀H₉₈N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 8.96 (s, 1H); 7.49 (t, 1H, J = 6.7 Hz); 4.86 (quint., 1H, J = 12.1 Hz, 6.1 Hz); 4.07 (t, 2H, J = 6.6 Hz); 3.44-3.37 (m, 5H); 3.20-2.98 (m, 5H); 2.37-2.26 (m, 4H); 2.17-2.02 (m, 2H); 1.80-1.69 (m, 3H); 1.68-1.60 (m, 6H); 1.57-1.47 (m, 4H); 1.46-1.17 (m, 55H); 0.90 (t, 9H, J = 5.9 Hz).

FV. Compound 269: 6-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)hexyl hexyl succinate

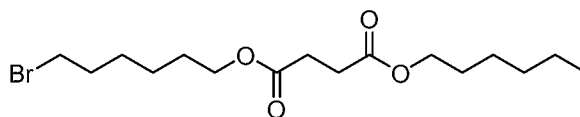
4-(Hexyloxy)-4-oxobutanoic acid

Chemical Formula: C₁₀H₁₈O₄

Molecular Weight: 202.25

[00315] A slurry of succinic anhydride (5 g, 49.4 mmol) in 1-hexanol (6.3 mL, 49.4 mmol) was heated to 80 °C and stirred for 20 hours after which it had become a colorless solution. This was allowed to cool to rt, diluted with EtOAc, washed twice with a 1N HCl solution, once with brine, dried (Na₂SO₄), filtered and the filtrate conc. to give 4-(hexyloxy)-4-oxobutanoic acid (9.87 g, 48.8 mmol, 99%) as a colorless liquid which was carried through without further purification. ¹H NMR (300 MHz, CDCl₃) δ: ppm 10.59 (br. s., 1H); 4.10 (quart., 2H, J = 11.9 Hz, 5.2 Hz); 2.65 (m, 4H); 1.62 (quint., 2H, J = 13.0 Hz, 6.9 Hz); 1.30 (m, 6H); 0.89 (t, 3H, J = 6.7 Hz) (carboxylate proton not observed).

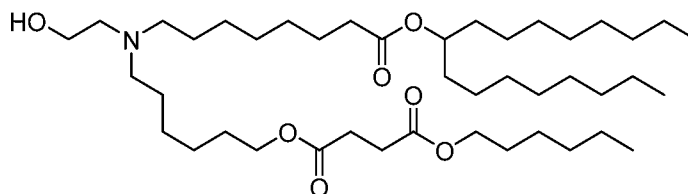
6-Bromohexyl hexyl succinate

Chemical Formula: $C_{16}H_{29}BrO_4$

Molecular Weight: 365.31

[00316] To a solution of 4-(hexyloxy)-4-oxobutanoic acid (1.0 g, 4.9 mmol) and 6-bromo-1-hexanol (0.75 mL, 5.2 mmol) in 20 mL dry DCM under dry nitrogen was added 1-ethyl-3-(dimethylaminopropyl)carbodiimide hydrochloride (1.67 g, 7.4 mmol) followed by 4-(dimethylamino)pyridine (0.3 g, 2.47 mmol) and finally N,N-diisopropylethylamine (2.6 mL, 14.8 mmol) to give a pale yellow solution. This was stirred at rt for 24 hours, after which TLC showed a mostly complete reaction. The solution was diluted with DCM, washed once with a saturated aqueous sodium bicarbonate solution (thick emulsion), dried ($MgSO_4$), filtered and the filtrate conc. to a colorless liquid/white solid mixture. This was purified by silica gel chromatography (0-25% EtOAc in hexanes) to give 6-bromohexyl hexyl succinate (0.92g, 2.5 mmol, 51%) as a pale yellow liquid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.11-4.06 (m, 4H); 3.41 (t, 2H, $J = 6.7$ Hz); 2.62 (s, 4H); 1.87 (quint., 2H, $J = 13.9$ Hz, 7.2 Hz); 1.69-1.57 (m, 4H); 1.50-1.30 (m, 10H); 0.89 (t, 3H, $J = 6.3$ Hz).

6-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)hexyl hexyl succinate

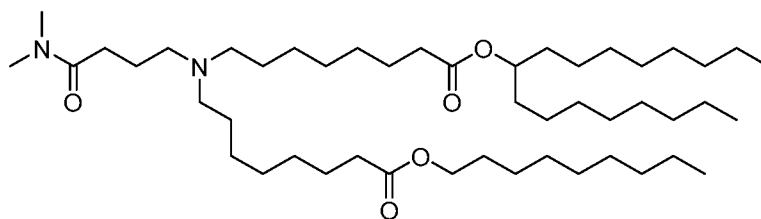
Chemical Formula: $C_{43}H_{83}NO_7$

Molecular Weight: 726.14

[00317] To a solution of heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (300 mg, 0.61 mmol) and 6-bromohexyl hexyl succinate (223 mg (0.61 mmol) in 8 mL dry acetonitrile under dry nitrogen was added potassium iodide (115 mg, 0.68 mmol) followed by powdered potassium carbonate (340 mg, 2.4 mmol) and the mixture diluted with 2 mL dry cyclopentyl methyl ether. The resulting white mixture was heated to 90 °C and stirred for 24 hours, then allowed to cool to rt, filtered, the filter solids washed with DCM and the filtrate conc. The residue was suspended in a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-30% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give 6-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)hexyl hexyl succinate (40 mg, 0.06 mmol, 9%) as a colorless oil.

UPLC/ELSD: RT = 3.15 min. MS (ES): m/z (MH⁺) 726.36 for C₄₃H₈₃NO₇. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.86 (quint., 1H, J = 12.2 Hz, 6.1 Hz,); 4.08 (t, 4H, J = 6.6 Hz); 3.52 (t, 2H, J = 5.0 Hz); 2.96 (br. s, 1H); 2.62 (s, 4H); 2.57 (t, 2H, J = 4.9 Hz); 2.44 (t, 4H, J = 6.4 Hz); 2.27 (t, 2H, J = 7.4 Hz); 1.70-1.56 (m, 6H); 1.54-1.37 (m, 8H); 1.36-1.15 (m, 40H); 0.87 (t, 9H, J = 5.9 Hz).

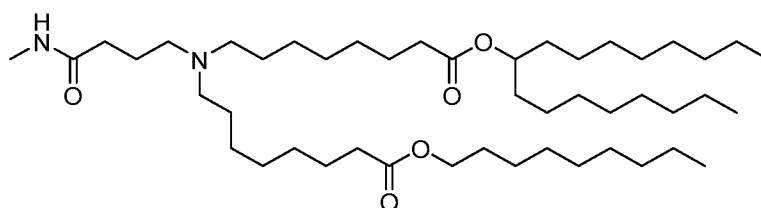
FW. Compound 238: Heptadecan-9-yl 8-((4-(dimethylamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₈H₉₄N₂O₅
Molecular Weight: 779.29

[00318] To a solution of 4-bromobutanoyl chloride (1.6 g, 8.62 mmol) in 15 mL dry THF cooled to -15 °C was added a 2M dimethylamine solution in THF (12 mL, 24 mmol), the resulting mixture stirred and allowed to warm to rt. The precipitated solids were removed via filtration and the filtrate concentrated to give crude 4-bromo-N,N-dimethylbutanamide. This was dissolved in 20 mL of a 1:1 acetonitrile / methyl cyclopentyl ether mixture, heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (1 g, 1.5 mmol), potassium carbonate (0.8 g, 6 mmol), potassium iodide (0.3 g, 1.8 mmol) added, the mixture heated to 80 °C and stirred overnight. The reaction was allowed to cool to rt, filtered and the filtrate conc. The residue was purified by silica gel chromatography (4:1 hexanes / acetone isocratic) to give heptadecan-9-yl 8-((4-(dimethylamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (180 mg, 0.23 mmol, 15%) as a light yellow oil. MS (CI): m/z (MH⁺) 779.7 for C₄₈H₉₄N₂O₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.83 (quint., 1H, J = 6 Hz); 4.03 (t, 2H, J = 7.5 Hz); 3-2.7 (m, 10H); 2.5 (t, 2H, J = 7.5 Hz); 2.26 (m, 4H); 2 (m, 2H); 1.7-1.4 (m, 14H); 1.4-1.2 (m, 50H); 0.8 (m, 9H).

FX. Compound 239: Heptadecan-9-yl 8-((4-(methylamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

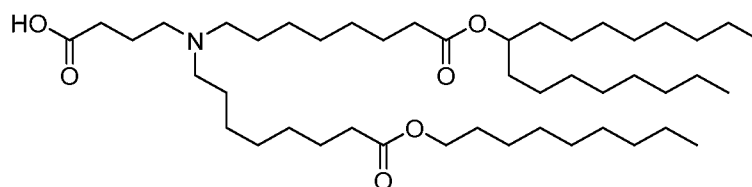


Chemical Formula: C₄₇H₉₂N₂O₅
Molecular Weight: 765.26

[00319] Compound 239 was prepared from heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (0.8 g, 1.2 mmol) analogously to Compound 238 except that a 2M methylamine solution in methanol (8 mL, 16 mmol) was used in place of a 2M dimethylamine solution in THF. The residue following filtration and concentration of the reaction mixture was purified by silica gel chromatography (4:1 hexanes / acetone isocratic) to give heptadecan-9-yl 8-((4-(methylamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.52 mmol, 43%) as a light yellow oil. MS (CI): m/z (MH⁺) 765.6 for C₄₇H₉₂N₂O₅. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.83 (quint., 1H, J = 6 Hz); 4.04 (t, 2H, J = 6 Hz); 3.6 (s, 3H); 2.4-2.2 (m, 12H); 1.8-1.4 (m, 14H); 1.4-1.2 (m, 50H); 0.8 (m, 9H); (amide proton not observed).

FY. Compound 240: Heptadecan-9-yl 8-((4-(methoxy(methyl)amino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

4-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid



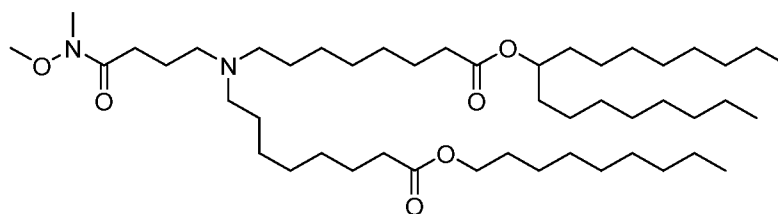
Chemical Formula: C₄₆H₈₉NO₆

Molecular Weight: 752.22

[00320] A mixture of periodic acid (7.3 g, 32 mmol) in 100 mL acetonitrile was stirred vigorously for 15 min. at 0 °C. To this was added a solution of heptadecan-9-yl 8-((4-hydroxybutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (10.75 g, 14.6 mmol) in 30 mL acetonitrile followed by pyridinium chlorochromate (0.16 g, 0.73 mmol). The resulting mixture was allowed to warm to rt for 4 hours after which LC/MS showed predominantly starting alcohol remaining. To the mixture was added additional pyridinium chlorochromate (0.16 g, 0.73 mmol) and stirring was continued for 1 hour. LC/MS showed more product formed after the addition of additional pyridinium chlorochromate, however, this reaction step was slow. The reaction mixture was diluted with EtOAc, washed with a water/brine (1:1) mixture, a saturated aqueous sodium bicarbonate solution, and finally brine. After drying (MgSO₄) and concentration, 13 g crude material was obtained which by NMR contained 20% starting alcohol along with some aldehyde intermediate. The crude material was dissolved in 120 mL 1:1 acetonitrile / TBME, periodic acid (13.0 g, 57 mmol) and pyridinium chlorochromate (0.16 g, 0.73 mmol) added and the mixture stirred at rt for 3 hours. Additional pyridinium chlorochromate (0.16 g, 0.73 mmol) was added and the mixture stirred at rt for 16 hours after which LC/MS showed almost no starting alcohol remained. The reaction mixture was diluted with EtOAc, washed with a water/brine (1:1) mixture, a saturated aqueous sodium bicarbonate

solution, and finally brine. The organics were dried (MgSO₄), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-6% then 10% methanol in dichloromethane) to give 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid (8.80 g, 11.7 mmol, 80%) as brown oil. MS (CI): m/z (MH⁺) 752.6 for C₄₆H₈₉NO₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.84 (quint., 1H, J = 6.3 Hz); 4.03 (t, 2H, J = 6.8 Hz); 3.12 (m, 2H); 3.00 (m, 4H); 2.52 (m, 2H); 2.27 (m, 4H); 2.08 (m, 2H); 1.81 (br. m, 4H); 1.60 (m, 6H); 1.48 (m, 4H); 1.24 (br. m, 48H); 0.86 (t, 9H, J = 6.9 Hz); carboxylate proton not observed.

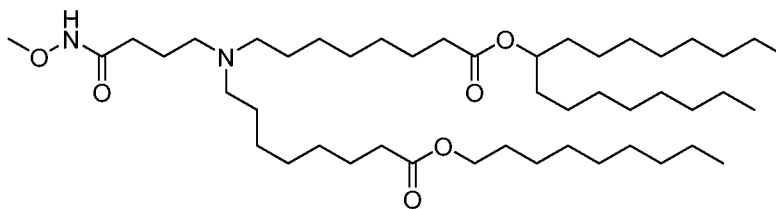
Heptadecan-9-yl 8-((4-(methoxy(methyl)amino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₈H₉₄N₂O₆
Molecular Weight: 795.29

[00321] To a solution of 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid (1.00 g, 1.33 mmol) in 40 mL dichloromethane was added carbonyldiimidazole (259 mg, 1.6 mmol) at 0 °C, the cooling bath removed and the mixture stirred at rt for 30 min. After cooling to 0 °C, N,O-dimethylhydroxylamine hydrochloride (156 mg, 1.6 mmol) and triethylamine (0.23 mL, 1.6 mmol) were added and the resulting mixture stirred at rt for 16 hours. Less than 10% of the starting acid remained by LC/MS so the reaction mixture was diluted with hexanes, washed once with water and brine. The organic layer was dried (MgSO₄), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-6% then 10% methanol in dichloromethane) to give 0.77 g of a mixture containing some starting acid. This material was again purified by silica gel chromatography (0-40% then 60% acetone in hexanes) to give heptadecan-9-yl 8-((4-(methoxy(methyl)amino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (210 mg, 0.26 mmol, 20%) as a colorless oil. HPLC/UV (214 nm): RT = 9.78 min. MS (CI): m/z (MH⁺) 795.7 for C₄₈H₉₄N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.85 (quint., 1H, J = 6.3 Hz); 4.04 (t, 2H, J = 6.8 Hz); 3.67 (s, 3H); 3.17 (s, 3H); 2.41 (m, 6H); 2.27 (m, 6H); 1.74 (m, 2H); 1.60 (m, 8H); 1.48 (m, 4H); 1.40 (m, 2H); 1.24 (br. m, 48H); 0.86 (t, 9H, J = 6.8 Hz).

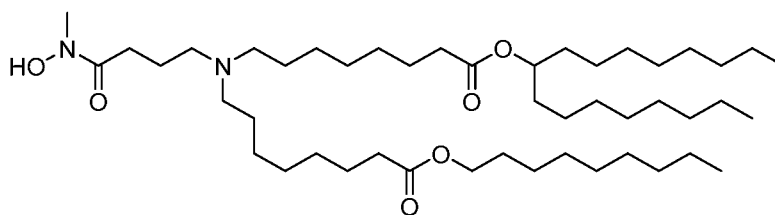
FZ. Compound 241: Heptadecan-9-yl 8-((4-(methoxyamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{47}H_{92}N_2O_6$

Molecular Weight: 781.26

[00322] To a mixture of 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid (1.00 g, 1.33 mmol) and O-methylhydroxylamine hydrochloride (178 mg, 2.13 mmol) in 20 mL dichloromethane was added 1-ethyl-3-(dimethylaminopropyl)carbodiimide hydrochloride (460 mg, 2.39 mmol) followed by triethylamine (0.30 mL, 2.13 mmol) and the mixture stirred at rt for 16 hours. Only a small amount of starting acid remained by LC/MS so the reaction mixture was diluted with hexanes, washed once with water and brine. The organic layer was dried ($MgSO_4$), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-6% then 10% methanol in dichloromethane) to give 0.63 g of a mixture containing some starting acid. This material was again purified by silica gel chromatography (0-40% then 80% acetone in hexanes) to give heptadecan-9-yl 8-((4-(methoxyamino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (0.56 g, 0.71 mmol, 53%) as a colorless oil. HPLC/UV (214 nm): RT = 9.49 min. MS (CI): m/z (MH⁺) 781.6 for $C_{47}H_{92}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.85 (quint., 1H, J = 6.3 Hz); 4.04 (t, 2H, J = 6.8 Hz); 3.73 (s, 3H); 2.48 (m, 2H); 2.42 (m, 4H); 2.28 (m, 6H); 1.73 (m, 4H); 1.60 (m, 6H); 1.48 (m, 6H); 1.24 (br. m, 48H); 0.87 (t, 9H, J = 7.1 Hz); hydroxamate proton not observed.

GA. Compound 242: Heptadecan-9-yl 8-((4-(hydroxy(methyl)amino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

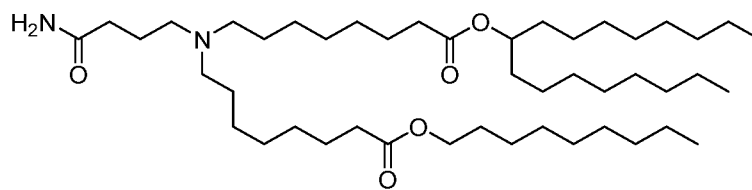
Chemical Formula: $C_{47}H_{92}N_2O_6$

Molecular Weight: 781.26

[00323] To a solution of 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid (1.08 g, 1.43 mmol) in 25 mL dichloromethane at 0 °C was added oxalyl chloride (121 μ L, 1.43 mmol) followed by 5 drops of DMF, the cooling bath removed

and the reaction mixture stirred at rt for 16 hours. To the resulting solution at 0 °C were added N-methylhydroxylamine hydrochloride (0.36 g, 4.3 mmol) and DMAP (355 mg, 0.29 mmol) followed by triethylamine (1.0 mL, 7.2 mmol), the reaction allowed to warm to rt and stirred for 16 hours. Only a small amount of starting acid remained by LC/MS so the reaction mixture was diluted with hexanes, washed once with water and brine. The organic layer was dried (MgSO₄), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-50% then 80% acetone in hexanes) to give heptadecan-9-yl 8-((4-(hydroxy(methyl)amino)-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (0.61 g, 0.78 mmol, 54%) as a yellow oil. HPLC/UV (214 nm): RT = 9.69 min. MS (CI): m/z (MH⁺) 781.6 for C₄₇H₉₂N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.85 (quint., 1H, J = 6.0 Hz); 4.04 (t, 2H, J = 6.9 Hz); 3.21 (s, 3H); 2.55 (m, 4H); 2.44 (m, 4H); 2.27 (m, 4H); 1.96 (m, 2H); 1.60 (m, 8H); 1.47 (m, 6H); 1.24 (br. m, 48H); 0.87 (t, 9H, J = 7.1 Hz); hydroxamate proton not observed.

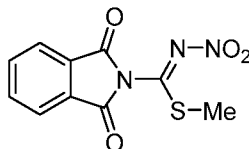
GB. Compound 243: Heptadecan-9-yl 8-((4-amino-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₆H₉₀N₂O₅
Molecular Weight: 751.24

[00324] To a solution of 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(8-(nonyloxy)-8-oxooctyl)amino)butanoic acid (1.0 g, 1.33 mmol) in 25 mL dichloromethane at 0 °C was added oxalyl chloride (120 μL, 1.33 mmol) followed by 5 drops of DMF, the cooling bath removed and the reaction mixture stirred at rt for 16 hours. The resulting solution was cooled to 0 °C, ammonia gas bubbled through for 5 min and the reaction maintained at 0 °C for two hours. Only a small amount of starting acid remained by LC/MS so the reaction mixture was diluted with dichloromethane and washed with brine. The organic layer was dried (MgSO₄), filtered and the filtrate conc. The residue was purified by silica gel chromatography (0-40% then 80% acetone in hexanes) to give heptadecan-9-yl 8-((4-amino-4-oxobutyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (0.30 g, 0.40 mmol, 30%) as a brown oil. HPLC/UV (214 nm): RT = 9.09 min. MS (CI): m/z (MH⁺) 751.6 for C₄₆H₉₀N₂O₅. ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.73 (bs, 1H); 5.22 (bs, 1H); 4.85 (quint., 1H, J = 6.3 Hz); 4.04 (t, 2H, J = 6.6 Hz); 2.45 (m, 2H); 2.37 (m, 4H); 2.27 (m, 6H); 1.75 (m, 2H); 1.60 (m, 8H); 1.50 (m, 4H); 1.40 (m, 2H); 1.24 (br. m, 48H); 0.87 (t, 9H, J = 6.5 Hz).

GC. Compound 248: Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
S-Methyl-N-nitro-N'-phthaloylisothiurea

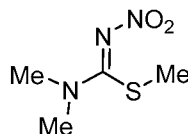


Chemical Formula: $C_{10}H_7N_3O_4S$

Molecular Weight: 265.24

[00325] To a solution of S-methyl-N-nitroisothiurea (5.0 g, 37 mmol) in 70 mL pyridine at 0 °C was added phthaloyl chloride (14.5 g, 10.3 mL, 72 mmol) dropwise over 25 min. The solution was stirred at 0 °C for 30 min during which a precipitate formed. The mixture was poured into 600 mL ice-cold 2N hydrochloric acid solution, the resulting solids filtered, washed with water and air-dried. The solids were precipitated from ethanol to give S-methyl-N-nitro-N'-phthaloylisothiurea (6.23 g, 23.5 mmol, 64%) as a white solid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.97-7.95 (m, 2H); 7.87-7.86 (m, 2H); 2.66 (s, 3H).

Methyl N,N-dimethyl-N'-nitrocarbimimidothioate

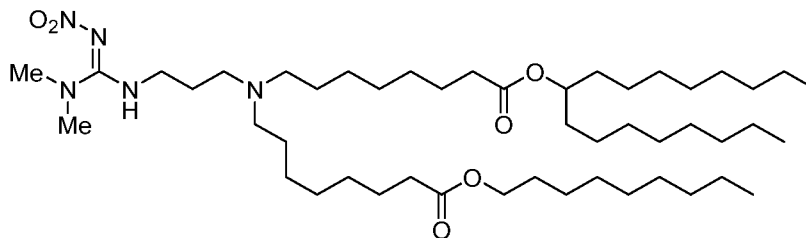


Chemical Formula: $C_4H_9N_3O_2S$

Molecular Weight: 163.20

[00326] To a solution of S-methyl-N-nitroso-N'-phthaloylisothiurea (1.5 g, 5.68 mmol) in 10 mL dichloromethane at 0 °C was added a solution of 2M dimethylamine solution in THF (2.84 mL, 5.68 mmol) in 5 mL methanol dropwise over 25 min. The reaction mixture was stirred at rt for 3 hours, conc., the residue dissolved in dichloromethane and purified by silica gel chromatography (4:1 hexane / ethyl acetate, isocratic) to give methyl N,N-dimethyl-N'-nitrocarbimimidothioate (678 mg, 4.15 mmol, 73 %) as a waxy white solid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 3.25 (s, 6H); 2.53 (s, 3H).

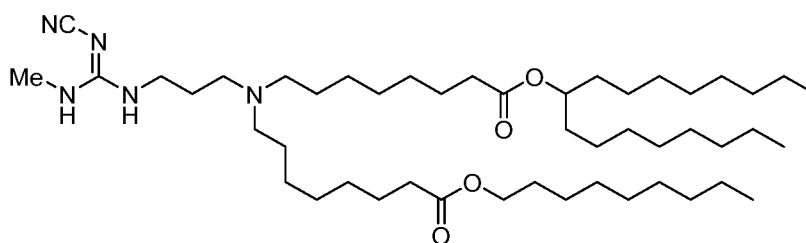
Heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_{48}H_{95}N_5O_6$
Molecular Weight: 838.32

[00327] To a solution of heptadecan-9-yl 8-((aminopropyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.69 mmol) in 20 mL methanol was added methyl-N,N-dimethyl-N'-nitrocarbamiimidothioate (118 mg, 0.73 mmol), the reaction mixture heated to reflux and stirred for 5 hours. No starting amine remained by LC/MS so the solvent was removed and the residue purified by silica gel chromatography (eluent dichloromethane, methanol, 1% ammonium hydroxide) to get 520 mg of impure material. This was again purified by silica gel chromatography (first 0-100% ethyl acetate in hexanes, then 0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-8-((3-(3,3-dimethyl-2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.26 mmol, 38%) as a light yellow oil. HPLC/UV 214 nm: RT = 9.48 min. MS (CI): m/z (MH⁺) 838.7 for $C_{48}H_{95}N_5O_6$. ¹H NMR (300 MHz, $CDCl_3$) δ : ppm 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.51 (t, 2H, J = 5.2 Hz); 3.05 (s, 6H); 2.66 (bs, 1H); 2.48 (bs, 2H); 2.28 (dt, 4H, J = 7.4 Hz, 3.8 Hz); 1.62-1.58 (m, 8H); 1.48-1.30 (m, 8H); 1.29-1.24 (m, 52H); 0.86 (t, 9H, J = 6.6 Hz).

GD. Compound 249: Heptadecan-9-yl (E)-8-((3-(2-cyano-3-methylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

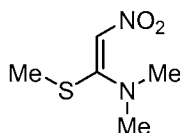


Chemical Formula: $C_{48}H_{93}N_5O_4$
Molecular Weight: 804.30

[00328] Compound 249 was prepared from heptadecan-9-yl 8-((3-(aminopropyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.55 mmol) analogously to Compound 168 except that a 2M solution of methylamine in methanol (1.4 mL, 2.8 mmol) was used in place of a 2M dimethylamine solution in THF. Following an aqueous workup the residue was purified by silica gel chromatography (dichloromethane, methanol /1% NH_4OH) to give heptadecan-9-yl

(E)-8-((3-(2-cyano-3-methylguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (260 mg, 0.32 mmol, 58%) as a light yellow oil. HPLC/UV 214 nm: RT = 9.83 min. MS (CI): m/z (MH⁺) 804.7 for C₄₈H₉₃N₅O₄. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.29 (m, 2H); 2.77 (d, 3H, J = 4.6 Hz); 2.52 (m, 1H); 2.44-2.39 (m, 3H); 2.28 (dt, 4H, J = 7.4 Hz, 3.6 Hz); 1.65-1.57 (m, 16H); 1.50- 1.41 (m, 3H); 1.30- 1.24 (m, 48H); 0.86 (t, 9H, J = 6.4 Hz).

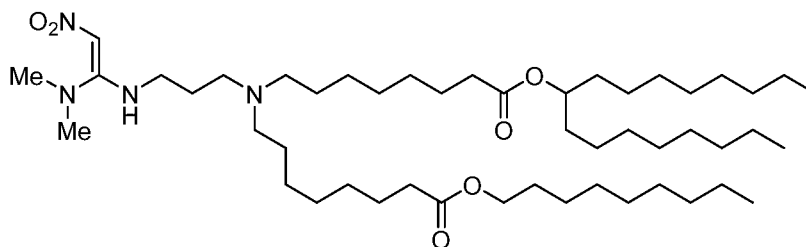
GE. Compound 250: Heptadecan-9-yl (Z)-8-((3-((1-(dimethylamino)-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate
(E)-N,N-Dimethyl-1-(methylthio)-2-nitroethen-1-amine



Chemical Formula: C₅H₁₀N₂O₂S
 Molecular Weight: 162.21

[00329] To a solution of (2-nitroethene-1,1-diyl)bis(methylsulfane) (EP 5984 A1)(1.0 g, 6.1 mmol) in acetonitrile at 0 °C was added a 2M dimethylamine in tetrahydrofuran (3 mL, 6 mmol) and the reaction mixture stirred at rt for 3 hours. The solvent was removed under vacuum and the crude product purified by silica gel chromatography (hexane, ethyl acetate) to get (E)-N,N-dimethyl-1-(methylthio)-2-nitroethen-1-amine (200 mg, 20%), containing N,N,N',N'-tetramethyl-2-nitroethene-1,1-diamine, as a reddish yellow oil, which was used without further purification. ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.67 (s, 1H); 3.20 (s, 6H); 2.46 (s, 3H).

Heptadecan-9-yl (Z)-8-((3-((1-(dimethylamino)-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



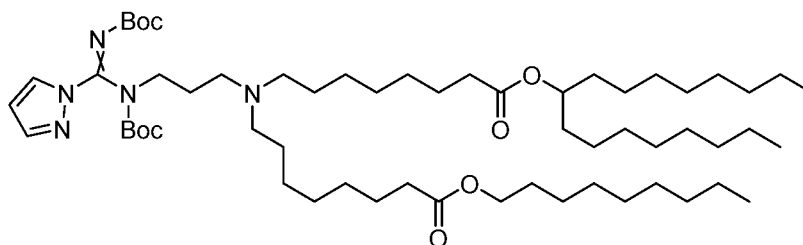
Chemical Formula: C₄₉H₉₆N₄O₆
 Molecular Weight: 837.33

[00330] To a solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.69 mmol) in 20 mL methanol was added (E)-N,N-dimethyl-1-(methylthio)-2-nitroethen-1-amine (112 mg, 0.69 mmol), the reaction mixture heated to reflux and stirred for 5 hours. The solvent was removed and the compound purified twice by silica gel chromatography [Column 1: hexane/ethyl acetate, then dichloromethane, methanol

/1% NH₄OH), Column 2: hexane/ethyl acetate, then dichloromethane, methanol /1% NH₄OH)] to give heptadecan-9-yl (Z)-8-((3-((1-(dimethylamino)-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (104 mg, 0.12 mmol, 18%) as a yellow oil. HPLC/UV 214 nm: RT = 8.69 min. MS (CI): m/z (MH⁺) 837.7 for C₄₈H₉₆N₄O₆. ¹H NMR (300 MHz, CDCl₃) δ: ppm 9.56 (bs, 1H); 6.49 (s, 1H); 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.34-3.32 (m, 2H); 2.92 (s, 6H); 2.49 (m, 2H); 2.37-2.33 (m, 4H); 2.27 (dt, 4H, J = 7.4 Hz, 3.8 Hz); 1.77-1.75 (m, 2H); 1.62-1.48 (m, 8H); 1.34-1.24 (m, 54H); 0.86 (t, 9H, J = 6.5 Hz).

GF. Compound 254: Heptadecan-9-yl 4-imino-9-(8-(nonyloxy)-8-oxooctyl)-2-oxa-3,5,9-triazaheptadecan-17-oate

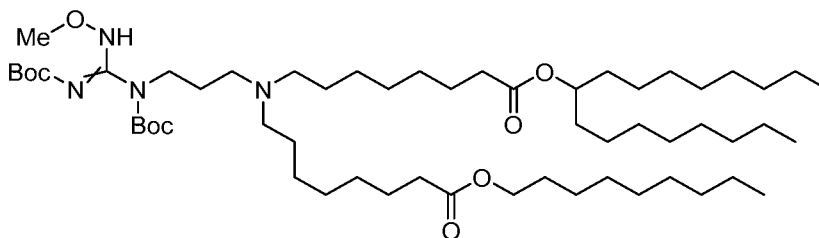
Heptadecan-9-yl 7-(tert-butoxycarbonyl)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-6-(1H-pyrazol-1-yl)-3-oxa-5,7,11-triazanonadec-5-en-19-oate



Chemical Formula: C₅₉H₁₀₉N₅O₈
Molecular Weight: 1016.55

[00331] To a solution of heptadecan-9-yl (8-((3-hydroxypropyl)(8-(nonyloxy)octyl)amino)octanoate (500 mg, 0.69 mmol) in 10 mL dry tetrahydrofuran were added triphenylphosphine (271.8 mg, 1.04 mmol) and tert-butyl (((tert-butoxycarbonyl)amino)(1H-pyrazol-1-yl)methylene)carbamate (Aldrich Chemical Co., St. Louis, MO; 214.3 mg, 0.69 mmol) and the reaction mixture cooled to 0 °C. To this was added diisopropyl azodicarboxylate (0.2 mL, 1.04 mmol) dropwise, the cooling bath removed and the reaction mixture stirred at rt for 24 hours. No starting alcohol remained by LC/MS so the solvent was removed and the residue purified by silica gel chromatography (0-40% ethyl acetate in hexanes) to give heptadecan-9-yl 7-(tert)-butoxycarbonyl)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-6-(1H-pyrazol-1-yl)-3-oxa-5,7,11-triazanonadec-5-en-19-oate (227 mg, 0.22 mmol, 32%) as a colorless oil. MS (CI): m/z (MH⁺) 1016.8 for C₅₉H₁₀₉N₅O₈. ¹H NMR (300 MHz, CDCl₃) δ: ppm 7.93 (s, 1H); 7.67 (s, 1H); 6.40 (s, 1H); 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.69-3.67 (m, 2H); 2.45 (t, 2H, J = 7.0 Hz) 2.35-2.23 (m, 8H); 1.88-1.84 (m, 2H); 1.57-1.49 (m, 10H); 1.38-1.24 (m, 70H); 0.86 (t, 9H, J = 6.5 Hz).

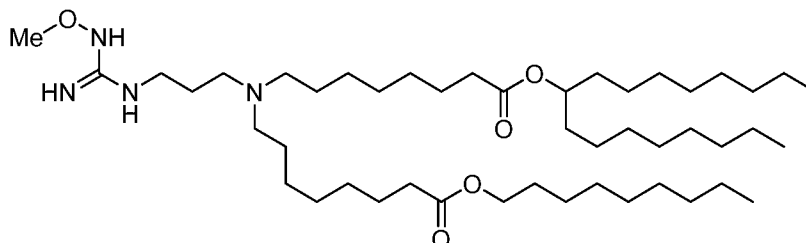
Heptadecan-9-yl 7-(tert-butoxycarbonyl)-6-(methoxyamino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-5-en-19-oate



Chemical Formula: $C_{57}H_{110}N_4O_9$
Molecular Weight: 995.53

[00332] To a solution of heptadecan-9-yl 7-(tert-butoxycarbonyl)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-6-(1H-pyrazol-1-yl)-3-oxa-5,7,11-triazanondec-5-en-19-oate (227 mg, 0.22 mmol) in 30 mL of a 1:1 cyclopentylmethyl ether / acetonitrile mixture was added O-methyl hydroxylamine hydrochloride (93.3 mg, 1.12 mmol) followed by N,N-diisopropylethylamine (0.2 mL, 1.12 mmol), the reaction mixture heated to 85 °C and stirred for 24 hours. The reaction had progressed ca. 80% by LC/MS so additional O-methyl hydroxylamine hydrochloride (93.3 mg, 1.12 mmol) followed by N,N-diisopropylethylamine (144.4 mg, 0.2 mL, 1.12 mmol) were added and the reaction mixture stirred at 85 °C for another 24 hours. No starting material remained by LC/MS so the solvent was removed and the residue purified by silica gel chromatography (1:1 hexane / ethyl acetate isocratic) to give heptadecan-9-yl 7-(tert-butoxycarbonyl)-6-(methoxyamino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-5-en-19-oate (189 mg, 0.19 mmol, 85%) as a colorless oil. MS (CI): m/z (MH⁺) 995.8 for $C_{57}H_{110}N_4O_9$. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.31 (s, 1H); 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.83 (s, 3H); 3.42 (t, 2H, J = 7.5 Hz); 2.48-2.32 (m, 6H); 2.26 (dt, 4H, J = 7.4 Hz, 3.8 Hz); 1.62-1.55 (m, 8H); 1.50-1.43 (m, 20H); 1.39-1.24 (m, 54H); 0.86 (t, 9H, J = 6.4 Hz).

Heptadecan-9-yl 4-imino-9-(8-(nonyloxy)-8-oxooctyl)-2-oxa-3,5,9-triazaheptadecan-17-oate

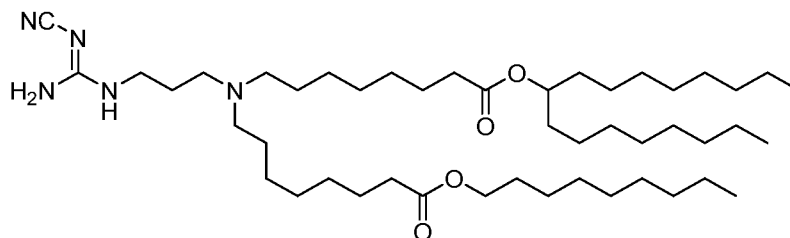


Chemical Formula: $C_{47}H_{94}N_4O_5$
Molecular Weight: 795.29

[00333] To a solution of heptadecan-9-yl 7-(tert-butoxycarbonyl)-6-(methoxyamino)-2,2-dimethyl-11-(8-(nonyloxy)-8-oxooctyl)-4-oxo-3-oxa-5,7,11-triazanonadec-5-en-19-oate (189 mg, 0.19 mmol) in 1 mL ethyl acetate at 0 °C was added a 4M hydrochloric acid solution in 1,4-dioxane (8 mL, 32 mmol) dropwise and the reaction mixture stirred at rt for 3 days. No starting

material remained by LC/MS and only completely deprotected product was observed. The reaction was conc., the residue dissolved in ethyl acetate and the solution washed once with a saturated aqueous sodium bicarbonate solution, then brine, dried (Na_2SO_4), filtered and the filtrate conc. The residue was purified by silica gel chromatography (dichloromethane, methanol /1% NH_4OH) to give heptadecan-9-yl 4-imino-9-(8-(nonyloxy)-8-oxooctyl)-2-oxa-3,5,9-triazaheptadecan-17-oate (120 mg, 0.15 mmol, 80%). MS (CI): m/z (MH^+) 795.7 for $\text{C}_{47}\text{H}_{94}\text{N}_4\text{O}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 4.87-4.83 (m, 1H); 4.04 (t, 2H, $J = 6.7$ Hz); 3.64 (s, 3H); 3.15 (bs, 2H); 2.51-2.49 (m, 2H); 2.42-2.38 (m, 4H); 2.27 (dt, 4H, $J = 7.4$ Hz, 3.7 Hz); 1.65-1.55 (m, 8H); 1.49-1.41 (m, 8H); 1.29- 1.24 (m, 50H); 0.86 (t, 9H, $J = 6.4$ Hz).

GG. Compound 266: Heptadecan-9-yl (E)-8-((3-(2-cyanoguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

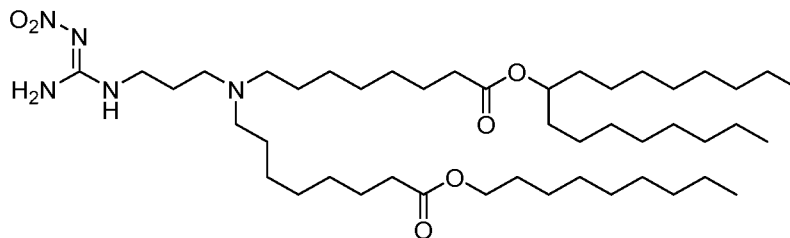


Chemical Formula: $\text{C}_{47}\text{H}_{91}\text{N}_5\text{O}_4$

Molecular Weight: 790.28

[00334] Compound 266 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.55 mmol) analogously to Compound 168 except that a 7M solution of ammonia in methanol (2 mL, 14 mmol) was used in place of a 2M dimethylamine solution in THF and the reaction was run in a sealed tube. Following an aqueous workup the residue was purified by silica gel chromatography (dichloromethane, methanol /1% NH_4OH) to give heptadecan-9-yl (E)-8-((3-(2-cyanoguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (170 mg, 0.21 mmol, 39%) as a light yellow oil. HPLC/UV 214 nm: RT = 9.26 min. MS (CI): m/z (MH^+) 790.7 for $\text{C}_{47}\text{H}_{91}\text{N}_5\text{O}_4$. ^1H NMR (300 MHz, CDCl_3) δ : ppm δ 4.87-4.83 (m, 1H); 4.04 (t, 2H, $J = 6.7$ Hz); 3.29-3.27 (m, 2H); 2.51-2.48 (m, 2H); 2.43-2.38 (m, 4H); 2.31-2.25 (m, 4H); 1.68-1.55 (m, 8H); 1.50- 1.48 (m, 4H); 1.40-1.37 (m, 4H); 1.30- 1.23 (m, 50H); 0.86 (t, 9H, $J = 6.6$ Hz); one guanidine proton not observed.

GH. Compound 274: Heptadecan-9-yl (E)-8-((3-(2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

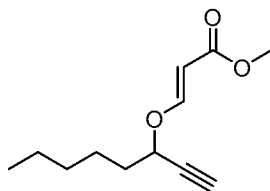
Chemical Formula: $C_{46}H_{91}N_5O_6$

Molecular Weight: 810.26

[00335] To a solution of heptadecan-9-yl 8-((aminopropyl)(8-nonyloxy)-8-oxooctyl)amino)octanoate (530 mg, 0.73 mmol) in 20 mL methanol was added methyl-N'-nitrocarbamimidothioate (104 mg, 0.77 mmol), the reaction mixture heated to reflux and stirred for 4 hours. No starting material remained by LC/MS and two product peaks were observed which correspond to two nitroguanidine regioisomers (Z and E). The amount of Z isomer decreases with reaction time as it converts to the more stable E isomer. The solvent was removed and the crude compound purified by silica gel chromatography (initially hexane, 0-100% ethyl acetate in hexanes, then 0-50% methanol /1% NH_4OH in dichloromethane) to give heptadecan-9-yl (E)-8-((3-(2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (160 mg, 0.20 mmol, 27%) as a colorless oil. HPLC/UV 214 nm: RT = 9.53 min. MS (CI): m/z (MH⁺) 810.7 for $C_{46}H_{91}N_5O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 8.41 (bs, 1H); 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.6 Hz); 3.36-3.34 (m, 2H); 2.51-2.41 (m, 6H); 2.28 (dt, 4H, J = 7.6 Hz, 3.7 Hz); 1.78 (bs, 2H); 1.63-1.58 (m, 8H); 1.50- 1.38 (m, 6H); 1.30- 1.23 (m, 50H); 0.86 (t, 9H, J = 6.8 Hz).

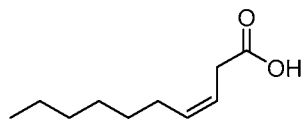
[00336] Also isolated was heptadecan-9-yl (Z)-8-((3-(2-nitroguanidino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (65 mg, 0.08 mmol, 11%) as a light yellow oil which slowly converted to the E isomer upon standing. HPLC/UV 214 nm: RT = 10.66 min. MS (CI): m/z (MH⁺) 810.6 for $C_{46}H_{91}N_5O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.87-4.80 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.36-3.34 (m, 2H); 2.48 (bs, 4H); 2.30-2.24 (m, 4H); 2.16-2.15 (m, 1H); 1.79 (bs, 1H); 1.62-1.42 (m, 15H); 1.30- 1.24 (m, 52H); 0.86 (t, 9H, J = 6.6 Hz).

GI. Compound 275: 7-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl (Z)-dec-3-enoate



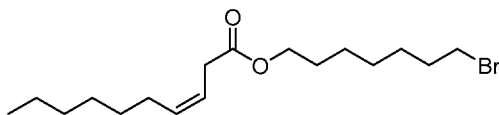
Chemical Formula: $C_{12}H_{18}O_3$
Molecular Weight: 210.27

[00337] To a solution of 1-octyn-3-ol (2.15 mL, 14.4 mmol) and methyl propiolate (1.2 mL, 14.4 mmol) in 100 mL dry DCM was added triethylamine (0.2 mL, 1.4 mmol) and the pale yellow solution stirred at rt for 20 hours after which no starting alcohol remained by TLC. The solution was conc. and the residue purified by silica gel chromatography (0-20% EtOAc in hexanes) to give methyl (E)-3-(oct-1-yn-3-yloxy)acrylate (2.92 g, 13.9 mmol, 97%) as a colorless liquid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.61 (d, 1H, $J = 12.5$ Hz); 5.38 (d, 1H, $J = 12.5$ Hz); 4.53 (td, 1H, $J = 6.6$ Hz, 2.0 Hz); 3.70 (s, 3H); 2.58 (d, 1H, $J = 2.0$ Hz); 1.91-1.75 (m, 2H); 1.52-1.41 (m, 2H); 1.37-1.26 (m, 4H); 0.90 (t, 3H, $J = 6.9$ Hz).



Chemical Formula:
 $C_{10}H_{18}O_2$
Molecular Weight: 170.25

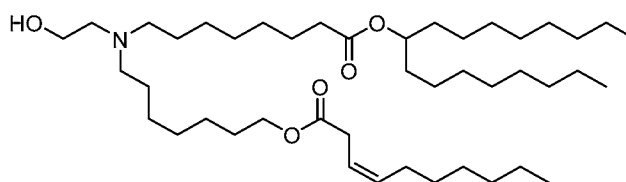
[00338] In a 5 mL microwave vial were combined 840 mg (4 mmol) methyl (E)-3-(oct-1-yn-3-yloxy)acrylate and 2 mL water to give a colorless bilayer. The vial was sealed and the mixture subjected to microwave irradiation at 175 °C for 90 minutes. The resulting bilayer was washed twice with DCM, the organics combined, dried ($MgSO_4$), filtered and the filtrate conc. to a dark orange oil. This was dissolved in hexanes and purified by silica gel chromatography (0-20% EtOAc in hexanes) to give (Z)-dec-3-enoic acid (155 mg, 0.91 mmol, 23%) as an orange oil. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 11.03 (br. s, 1H); 5.70-5.44 (m, 2H); 3.14 (d, 2H, $J = 6.6$ Hz); 2.04 (q., 2H, $J = 6.8$ Hz); 1.43-1.13 (m, 8H); 0.88 (t, 3H, $J = 6.8$ Hz). (Z)-Geometry confirmed by 1D selective gradient NOEsy experiments irradiating at 2.07 ppm (C-5 protons) and 3.16 ppm (C-2 protons).



Chemical Formula: $C_{17}H_{31}BrO_2$
Molecular Weight: 347.34

[00339] To a solution of (Z)-dec-3-enoic acid (220 mg, 1.29 mmol) and 7-bromo-1-heptanol (250 μ L, 1.42 mmol) in 10 mL dry DCM were added 1-ethyl-3-

(dimethylaminopropyl)carbodiimide hydrochloride (440 mg, 1.94 mmol) followed by DMAP (80 mg, 0.65 mmol) and finally *N,N*-diisopropylethylamine (680 μ L, 3.88 mmol). The resulting orange solution was stirred at room temp. for 24 hours, after which TLC showed no starting acid remaining. The solution was diluted with DCM, washed once with a saturated aqueous sodium bicarbonate solution (thick emulsion), once with an aqueous 10% citric acid solution, dried (MgSO_4), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-15% EtOAc in hexanes) to give 7-bromoheptyl (*Z*)-dec-3-enoate (250 mg, 0.72 mmol, 56%) as a slightly yellow liquid. ^1H NMR (300 MHz, CDCl_3) δ : ppm 5.65-5.49 (m, 2H); 4.07 (t, 2H, $J = 6.7$ Hz); 3.40 (t, 2H, $J = 6.8$ Hz); 3.08 (d, 2H, $J = 5.5$ Hz); 2.04 (q., 2H, $J = 6.8$ Hz); 1.92-1.79 (m, 2H); 1.70-1.56 (m, 2H); 1.51-1.20 (m, 14H); 0.88 (t, 3H, $J = 6.3$ Hz).

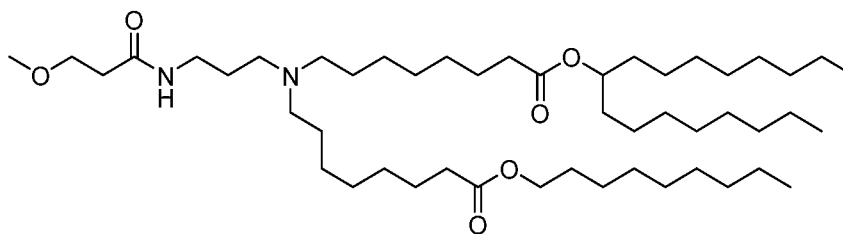


Chemical Formula: $\text{C}_{44}\text{H}_{85}\text{NO}_5$
Molecular Weight: 708.17

[00340] Compound 285 was prepared from heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (350 mg, 0.71 mmol) analogously to compound 284 except that 7-bromoheptyl (*Z*)-dec-3-enoate (250 mg, 0.72 mmol) was used in place of 5-bromopentyl octyl malonate. Following an aqueous workup the resulting yellow oil was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give 7-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl (*Z*)-dec-3-enoate (205 mg, 0.29 mmol, 41%) as a colorless oil.

UPLC/ELSD: RT = 3.35 min. MS (ES): m/z (MH^+) 708.75 for $\text{C}_{44}\text{H}_{85}\text{NO}_5$. ^1H NMR (300 MHz, CDCl_3) δ : ppm 5.64-5.48 (m, 2H); 4.86 (quint., 1H, $J = 6.2$ Hz); 4.07 (t, 2H, $J = 6.7$ Hz); 3.55 (t, 2H, $J = 5.0$ Hz); 3.40 (t, 2H, $J = 6.8$ Hz); 3.08 (d, 2H, $J = 5.6$ Hz); 2.61 (t, 2H, $J = 4.1$ Hz); 2.47 (t, 4H, $J = 6.8$ Hz); 2.27 (t, 2H, $J = 7.5$ Hz); 2.04 (q., 2H, $J = 6.8$ Hz); 1.70-1.55 (m, 4H); 1.54-1.40 (m, 6H); 1.39-1.13 (m, 45H); 0.87 (t, 9H, $J = 6.5$ Hz).

GJ. Compound 276: Heptadecan-9-yl 8-((3-(3-methoxypropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

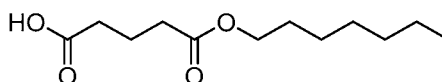


Chemical Formula: $C_{49}H_{96}N_2O_6$
Molecular Weight: 809.32

[00341] Compound 276 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) analogously to Compound 178 except that 3-methoxypropanoyl chloride (Oakwood Chemical, Estill, SC) (57 μ L, 0.52 mmol) was used in place of methoxyacetyl chloride. Following an aqueous workup the residue was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(3-methoxypropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (140 mg, 0.55 mmol, 31%) as a yellow oil. UPLC/ELSD: RT = 3.48 min. MS (ES): m/z (MH^+) 809.78 for $C_{49}H_{96}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.48 (s, 1H); 4.86 (quint., 1H, J = 12.6 Hz, 6.1 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.91 (s, 2H); 3.55 (quart., 2H, J = 13.8 Hz, 7.0 Hz); 3.36 (d, 2H, J = 5.8 Hz); 2.53-2.43 (m, 2H); 2.41-2.32 (br. m, 3H); 2.31-2.23 (m, 4H); 1.70-1.56 (m, 8H); 1.55-1.37 (m, 8H); 1.36-1.14 (m, 52H); 0.88 (t, 9H, J = 7.5 Hz).

GK. Compound 277: 4-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)butyl heptyl glutarate

Step 1: 5-(Heptyloxy)-5-oxopentanoic acid

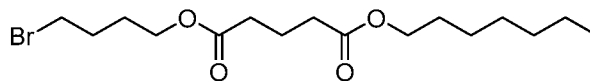


Chemical Formula: $C_{12}H_{22}O_4$
Molecular Weight: 230.30

[00342] A slurry of 5 g (41.6 mmol) glutaric anhydride in 7.2 mL (50 mmol) 1-heptanol was heated to 90 $^{\circ}C$ and stirred for 20 hours after which it had become a colorless solution. This was allowed to cool to rt, diluted with a saturated aqueous sodium bicarbonate solution (~50 mL) and extracted three times with diethyl ether. The aqueous layer was adjusted to pH ~3 with an aqueous 4N HCl solution and the resulting cloudy mixture extracted three times with EtOAc. The EtOAc phases were combined, washed once with brine, dried, (Na_2SO_4), filtered and the filtrate conc. to give 5-(heptyloxy)-5-oxopentanoic acid (7.36 g, 31.9 mmol, 77%) as a colorless liquid which was carried through to the next step without further purification. ^1H NMR (300

MHz, CDCl₃) δ : ppm 11.40 (br. s., 1H); 4.06 (t., 2H, J = 6.8 Hz); 2.41 (m, 4H); 1.95 (quint., 2H, J = 14.5 Hz, 7.3 Hz); 1.61 (m, 2H); 1.28 (m, 8H); 0.88 (t, 3H, J = 5.8 Hz).

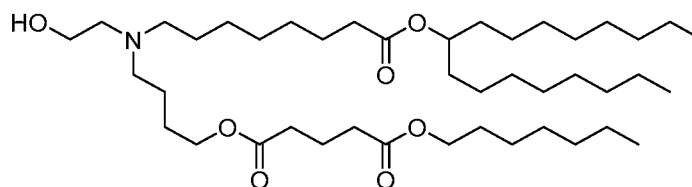
Step 2: 4-bromobutyl heptyl glutarate



Chemical Formula: C₁₆H₂₉BrO₄
Molecular Weight: 365.31

[00343] To a solution of 5-(heptyloxy)-5-oxopentanoic acid (1.5 g, 6.5 mmol) and 4-bromo-1-butanol (0.82 mL, 6.8 mmol) in 20 mL dry DCM under dry nitrogen was added 1-ethyl-3-(dimethylaminopropyl)carbodiimide hydrochloride (2.2 g, 9.8 mmol) followed by 4-(dimethylamino)pyridine (0.4 g, 3.26 mmol) and finally N,N-diisopropylethylamine (3.4 mL, 19.5 mmol) to give a pale yellow solution. This was stirred at rt for 24 hours, after which LC/MS showed no starting acid remaining. The solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution (thick emulsion), dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-20% EtOAc in hexanes) to give 4-bromobutyl heptyl glutarate (0.34 g, 0.93 mmol, 14%) as a pale yellow oil. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.11-4.06 (m, 4H); 3.41 (t, 2H, J = 6.7 Hz); 2.62 (s, 4H); 1.87 (quint., 2H, J = 13.9 Hz, 7.2 Hz); 1.69-1.57 (m, 4H); 1.50-1.30 (m, 10H); 0.89 (t, 3H, J = 6.3 Hz).

Step 3: 4-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)butyl heptyl glutarate



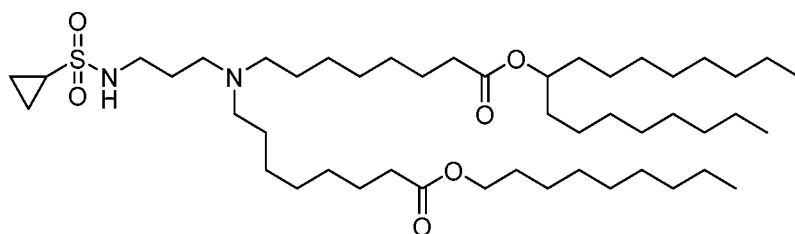
Chemical Formula: C₄₃H₈₃NO₇
Molecular Weight: 726.14

[00344] To a solution of heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (300 mg, 0.61 mmol) and 6-bromohexyl hexyl succinate (223 mg (0.61 mmol) in 8 mL dry acetonitrile under dry nitrogen was added potassium iodide (115 mg, 0.68 mmol) followed by powdered potassium carbonate (340 mg, 2.4 mmol) and the mixture diluted with 2 mL dry cyclopentyl methyl ether. The resulting white mixture was heated to 90 °C and stirred for 24 hours, then allowed to cool to rt, filtered, the filter solids washed with DCM and the filtrate conc. The residue was suspended in a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was

purified by silica gel chromatography (0-30% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give 4-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)butyl heptyl glutarate (140 mg, 0.19 mmol, 32%) as a colorless oil.

UPLC/ELSD: RT = 3.22 min. MS (ES): m/z (MH⁺) 726.63 for C₄₃H₈₃NO₇. ¹H NMR (300 MHz, CDCl₃) δ: ppm 4.86 (quint., 1H, J = 12.2 Hz, 6.1 Hz,); 4.07 (quart., 4H, J = 12.1 Hz, 6.0 Hz); 3.53 (t, 2H, J = 5.0 Hz); 2.88 (br. s, 1H); 2.58 (t, 2H, J = 4.7 Hz); 2.47 (quart., 4H, J = 16.8 Hz, 7.0 Hz); 2.37 (t, 4H, J = 7.0 Hz); 2.27 (t, 2H, J = 7.4 Hz); 1.94 (quint., 2H, J = 14.7 Hz, 7.3 Hz); 1.70-1.55 (m, 6H); 1.54-1.37 (m, 8H); 1.36-1.15 (m, 38H); 0.87 (t, 9H, J = 6.1 Hz).

GL. Compound 278: Heptadecan-9-yl 8-((3-(cyclopropanesulfonamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

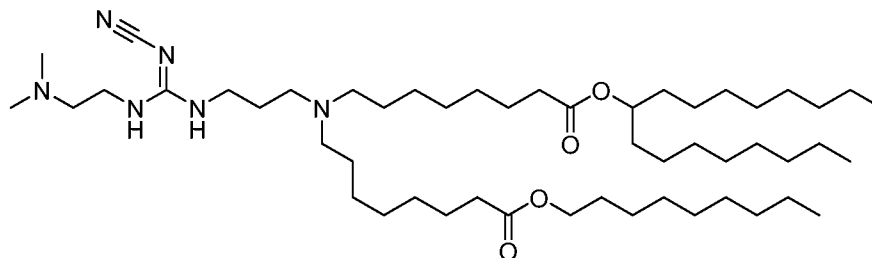


Chemical Formula: C₄₈H₉₄N₂O₆S
Molecular Weight: 827.35

[00345] Compound 278 was prepared from heptadecan-9-yl 8-((3-(aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) analogously to Compound 109 except that cyclopropanesulfonyl chloride (Oakwood Chemical, Estill, SC) (54 uL, 0.52 mmol) was used in place of methanesulfonyl chloride. Following an aqueous workup the residue was purified by silica gel chromatography (0-40% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(cyclopropanesulfonamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (125 mg, 0.15 mmol, 44%) as a slightly yellow oil.

UPLC/ELSD: RT = 3.45 min. MS (ES): m/z (MH⁺) 827.82 for C₄₉H₉₄N₂O₆S. ¹H NMR (300 MHz, CDCl₃) δ: ppm 6.95 (br. s, 1H); 4.86 (quint., 1H, J = 12.4 Hz, 6.2 Hz); 4.05 (t, 2H, J = 6.8 Hz); 3.48 (quart., 1H, J = 14.1 Hz, 7.0 Hz); 3.26 (t, 2H, J = 5.6 Hz); 2.63-2.47 (br. m, 2H); 2.45-2.32 (br. m, 4H); 2.31-2.21 (m, 4H); 1.77-1.68 (m, 2H); 1.61 (br. t, 6H, J = 6.8 Hz); 1.55-1.39 (m, 8H); 1.38-1.17 (m, 48H); 1.16-1.10 (m, 2H); 0.98-0.92 (m, 2H); 0.88 (t, 9H, J = 6.0 Hz).

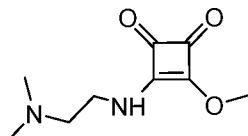
GM. Compound 279: Heptadecan-9-yl (Z)-6-(cyanoimino)-2-methyl-11-(8-(nonyloxy)-8-oxooctyl)-2,5,7,11-tetraazanonadecan-19-oate



Chemical Formula: $C_{51}H_{100}N_6O_4$
Molecular Weight: 861.40

[00346] Compound 279 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) analogously to Compound 168 except that neat *N,N*-dimethylethylene-1,2-diamine (160 μ L, 1.4 mmol) was used in place of dimethylamine solution in THF. Following an aqueous workup the residue was purified by silica gel chromatography (0-100% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl (Z)-6-(cyanoimino)-2-methyl-11-(8-(nonyloxy)-8-oxooctyl)-2,5,7,11-tetraazanonadecan-19-oate (110 mg, 0.13 mmol, 37%) as a slightly yellow oil. UPLC/ELSD: RT = 3.10 min. MS (ES): m/z (MH^+) 861.94 for $C_{51}H_{100}N_6O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.91 (br. s., 1H); 4.86 (quint., 1H, $J = 6.2$ Hz); 4.05 (t, 2H, $J = 6.8$ Hz); 3.28-3.18 (m, 4H); 2.53-2.40 (m, 7H); 2.32-2.22 (m, 10H); 1.75-1.55 (m, 8H); 1.49-1.43 (m, 8H); 1.32-1.26 (br. m, 50H); 0.88 (t, 9H, $J = 6.1$ Hz).

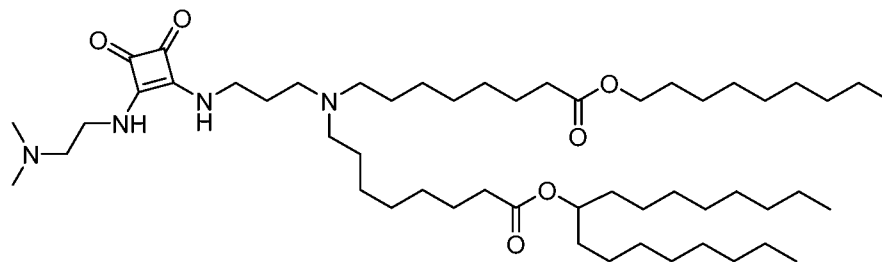
GN. Compound 280: Heptadecan-9-yl 8-((3-((2-((2-(dimethylamino)ethyl)amino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



Chemical Formula: $C_9H_{14}N_2O_3$
Molecular Weight: 198.22

[00347] To a solution of 3,4-dimethoxy-3-cyclobutene-1,2-dione (500 mg, 3.45 mmol) in 60 mL diethyl ether was added a solution of 0.42 mL (3.8 mmol) *N,N*-dimethylethylene-1,2-diamine in 10 mL ether rapidly dropwise over five minutes and the resulting mixture was stirred at room temp for 24 hours, then filtered, the filter solids washed with diethyl ether and air-dried. The filter solids were dissolved in hexanes, filtered, the filtrate diluted with EtOAc to turbidity and the mixture allowed to cool to room temp., then cooled to 0 $^{\circ}C$ to give a ppt. This was isolated via filtration, washed with hexanes, air-dried, then dried under vacuum to give 3-((2-(dimethylamino)ethyl)amino)-4-methoxycyclobut-3-ene-1,2-dione (255 mg, 1.29 mmol, 37%) as a white solid. The compound exists as two rotamers at room temp in chloroform. ^1H NMR

(300 MHz, CDCl₃) δ : ppm 6.35 (br. s, 0.65H); 6.09 (br. s, 0.35H); 4.39 (s, 3H); 3.73 (br. s, 0.75H); 3.46 (br. s, 1.25H); 2.50 (m, 2H); 2.25 (s, 6H).

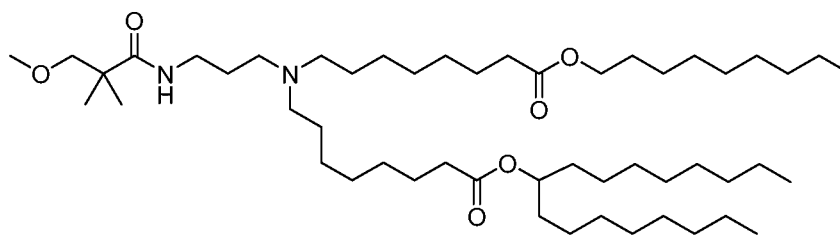


Chemical Formula: C₅₃H₁₀₀N₄O₆

Molecular Weight: 889.41

[00348] Compound 280 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (300 mg, 0.42 mmol) analogously to Compound 169 except that 3-((2-(dimethylamino)ethyl)amino)-4-methoxycyclobut-3-ene-1,2-dione (160 μ L, 1.4 mmol) was used in place of 3-(dimethylamino)-4-methoxycyclobut-3-ene-1,2-dione and the solution was heated to 40 °C. The solution was reduced in a stream of nitrogen and the residue purified by silica gel chromatography (0-100% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-((2-((2-(dimethylamino)ethyl)amino)-3,4-dioxocyclobut-1-en-1-yl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (105 mg, 0.12 mmol, 28%) as a yellow paste. UPLC/ELSD: RT = 3.16 min. MS (ES): m/z (MH⁺) 890.06 for C₅₃H₁₀₀N₄O₆. ¹H NMR (300 MHz, CDCl₃) δ : ppm 7.58 (br. s., 1H); 6.20 (br. s, 1H); 4.86 (quint., 1H, J = 5.9 Hz); 4.05 (t, 2H, J = 6.7 Hz); 3.76-3.60 (m, 4H); 2.63 (br. s, 2H); 2.54-2.44 (m, 6H); 2.28 (m, 10H); 1.74 (br. s, 2H); 1.61 (m, 6H); 1.49 (m, 8H); 1.25 (br. m, 48H); 0.88 (t, 9H, J = 6.0 Hz).

GO. Compound 281: Heptadecan-9-yl 8-((3-(3-methoxy-2,2-dimethylpropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate



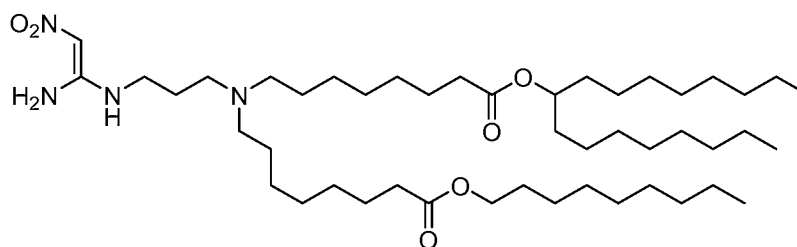
Chemical Formula: C₅₁H₁₀₀N₂O₆

Molecular Weight: 837.37

[00349] Compound 281 was prepared from heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (250 mg, 0.35 mmol) analogously to Compound 252 except that 3-methoxy-2,2-dimethylpropanoic acid (Enamine LLC, Monmouth Junction, NJ)(63 mg, 0.52 mmol) was used instead of (methylthio)acetic acid. Following an aqueous workup the

residue was purified by silica gel chromatography (0-50% (mixture of 1% NH₄OH, 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(3-methoxy-2,2-dimethylpropanamido)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (125 mg, 0.15 mmol, 43%) as a colorless oil. UPLC/ELSD: RT = 3.63 min. MS (ES): m/z (MH⁺) 837.99 for C₅₁H₁₀₀N₂O₆. ¹H NMR (300 MHz, CDCl₃) δ : ppm 9.26 (s, 1H); 7.39 (t, 1H, J = 6.3 Hz); 4.85 (quint., 1H, J = 6.3 Hz); 4.05 (t, 2H, J = 6.8 Hz); 3.42-3.32 (m, 7H); 3.12-2.98 (m, 5H); 2.33-2.23 (m, 4H); 2.04 (br. s, 2H); 1.75-1.53 (br. m, 14H); 1.51-1.10 (m, 54H); 0.88 (t, 9H, J = 6.1 Hz).

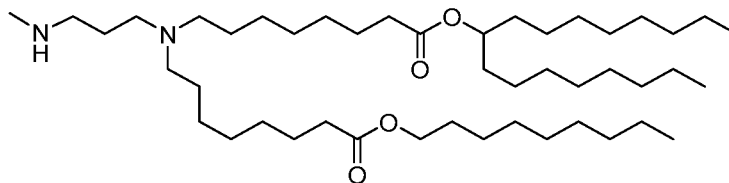
GP. Compound 282: Heptadecan-9-yl 8-((3-((1-amino-2-nitrovinyl)amino)propyl)(8-(nonyl oxy)-8-oxooctyl)amino)octanoate



Chemical Formula: C₄₇H₉₂N₄O₆
Molecular Weight: 809.28

[00350] A solution of heptadecan-9-yl 8-((3-aminopropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.69 mmol) and (2-nitroethene-1,1-diyl)bis(methylsulfane) (125 mg, 0.76 mmol) in methanol (5 mL) was stirred at 80 °C in a sealed tube for 5 hours. Then ammonia solution (7 N in methanol, 5 mL, 35 mmol) was added and the reaction mixture further heated at 80 °C for 2 hours. The solvent was removed and the crude material purified by silica gel chromatography (SiO₂: EtOAc/Hexane 0 to 100%, then methanol containing 1% ammonium hydroxide/dichloromethane 0 to 20%) to give heptadecan-9-yl (*E*)-8-((3-((1-amino-2-nitrovinyl)amino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (80 mg, 12%) as a yellow oil. HPLC/UV (214 nm): RT = 8.78 min. MS (CI): m/z (MH⁺) 809.6 for C₄₇H₉₂N₄O₆. ¹H NMR (300 MHz, CDCl₃): δ ppm 6.49 (s, 1H); 4.87-4.83 (m, 1H); 4.04 (t, 2H, J = 6.7 Hz); 3.36 (m, 2H); 2.49-2.39 (m, 6H); 2.27 (dt, 4H, J = 4.3 Hz, 7.2 Hz); 1.77-1.75 (m, 2H); 1.62-1.48 (m, 15H); 1.34-1.24 (m, 50H); 0.86 (t, 9H, J = 6.5 Hz).

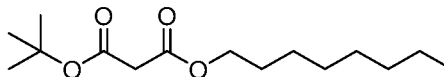
GQ. Compound 283: Heptadecan-9-yl 8-((3-(methylamino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

Chemical Formula: $C_{46}H_{92}N_2O_4$

Molecular Weight: 737.25

[00351] To a solution of heptadecan-9-yl 8-((3-chloropropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (400 mg, 0.54 mmol) in 2 mL 2-propanol was added sodium iodide (10 mg, cat.) followed by 4 mL (8 mmol) of a 2M methylamine solution in THF to give a yellow solution. This was heated to 55 °C and stirred for three days after which no starting chloride remained by LC/MS. The mixture was conc. in a stream of nitrogen and the residue purified by silica gel chromatography (0-50% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give heptadecan-9-yl 8-((3-(methylamino)propyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (220 mg, 0.30 mmol, 55%) as a pale yellow oil. UPLC/ELSD: RT = 2.98 min. MS (ES): m/z (MH^+) 737.70 for $C_{46}H_{92}N_2O_4$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (quint., 1H, $J = 6.1$ Hz); 4.05 (t, 2H, $J = 6.7$ Hz); 2.72 (t, 2H, $J = 6.5$ Hz); 2.51 (t, 2H, $J = 6.1$ Hz); 2.46 (s, 3H); 2.40 (t, 4H, $J = 6.3$ Hz); 2.32-2.23 (m, 4H); 1.76-1.55 (m, 8H); 1.54 - 1.36 (m, 8H); 1.35-1.12 (br. m, 49H); 0.87 (t, 9H, $J = 5.9$ Hz).

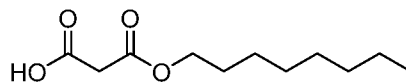
GR. Compound 284: 5-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)pentyl octyl malonate

Chemical Formula: $C_{15}H_{28}O_4$

Molecular Weight: 272.39

[00352] To a solution of mono-*tert*-butyl malonate (Oakwood Products, Inc., Estill, SC) (1.5 g, 9.2 mmol) and 1-octanol (1.6 mL, 10.1 mmol) in 20 mL dry DCM was added 1-ethyl-3-((dimethylaminopropyl)carbodiimide hydrochloride (3.1 g, 13.8 mmol) followed by 4-((dimethylamino)pyridine (0.34 g, 2.7 mmol) and finally *N,N*-diisopropylethylamine (4.8 mL, 27.5 mmol) with stirring under dry nitrogen to give a colorless solution. This was stirred at room temp. for 24 hours, after which LC/MS showed no starting acid remaining. The yellow solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution, twice with an aqueous 10% citric acid solution, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil which was purified by silica gel chromatography (0-15% EtOAc in hexanes) to give *tert*-butyl octyl malonate (1.86 g, 6.8 mmol, 74%) as a colorless liquid. ^1H

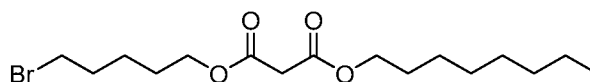
NMR (300 MHz, CDCl₃) δ : ppm 4.11-4.06 (m, 4H); 3.41 (t, 2H, J = 6.7 Hz); 2.62 (s, 4H); 1.87 (quint., 2H, J = 7.2 Hz); 1.69-1.57 (m, 4H); 1.50-1.30 (m, 10H); 0.89 (t, 3H, J = 6.3 Hz).



Chemical Formula: C₁₁H₂₀O₄

Molecular Weight: 216.28

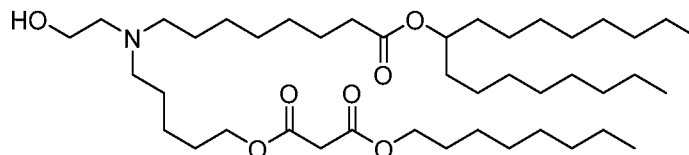
[00353] To a solution of *tert*-butyl octyl malonate (1.5 g, 5.5 mmol) in 10 mL DCM at 0 °C was added trifluoroacetic acid (5 mL, excess) rapidly dropwise with stirring to give a colorless solution. The resulting colorless solution was allowed to warm to room temp and stirred for 24 hours, after which the reaction was incomplete by TLC. The solution was heated to 45 °C and stirred for three hours after which no starting material remained by TLC. The pale yellow solution was allowed to cool to room temp, conc., and the residue purified by silica gel chromatography (0-30% EtOAc in hexanes) to give 3-(octyloxy)-3-oxopropanoic acid (0.9 g, 4.2 mmol, 75%) as a colorless liquid. ¹H-NMR (500 MHz, CDCl₃) δ ppm 4.19 (t, 2H, J = 6.8 Hz); 3.44 (s, 2H); 1.66 (quint., 2H, J = 7.1 Hz); 1.40-1.19 (m, 10H); 0.88 (t, 3H, J = 7.0 Hz); carboxylate proton not observed.



Chemical Formula: C₁₆H₂₉BrO₄

Molecular Weight: 365.31

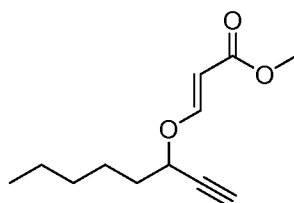
[00354] To a solution of 3-(octyloxy)-3-oxopropanoic acid (900 mg, 4.2 mmol) and 5-bromo-1-pentanol (0.58 mL, 4.4 mmol) in 20 mL dry dichloromethane was added 1-ethyl-3-(dimethylaminopropyl)carbodiimide hydrochloride (1.4 g, 6.2 mmol) followed by 4-(dimethylamino)pyridine (250 mg, 2.1 mmol) and finally *N,N*-diisopropylethylamine (2.2 mL, 12.5 mmol) with stirring under dry nitrogen. The colorless solution was stirred at room temp. for 24 hours, after which TLC showed no starting acid remaining. The solution was diluted with DCM, washed twice with a saturated aqueous sodium bicarbonate solution (thick emulsion), once with an aqueous 10% citric acid solution, dried (MgSO₄), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-20% EtOAc in hexanes) to give 5-bromopentyl octyl malonate (810 mg, 2.2 mmol, 53%) as a colorless liquid. UPLC/ELSD: RT = 2.17 min. MS (ES): m/z (M+Na⁺) 387.24 for C₁₆H₂₉BrO₄. ¹H NMR (300 MHz, CDCl₃) δ : ppm 4.15 (dt, 4H, J = 8.2 Hz, 6.6 Hz); 3.41 (t, 2H, J = 6.8 Hz); 3.37 (s, 2H); 1.95-1.85 (m, 2H); 1.74-1.59 (m, 4H); 1.57-1.47 (m, 2H); 1.39-1.20 (m, 10H); 0.88 (t, 3H, J = 6.6 Hz).

Chemical Formula: $C_{43}H_{83}NO_7$

Molecular Weight: 726.14

[00355] To a solution of heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (400 mg, 0.81 mmol) and 6-bromohexyl hexyl succinate (300 mg (0.81 mmol) in 8 mL dry acetonitrile under dry nitrogen was added potassium iodide (150 mg, 0.9 mmol) followed by powdered potassium carbonate (450 mg, 3.3 mmol) and the mixture diluted with 2 mL dry cyclopentyl methyl ether. The resulting white mixture was heated to 90 °C and stirred for 24 hours, then allowed to cool to rt, filtered, the filter solids washed with DCM and the filtrate conc. The residue was suspended in a 50% saturated aqueous sodium bicarbonate solution and extracted twice with DCM. The organics were combined, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give 5-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)pentyl octyl malonate (225 mg, 0.31 mmol, 38%) as a colorless oil. UPLC/ELSD: RT = 3.24 min. MS (ES): m/z (MH^+) 726.87 for $C_{43}H_{83}NO_7$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 4.86 (quint., 1H, 6.1 Hz,); 4.14 (td, 4H, J = 6.7 Hz, 2.9 Hz); 3.57 (m, 2H); 3.37 (s, 2H); 2.63 (br. s, 2H); 2.51 (br. s, 4H); 2.27 (t, 2H, J = 7.4 Hz); 1.73-1.56 (m, 6H); 1.55-1.42 (m, 8H); 1.41-1.16 (m, 43H); 0.88 (t, 9H, J = 6.1 Hz).

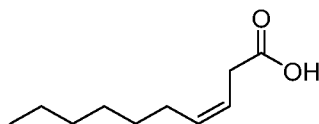
GS. Compound 285: 7-((8-(Heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl (Z)-dec-3-enoate

Chemical Formula: $C_{12}H_{18}O_3$

Molecular Weight: 210.27

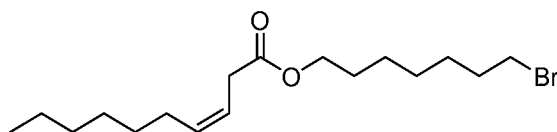
[00356] To a solution of 1-octyn-3-ol (2.15 mL, 14.4 mmol) and methyl propiolate (1.2 mL, 14.4 mmol) in 100 mL dry DCM was added triethylamine (0.2 mL, 1.4 mmol) and the pale yellow solution stirred at rt for 20 hours after which no starting alcohol remained by TLC. The solution was conc. and the residue purified by silica gel chromatography (0-20% EtOAc in hexanes) to give methyl (E)-3-(oct-1-yn-3-yloxy)acrylate (2.92 g, 13.9 mmol, 97%) as a colorless liquid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 7.61 (d, 1H, J = 12.5 Hz); 5.38 (d, 1H, J =

12.5 Hz); 4.53 (td, 1H, $J = 6.6$ Hz, 2.0 Hz); 3.70 (s, 3H); 2.58 (d, 1H, $J = 2.0$ Hz); 1.91-1.75 (m, 2H); 1.52-1.41 (m, 2H); 1.37-1.26 (m, 4H); 0.90 (t, 3H, $J = 6.9$ Hz).



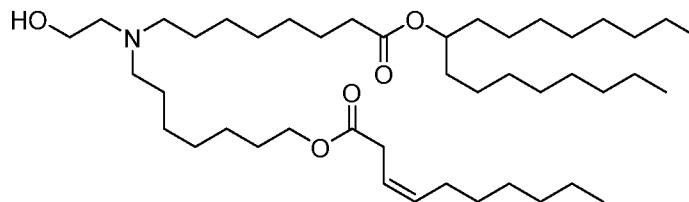
Chemical Formula:
 $C_{10}H_{18}O_2$
 Molecular Weight: 170.25

[00357] In a 5 mL microwave vial were combined 840 mg (4 mmol) methyl (*E*)-3-(oct-1-yn-3-yloxy)acrylate and 2 mL water to give a colorless bilayer. The vial was sealed and the mixture subjected to microwave irradiation at 175 °C for 90 minutes. The resulting bilayer was washed twice with DCM, the organics combined, dried ($MgSO_4$), filtered and the filtrate conc. to a dark orange oil. This was dissolved in hexanes and purified by silica gel chromatography (0-20% EtOAc in hexanes) to give (*Z*)-dec-3-enoic acid (155 mg, 0.91 mmol, 23%) as an orange oil. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 11.03 (br. s, 1H); 5.70-5.44 (m, 2H); 3.14 (d, 2H, $J = 6.6$ Hz); 2.04 (q., 2H, $J = 6.8$ Hz); 1.43-1.13 (m, 8H); 0.88 (t, 3H, $J = 6.8$ Hz). (*Z*)-Geometry confirmed by 1D selective gradient NOEsy experiments irradiating at 2.07 ppm (C-5 protons) and 3.16 ppm (C-2 protons).



Chemical Formula: $C_{17}H_{31}BrO_2$
 Molecular Weight: 347.34

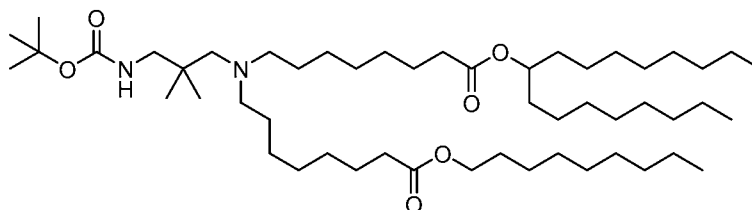
[00358] To a solution of (*Z*)-dec-3-enoic acid (220 mg, 1.29 mmol) and 7-bromo-1-heptanol (250 μ L, 1.42 mmol) in 10 mL dry DCM were added 1-ethyl-3-(dimethylaminopropyl)carbodiimide hydrochloride (440 mg, 1.94 mmol) followed by DMAP (80 mg, 0.65 mmol) and finally *N,N*-diisopropylethylamine (680 μ L, 3.88 mmol). The resulting orange solution was stirred at room temp. for 24 hours, after which TLC showed no starting acid remaining. The solution was diluted with DCM, washed once with a saturated aqueous sodium bicarbonate solution (thick emulsion), once with an aqueous 10% citric acid solution, dried ($MgSO_4$), filtered and the filtrate conc. to a yellow oil. This was purified by silica gel chromatography (0-15% EtOAc in hexanes) to give 7-bromoheptyl (*Z*)-dec-3-enoate (250 mg, 0.72 mmol, 56%) as a slightly yellow liquid. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.65-5.49 (m, 2H); 4.07 (t, 2H, $J = 6.7$ Hz); 3.40 (t, 2H, $J = 6.8$ Hz); 3.08 (d, 2H, $J = 5.5$ Hz); 2.04 (q., 2H, $J = 6.8$ Hz); 1.92-1.79 (m, 2H); 1.70-1.56 (m, 2H); 1.51-1.20 (m, 14H); 0.88 (t, 3H, $J = 6.3$ Hz).



Chemical Formula: $C_{44}H_{85}NO_5$
Molecular Weight: 708.17

[00359] Compound 285 was prepared from heptadecan-9-yl 8-((2-hydroxyethyl)amino)octanoate (350 mg, 0.71 mmol) analogously to compound 284 except that 7-bromoheptyl (Z)-dec-3-enoate (250 mg, 0.72 mmol) was used in place of 5-bromopentyl octyl malonate. Following an aqueous workup the resulting yellow oil was purified by silica gel chromatography (0-40% (mixture of 1% NH_4OH , 20% MeOH in dichloromethane) in dichloromethane) to give 7-((8-(heptadecan-9-yloxy)-8-oxooctyl)(2-hydroxyethyl)amino)heptyl (Z)-dec-3-enoate (205 mg, 0.29 mmol, 41%) as a colorless oil. UPLC/ELSD: RT = 3.35 min. MS (ES): m/z (MH^+) 708.75 for $C_{44}H_{85}NO_5$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 5.64-5.48 (m, 2H); 4.86 (quint., 1H, $J = 6.2$ Hz); 4.07 (t, 2H, $J = 6.7$ Hz); 3.55 (t, 2H, $J = 5.0$ Hz); 3.40 (t, 2H, $J = 6.8$ Hz); 3.08 (d, 2H, $J = 5.6$ Hz); 2.61 (t, 2H, $J = 4.1$ Hz); 2.47 (t, 4H, $J = 6.8$ Hz); 2.27 (t, 2H, $J = 7.5$ Hz); 2.04 (q, 2H, $J = 6.8$ Hz); 1.70-1.55 (m, 4H); 1.54-1.40 (m, 6H); 1.39-1.13 (m, 45H); 0.87 (t, 9H, $J = 6.5$ Hz).

GT. Compound 286: Heptadecan-9-yl 8-((3-(tert-butoxycarbonyl)amino)-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate

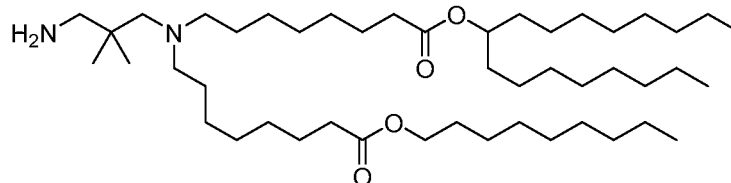


Chemical Formula: $C_{52}H_{102}N_2O_6$
Exact Mass: 850.77

[00360] Heptadecan-9-yl 8-((3-((tert-butoxycarbonyl)amino)-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate was prepared from heptadecan-9-yl 8-((8-(nonyloxy)-8-oxooctyl)amino)octanoate (500 mg, 0.75 mmol) analogously to compound 244 except that *tert*-butyl (2,2-dimethyl-3-oxopropyl)carbamate (Enamine LLC, Monmouth Junction, NJ) (231 mg, 1.13 mmol) was used in place of *N*-Boc-glycinal, three equivalents of sodium triacetoxymethylborohydride were required and the reaction was run at 50 °C for three days. Following an aqueous workup the resulting yellow oil was purified by silica gel chromatography (0-50% methanol in DCM) and the product-containing fractions pooled and conc. to a colorless

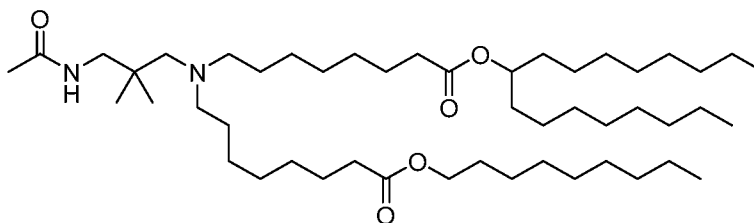
oil/white solid mixture. This was purified by silica gel chromatography (0-25% EtOAc in hexanes) to give heptadecan-9-yl 8-((3-((tert-butoxycarbonyl)amino)-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (85 mg, 0.1 mmol, 13%) as a pale yellow oil.

UPLC/ELSD: RT = 3.65 min. MS (ES): m/z (MH^+) 852.01 for $C_{52}H_{102}N_2O_6$. ^1H NMR (300 MHz, $CDCl_3$) δ : ppm 6.32 (br. s, 1H); 4.86 (quint., 1H, $J = 6.1$ Hz); 4.05 (t, 2H, $J = 6.8$ Hz); 2.99 (d, 2H, $J = 4.6$ Hz); 2.37 (t, 4H, $J = 7.4$ Hz); 2.32-2.19 (m, 6H); 1.69-1.55 (m, 6H); 1.54-1.37 (m, 16H); 1.36-1.15 (m, 49H); 0.91-0.84 m, 15H).



Chemical Formula: $C_{47}H_{94}N_2O_4$
Molecular Weight: 751.28

[00361] To a solution of heptadecan-9-yl 8-((3-((tert-butoxycarbonyl)amino)-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (85 mg, 0.1 mmol) in 2 mL DCM cooled to 0 °C was added a 2M hydrogen chloride solution in diethyl ether (0.5 mL, excess) with stirring to give a colorless solution. This was allowed to warm to room temp, then heated to 40 °C and stirred for two hours after which no starting material remained by LC/MS. The solution was allowed to cool to room temp and conc. in a stream of nitrogen, the residue redissolved in ether, conc. and placed under high vacuum overnight to give heptadecan-9-yl 8-((3-amino-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (79.3 mg, 0.096 mmol, 96%) as a colorless foamy solid (assumed to be the dihydrochloride). Carried through without further purification. UPLC/ELSD: RT = 3.12 min. MS (ES): m/z (MH^+) 751.97 for $C_{47}H_{94}N_2O_4$.



Chemical Formula: $C_{49}H_{96}N_2O_5$
Molecular Weight: 793.32

[00362] To a solution of heptadecan-9-yl 8-((3-amino-2,2-dimethylpropyl)(8-(nonyloxy)-8-oxooctyl)amino)octanoate (assumed to be the dihydrochloride) (79 mg (0.096 mmol) and triethylamine (41 μ L, 0.29 mmol) in 2 mL dry DCM cooled to 0 °C was added acetic anhydride (13 μ L, 0.15 mmol) dropwise with stirring. After 15 minutes the cooling bath was removed and

DEMANDE OU BREVET VOLUMINEUX

LA PRÉSENTE PARTIE DE CETTE DEMANDE OU CE BREVET COMPREND PLUS D'UN TOME.

CECI EST LE TOME 1 DE 2
CONTENANT LES PAGES 1 À 333

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THIS SECTION OF THE APPLICATION/PATENT CONTAINS MORE THAN ONE VOLUME

THIS IS VOLUME 1 OF 2
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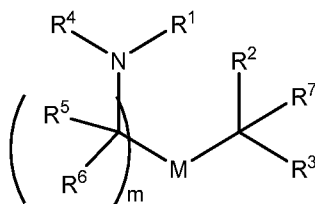
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NOTE POUR LE TOME / VOLUME NOTE:

CLAIMS

1. A compound of Formula (I):



(I) or its N-oxide,

or a salt or isomer thereof, wherein:

5 R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

10 R⁴ is selected from the group consisting of -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹²)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, and -C(O)NQR, where Q is -(CH₂)_nN(R)₂, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

15 each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

R¹² is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl, C₂₋₃ alkenyl, and H;

25 each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and

C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and

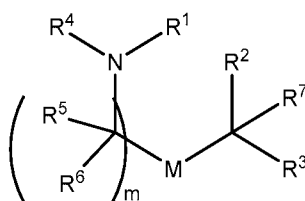
C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

5 each X is independently selected from the group consisting of F, Cl, Br, and I; and

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

2. A compound of Formula (I):



(I) or its N-oxide,

or a salt or isomer thereof, wherein:

10 or a salt or isomer thereof, wherein

R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R'';

15 R² and R³ are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R² and R³, together with the atom to which they are attached, form a heterocycle or carbocycle;

R⁴ is selected from the group consisting of -(CH₂)_nQ, -(CH₂)_nCHQR, -(CH₂)_oC(R¹²)₂(CH₂)_{n-o}Q, -CHQR, -CQ(R)₂, and -C(O)NQR, where Q is -(CH₂)_nN(R)₂, each o is independently selected from 1, 2, 3, and 4, and each n is independently selected from 1, 2, 3, 4, and 5;

20 R^x is selected from the group consisting of C₁₋₆ alkyl, C₂₋₆ alkenyl, -(CH₂)_rOH, and -(CH₂)_rNR₂,

wherein r is selected from 1, 2, 3, 4, 5, and 6;

each R⁵ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

25 each R⁶ is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R⁷ is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

5 R⁸ is selected from the group consisting of C₃₋₆ carbocycle and heterocycle;

R⁹ is selected from the group consisting of H, CN, NO₂, C₁₋₆ alkyl, -OR, -S(O)₂R, -S(O)₂N(R)₂, C₂₋₆ alkenyl, C₃₋₆ carbocycle and heterocycle;

R¹² is selected from the group consisting of H, OH, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

each R is independently selected from the group consisting of C₁₋₆ alkyl, C₁₋₃ alkyl-aryl,

10 C₂₋₃ alkenyl, (CH₂)_qOR*, and H,

and each q is independently selected from 1, 2, and 3;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and

15 C₃₋₁₅ alkenyl;

each R* is independently selected from the group consisting of C₁₋₁₂ alkyl and

C₂₋₁₂ alkenyl;

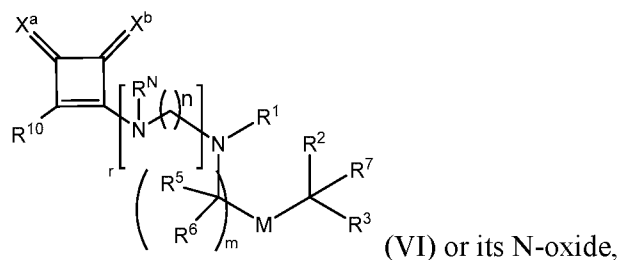
each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I; and

20 m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13.

3. The compound of claim 1 or 2, wherein R⁴ is C(O)NQR.

4. A compound of Formula (VI):



or a salt or isomer thereof, wherein

25 R¹ is selected from the group consisting of C₅₋₃₀ alkyl, C₅₋₂₀ alkenyl, -R*YR'', -YR'', and -R''M'R';

R^2 and R^3 are independently selected from the group consisting of H, C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle;

each R^5 is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R^6 is independently selected from the group consisting of OH, C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

M and M' are independently selected from -C(O)O-, -OC(O)-, -OC(O)-M''-C(O)O-, -C(O)N(R')-, -N(R')C(O)-, -C(O)-, -C(S)-, -C(S)S-, -SC(S)-, -CH(OH)-, -P(O)(OR')O-, -S(O)₂-, -S-S-, an aryl group, and a heteroaryl group, in which M'' is a bond, C₁₋₁₃ alkyl or C₂₋₁₃ alkenyl;

R^7 is selected from the group consisting of C₁₋₃ alkyl, C₂₋₃ alkenyl, and H;

each R is independently selected from the group consisting of H, C₁₋₃ alkyl, and C₂₋₃ alkenyl;

R^N is H, or C₁₋₃ alkyl;

each R' is independently selected from the group consisting of C₁₋₁₈ alkyl, C₂₋₁₈ alkenyl, -R*YR'', -YR'', and H;

each R'' is independently selected from the group consisting of C₃₋₁₅ alkyl and C₃₋₁₅ alkenyl;

each R^* is independently selected from the group consisting of C₁₋₁₂ alkyl and C₂₋₁₂ alkenyl;

each Y is independently a C₃₋₆ carbocycle;

each X is independently selected from the group consisting of F, Cl, Br, and I;

X^a and X^b are each independently O or S;

R^{10} is selected from the group consisting of H, halo, -OH, R, -N(R)₂, -CN, -N₃, -C(O)OH, -C(O)OR, -OC(O)R, -OR, -SR, -S(O)R, -S(O)OR, -S(O)₂OR, -NO₂, -S(O)₂N(R)₂, -N(R)S(O)₂R, -NH(CH₂)_{t1}N(R)₂, -NH(CH₂)_{p1}O(CH₂)_{q1}N(R)₂, -NH(CH₂)_{s1}OR, -N((CH₂)_sOR)₂, -N(R)-carbocycle, -N(R)-heterocycle, -N(R)-aryl, -N(R)-heteroaryl, -N(R)(CH₂)_{t1}-carbocycle, -N(R)(CH₂)_{t1}-heterocycle, -N(R)(CH₂)_{t1}-aryl, -N(R)(CH₂)_{t1}-heteroaryl, a carbocycle, a heterocycle, aryl and heteroaryl;

m is selected from 5, 6, 7, 8, 9, 10, 11, 12, and 13;

n is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10;

r is 0 or 1

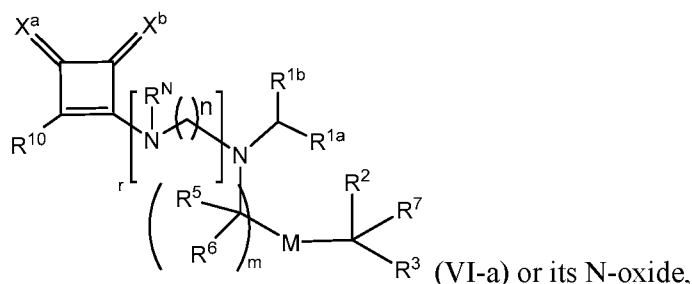
t^1 is selected from 1, 2, 3, 4, and 5;

p^1 is selected from 1, 2, 3, 4, and 5;

q^1 is selected from 1, 2, 3, 4, and 5; and

s^1 is selected from 1, 2, 3, 4, and 5.

- 5 5. A compound of claim 4, wherein the compound is of Formula (VI-a):

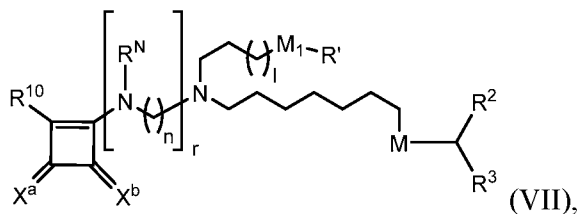


or a salt or isomer thereof, wherein

R^{1a} and R^{1b} are independently selected from the group consisting of C₁₋₁₄ alkyl and C₂₋₁₄ alkenyl; and

- 10 R^2 and R^3 are independently selected from the group consisting of C₁₋₁₄ alkyl, C₂₋₁₄ alkenyl, -R*YR'', -YR'', and -R*OR'', or R^2 and R^3 , together with the atom to which they are attached, form a heterocycle or carbocycle.

6. The compound of any one of the preceding claims, wherein the compound is of Formula (VII):



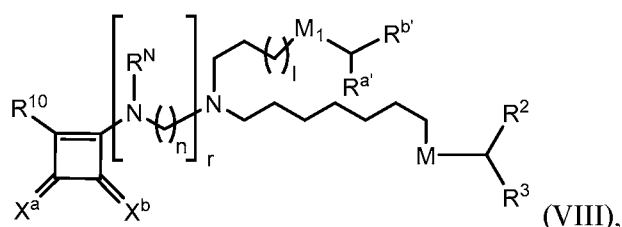
or its N-oxide, or a salt or isomer thereof, wherein

l is selected from 1, 2, 3, 4, and 5;

M_1 is a bond or M'; and

R^2 and R^3 are independently selected from the group consisting of H, C₁₋₁₄ alkyl, and C₂₋₁₄ alkenyl.

7. The compound of any one of the preceding claims, wherein the compound is of Formula (VIII):



or its N-oxide, or a salt or isomer thereof, wherein

l is selected from 1, 2, 3, 4, and 5;

M₁ is a bond or M'; and

5 R^{a'} and R^{b'} are independently selected from the group consisting of C₁₋₁₄ alkyl and C₂₋₁₄ alkenyl; and

R² and R³ are independently selected from the group consisting of C₁₋₁₄ alkyl, and C₂₋₁₄ alkenyl.

8. The compound of any one of the preceding claims, wherein one of M and M' is -S-S-, and
10 the other is -C(O)O- or -OC(O)-.

9. The compound of any one of the preceding claims, wherein M is -C(O)O- or -OC(O)-.

10. The compound of any one of the preceding claims, wherein M is -OC(O)-M''-C(O)O-, in which M'' is C₁₋₆ alkyl or C₂₋₆ alkenyl.

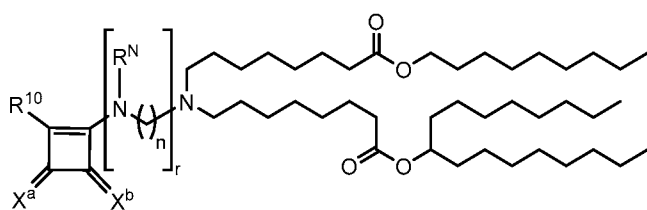
11. The compound of any one of the preceding claims, wherein R¹ is selected from the group
15 consisting of -R*YR'', -YR'', and -R''M'R'.

12. The compound of any one of the preceding claims, wherein R' is selected from C₄ alkyl, C₄ alkenyl, C₅ alkyl, C₅ alkenyl, C₆ alkyl, C₆ alkenyl, C₇ alkyl, C₇ alkenyl, C₉ alkyl, C₉ alkenyl, C₁₁ alkyl, C₁₁ alkenyl, C₁₇ alkyl, C₁₇ alkenyl, C₁₈ alkyl, and C₁₈ alkenyl, each of which is either linear or branched.

20 13. The compound of any one of the preceding claims, wherein R² and R³ are the same.

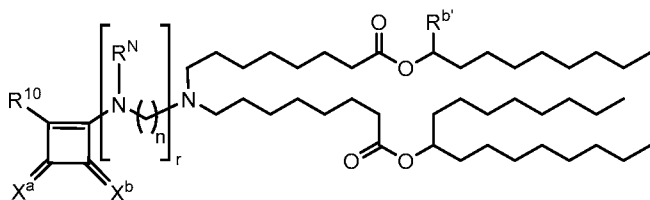
14. The compound of any one of the preceding claims, wherein R² and R³ are C₈ alkyl.

15. The compound of any one of the preceding claims, wherein the compound is of the Formula (VIIa),



(VIIa), or its N-oxide, or a salt or isomer thereof.

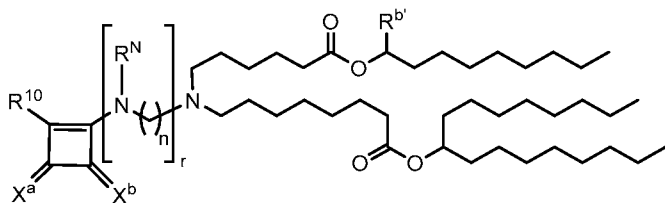
16. The compound of any one of the preceding claims, wherein the compound is of the Formula (VIIIa),



5

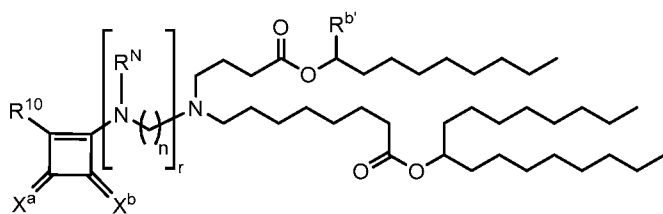
(VIIIa), or its N-oxide, or a salt or isomer thereof, wherein R^{b'} is H, methyl, or ethyl.

17. The compound of any one of the preceding claims, wherein the compound is of the Formula (VIIIb),

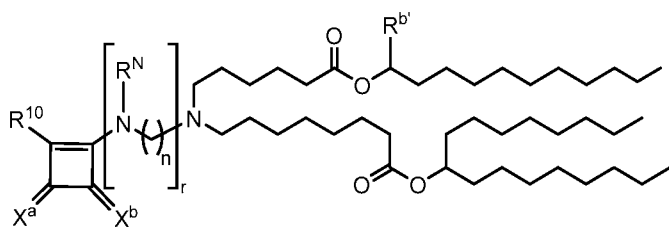
(VIIIb), or its N-oxide, or a salt or isomer thereof, wherein R^{b'} is H, methyl, or ethyl.

10

18. The compound of any one of the preceding claims, wherein the compound is of the Formula (VIIIc) or (VIIId),



(VIIIc),



(VIIIId), or its N-oxide, or a salt or

isomer thereof, wherein $R^{b'}$ is H, methyl, or ethyl.

19. The compound of any one of the preceding claims, wherein r is 1.

20. The compound of any one of the preceding claims, wherein n is 2 or 4.

21. The compound of any one of the preceding claims, wherein R^N is H.

22. The compound of any one of the preceding claims, wherein X^a is O.

23. The compound of any one of the preceding claims, wherein X^a is S.

24. The compound of any one of the preceding claims, wherein X^b is O.

25. The compound of any one of the preceding claims, wherein X^b is S.

26. The compound of any one of the preceding claims, wherein R^{10} is selected from the group consisting of $N(R)_2$, $-NH(CH_2)_{t1}N(R)_2$, $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, $-NH(CH_2)_{s1}OR$, $-N((CH_2)_{s1}OR)_2$, and a heterocycle.

27. The compound of any one of the preceding claims, wherein R^{10} is selected from the group consisting of $-NH(CH_2)_{t1}N(R)_2$, $-NH(CH_2)_{p1}O(CH_2)_{q1}N(R)_2$, $-NH(CH_2)_{s1}OR$, $-N((CH_2)_{s1}OR)_2$, and a heterocycle.

28. The compound of any one of the preceding claims, wherein R^{10} is selected from the group consisting of $-N(R)$ -carbocycle, $-N(R)$ -heterocycle, $-N(R)$ -aryl, and $-N(R)$ -heteroaryl.

29. The compound of any one of the preceding claims, wherein R^{10} is selected from the group consisting of $-N(R)(CH_2)_{t1}$ -carbocycle, $-N(R)(CH_2)_{t1}$ -heterocycle, $-N(R)(CH_2)_{t1}$ -aryl, and $-N(R)(CH_2)_{t1}$ -heteroaryl.

30. The compound of any one of the preceding claims, wherein t^1 is 2, 3, or 4.

31. The compound of any one of the preceding claims, wherein p^1 is 2.

32. The compound of any one of the preceding claims, wherein q^1 is 2.

33. The compound of any one of the preceding claims, wherein s^1 is 2.

34. The compound of any one of the preceding claims, wherein R¹⁰ is morpholinyl, methylpiperazinyl, –NH-tetrahydropyranyl, or –NH-oxetanyl.

35. The compound of any one of the preceding claims, selected from compounds 340-400.

36. A nanoparticle composition comprising a lipid component comprising a compound
5 according to any one of the preceding claims.

37. The nanoparticle composition of any one of the preceding claims, wherein the lipid component further comprises a phospholipid.

38. The nanoparticle composition of any one of the preceding claims, wherein the phospholipid is selected from the group consisting of 1,2-dilinoeoyl-sn-glycero-3-phosphocholine (DLPC),
10 1,2-dimyristoyl-sn-glycero-phosphocholine (DMPC), 1,2-dioeoyl-sn-glycero-3-phosphocholine (DOPC), 1,2-dipalmitoyl-sn-glycero-3-phosphocholine (DPPC), 1,2-distearoyl-sn-glycero-3-phosphocholine (DSPC), 1,2-diundecanoyl-sn-glycero-phosphocholine (DUPC), 1-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine (POPC), 1,2-di-O-octadecenyl-sn-glycero-3-phosphocholine (18:0 Diether PC), 1-oleoyl-2-cholesterylhemisuccinoyl-sn-glycero-3-phosphocholine (OChemPC), 1-hexadecyl-sn-glycero-3-phosphocholine (C16 Lyso PC), 1,2-dilinolenoyl-sn-glycero-3-phosphocholine, 1,2-diarachidonoyl-sn-glycero-3-phosphocholine, 1,2-didocosahexaenoyl-sn-glycero-3-phosphocholine, 1,2-dioeoyl-sn-glycero-3-phosphoethanolamine (DOPE), 1,2-diphytanoyl-sn-glycero-3-phosphoethanolamine (ME 16.0 PE), 1,2-distearoyl-sn-glycero-3-phosphoethanolamine, 1,2-dilinoeoyl-sn-glycero-3-phosphoethanolamine, 1,2-dilinolenoyl-sn-glycero-3-phosphoethanolamine, 1,2-diarachidonoyl-sn-glycero-3-phosphoethanolamine, 1,2-didocosahexaenoyl-sn-glycero-3-phosphoethanolamine, 1,2-dioeoyl-sn-glycero-3-phospho-rac-(1-glycerol) sodium salt (DOPG), dipalmitoylphosphatidylglycerol (DPPG), palmitoyl-oleoylphosphatidylethanolamine (POPE), distearoyl-phosphatidyl-ethanolamine (DSPE), dipalmitoyl phosphatidyl ethanolamine (DPPE),
25 dimyristoylphosphoethanolamine (DMPE), 1-stearoyl-2-oleoyl-phosphatidylethanolamine (SOPE), 1-stearoyl-2-oleoyl-phosphatidylcholine (SOPC), sphingomyelin, phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, phosphatidic acid, palmitoyl-oleoyl phosphatidylcholine, lysophosphatidylcholine, lysophosphatidylethanolamine (LPE), and mixtures thereof.

39. The nanoparticle composition of any one of the preceding claims, wherein the lipid component further comprises a structural lipid.

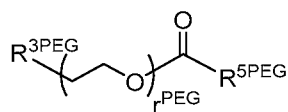
40. The nanoparticle composition of any one of the preceding claims, wherein the structural lipid is selected from the group consisting of cholesterol, fecosterol, sitosterol, ergosterol, campesterol, stigmasterol, brassicasterol, tomatidine, ursolic acid, alpha-tocopherol, and mixtures thereof.

5 41. The nanoparticle composition of any one of the preceding claims, wherein the lipid component further comprises a PEG lipid.

42. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is selected from the group consisting of a PEG-modified phosphatidylethanolamine, a PEG-modified phosphatidic acid, a PEG-modified ceramide, a PEG-modified dialkylamine, a PEG-
10 modified diacylglycerol, a PEG-modified dialkylglycerol, and mixtures thereof.

43. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid includes a PEG moiety having a size of from about 1000 Da to about 20 kDa.

44. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is a compound of Formula (V):



15 (V), or a salt or isomer thereof, wherein:

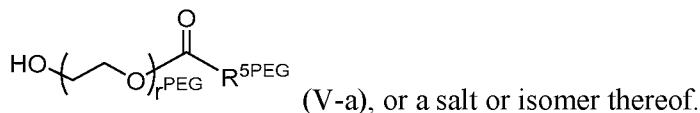
$\text{R}^{3\text{PEG}}$ is ---OR^{O} ;

R^{O} is hydrogen, C_{1-5} alkyl or an oxygen protecting group;

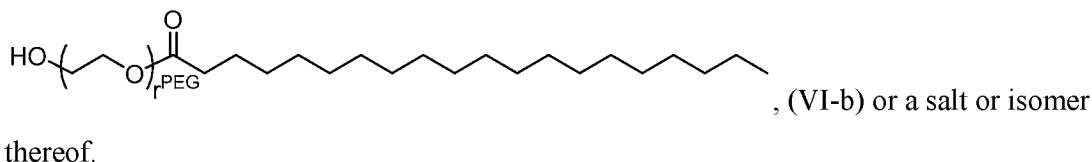
r^{PEG} is an integer between 1 and 100;

$\text{R}^{5\text{PEG}}$ is C_{10-40} alkyl, C_{10-40} alkenyl, or C_{10-40} alkynyl; and optionally one or more methylene
20 groups of $\text{R}^{5\text{PEG}}$ are independently replaced with C_{3-10} carbocyclylene, 4 to 10 membered heterocyclylene, C_{6-10} arylene, 4 to 10 membered heteroarylene, $\text{---N(R}^{\text{N}}\text{)---}$, ---O--- , ---S--- , ---C(O)--- , $\text{---C(O)N(R}^{\text{N}}\text{)---}$, $\text{---NR}^{\text{N}}\text{C(O)---}$, $\text{---NR}^{\text{N}}\text{C(O)N(R}^{\text{N}}\text{)---}$, ---C(O)O--- , ---OC(O)--- , ---OC(O)O--- , $\text{---OC(O)N(R}^{\text{N}}\text{)---}$, $\text{---NR}^{\text{N}}\text{C(O)O---}$, ---C(O)S--- , ---SC(O)--- , $\text{---C(=NR}^{\text{N}}\text{)---}$, $\text{---C(=NR}^{\text{N}}\text{)N(R}^{\text{N}}\text{)---}$, $\text{---NR}^{\text{N}}\text{C(=NR}^{\text{N}}\text{)---}$, $\text{---NR}^{\text{N}}\text{C(=NR}^{\text{N}}\text{)N(R}^{\text{N}}\text{)---}$, ---C(S)--- , $\text{---C(S)N(R}^{\text{N}}\text{)---}$, $\text{---NR}^{\text{N}}\text{C(S)---}$, $\text{---NR}^{\text{N}}\text{C(S)N(R}^{\text{N}}\text{)---}$,
25 ---S(O)--- , ---OS(O)--- , ---S(O)O--- , ---OS(O)O--- , $\text{---OS(O)}_2\text{---}$, $\text{---S(O)}_2\text{O---}$, $\text{---OS(O)}_2\text{O---}$, $\text{---N(R}^{\text{N}}\text{)S(O)---}$, $\text{---S(O)N(R}^{\text{N}}\text{)---}$, $\text{---N(R}^{\text{N}}\text{)S(O)N(R}^{\text{N}}\text{)---}$, $\text{---OS(O)N(R}^{\text{N}}\text{)---}$, $\text{---N(R}^{\text{N}}\text{)S(O)O---}$, $\text{---S(O)}_2\text{---}$, $\text{---N(R}^{\text{N}}\text{)S(O)}_2\text{---}$, $\text{---S(O)}_2\text{N(R}^{\text{N}}\text{)---}$, $\text{---N(R}^{\text{N}}\text{)S(O)}_2\text{N(R}^{\text{N}}\text{)---}$, $\text{---OS(O)}_2\text{N(R}^{\text{N}}\text{)---}$, or $\text{---N(R}^{\text{N}}\text{)S(O)}_2\text{O---}$; and
each instance of R^{N} is independently hydrogen, C_{1-6} alkyl, or a nitrogen protecting group.

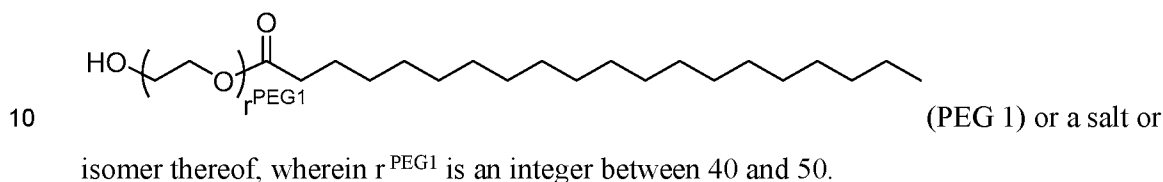
45. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is a compound of Formula (V-a):



46. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is a compound of Formula (VI-b):



47. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is a compound having the formula:



48. The nanoparticle composition of any one of the preceding claims, wherein the PEG lipid is a compound having the formula:

$$\text{HO}-(\text{CH}_2\text{CH}_2\text{O})_{45}-\text{C}(=\text{O})-\text{C}_{20}\text{H}_{41},$$

or a salt or isomer thereof.

49. The nanoparticle composition of any one of the preceding claims, wherein the lipid component further comprises a cationic and/or ionizable lipid selected from the group consisting of 3-(didodecylamino)-N1,N1,4-tridodecyl-1-piperazineethanamine (KL10), N1-[2-(didodecylamino)ethyl]-N1,N4,N4-tridodecyl-1,4-piperazinediethanamine (KL22), 14,25-ditridecyl-15,18,21,24-tetraaza-octatriacontane (KL25), 1,2-dilinoleyloxy-N,N-dimethylaminopropane (DLin-DMA), 2,2-dilinoleyl-4-dimethylaminomethyl-[1,3]-dioxolane (DLin-K-DMA), heptatriaconta-6,9,28,31-tetraen-19-yl 4-(dimethylamino)butanoate (DLin-MC3-DMA), 2,2-dilinoleyl-4-(2-dimethylaminoethyl)-[1,3]-dioxolane (DLin-KC2-DMA), 1,2-dioleyloxy-N,N-dimethylaminopropane (DODMA), 2-({8-[(3β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-[(9Z,12Z)-octadeca-9,12-dien-1-yloxy]propan-1-amine (Octyl-CLinDMA), (2R)-2-({8-[(3β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-

[(9Z,12Z)-octadeca-9,12-dien-1-yloxy]propan-1-amine (Octyl-CLinDMA (2R)), and (2S)-2-({8-[(3 β)-cholest-5-en-3-yloxy]octyl}oxy)-N,N-dimethyl-3-[(9Z,12Z)-octadeca-9,12-dien-1-yloxy]propan-1-amine (Octyl-CLinDMA (2S)).

50. The nanoparticle composition of any one of the preceding claims, wherein the lipid
5 component comprises about 30 mol % to about 60 mol % said compound, about 0 mol % to about 30 mol % phospholipid, about 18.5 mol % to about 48.5 mol % structural lipid, and about 0 mol % to about 10 mol % PEG lipid.

51. The nanoparticle composition of any one of the preceding claims, wherein the lipid
10 component comprises about 50 mol % said compound, about 10 mol % phospholipid, about 38.5 mol % structural lipid, and about 1.5 mol % PEG lipid.

52. The nanoparticle composition of any one of the preceding claims, further comprising a therapeutic and/or prophylactic agent.

53. The nanoparticle composition of any one of the preceding claims, wherein the therapeutic and/or prophylactic agent is a vaccine or a compound capable of eliciting an immune response.

15 54. The nanoparticle composition of any one of the preceding claims, wherein the therapeutic and/or prophylactic agent is a nucleic acid.

55. The nanoparticle composition of any one of the preceding claims, wherein the therapeutic and/or prophylactic agent is a ribonucleic acid (RNA).

56. The nanoparticle composition of any one of the preceding claims, wherein the RNA is
20 selected from the group consisting of a small interfering RNA (siRNA), an asymmetrical interfering RNA (aiRNA), a microRNA (miRNA), a Dicer-substrate RNA (dsRNA), a small hairpin RNA (shRNA), a messenger RNA (mRNA), and mixtures thereof.

57. The nanoparticle composition of any one of the preceding claims, wherein the RNA is an mRNA.

25 58. The nanoparticle composition of any one of the preceding claims, wherein the mRNA includes one or more of a stem loop, a chain terminating nucleoside, a polyA sequence, a polyadenylation signal, and/or a 5' cap structure.

59. The nanoparticle composition of any one of the preceding claims, wherein the encapsulation efficiency of the therapeutic and/or prophylactic agent is at least 50%, at least 80%, or at least 90%.
60. The nanoparticle composition of any one of the preceding claims, wherein the wt/wt ratio of the lipid component to the therapeutic and/or prophylactic agent is from about 10:1 to about 60:1.
61. The nanoparticle composition of any one of the preceding claims, wherein the wt/wt ratio of the lipid component to the therapeutic and/or prophylactic agent is about 20:1.
62. The nanoparticle composition of any one of the preceding claims, wherein the N:P ratio is from about 2:1 to about 30:1.
63. The nanoparticle composition of any one of the preceding claims, wherein the N:P ratio is about 5.67:1.
64. The nanoparticle composition of any one of the preceding claims, wherein the mean size of the nanoparticle composition is from about 70 nm to about 100 nm.
65. The nanoparticle composition of any one of the preceding claims, wherein the polydispersity index of the nanoparticle composition is from about 0.10 to about 0.20.
66. The nanoparticle composition of any one of the preceding claims, wherein the nanoparticle composition has a zeta potential of about -10 mV to about +20 mV.
67. The nanoparticle composition of any one of the preceding claims, wherein the nanoparticle has a surface pKa of about 6.6.
68. The nanoparticle composition of any one of the preceding claims, wherein the nanoparticle has an endosomal escape efficiency of about 15%.
69. A pharmaceutical composition comprising the nanoparticle composition of any one of the preceding claims and a pharmaceutically acceptable carrier.
70. A method of delivering a therapeutic and/or prophylactic agent to a mammalian cell, the method comprising administering to a subject the nanoparticle composition of any one of the preceding claims, said administering comprising contacting the cell with the nanoparticle composition, whereby the therapeutic and/or prophylactic agent is delivered to the cell.

71. A method of producing a polypeptide of interest in a mammalian cell, the method comprising contacting the cell with the nanoparticle composition of any one of the preceding claims, wherein the therapeutic and/or prophylactic agent is an mRNA, and wherein the mRNA encodes the polypeptide of interest, whereby the mRNA is capable of being translated in the cell to produce the polypeptide of interest.
72. A method of treating a disease or disorder in a mammal in need thereof, the method comprising administering to the mammal a therapeutically effective amount of the nanoparticle composition of any one of the preceding claims.
73. A method of specifically delivering a therapeutic and/or prophylactic agent to a mammalian organ, the method comprising administering to a mammal the nanoparticle composition of any one of the preceding claims, said administering comprising contacting the mammalian organ with the nanoparticle composition, whereby the therapeutic and/or prophylactic agent is delivered to the organ.
74. The nanoparticle composition of any one of the preceding claims, for use in the treatment of a disease or disorder in a mammal in need thereof.
75. The nanoparticle composition of any one of the preceding claims, for use as a medicament for the treatment of a disease or disorder in a mammal in need thereof.
76. The use of a nanoparticle composition of any one of the preceding claims, in the manufacture of a medicament for the treatment of a disease or disorder in a mammal in need thereof.
77. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein the disease or disorder is characterized by dysfunctional or aberrant protein or polypeptide activity.
78. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein the disease or disorder is selected from the group consisting of infectious diseases, cancer and proliferative diseases, genetic diseases, autoimmune diseases, diabetes, neurodegenerative diseases, cardio- and reno-vascular diseases, and metabolic diseases.
79. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein the mammal is a human.

80. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein the nanoparticle composition is administered intravenously, intramuscularly, intradermally, subcutaneously, intranasally, or by inhalation.

5 81. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein the nanoparticle composition is administered subcutaneously.

82. The method, use, or nanoparticle composition for use of any one of the preceding claims, wherein a dose of about 0.001 mg/kg to about 10 mg/kg of the therapeutic and/or prophylactic agent is administered to the mammal, or wherein the medicament comprises 0.001 mg/kg to about 10 mg/kg of the therapeutic and/or prophylactic agent.

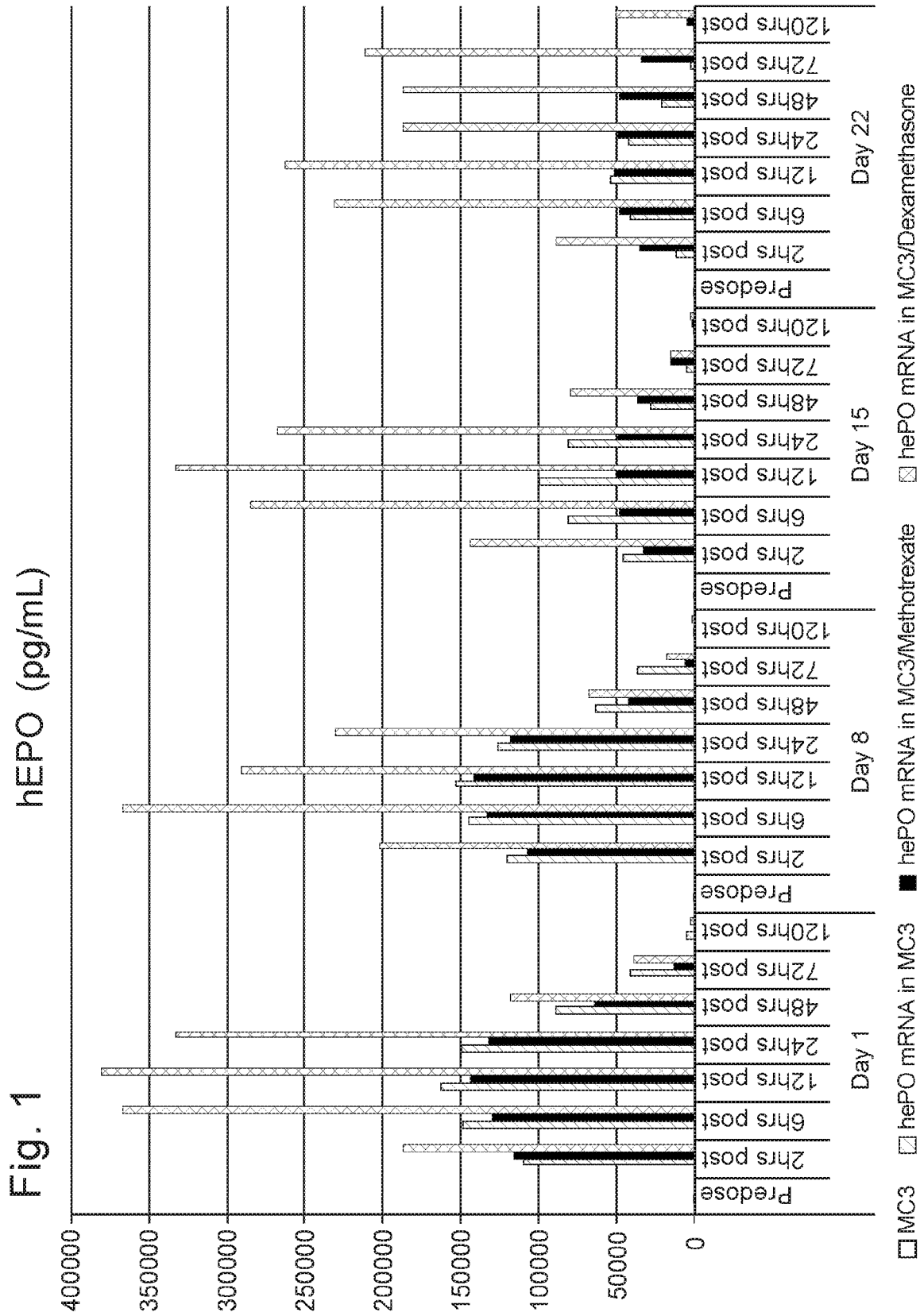
10 83. The method of any one of the preceding claims, further comprising, prior to the contacting or administering step, pretreating said mammal with one or more additional compounds, wherein pretreating comprises administering said one or more additional compounds to said mammal.

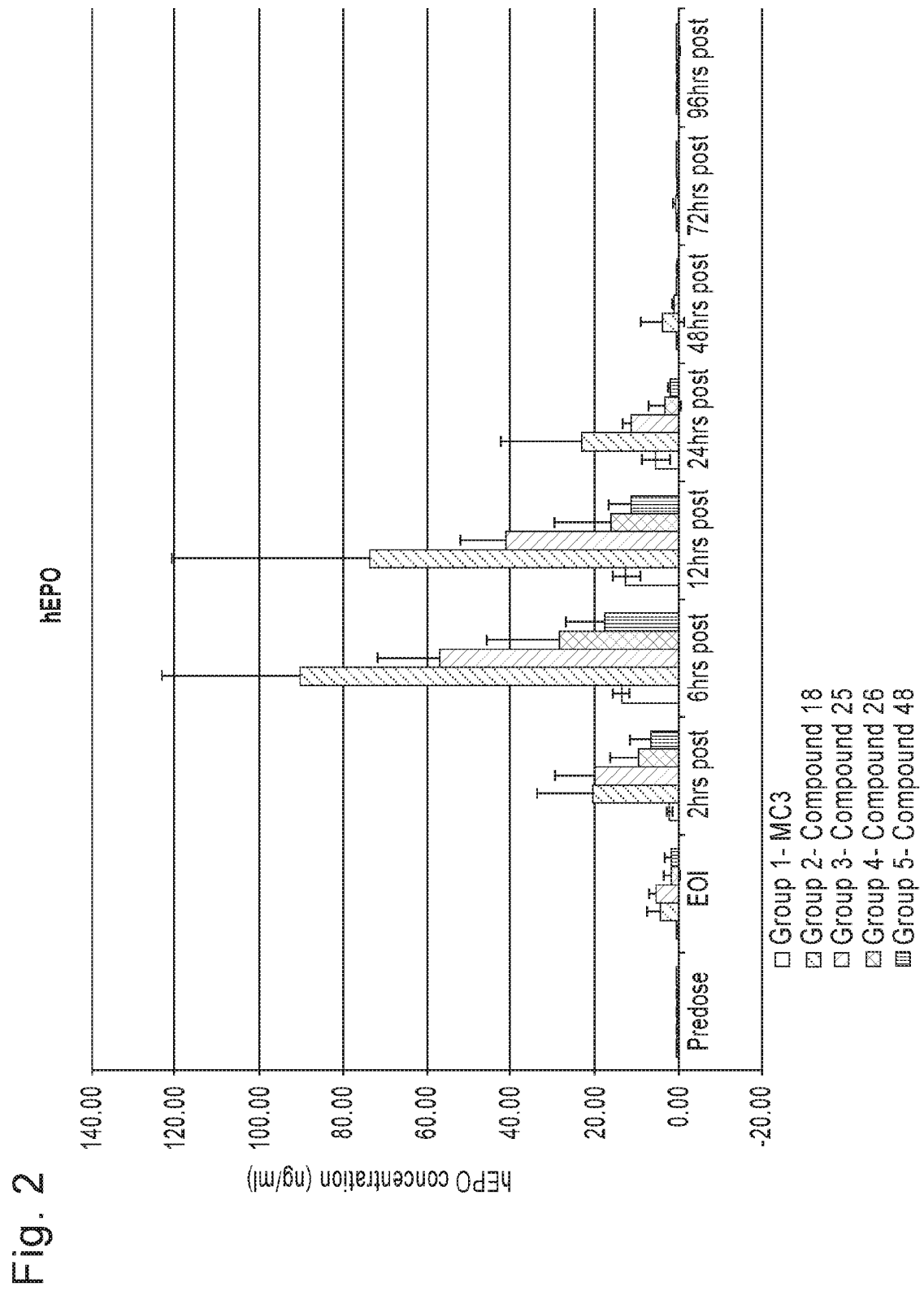
15 84. The method of any one of the preceding claims, wherein said mammal is pretreated two weeks or fewer, one week or fewer, 24 or fewer hours prior to the contacting or administering step.

85. The method of any one of the preceding claims, wherein said mammal is pretreated about one hour prior to the contacting or administering step.

20 86. The method of any one of the preceding claims, wherein said one or more additional compounds are selected from the group consisting of anti-inflammatory compounds, steroids, statins, estradiols, BTK inhibitors, S1P1 agonists, glucocorticoid receptor modulators (GRMs), and anti-histamines.

87. The method of any one of the preceding claims, wherein said one or more additional compounds are selected from the group consisting of dexamethasone, methotrexate, acetaminophen, an H1 receptor blocker, and an H2 receptor blocker.





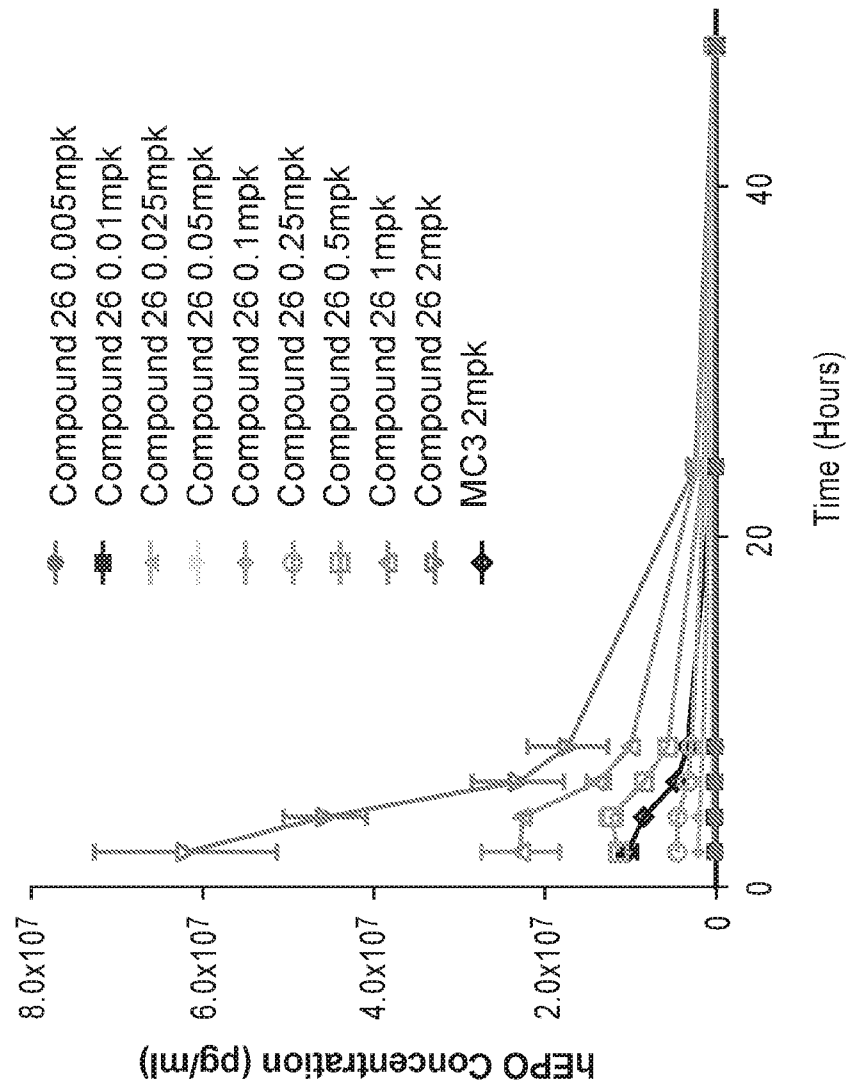


Fig. 3

Fig. 4

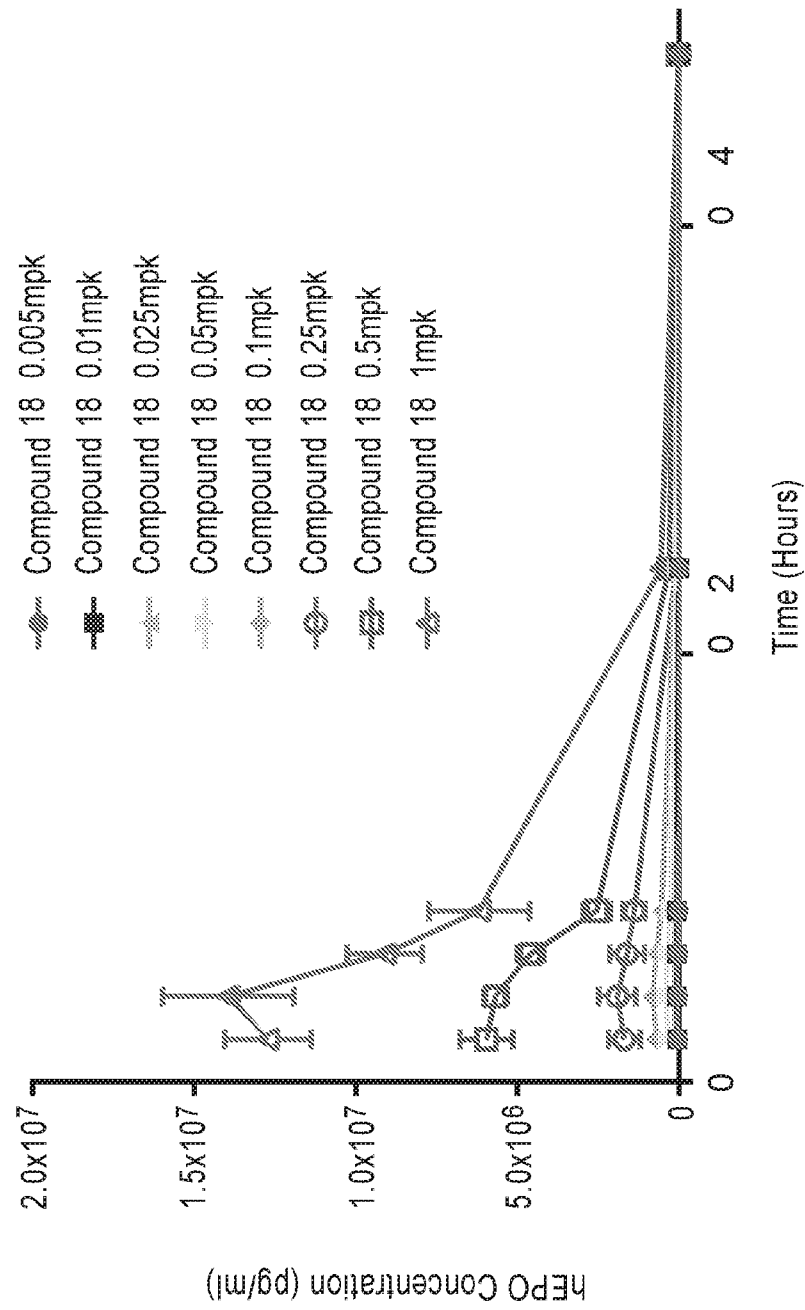


Fig. 5

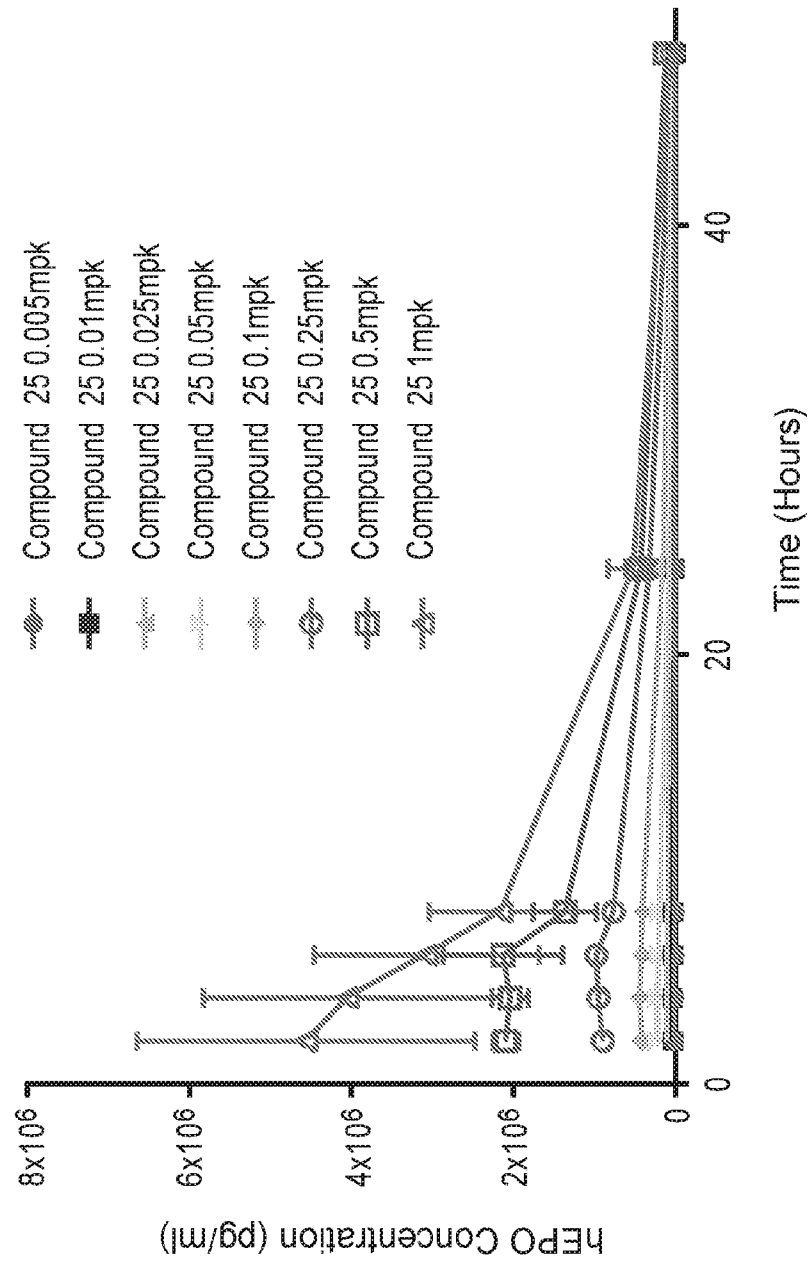
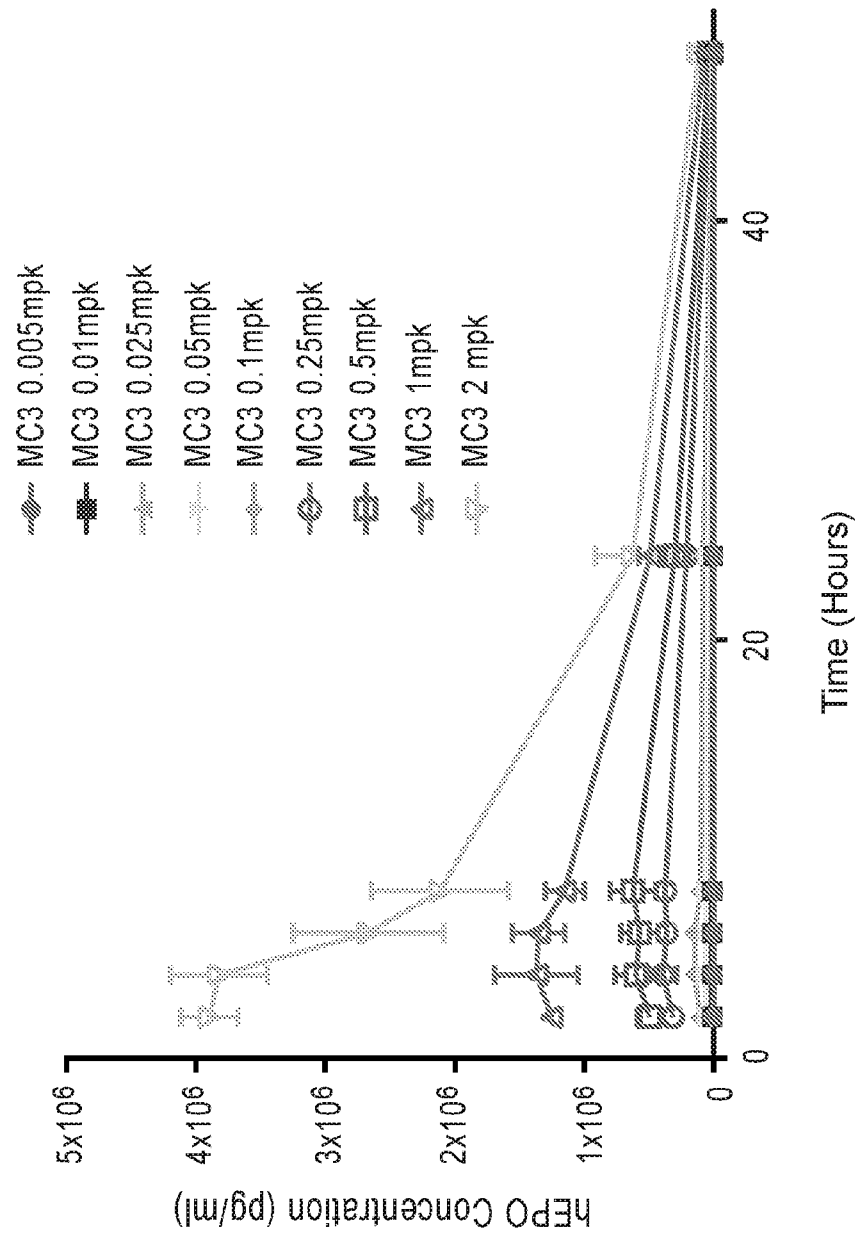


Fig. 6



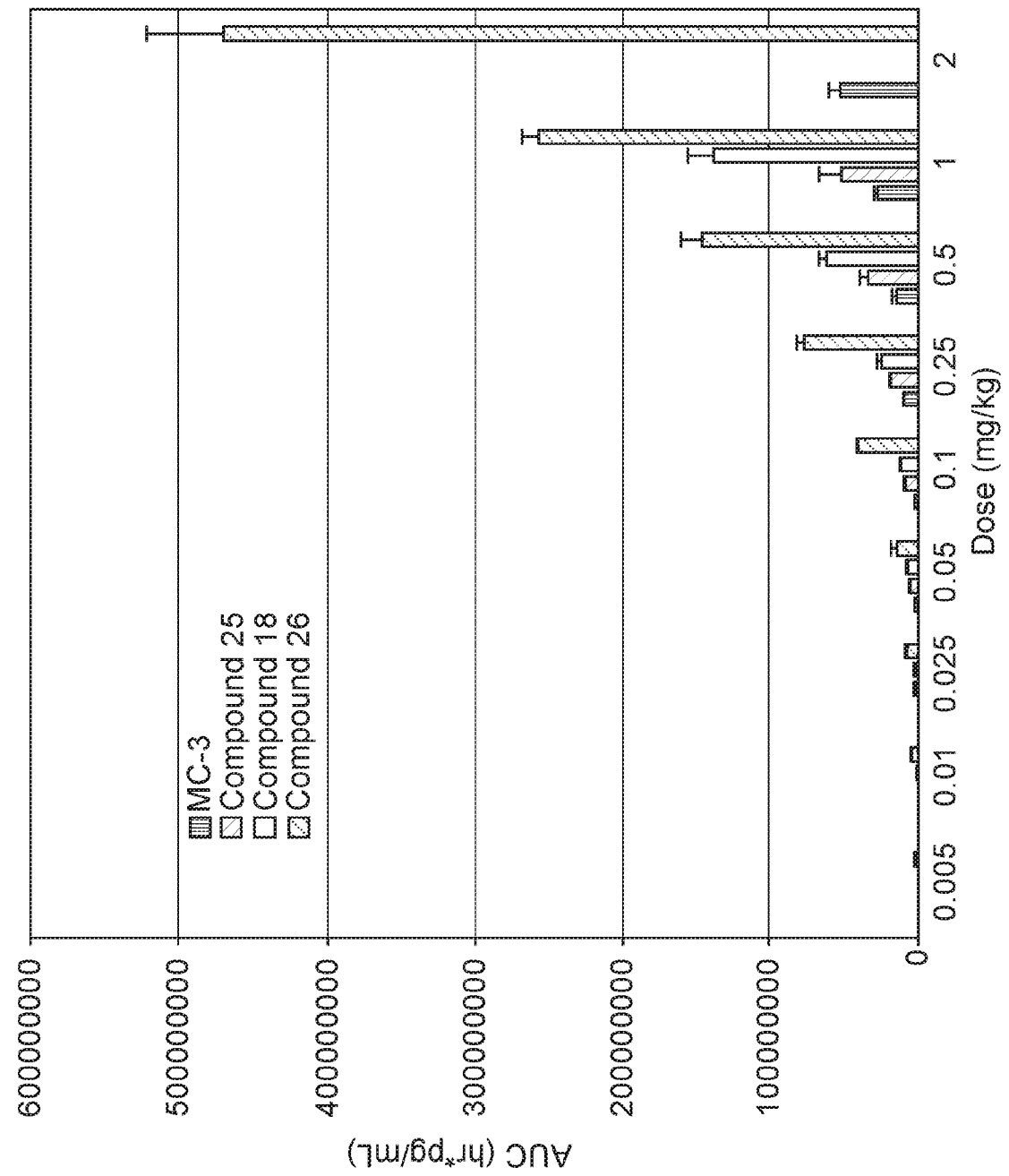


Fig. 8

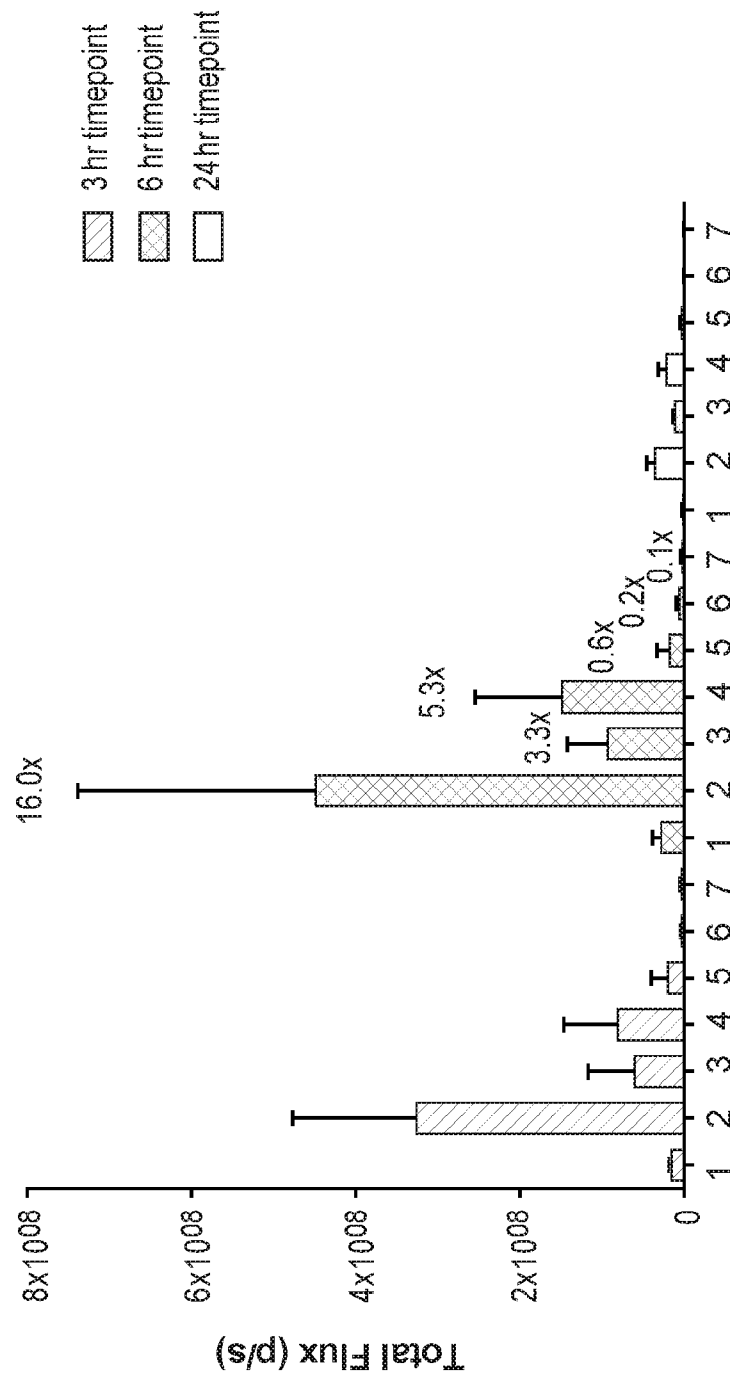
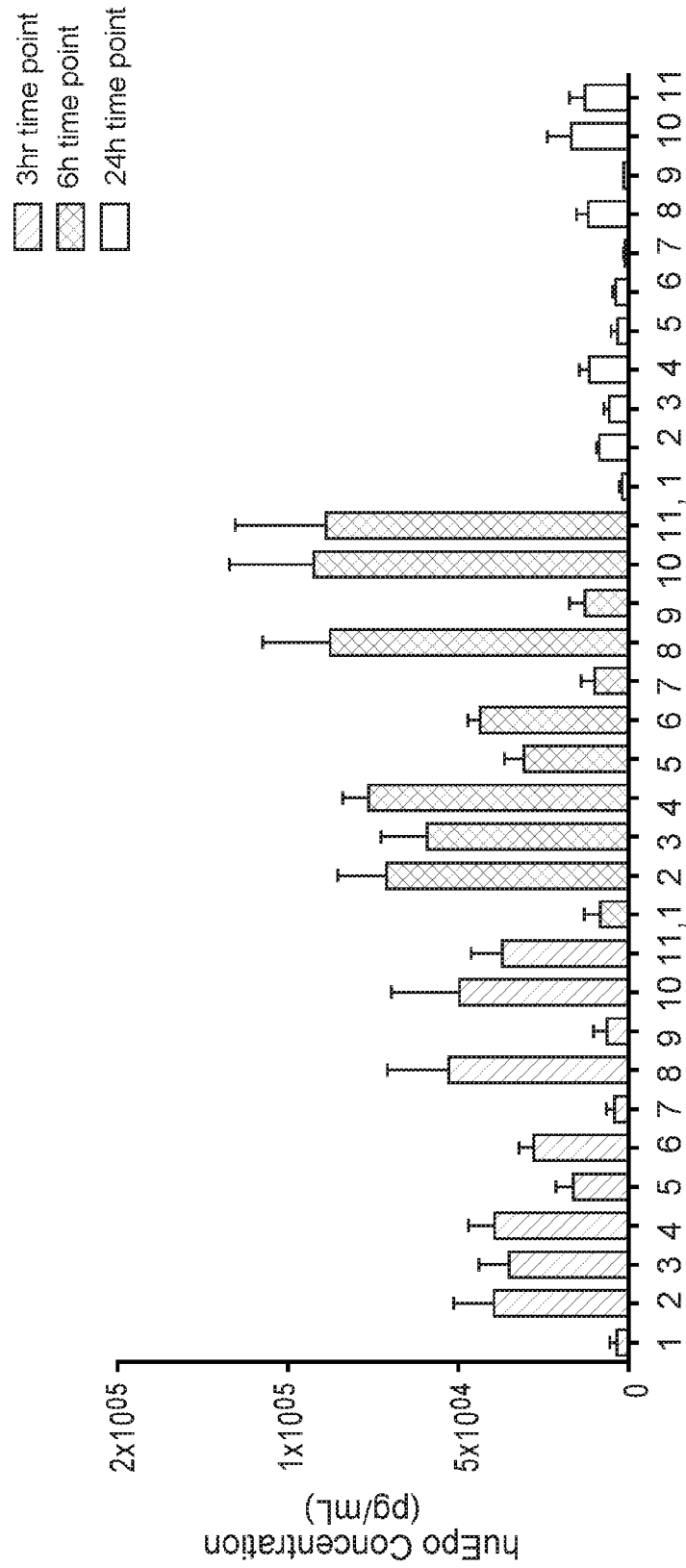
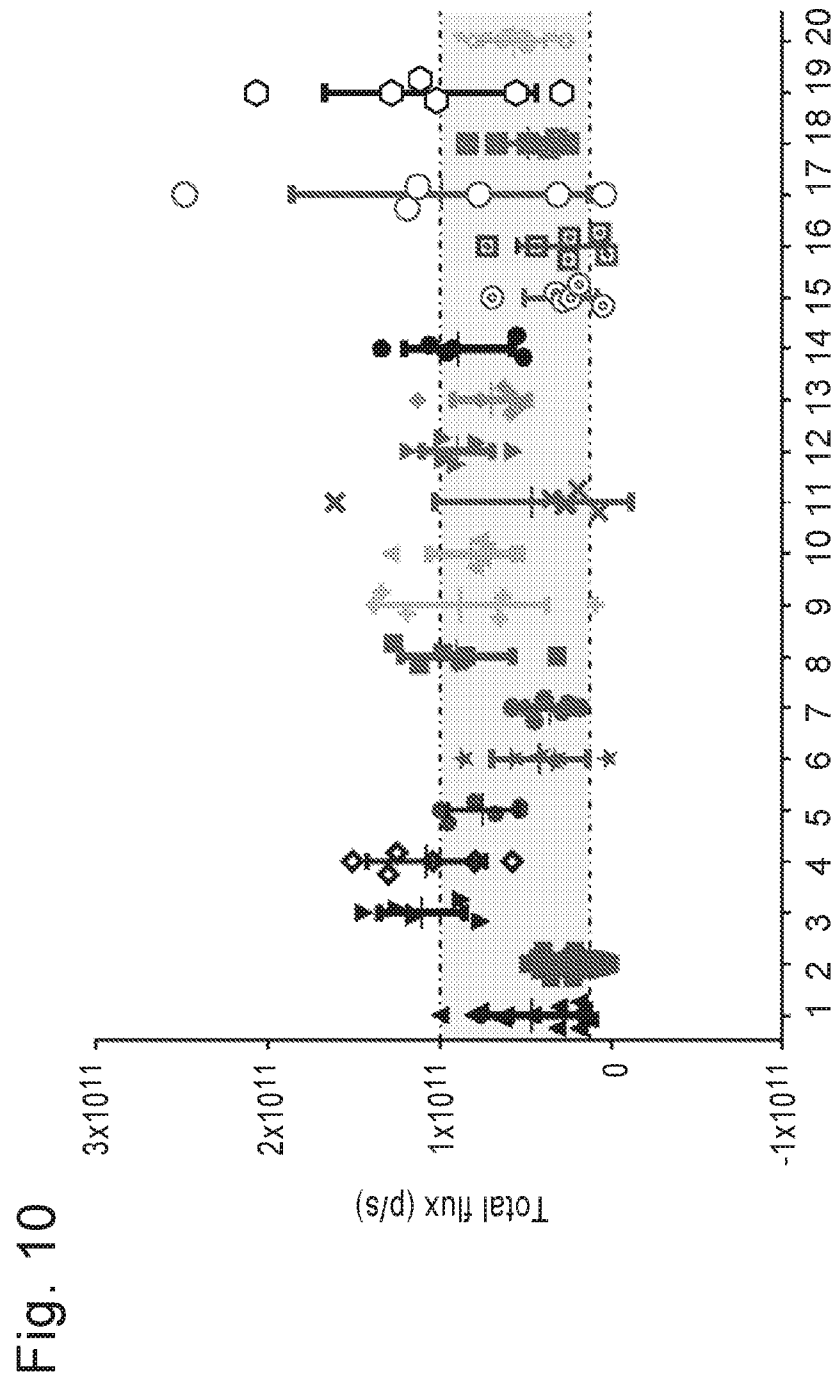


Fig. 9





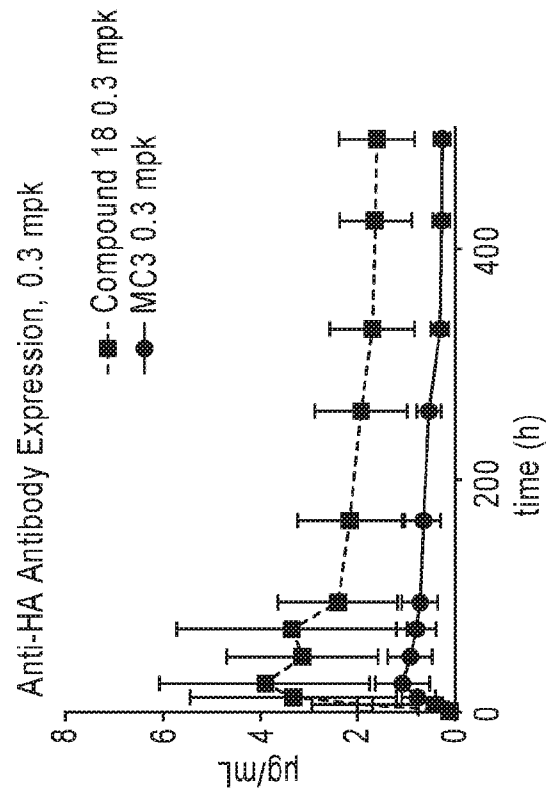


Fig. 11B

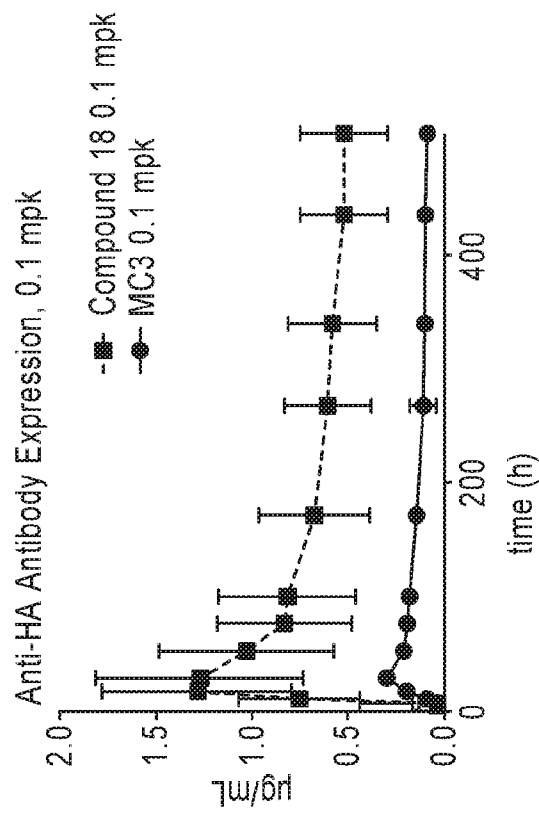


Fig. 11A

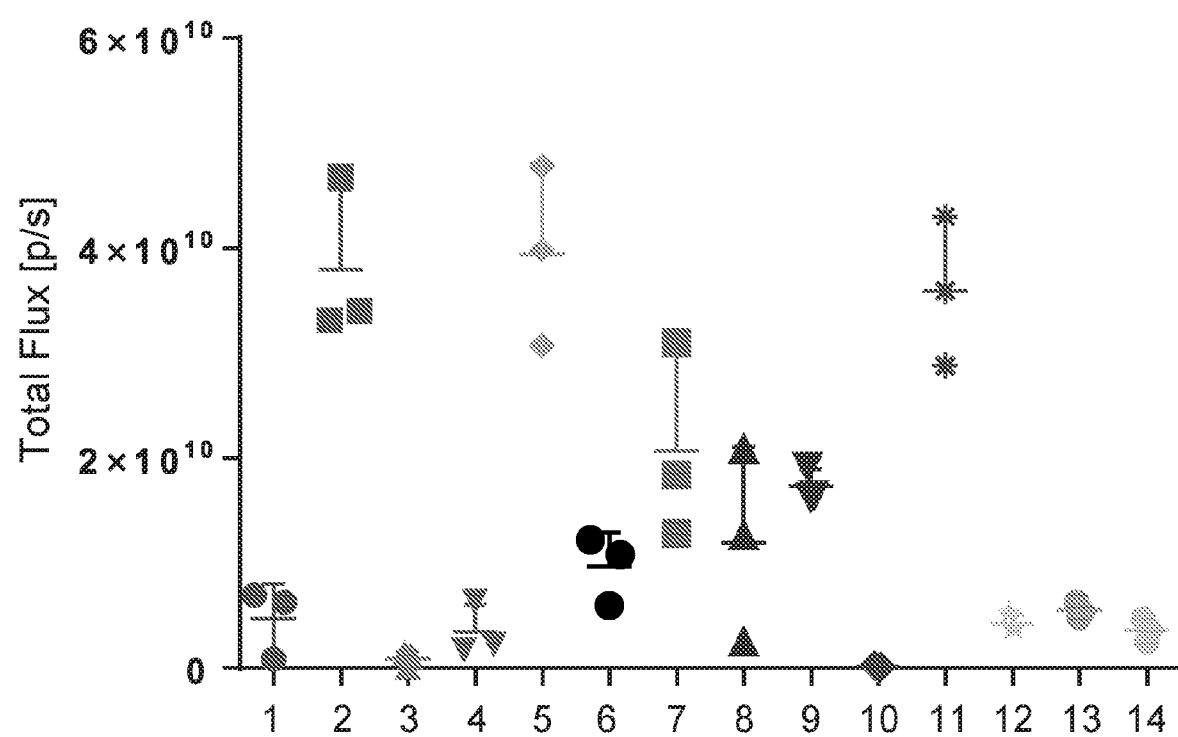


Fig. 12A

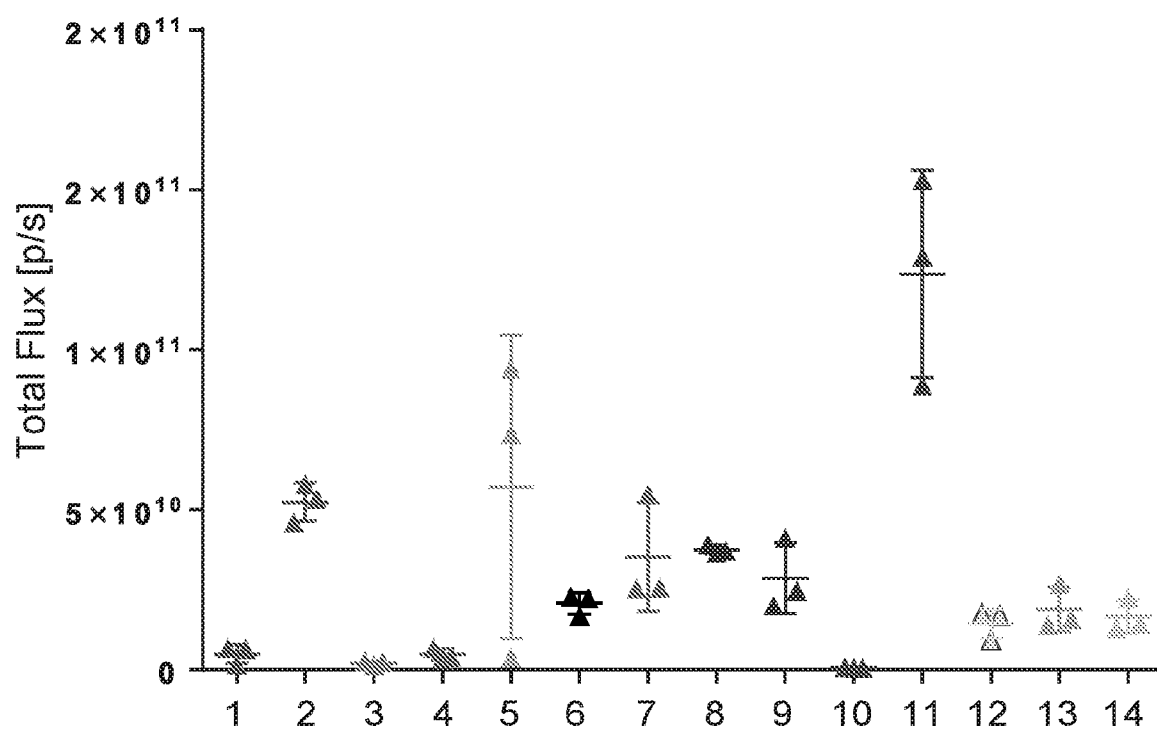


Fig. 12B

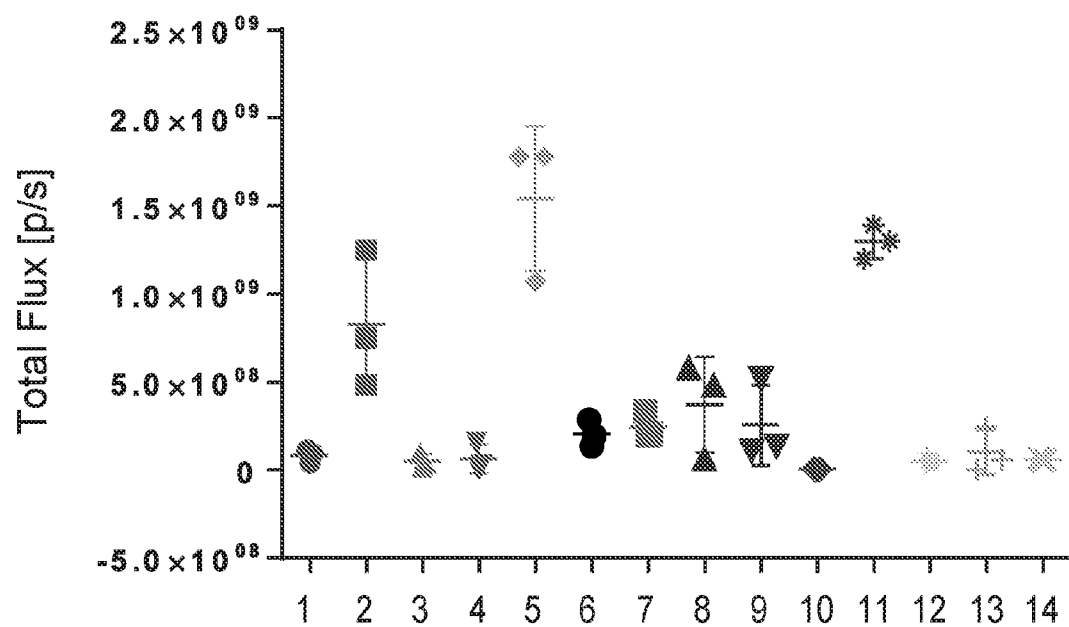


Fig. 12C

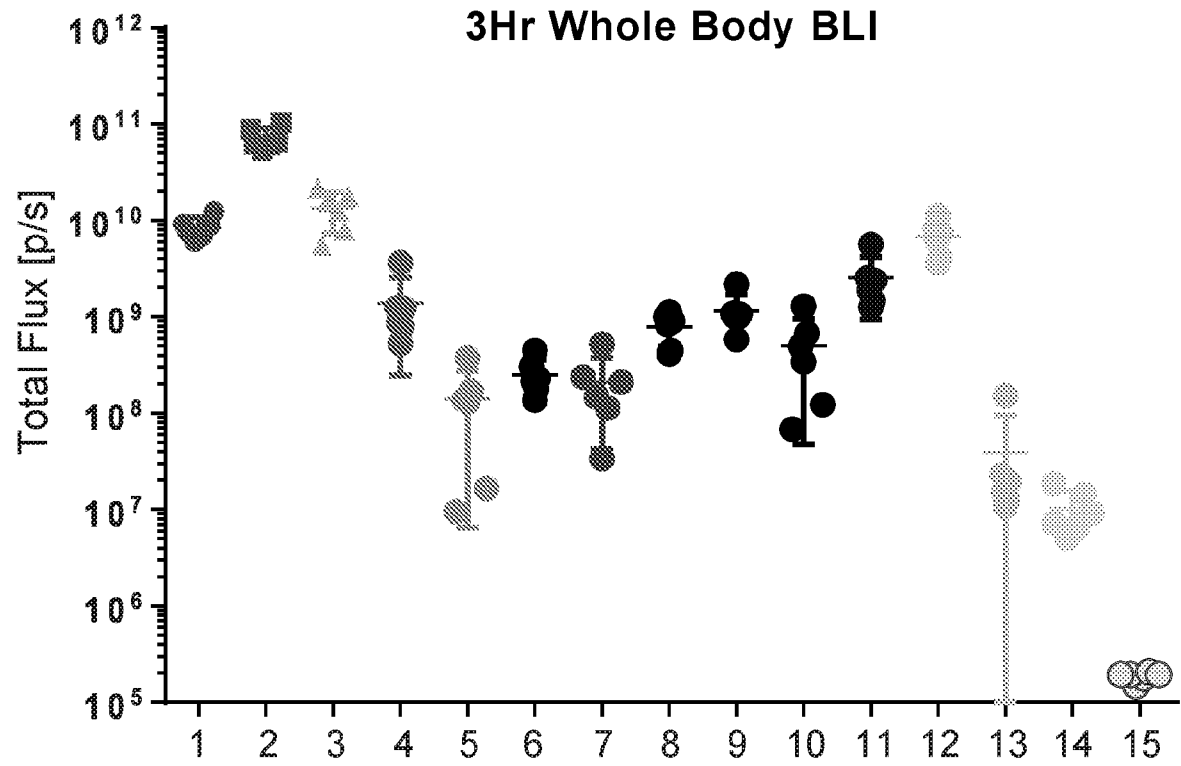


Fig. 13A

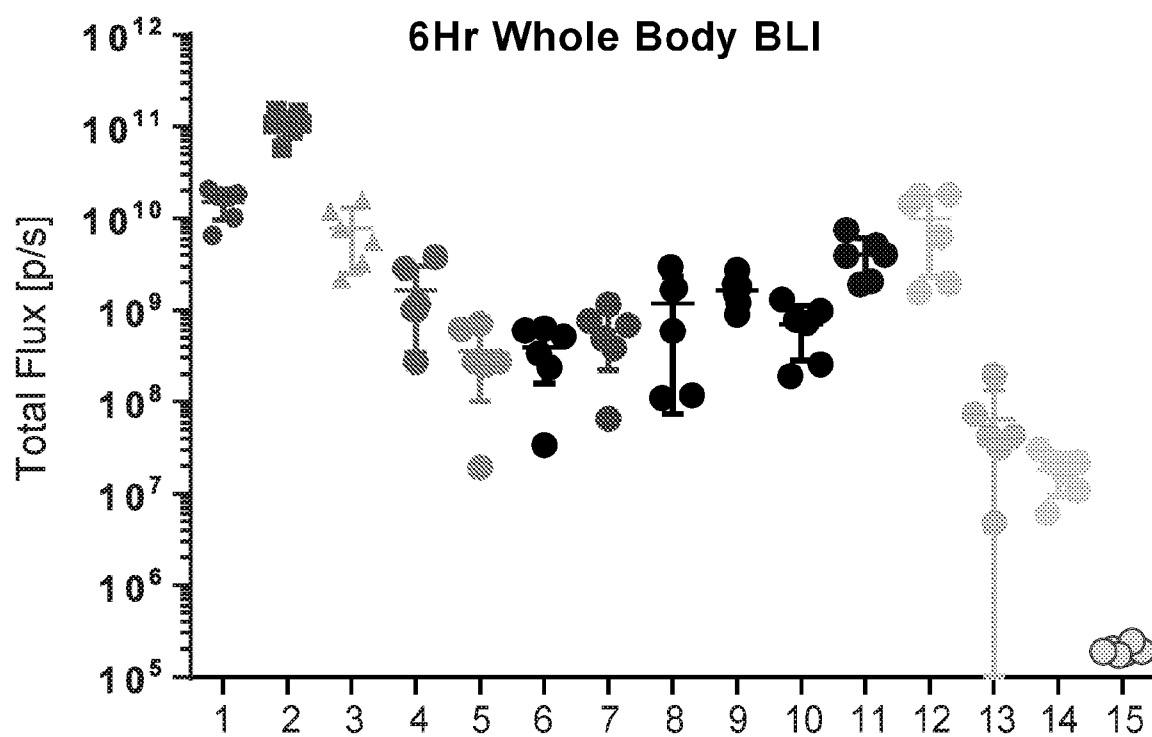


Fig. 13B

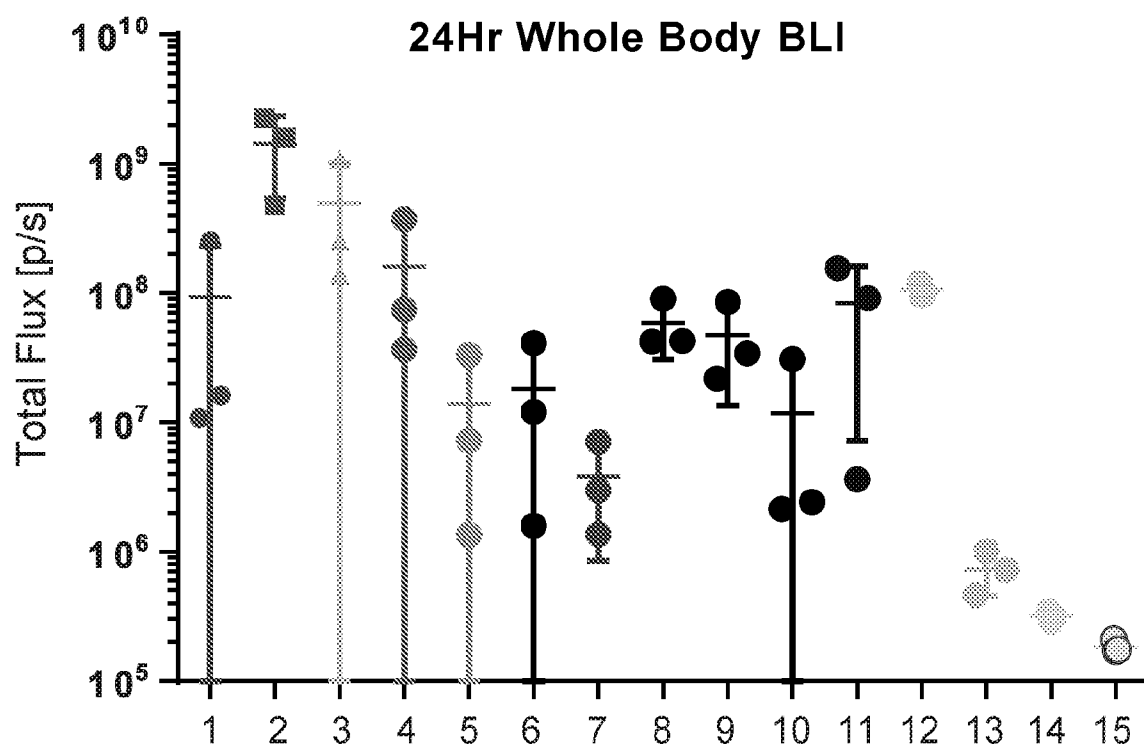


Fig. 13C

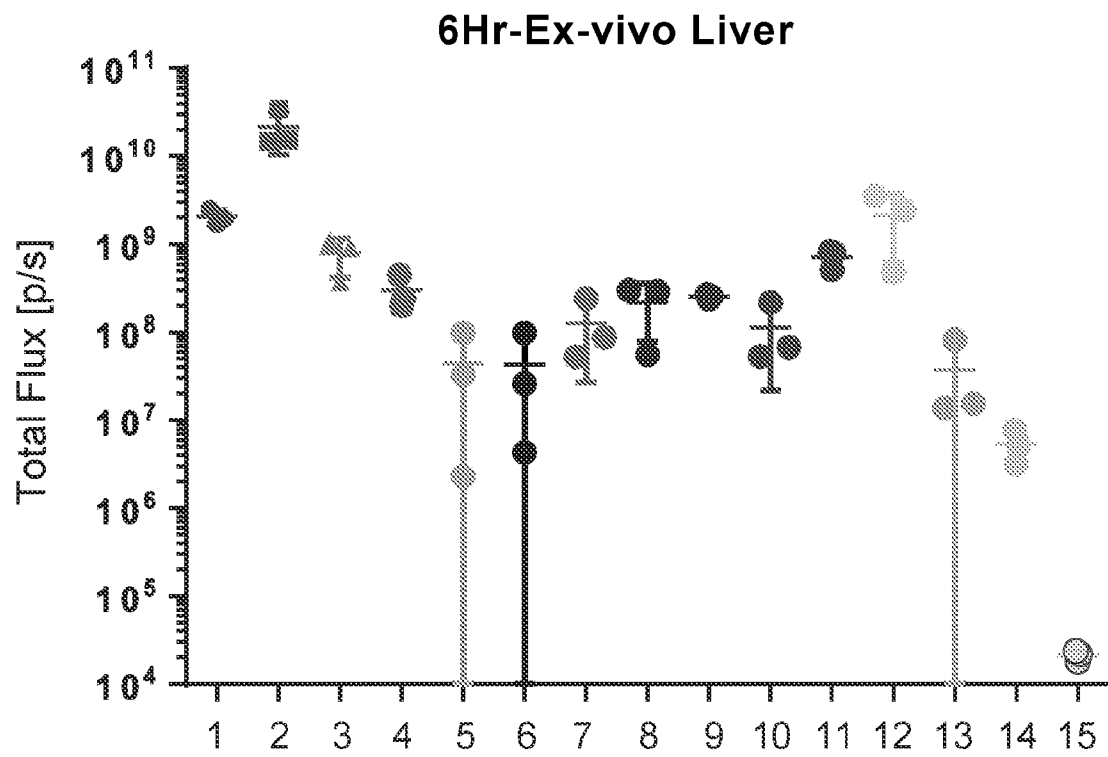


Fig. 14A

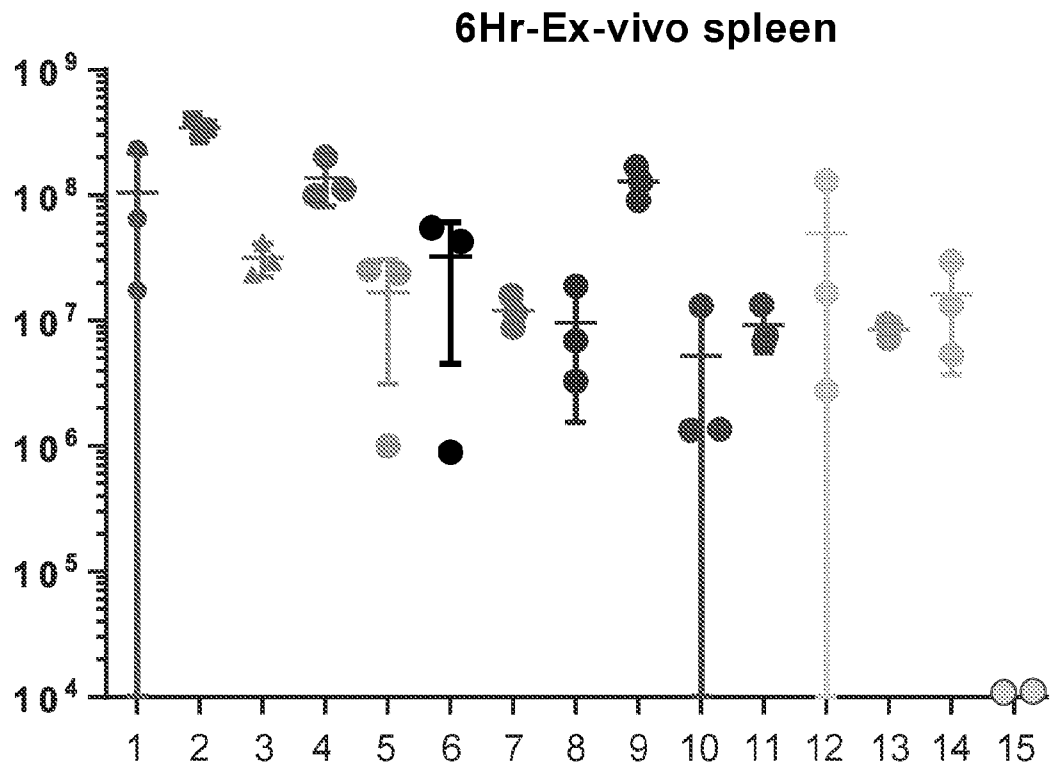


Fig. 14B

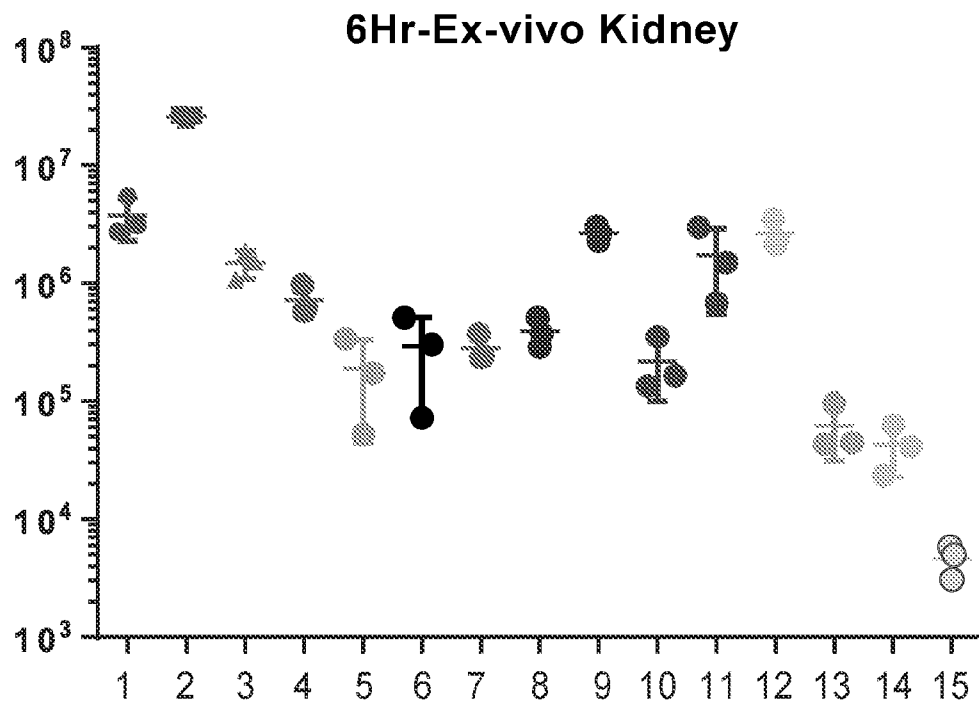


Fig. 14C

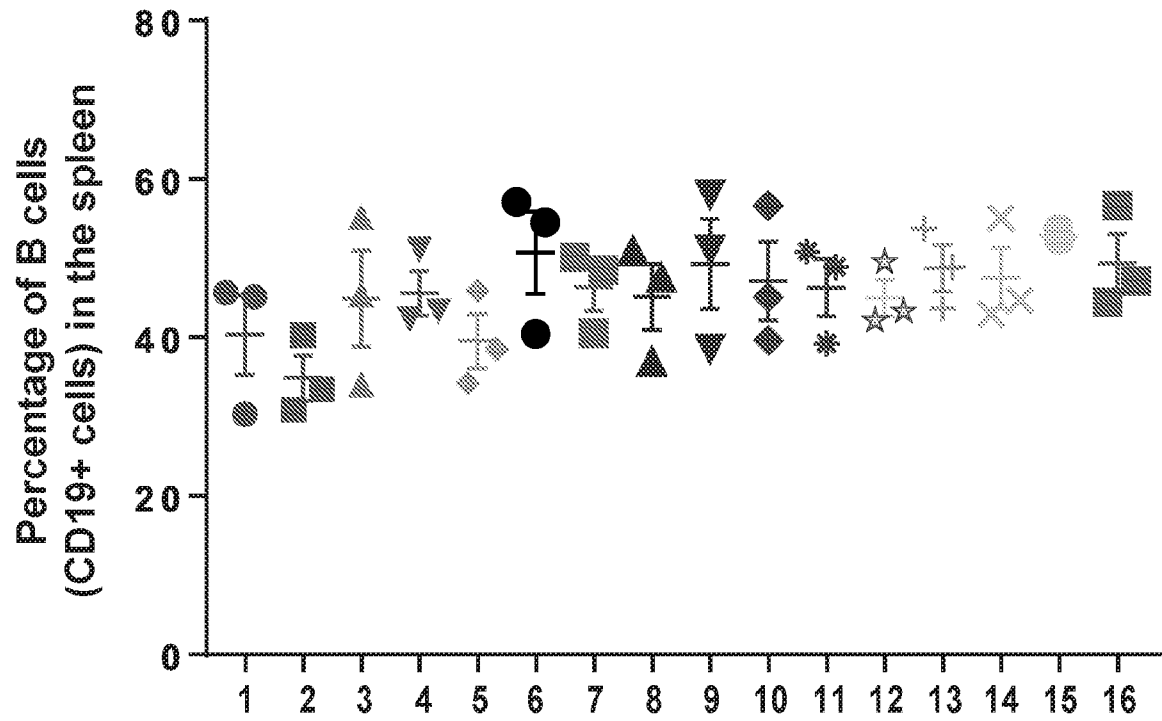


Fig. 15A

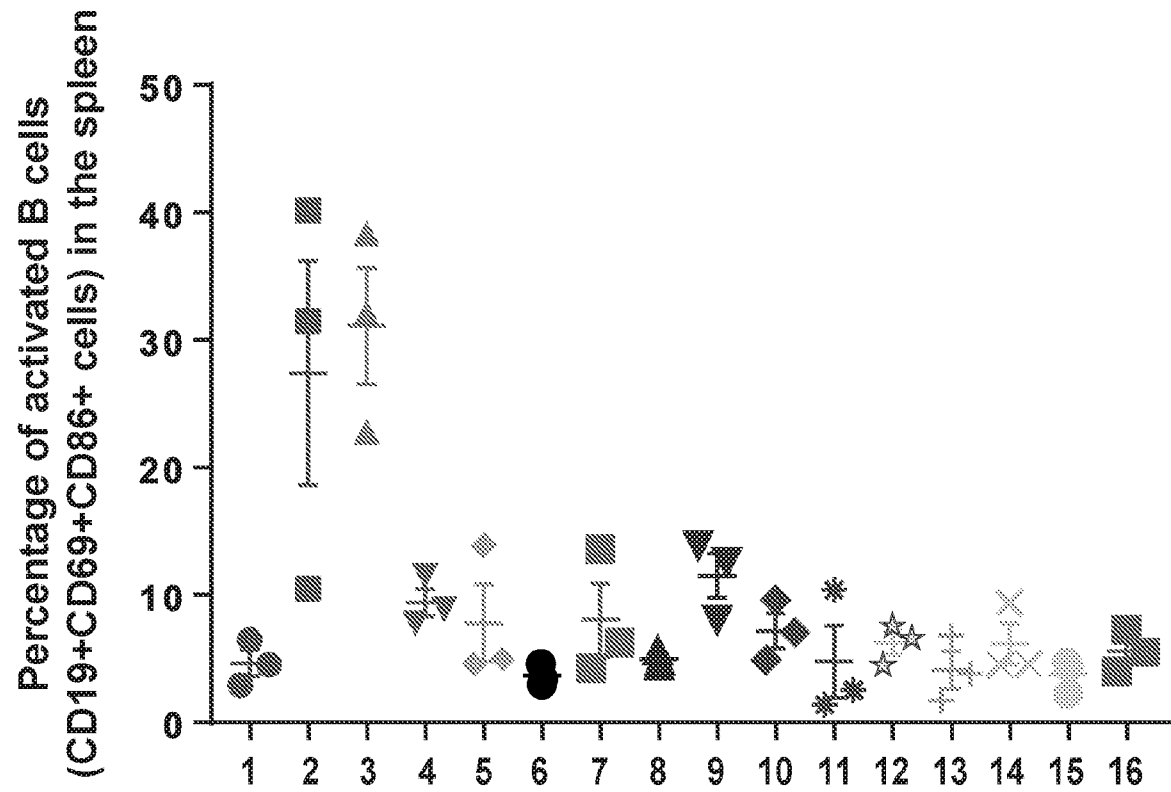


Fig. 15B

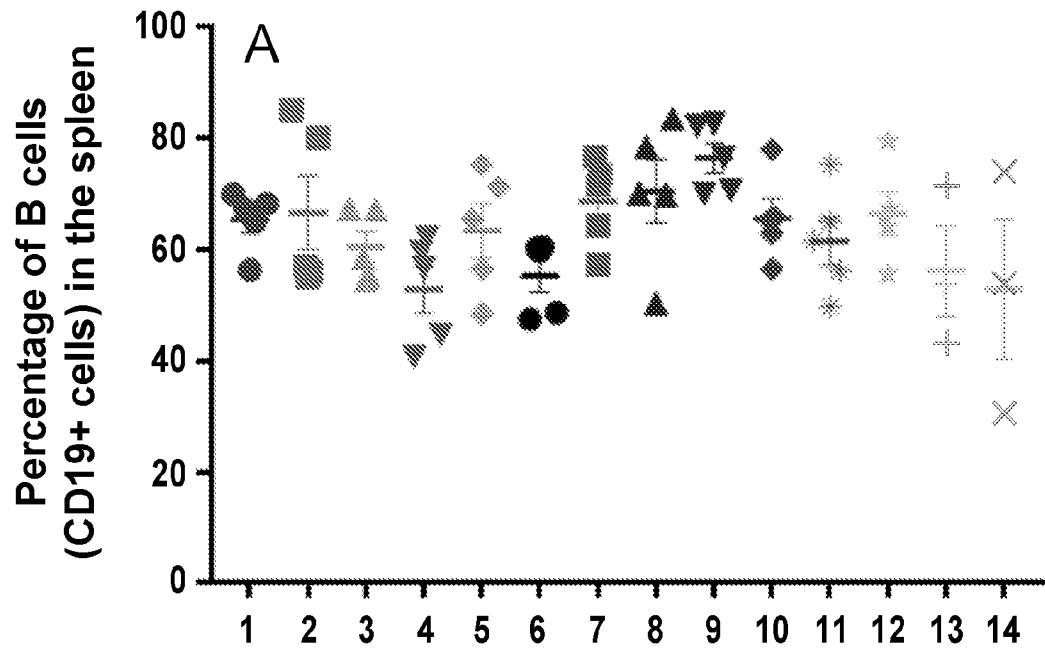


Fig. 16A

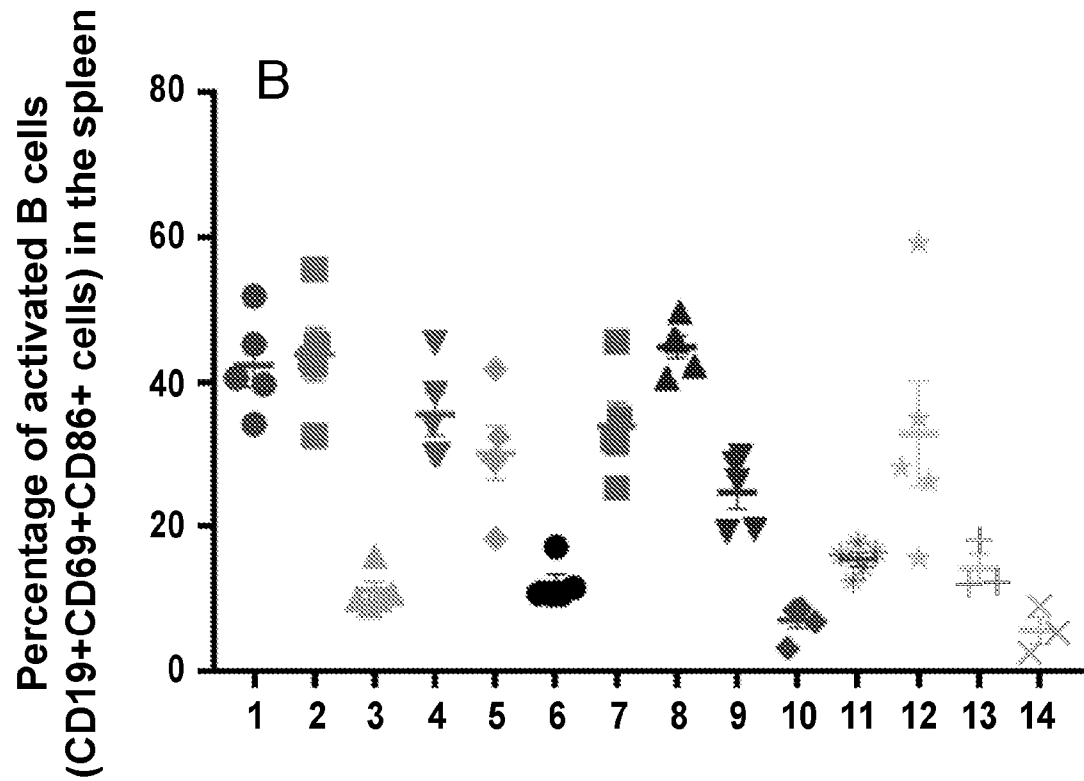


Fig. 16B

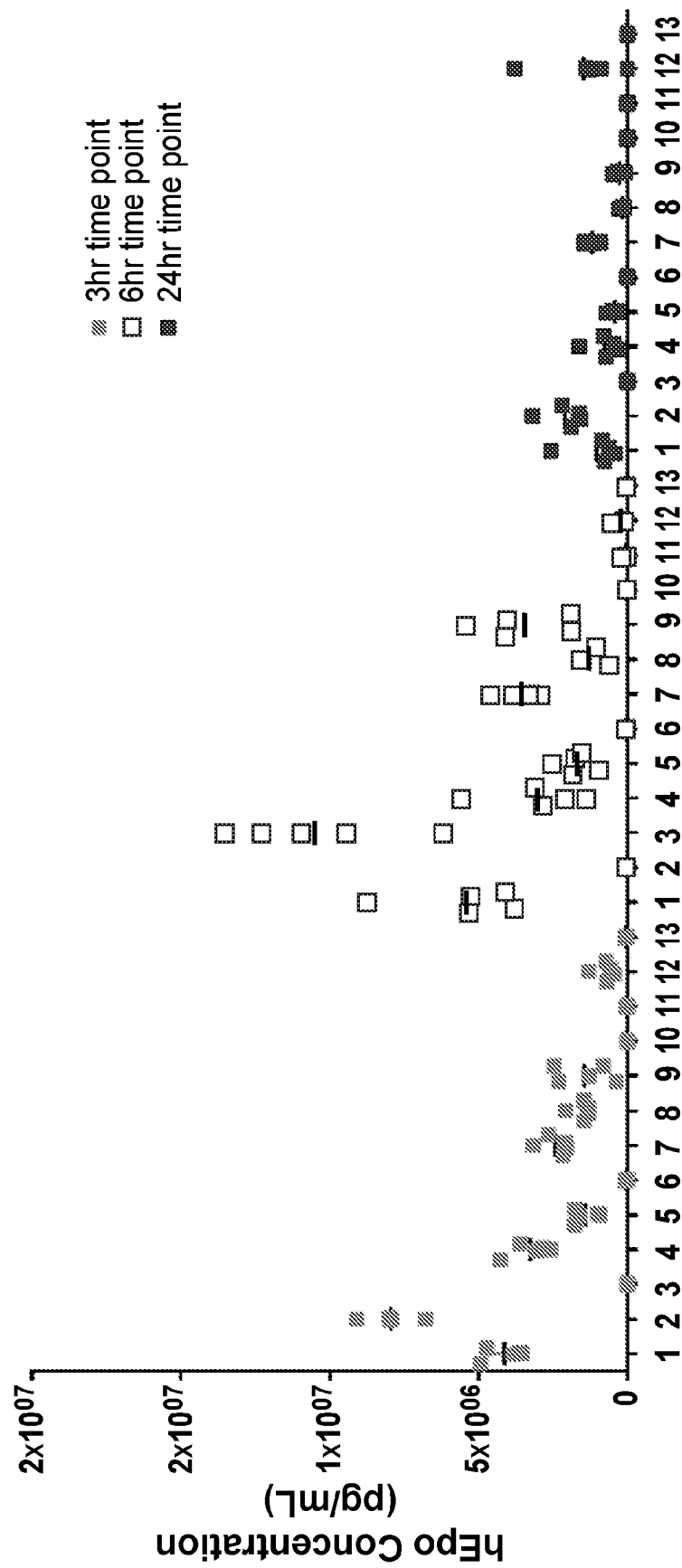


Fig. 17

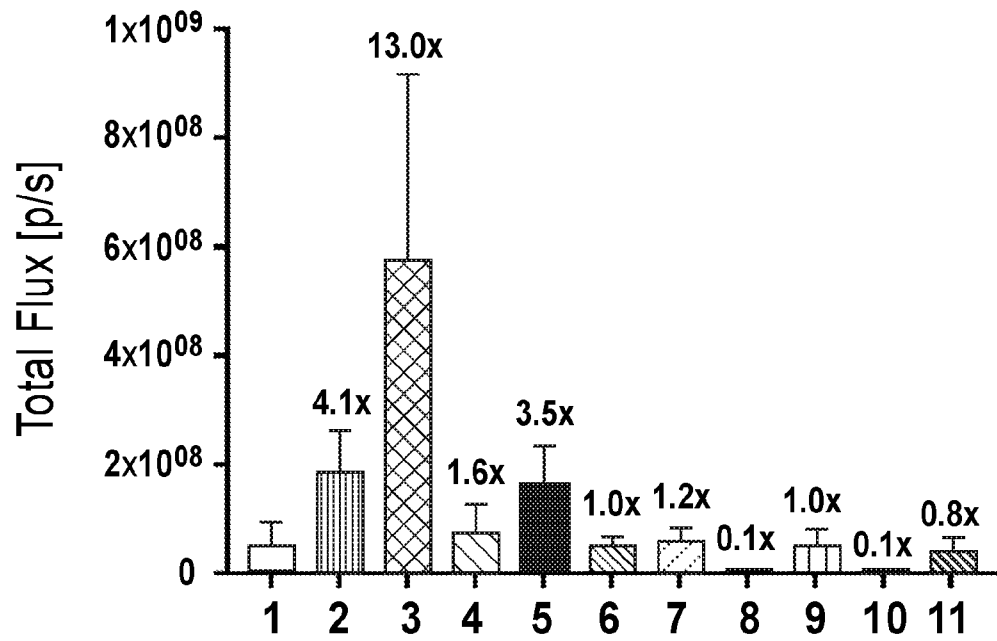


Fig. 18A

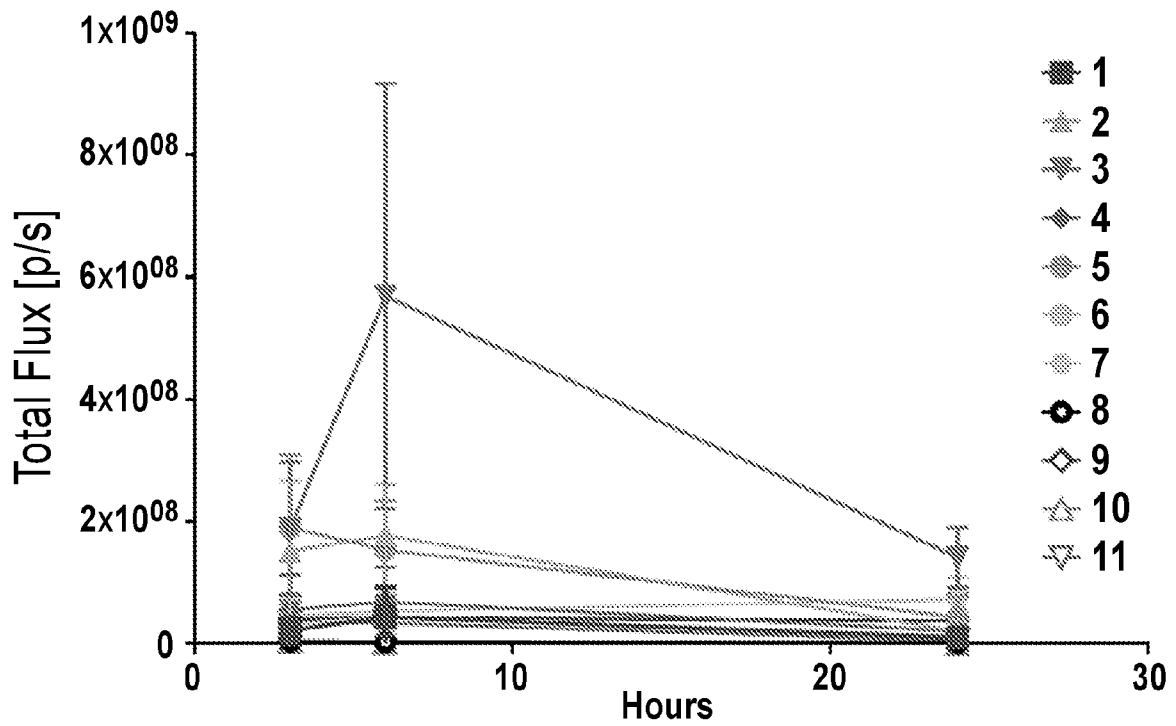


Fig. 18B

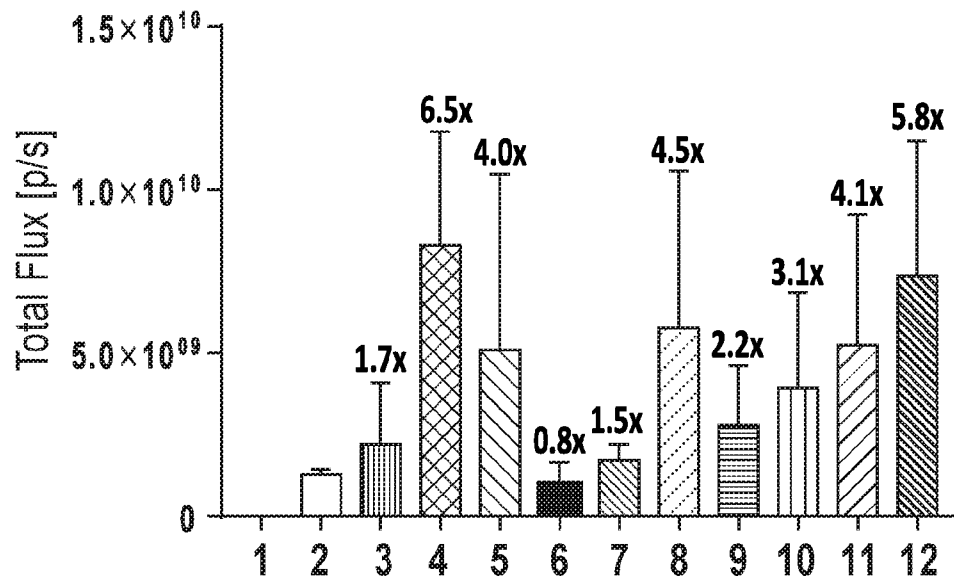


Fig. 19A

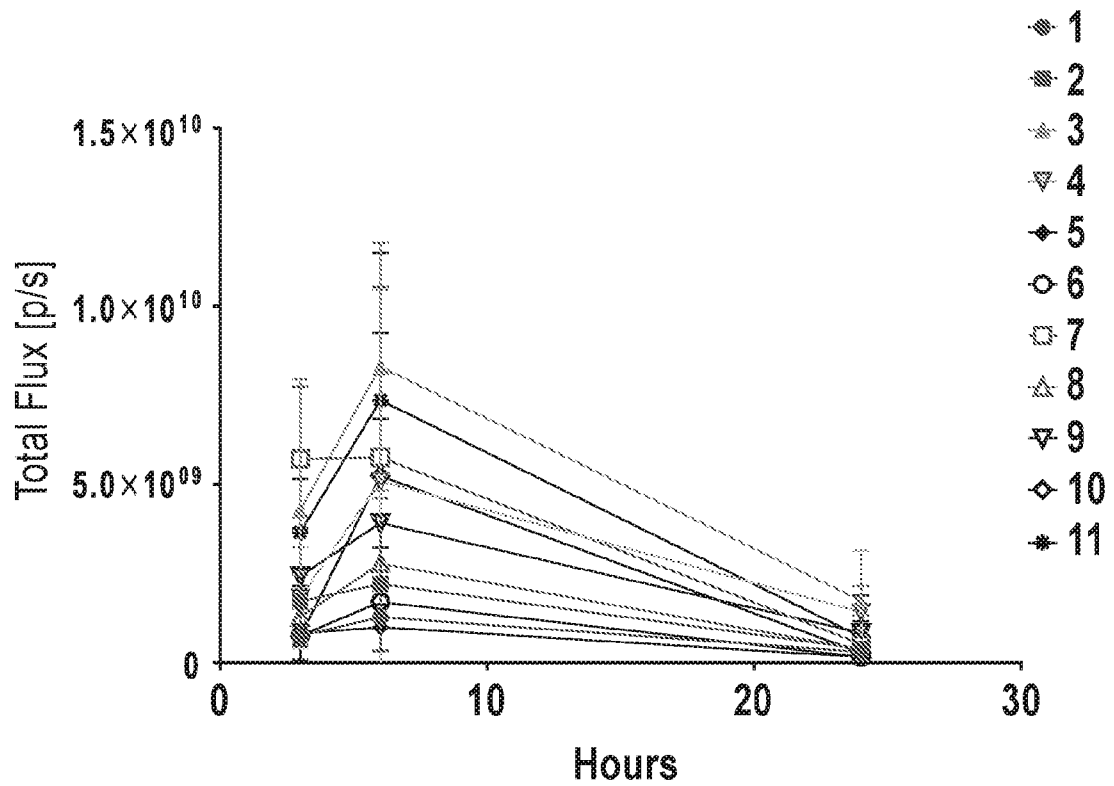
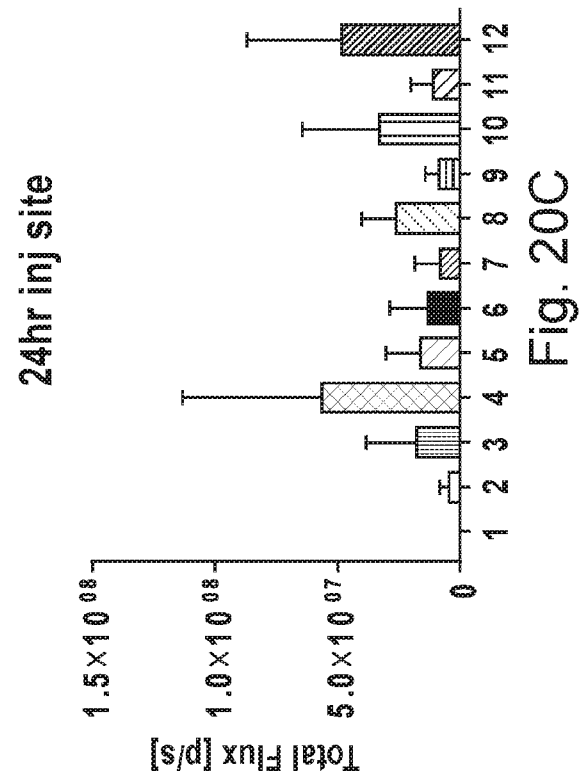
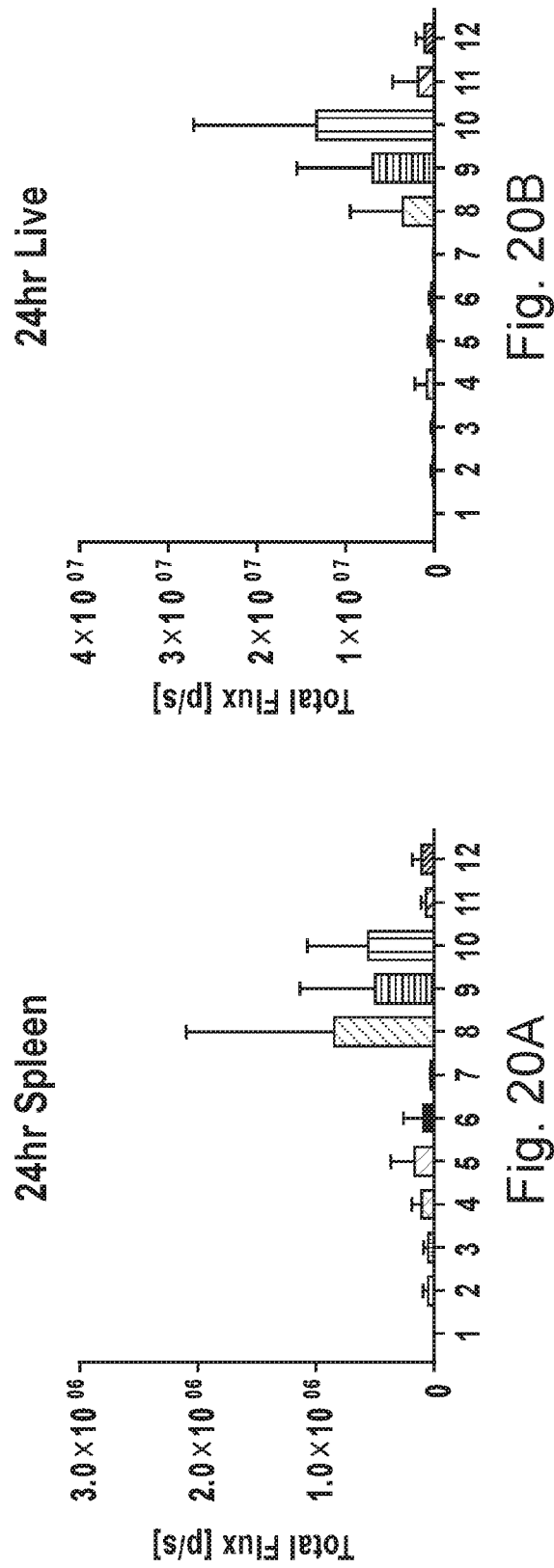


Fig. 19B



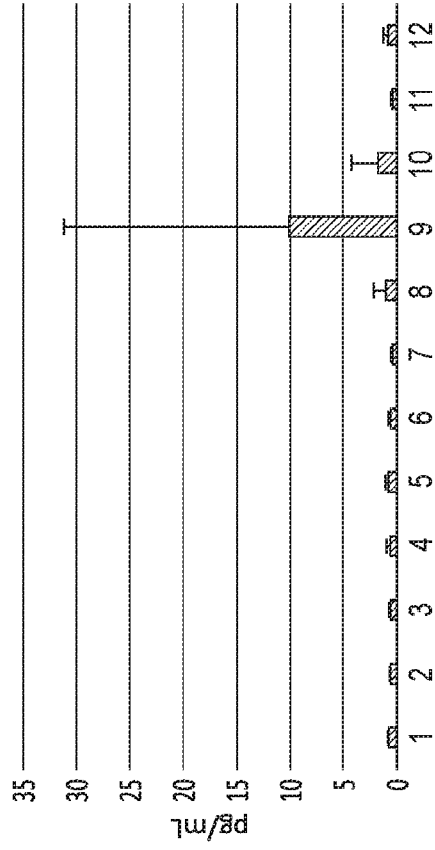


Fig. 21B

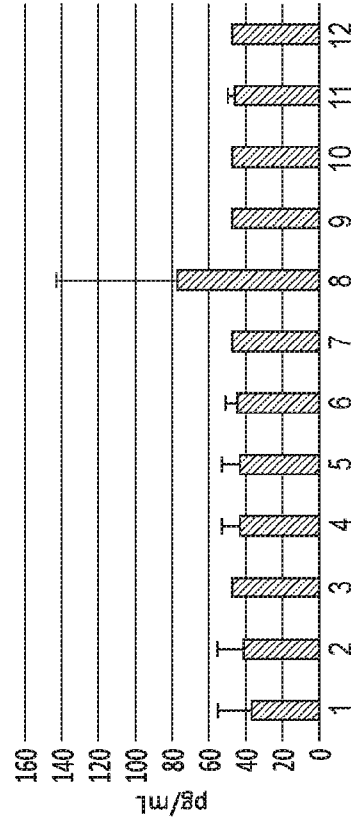


Fig. 21D

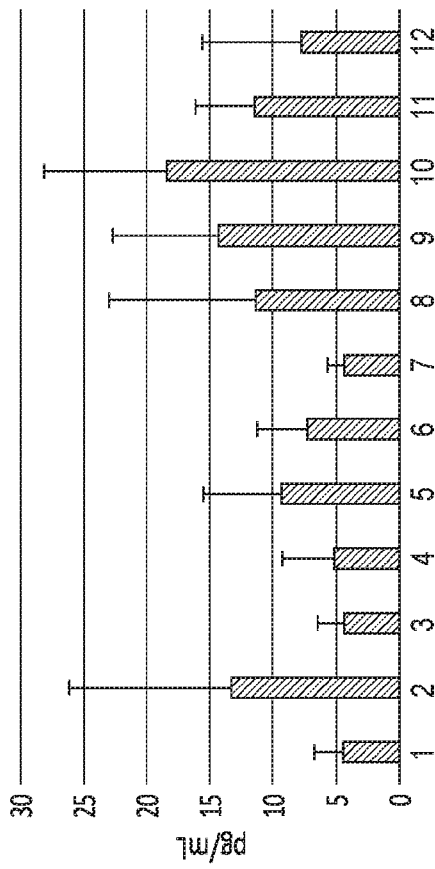


Fig. 21A

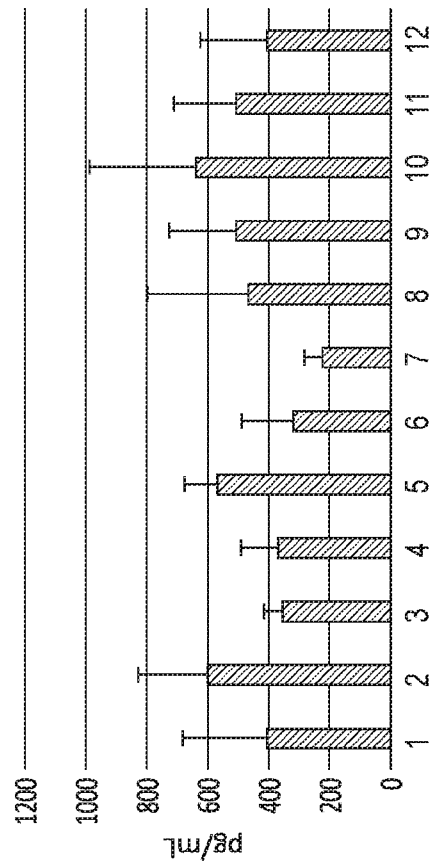


Fig. 21C

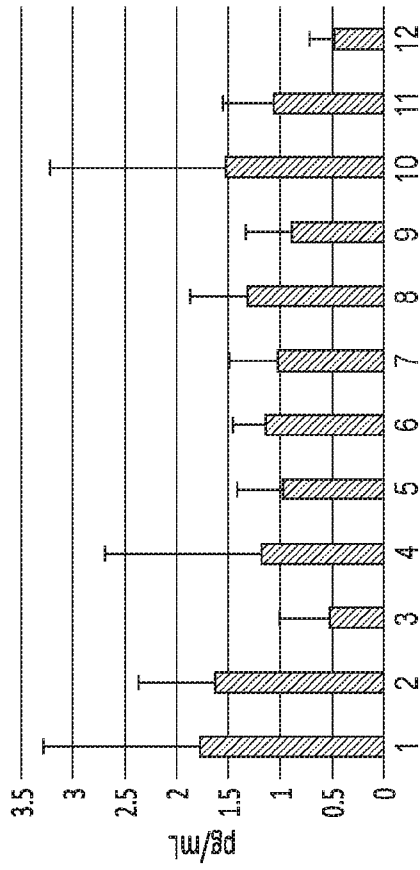


Fig. 21F

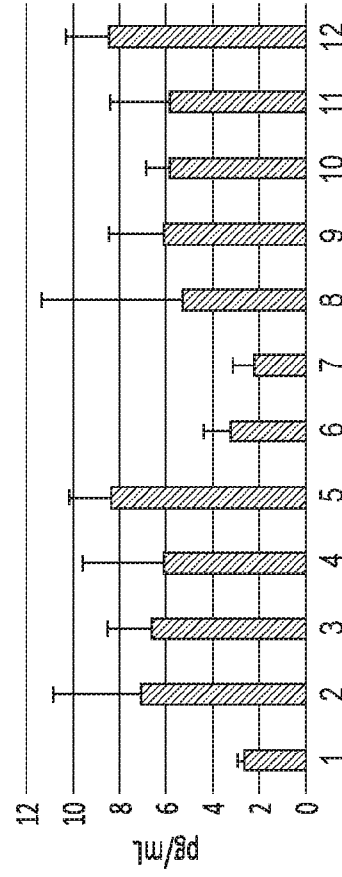


Fig. 21H

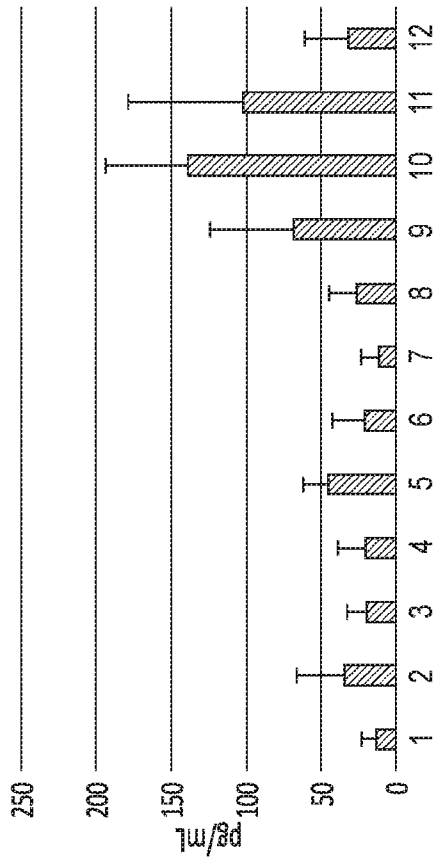


Fig. 21E

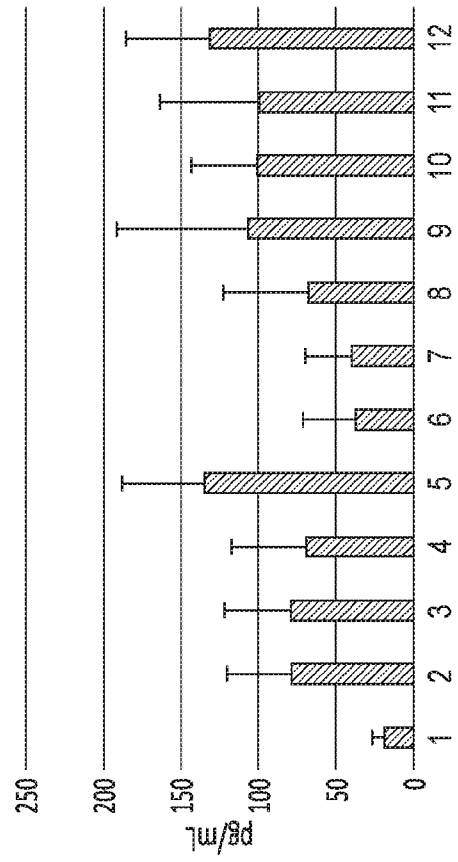


Fig. 21G

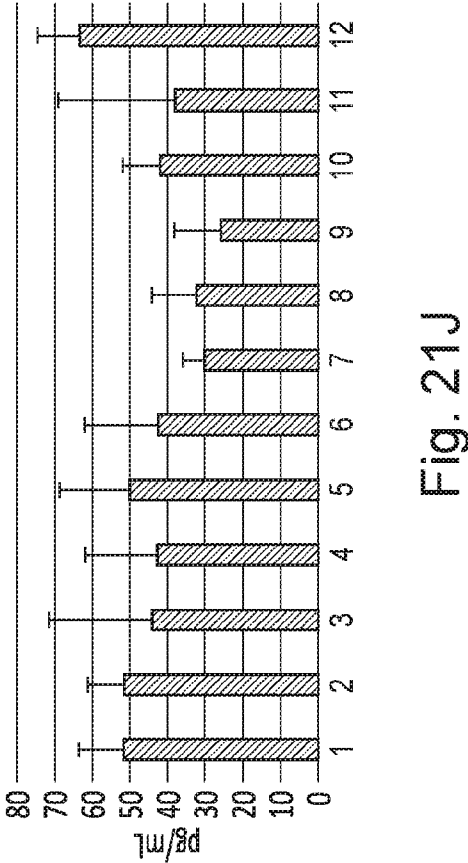


Fig. 21J

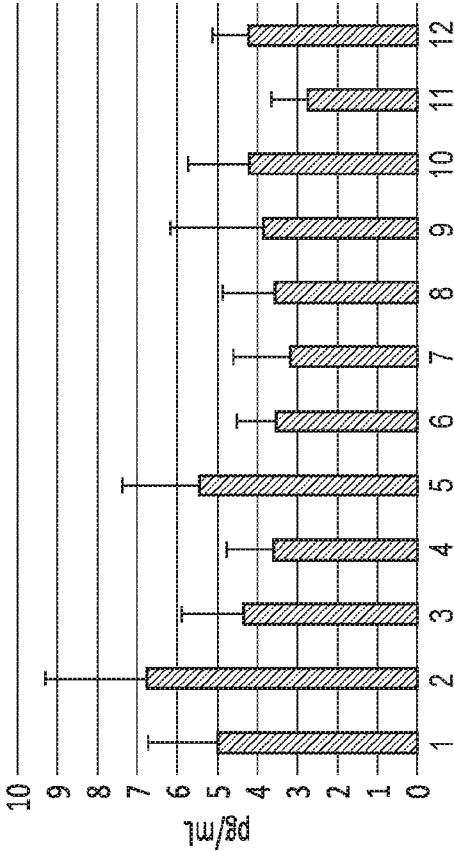


Fig. 21I

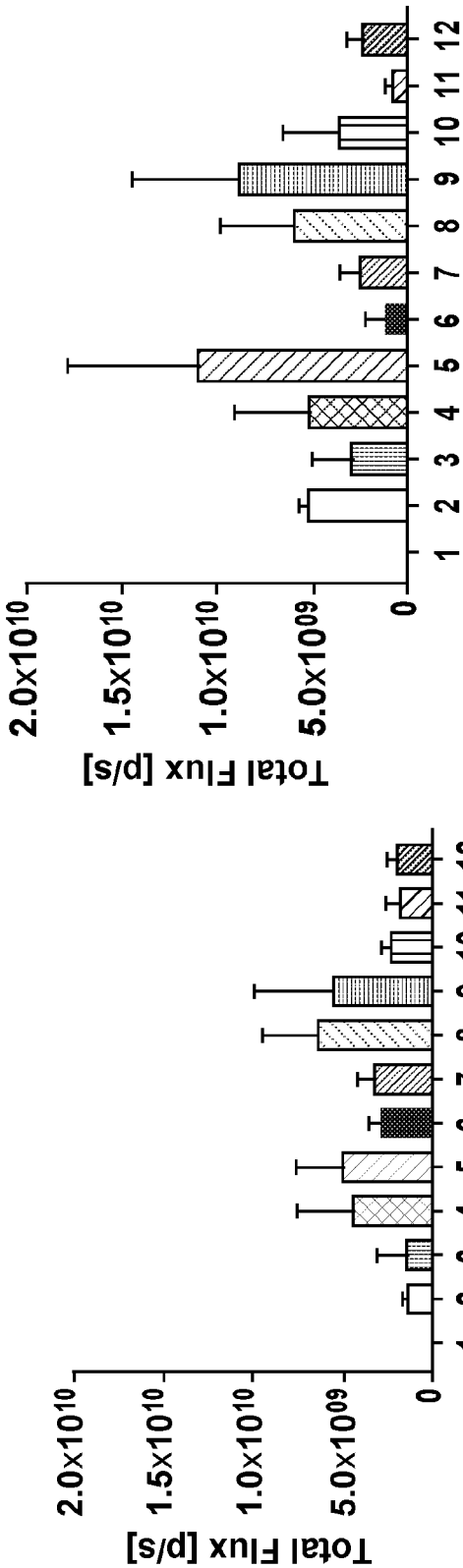


Fig. 22B

Fig. 22A

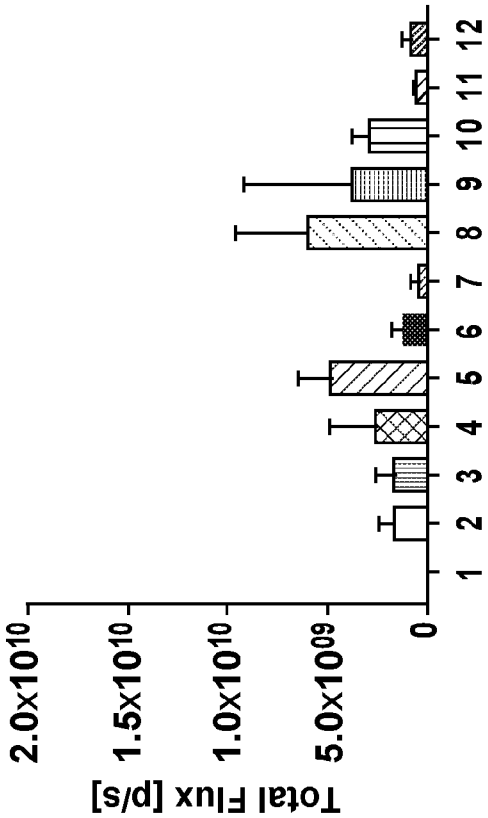
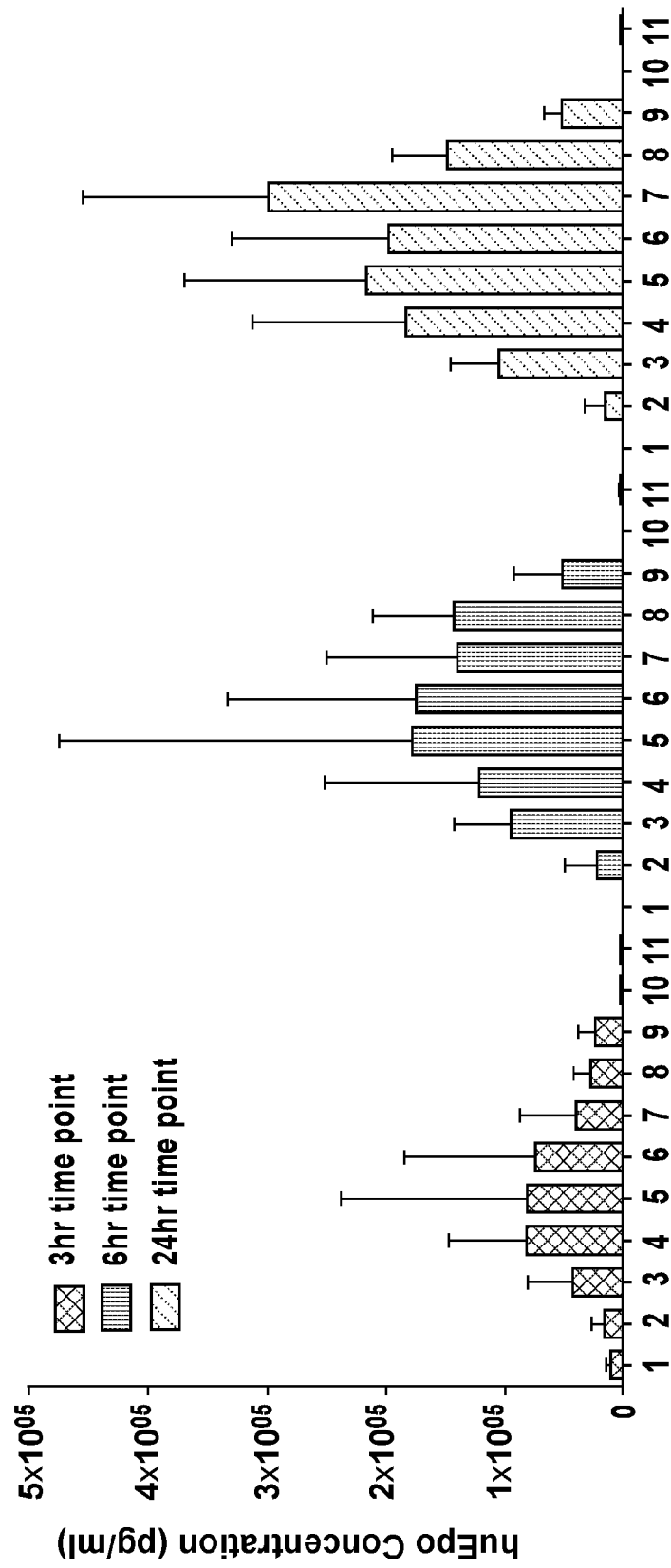


Fig. 22C

Fig. 23



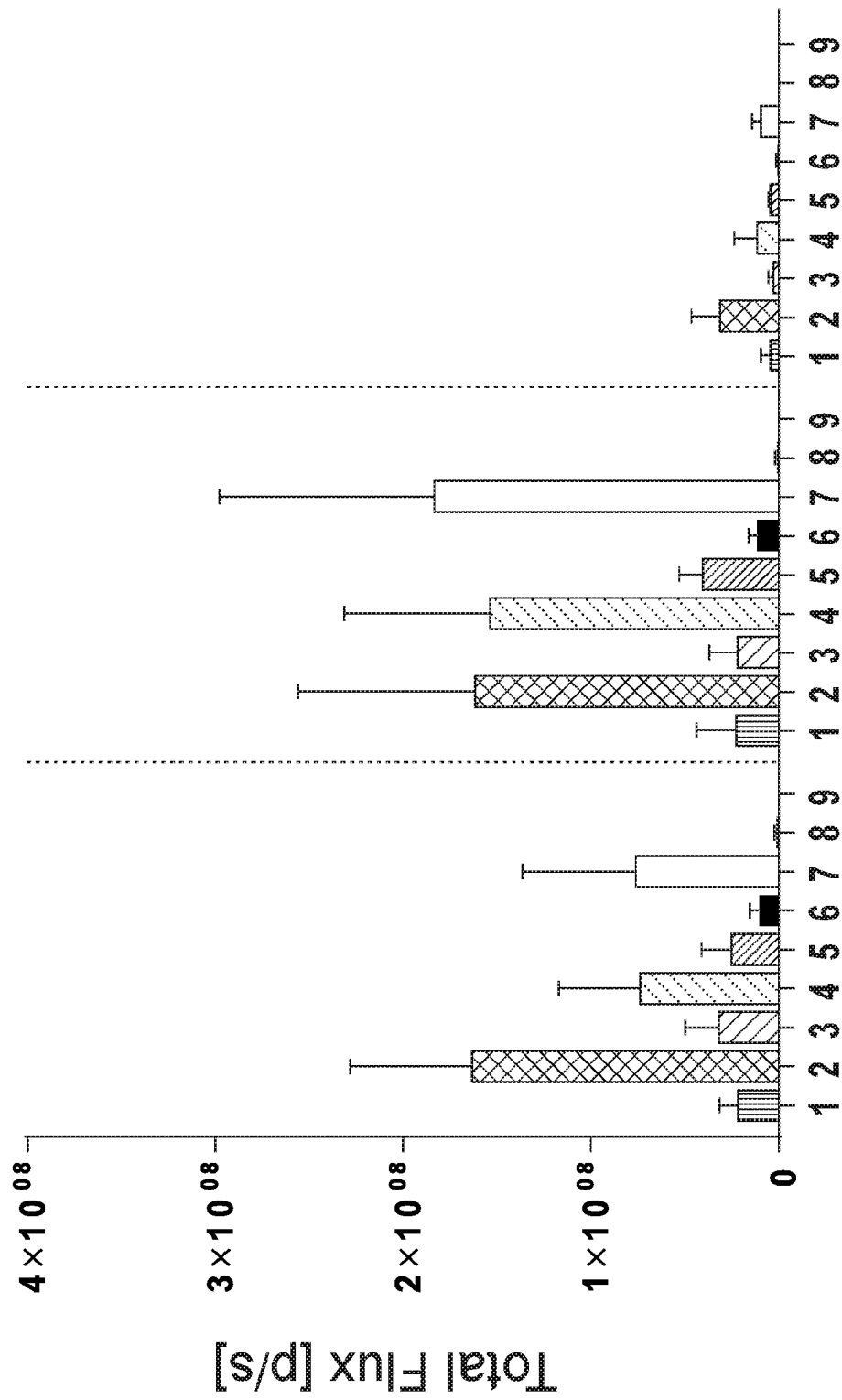


Fig. 24

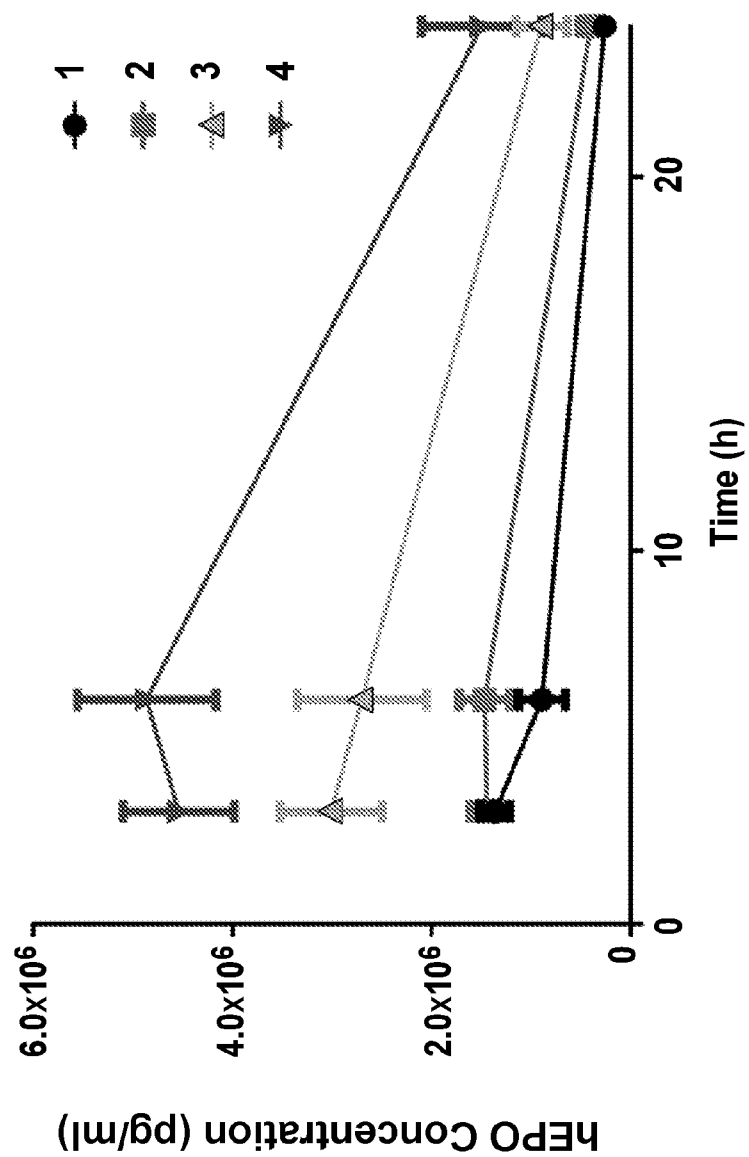


Fig. 25

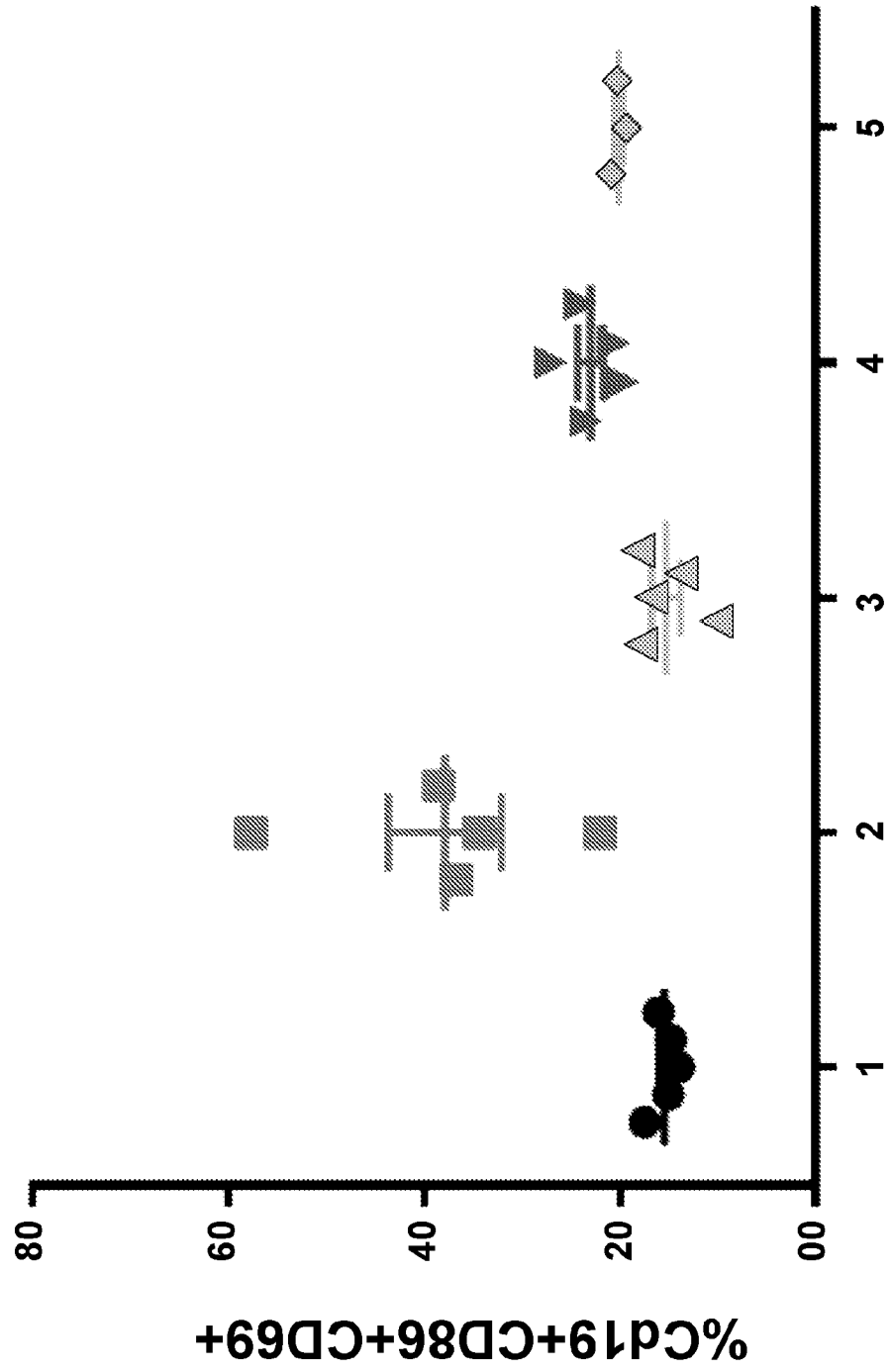


Fig. 26

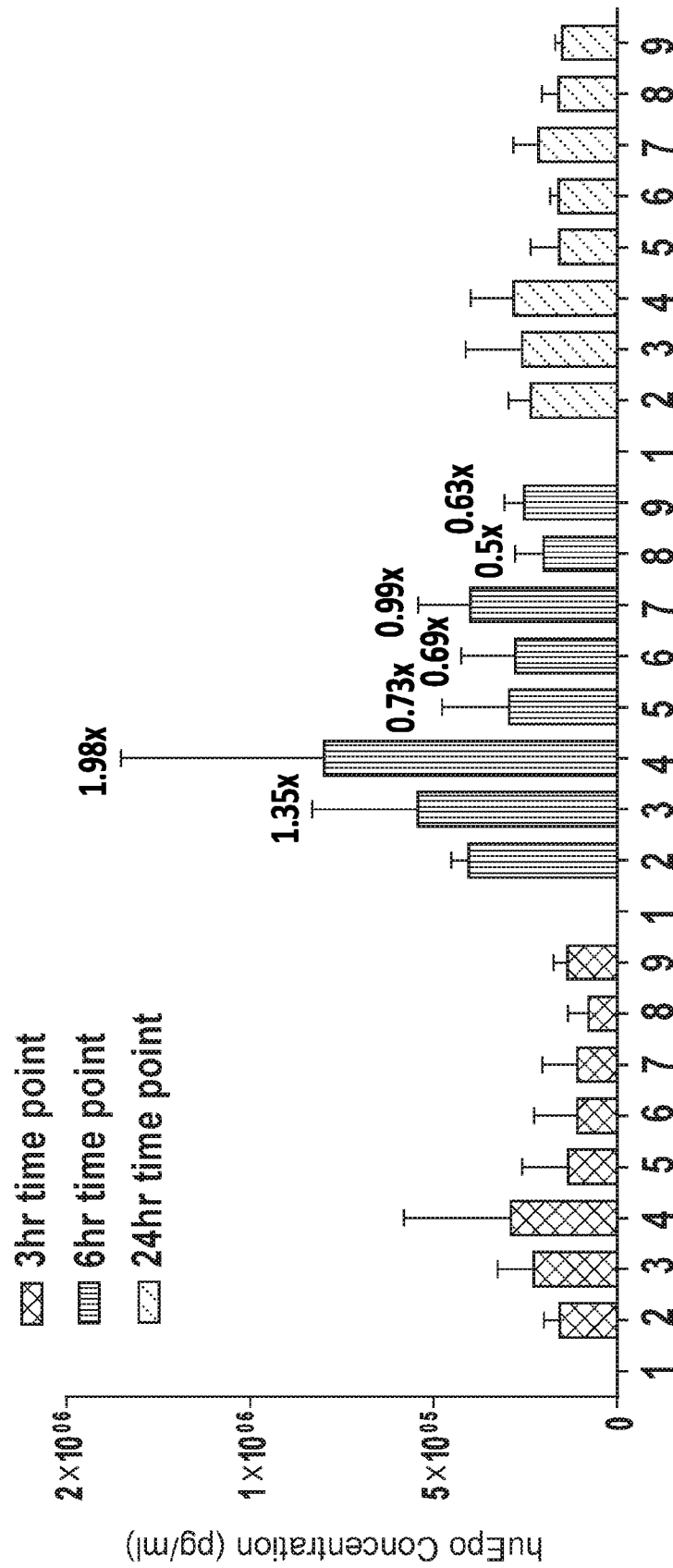


Fig. 27

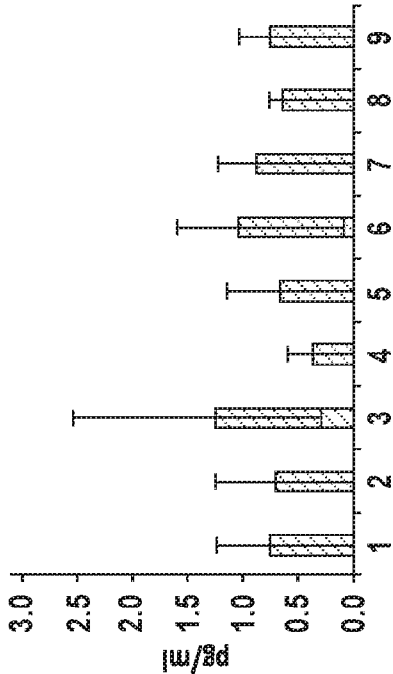


Fig. 28B

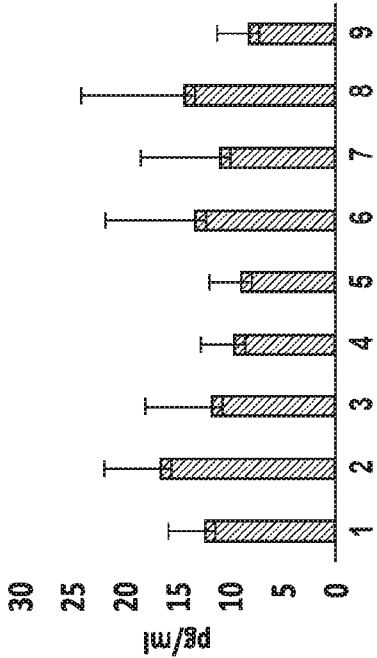


Fig. 28D

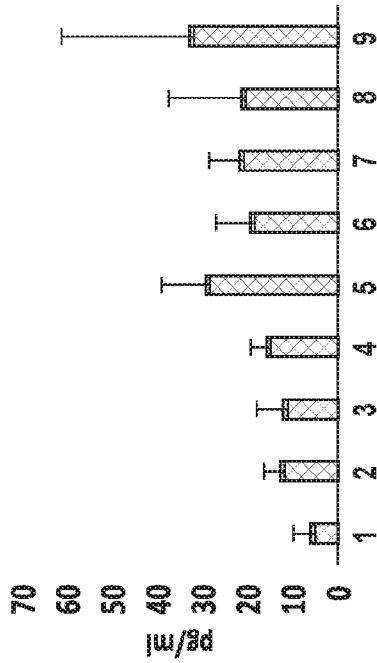


Fig. 28A

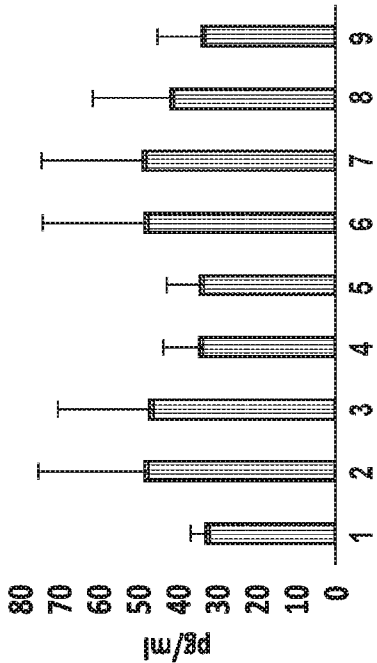
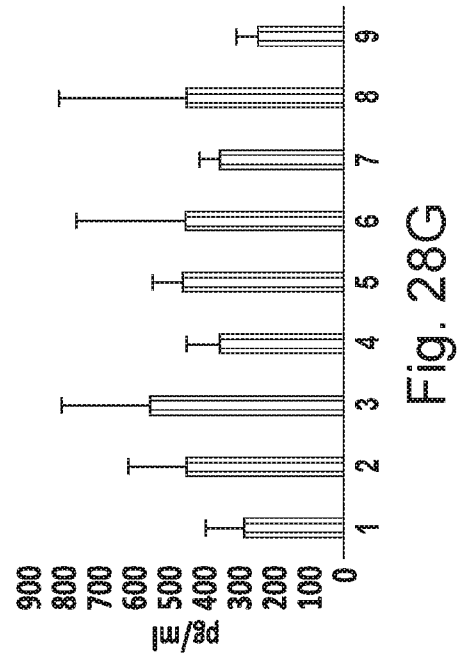
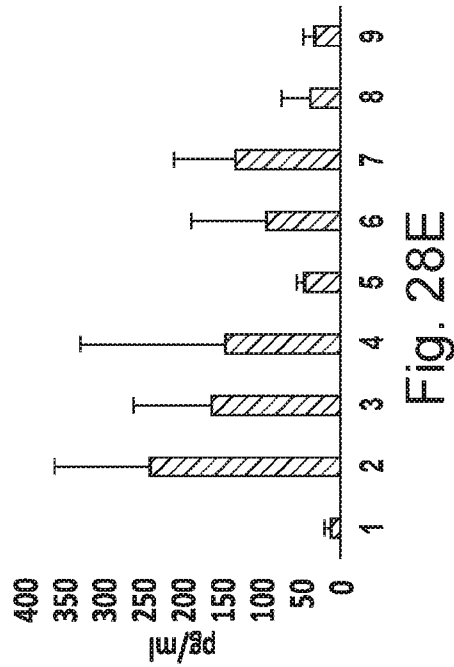
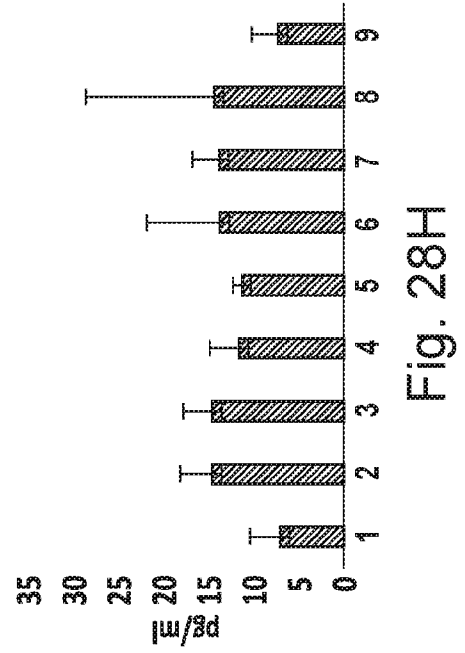
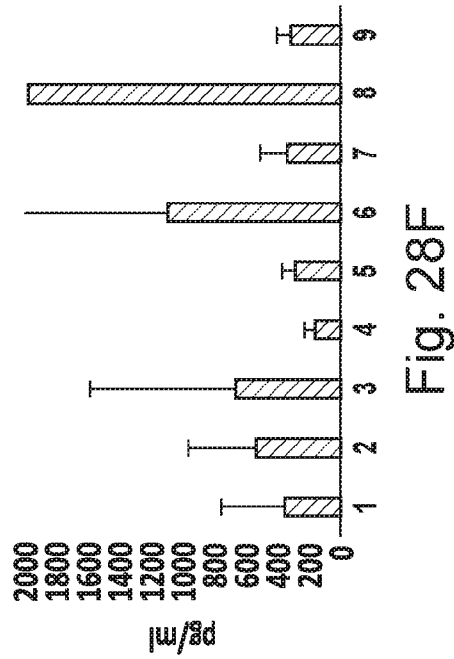


Fig. 28C



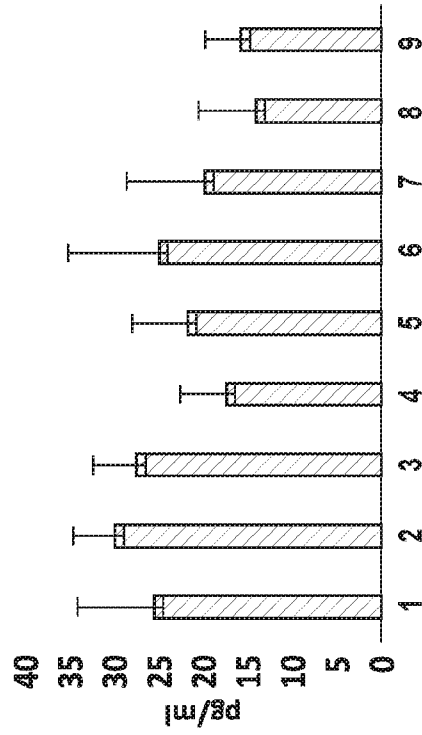


Fig. 28J

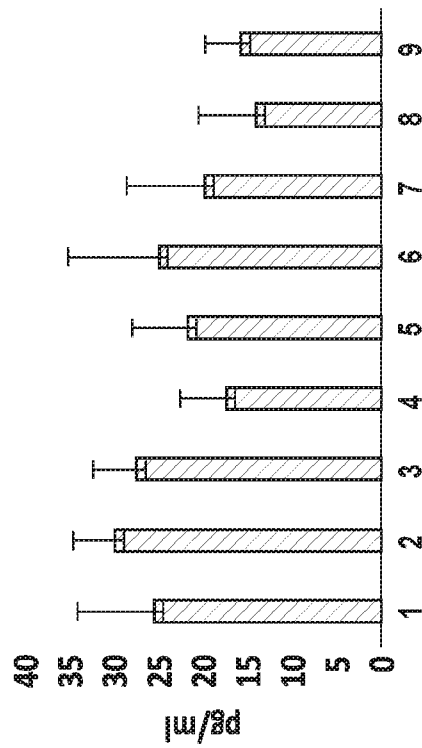
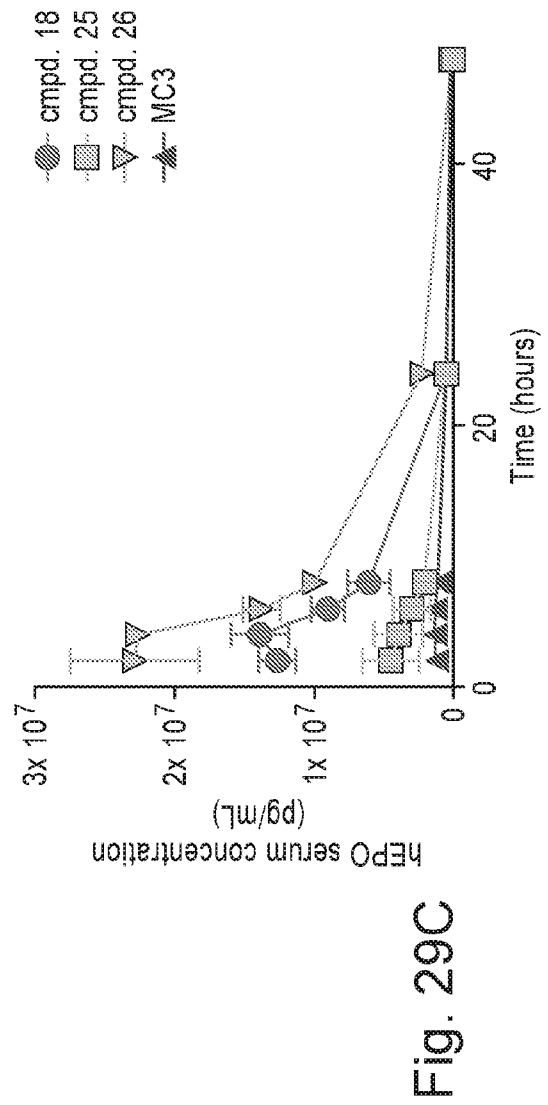
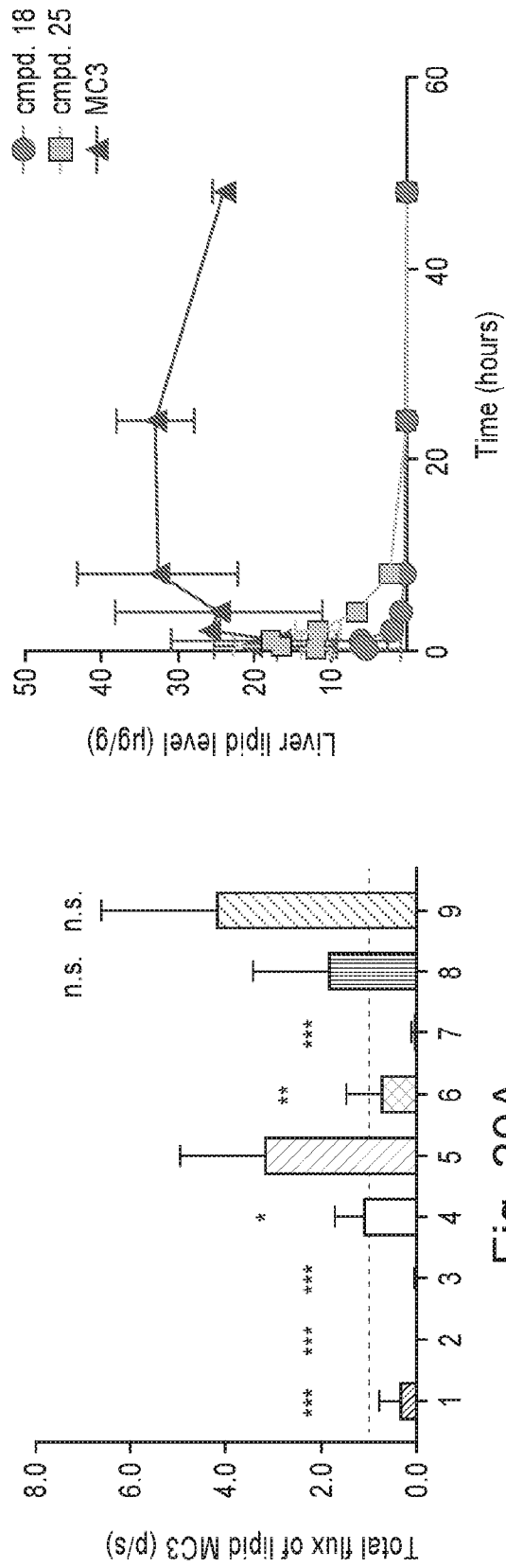


Fig. 28I



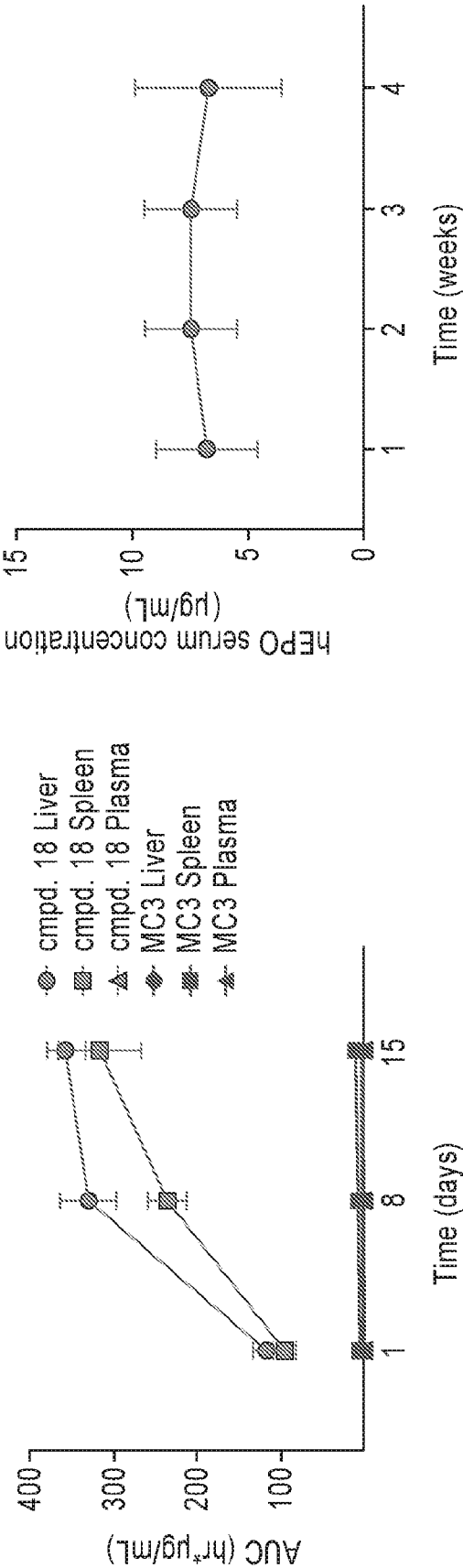


Fig. 30A

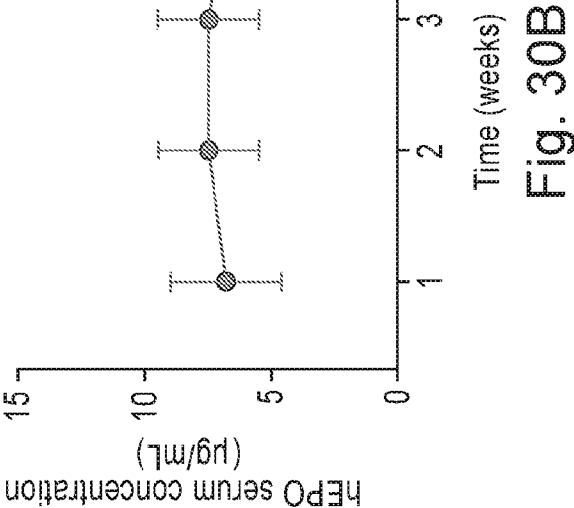


Fig. 30B

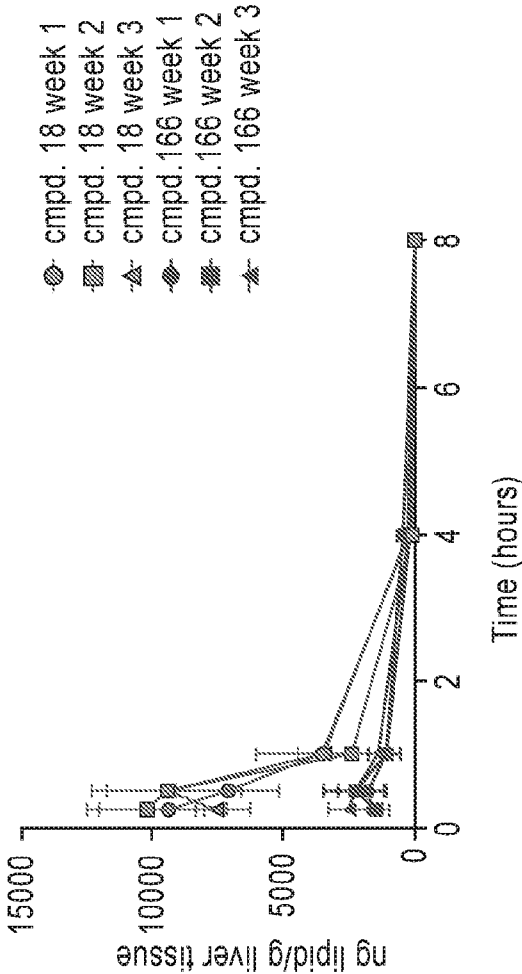


Fig. 30C

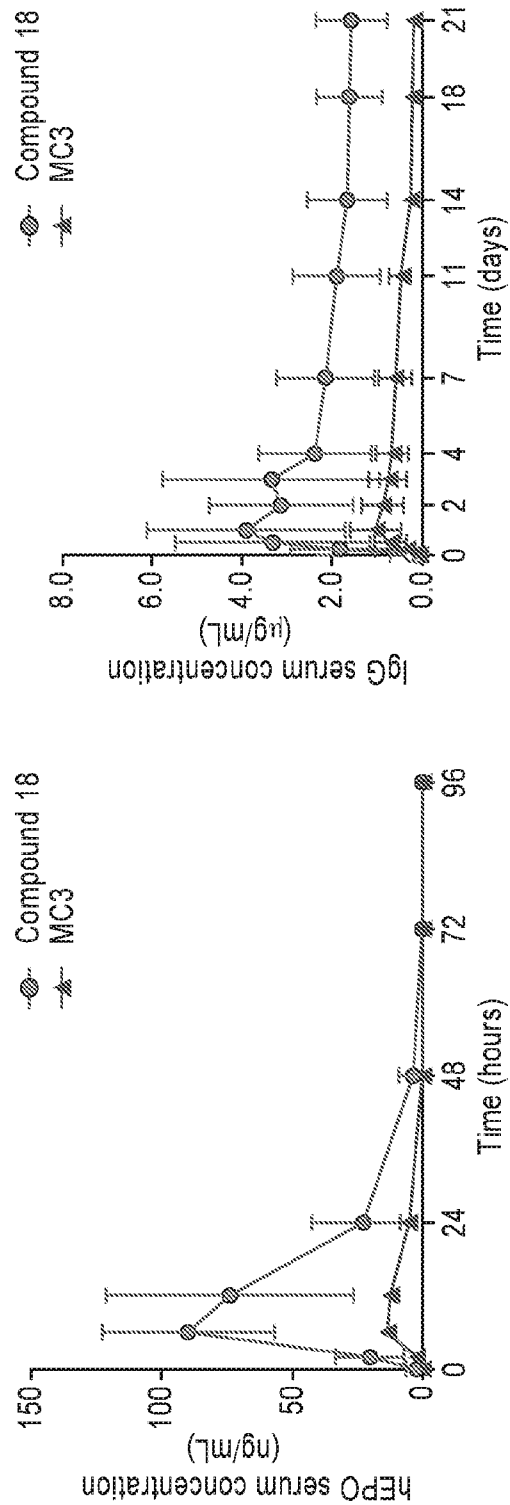


Fig. 31A

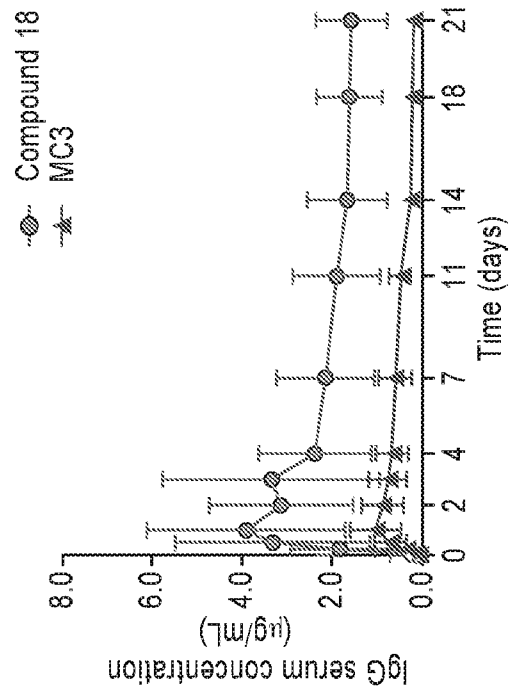


Fig. 31B

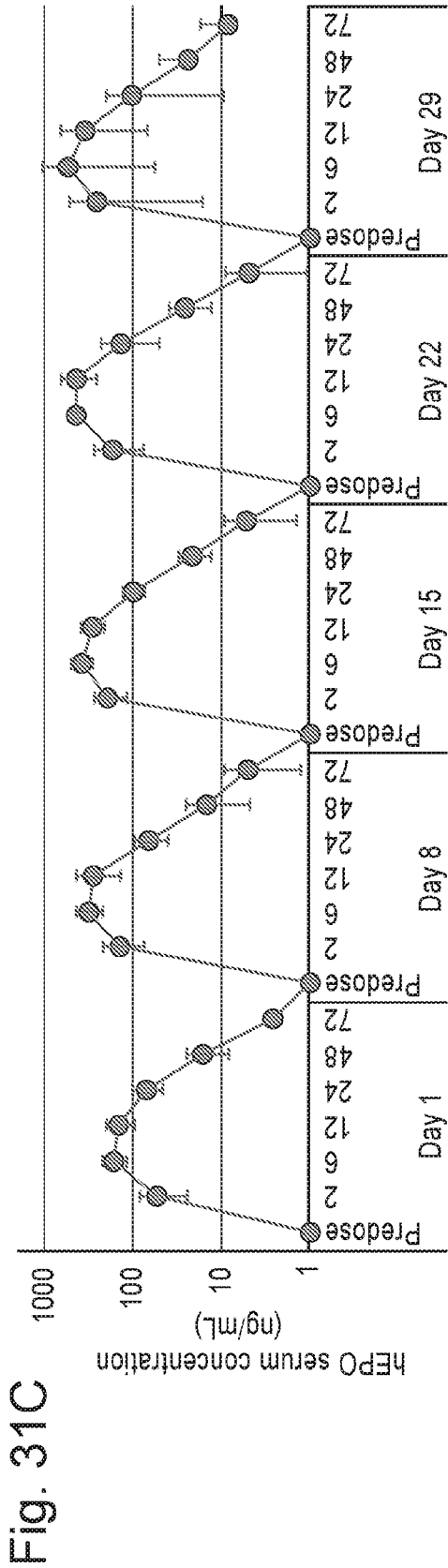


Fig. 31C

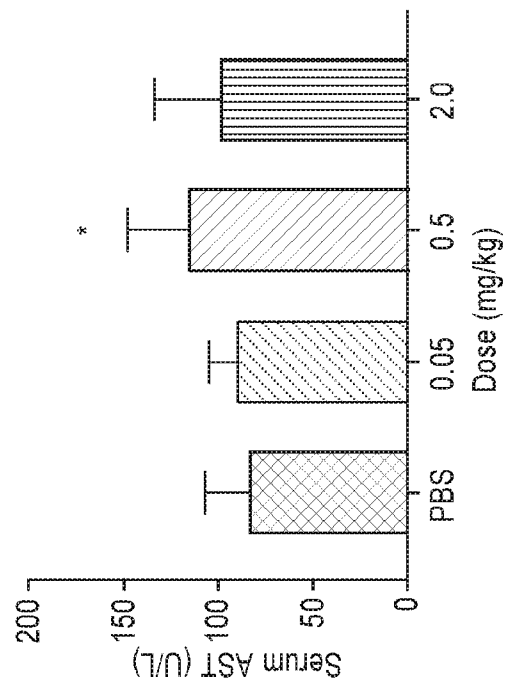


Fig. 32B

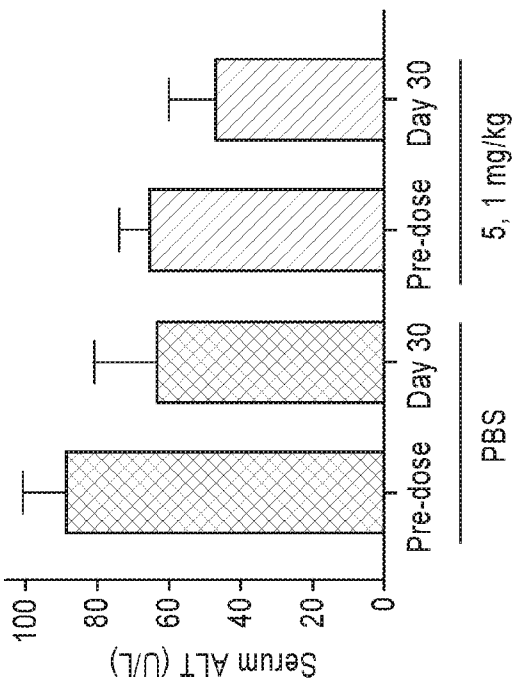


Fig. 32D

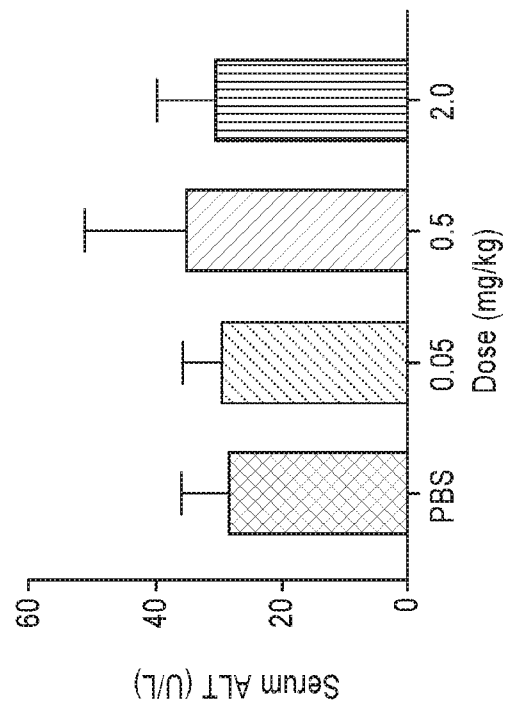


Fig. 32A

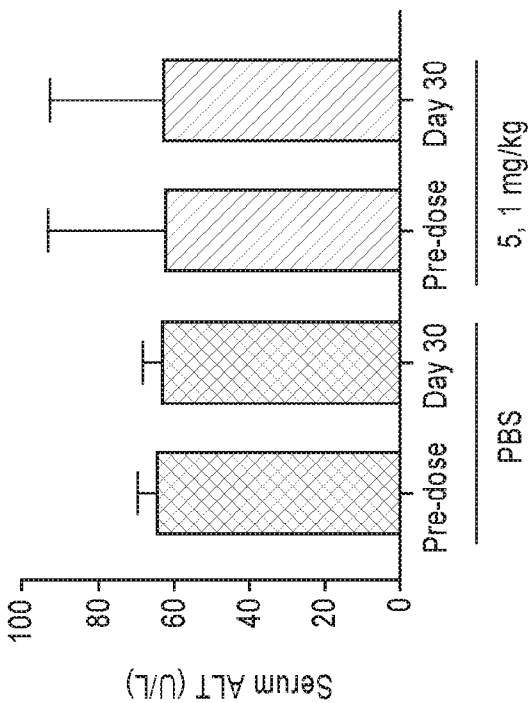


Fig. 32C

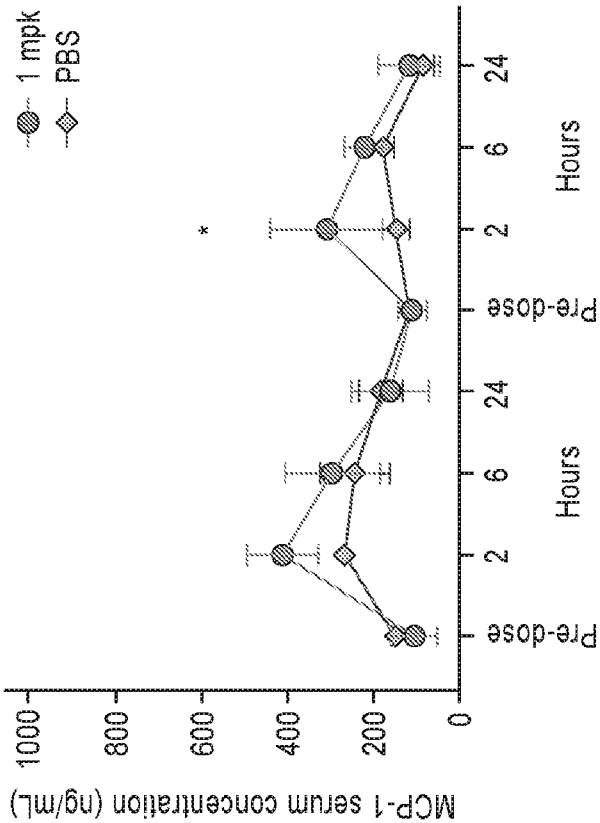


Fig. 33B

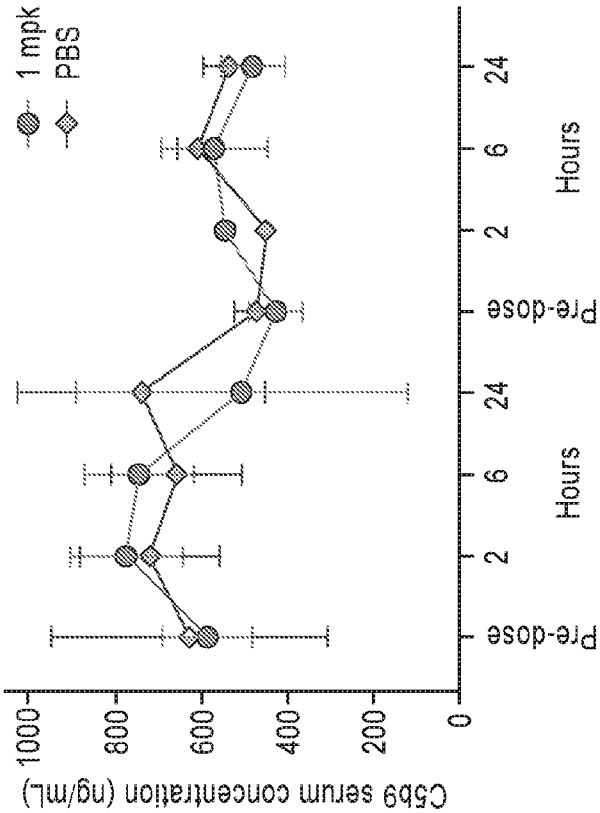
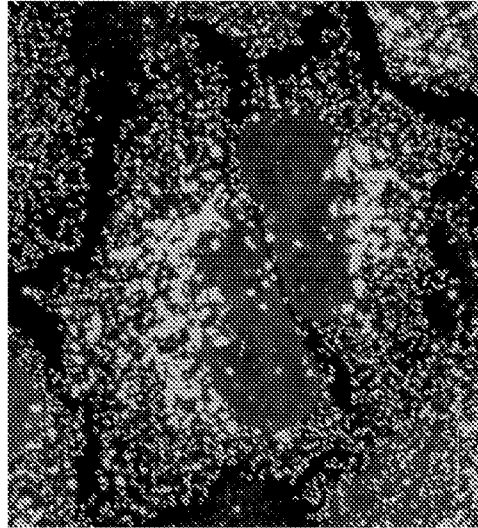


Fig. 33A



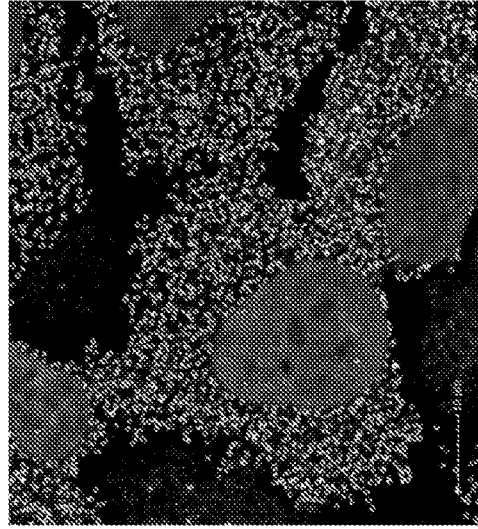
Single mRNA molecules
(image analysis overlay)

Fig. 34A



Luciferase mRNA
(smFISH)

Fig. 34B



Nuclei
(DAPI)

Fig. 34C

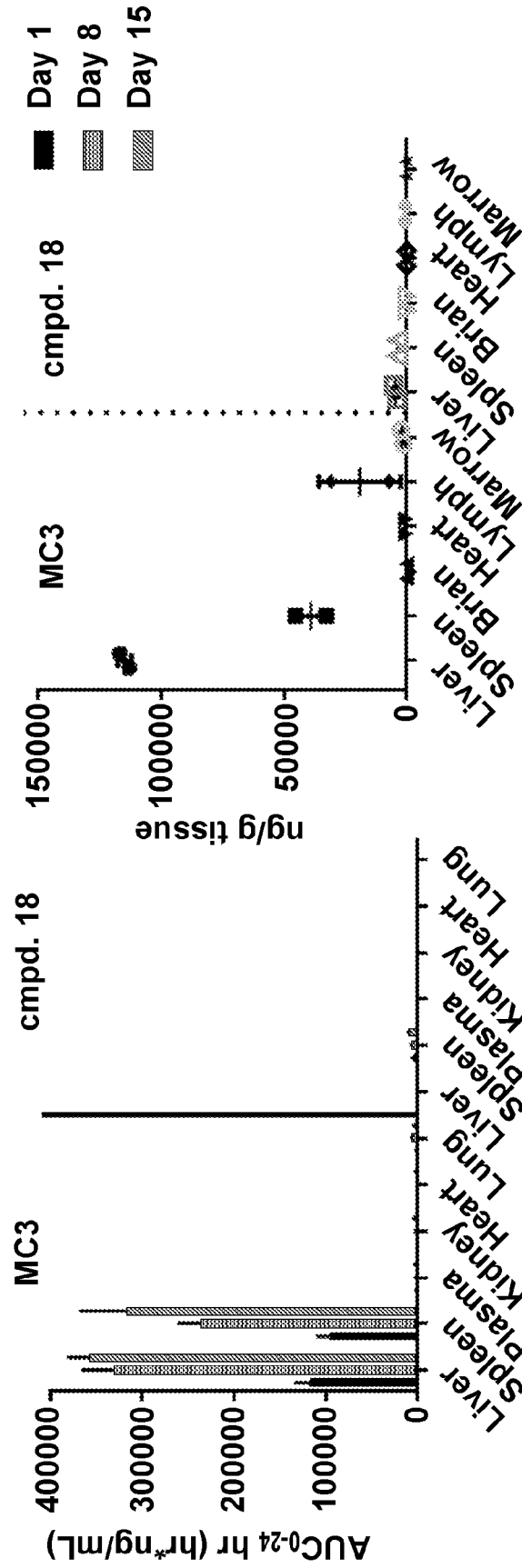


Fig. 35B

Fig. 35A

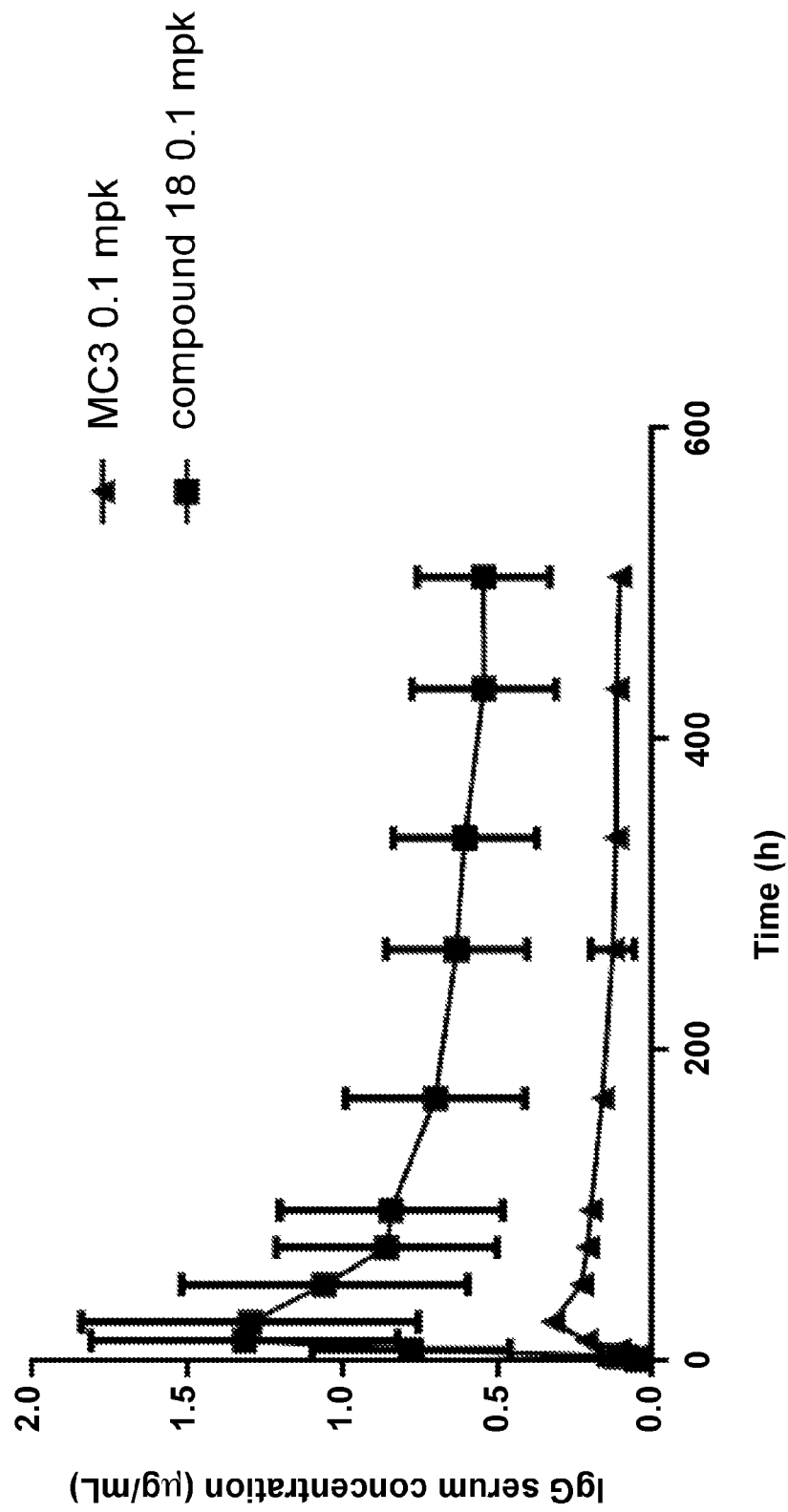
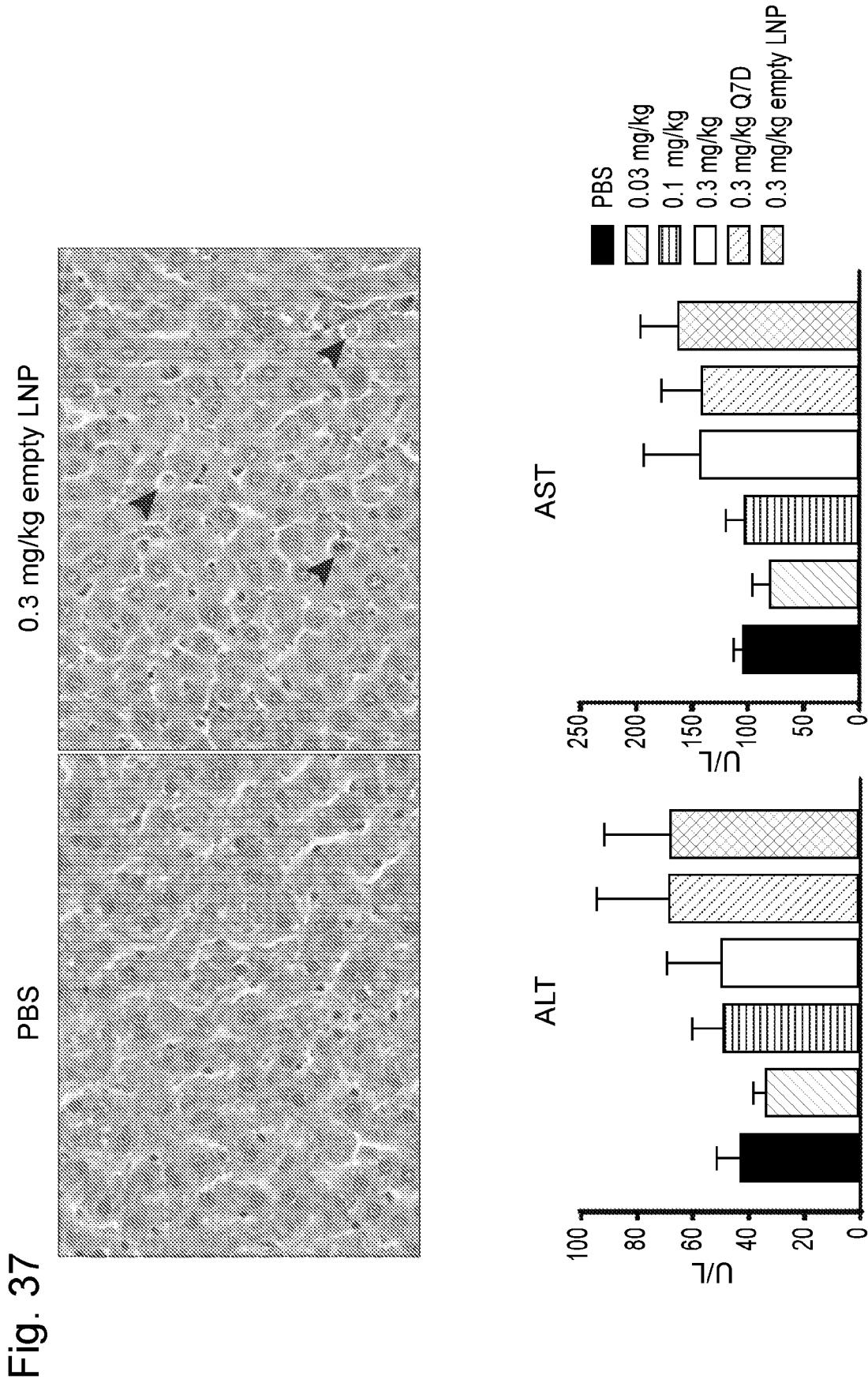


Fig. 36



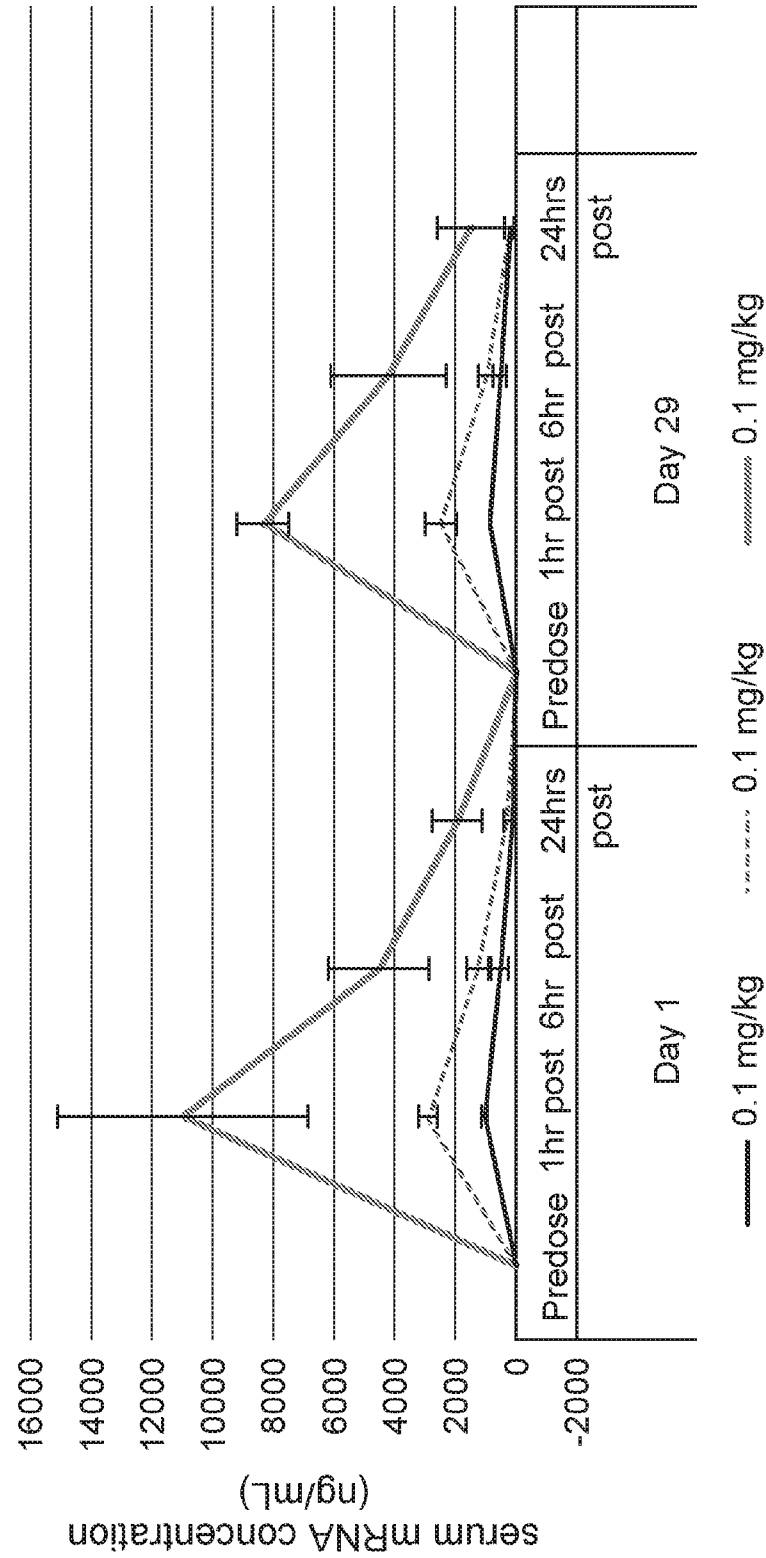


Fig. 38

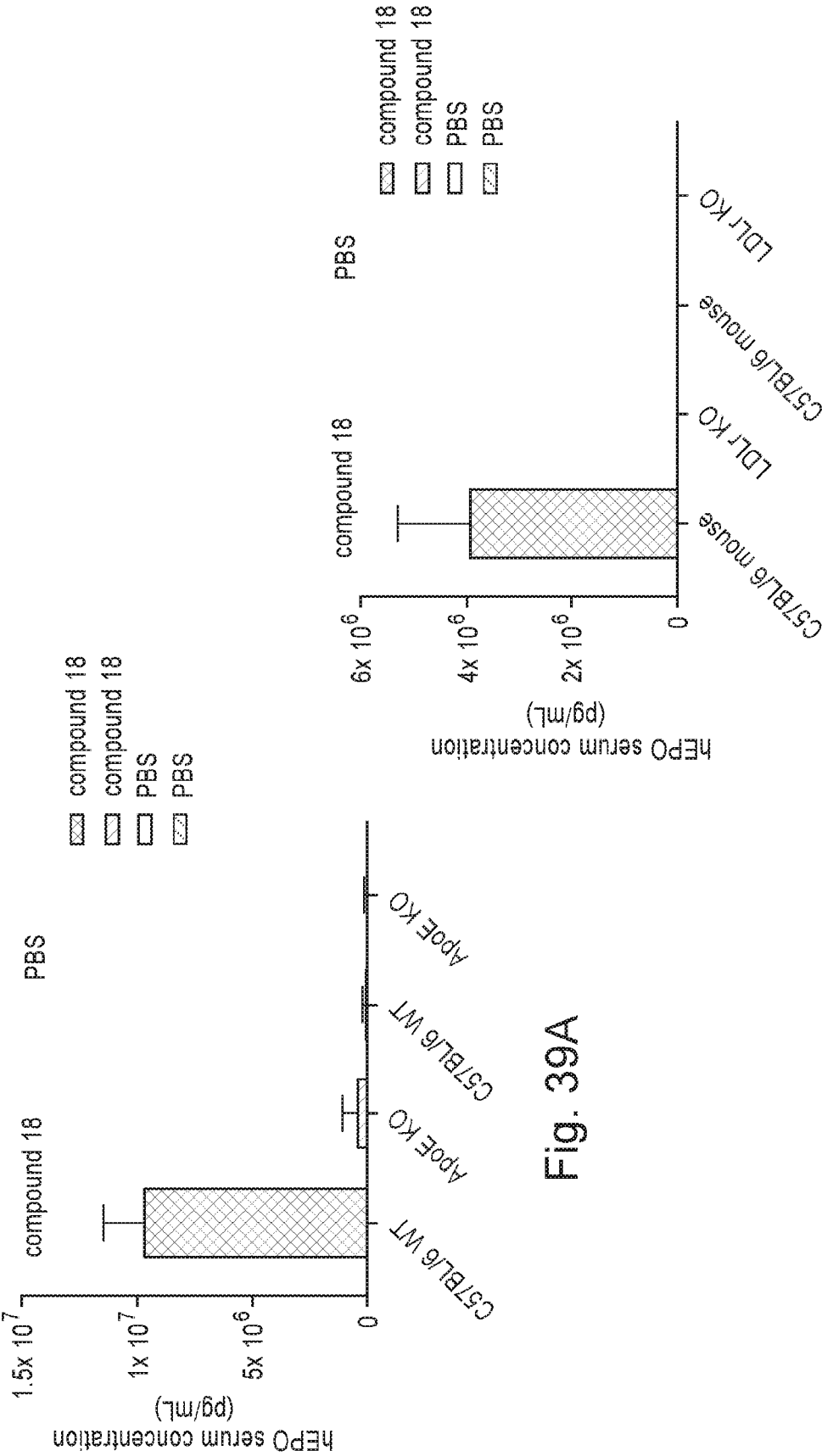


Fig. 39B

Fig. 39A

Fig. 40B

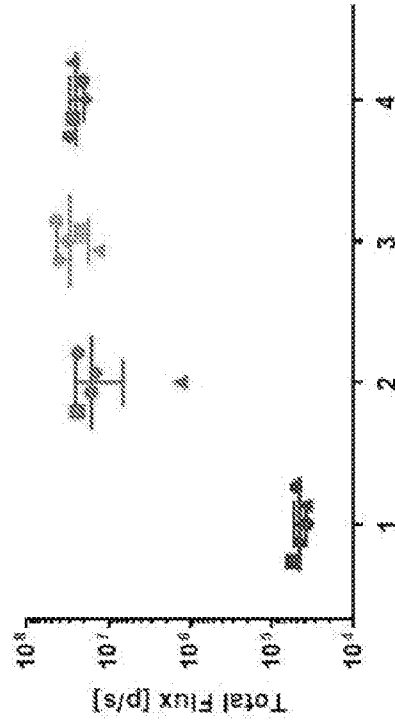


Fig. 40A

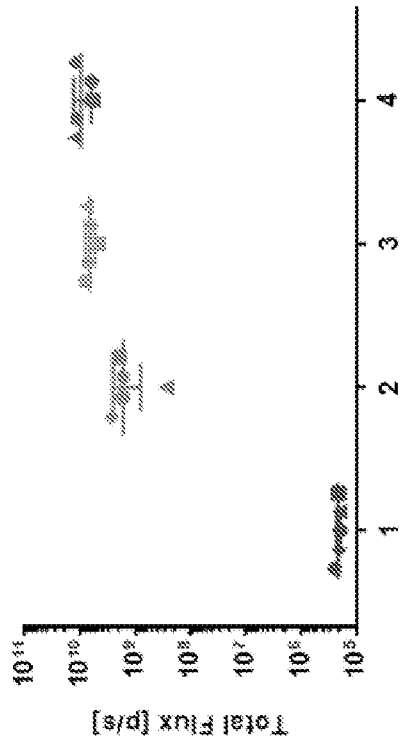


Fig. 40C

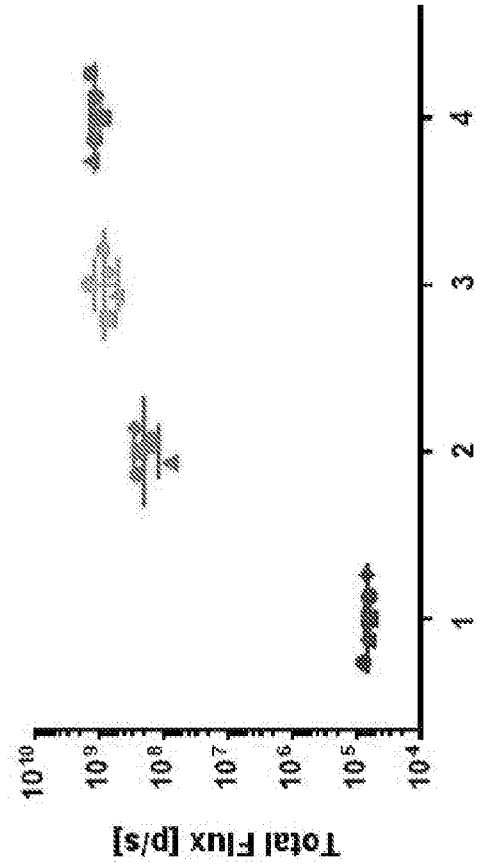


Fig. 41

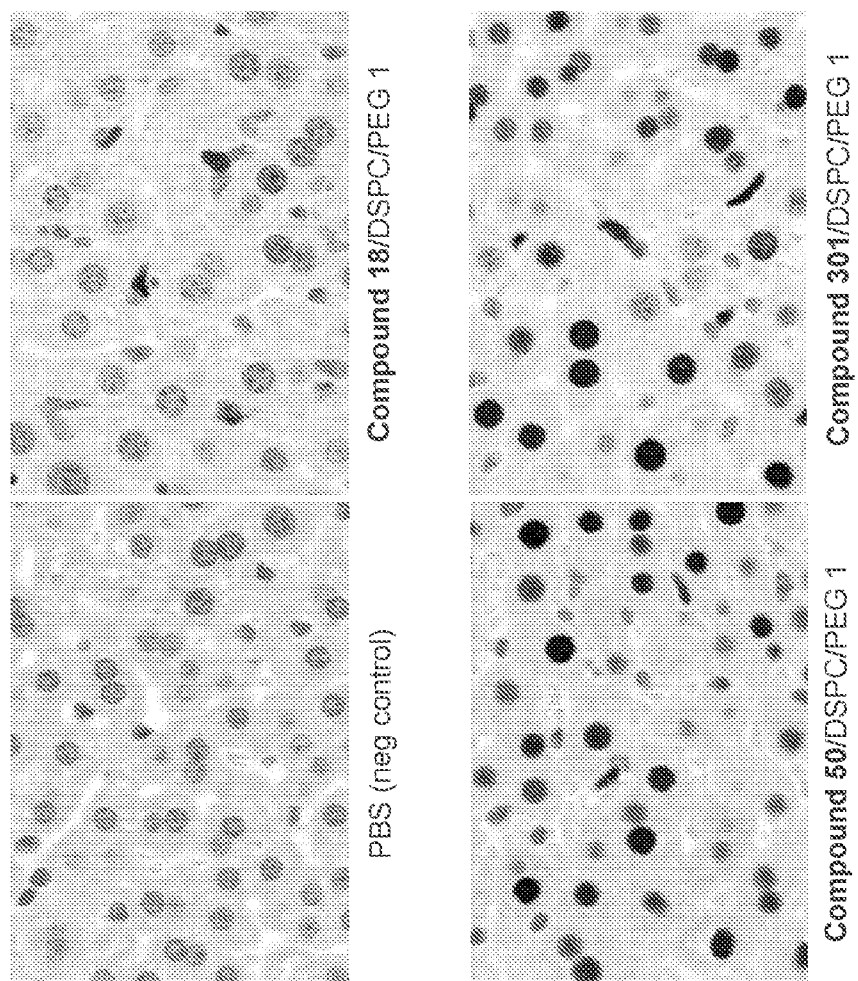


Fig. 42

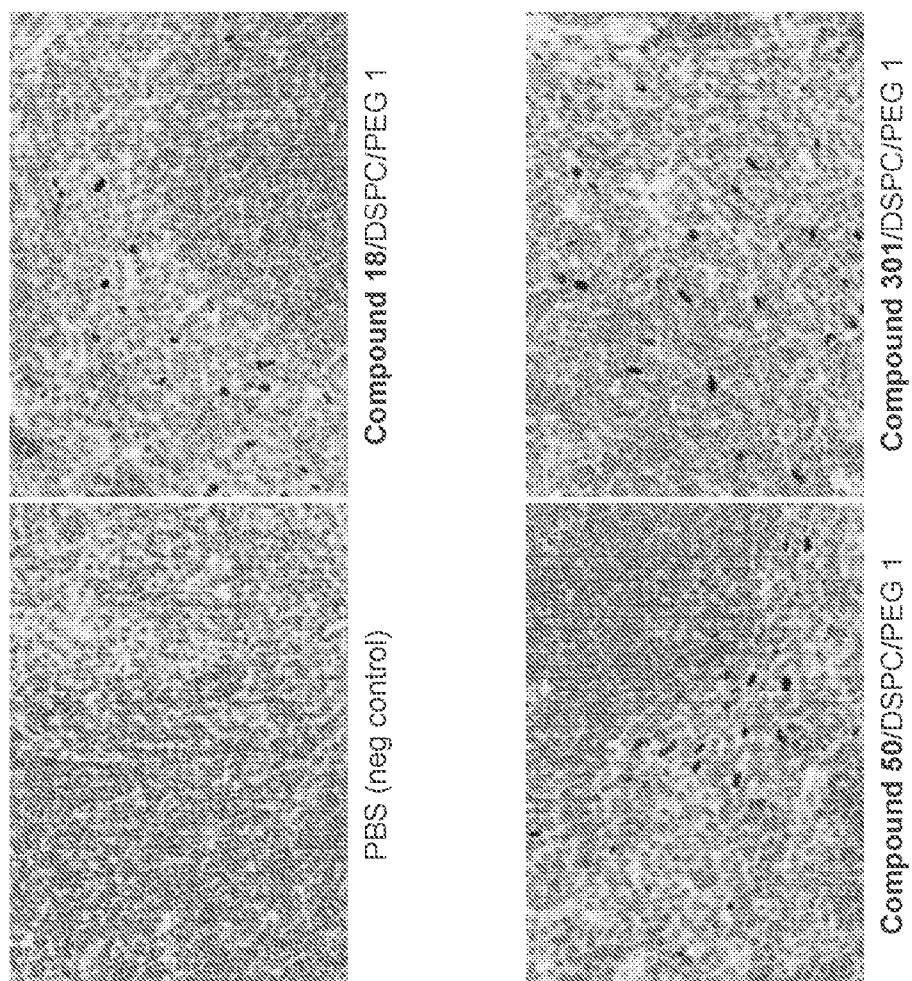


Fig. 43A

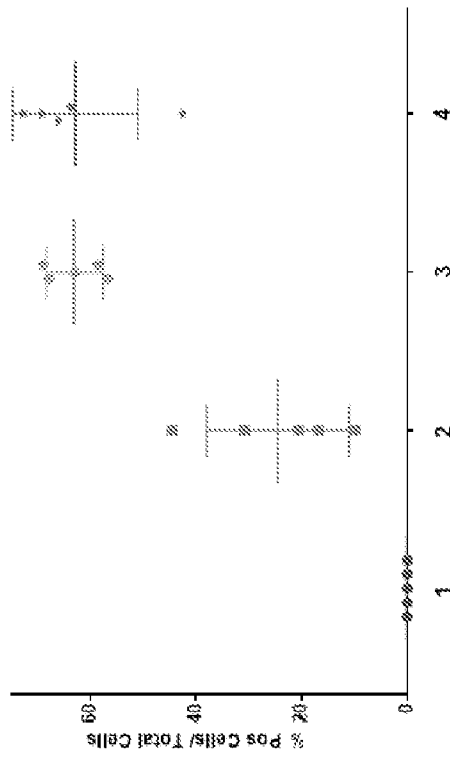
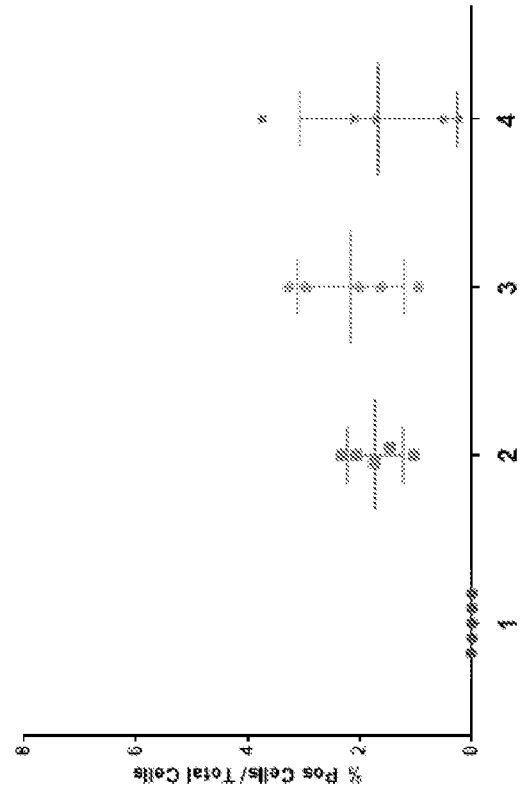


Fig. 43B



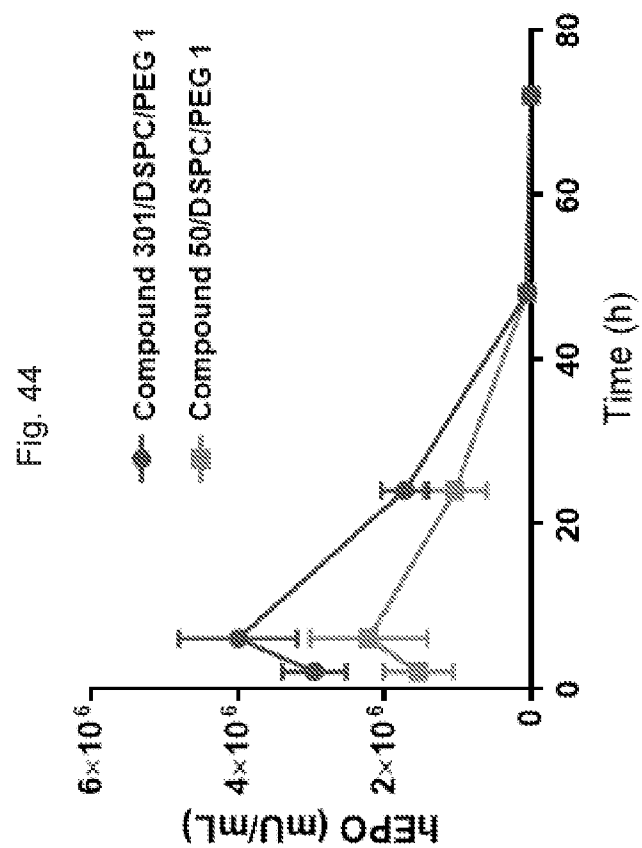


Fig. 45A

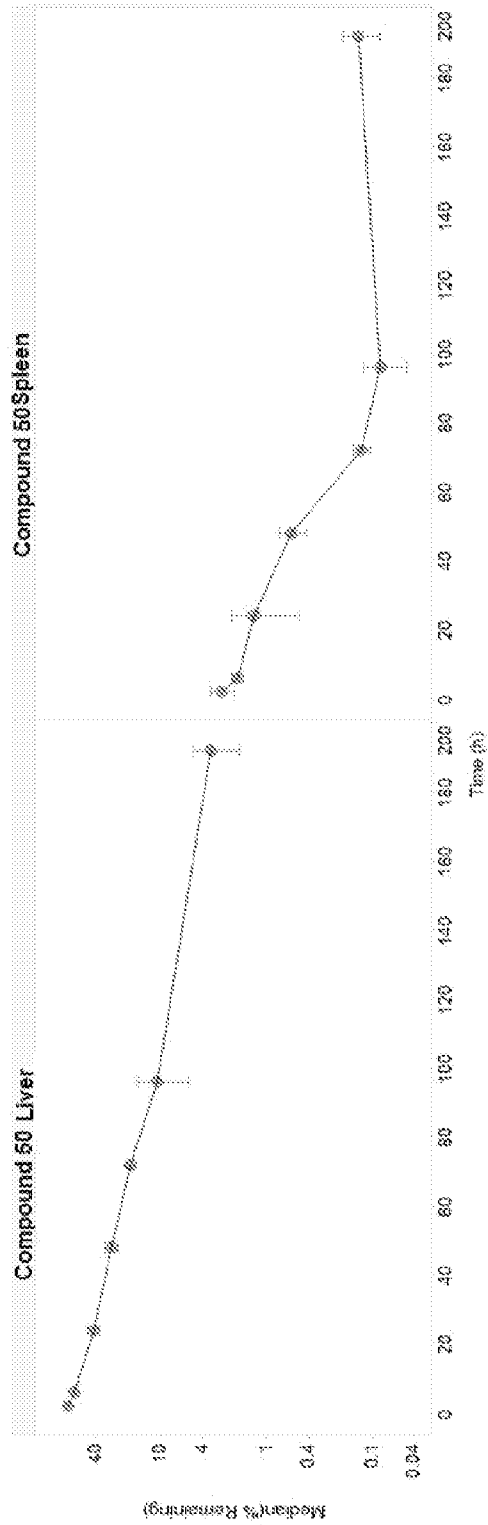
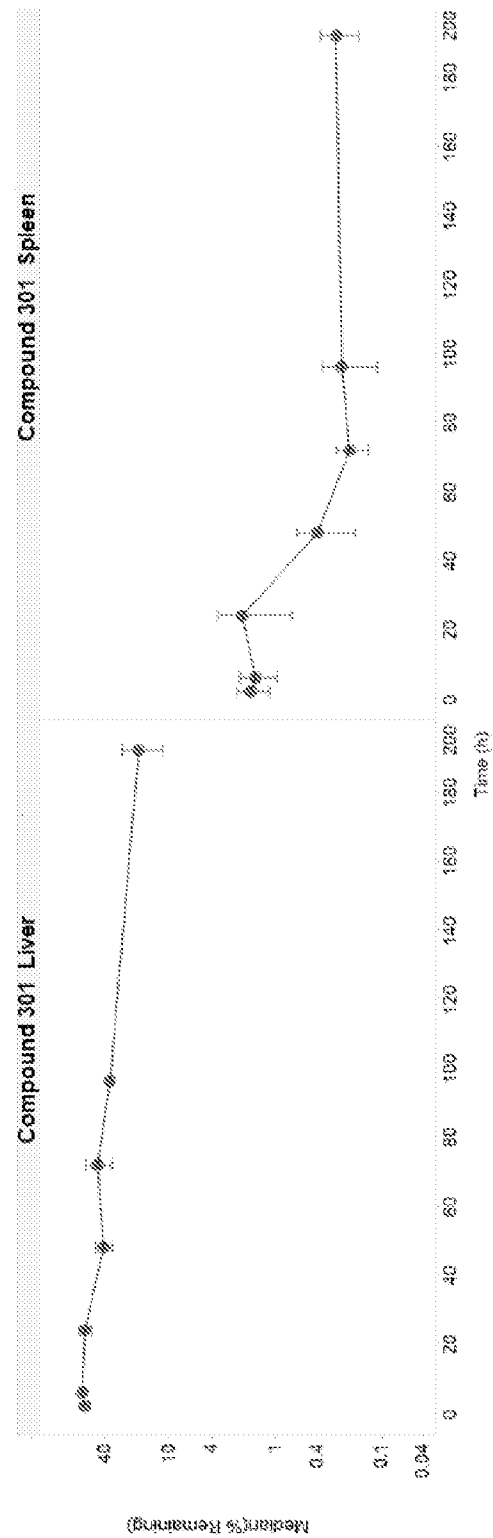
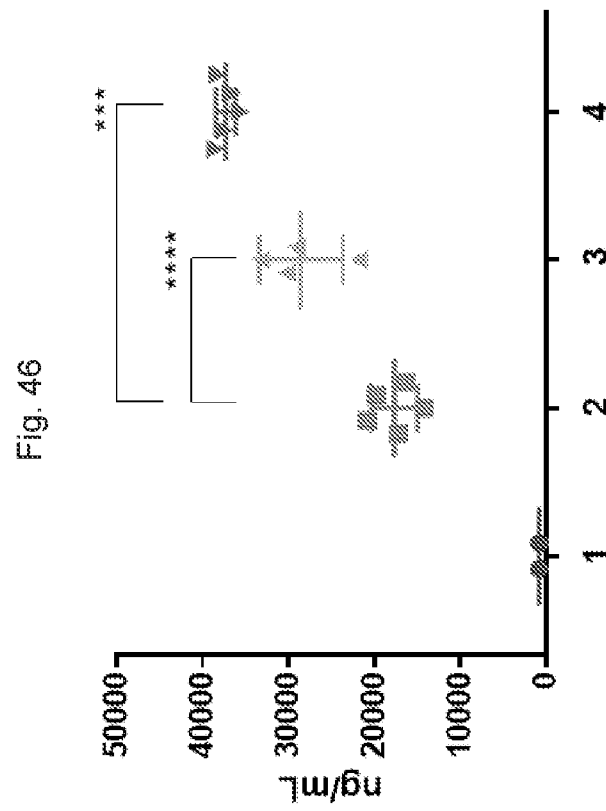


Fig. 45B





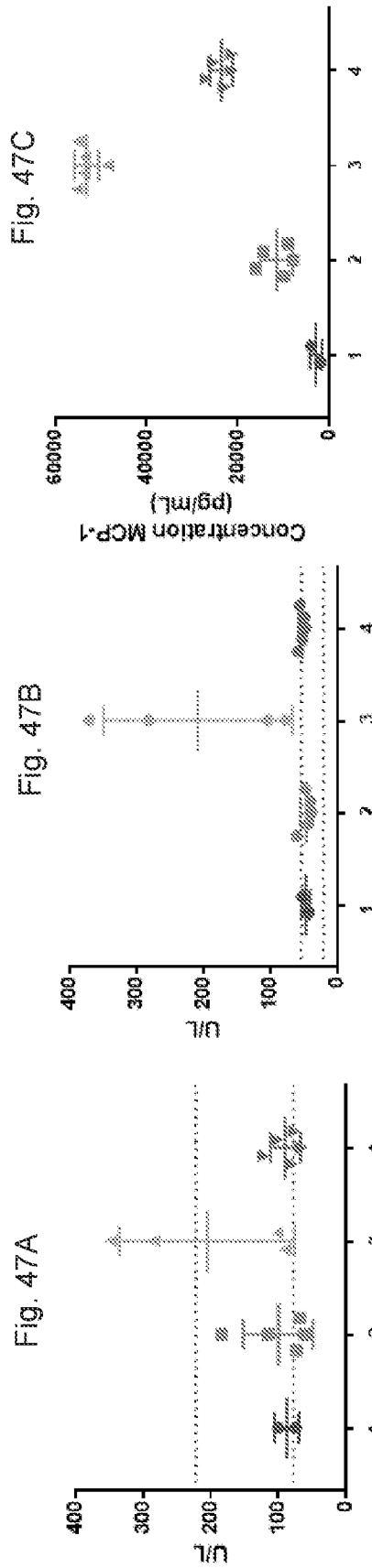


Fig. 47E

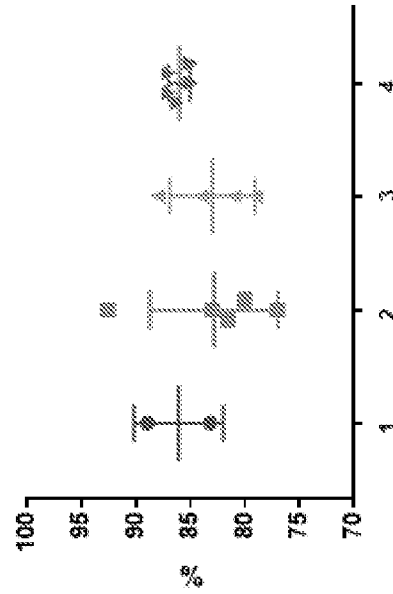


Fig. 47D

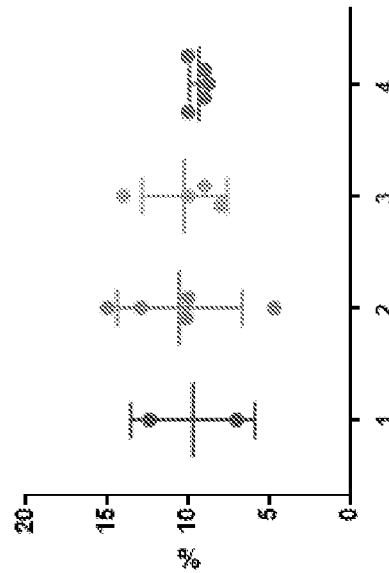


Fig. 1

hEPO (pg/mL)

