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(54) Title: FATTY ACID AMIDES, COMPOSITIONS AND METHODS OF USE

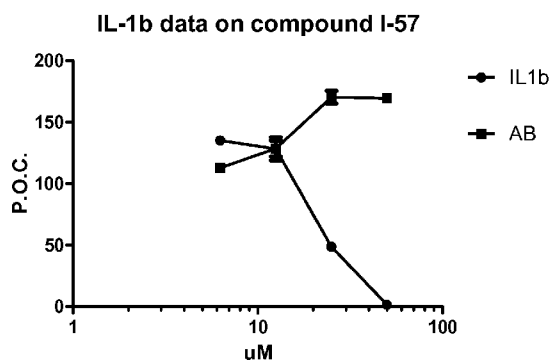


FIG. 1

(57) Abstract: The invention relates to fatty acid amides; compositions comprising an effective amount of a fatty acid amide; and methods for treating or preventing cancer, a metabolic disease or a neurodegenerative disease comprising the administration of an effective amount of a fatty acid amide.



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FATTY ACID AMIDES, COMPOSITIONS AND METHODS OF USE**PRIORITY**

[0001] This application claims the benefit of US 61/529,760 filed August 31, 2011 and US 61/596,516 filed February 9, 2012, the entire disclosures of which are relied on and hereby incorporated into this application by reference.

FIELD OF THE INVENTION

[0002] The invention relates to fatty acid amides; compositions comprising an effective amount of a fatty acid amide; formulations and methods for treating or preventing a given type of cancer, a metabolic, autoimmune or neurodegenerative disorder comprising the administration of an effective amount of a fatty acid amide. All patents, patent applications, and publications cited herein are hereby incorporated into this application by reference in their entireties.

BACKGROUND OF THE INVENTION

[0003] Oily cold water fish, such as salmon, trout, herring, and tuna are the source of dietary marine omega-3 fatty acids, with eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) being the key marine derived omega-3 fatty acids. Omega-3 fatty acids have previously been shown to improve insulin sensitivity and glucose tolerance in normoglycemic men and in obese individuals. Omega-3 fatty acids have also been shown to improve insulin resistance in obese and non-obese patients with an inflammatory phenotype. Lipid, glucose, and insulin metabolism have been shown to improve in overweight hypertensive subjects through treatment with omega-3 fatty acids. Omega-3 fatty acids (EPA/DHA) have also been shown to decrease triglycerides and to reduce the risk for sudden death caused by cardiac arrhythmias in addition to improve mortality in patients at risk of a cardiovascular event. Omega-3 fatty acids have also been taken as dietary supplements part of therapy used to treat dyslipidemia, and anti-inflammatory properties. A higher intake of omega-3 fatty acids lower levels of circulating TNF- α and IL-6, two of the cytokines that are markedly increased during inflammation processes (Chapkin et al, *Prostaglandins, Leukot Essent Fatty Acids* **2009**, 81, p. 187-191; Duda et al, *Cardiovasc Res* **2009**, 84, p. 33-41). In addition, a higher intake of omega-3 fatty acids has been shown to increase levels of the well-characterized anti-inflammatory cytokine IL-10 (Bradley et al, *Obesity (Silver Spring)* **2008**,

16, p. 938-944). A recent study (Wang et al, *Molecular Pharmaceutics* **2010**, 7, p. 2185-2193) has demonstrated that DHA could also induce the Nrf2 and the Nrf2-target gene Heme-oxygenase 1 (HO-1) and this pathway could play a significant role in suppressing LPS-mediated inflammation. A number of studies have now indicated that DHA could play a significant role in cancer (For reviews see: Gleissman, H. et al *Experimental Cell Research* **2010**, 316, p. 1365-73; Bougnoux, P. et al *Progress in Lipid Research* **2010**, 49, p. 76-86; Spencer, L. et al, *Eur. J. Cancer* **2009**, 45, p. 2077-86; Serini, S. et al *Apoptosis* **2009**, 14, p. 135-152; Browever, I. A. *Prostaglandins, Leukotrienes and Essential Fatty Acids* **2008**, 79, p. 97-99). For instance, DHA was able to induce p53-dependent growth inhibition of transformed colon and lung carcinomas (Kikawa et al, *J. of Cancer Science and Therapy*, **2011**, 3, p. 1-4). DHA has also been shown to prevent breast cancer cell metastasis to bone in a mouse model utilizing MDA-MB-231 human breast cancer cells (Mandal et al, *Biochem. & Biophys. Res. Communications* **2010**, 402, p. 602-607).

[0004] Chronic oxidative stress and inflammation have now been linked to the development and progression of a number of debilitating diseases. Some of these diseases include renal failure, heart failure, atherosclerosis, osteoporosis, cancer, chronic obstructive pulmonary disease (COPD), Parkinson's disease and Alzheimer's disease. Activation of the Nrf2 pathway in order to resolve this chronic oxidative stress and inflammation appears to be a particularly promising new therapeutic approach (For a review see Gozzelino, R. et al *Annu. Rev. Pharmacol. Toxicol.* **2010**, 50, p. 323-54). For instance, small molecule activators of Nrf2 have now been shown to be effective in the cisplatin-induced nephrotoxicity mouse model (Aleksunes et al, *J. Pharmacology & Experimental Therapeutics* **2010**, 335, p. 2-12), the transgenic Tg19959 mouse model of Alzheimer's disease (Dumont et al, *J. Neurochem.* **2009**, 109, p. 502-12), the mouse model for COPD (Sussan, T. E. et al *Proc. Natl. Acad. Sci. USA* **2009**, 106, p. 250-5), and the murine 4T1 breast tumor model (Ling, X. et al *Cancer Res.* **2007**, 67, p. 4210-8). Recent data suggested that DHA and EPA can potentially mitigate the progression of many diseases in which oxidative stress represents a common underlying cause (Gao et al, *J. Biological Chem.* **2007**, 282, issue 4, p. 2529-37; Wang et al, *Mol. Pharmaceutics* **2010**, 7, issue 6, p. 2185-2193). The oxidized form of omega-3 fatty acids can presumably react directly with Keap1, a negative regulator of Nrf2, in order to induce Nrf2 gene expression.

[0005] There are many amines that can be covalently coupled with omega-3 fatty acids to produce fatty acid amides with improved biological activity. The fatty acid amides disclosed herein have been designed to be stable in the plasma. However, in targeted tissues, intracellular enzymes will hydrolyze the fatty acid amides into the individual components, i.e. the omega-3 fatty acid and the amine moiety. In some embodiments, certain amine moieties do not necessarily display any significant biological activity. However, when these amines are coupled to an omega-3 fatty acid, the resulting fatty acid amides can be delivered into targeted tissues more efficiently to produce a biological effect that cannot be replicated by administering the fatty acid alone or in non covalent combination with the amine portion. In some embodiments, certain “PEGylated” amines are used to form fatty acid amides. “PEGylation” is a common technique of incorporating polyethylene glycol (PEG) chains into a molecule to improve its hydrophobicity and pharmacokinetic profile (Veronese et al *Drug Discovery Today* **2005**, *10*, p. 1451-8). When omega-3 fatty acids are coupled to a “PEGylated” amine, the resulting fatty acid amides can have an improved circulatory time and pharmacokinetic profile, in addition to being delivered into targeted tissues more efficiently than the corresponding acid. In some embodiments, the amine component itself displays significant biological activity. When these biologically active amines are coupled to an omega-3 fatty acid, the resulting fatty acid amides will produce a biological effect that cannot be replicated by administering the individual components or a noncovalent combination of the individual components. In some instances, the biological activity can be synergistic. In other instances, the side effects of the biologically active amines can be reduced since the individual components of the fatty acid amides are only released inside targeted tissues by hydrolysis involving various intracellular enzymes. Non-limiting examples of biologically active amine components are cystamine, cysteamine, glucosamine, dexpramipexole, sapropterin, N-acylated cysteine, pencillamine, triethylenetetramine, 4-aminopyridine, fingolimod, and pramipexole.

[0006] Cysteamine has been used extensively to treat nephropathic cystinosis, an orphan genetic lysosomal storage disorder characterized by a massive accumulation of crystalline cystine within cells. Treatment of nephropathic cystinotic fibroblasts with cysteamine has been shown to significantly reduce the excess cystine present in these cells (For a review, see Gahl et al *N. Engl. J. Med.* **2002**, *347*, p. 111-121). Cystamine, the disulfide form of cysteamine, has also been found to be useful in reducing cystine level in nephropathic

cystinotic fibroblasts (Thoene et al *Proc. Roy. Soc. Med.* **1977**, 70, Suppl. 3, p. 37-40). In addition, cysteamine and cystamine have been found to be neuroprotective in the YAC128 mouse model of Huntington's disease (Van Raamsdonk et al *J. Neurochem.* **2005**, 95, p. 210-220). Fatty acid amide derivatives consisting of an omega-3 fatty acid that has been covalently linked to either cystamine or cysteamine can have an additional anti-inflammatory and neuroprotective effect that cannot be replicated by administering the individual components or the combination of the individual components.

[0007] Glucosamine has been used clinically to reduce the debilitating symptoms of osteoarthritis. In terms of mechanism of action, the anti-inflammatory properties of glucosamine can be partly attributed to the inhibition of prostaglandin E2 (PGE2) synthesis through the reduction of COX-2 (Kapor et al *J. Rheumatology* **2012**, 39, p. 635-644). In addition, treatment with glucosamine can also up-regulate the gene expression of heme oxygenase (HO-1), an important protective cellular mechanism toward reactive oxygen species (Valvasan et al *Rheumatology* **2008**, 47, p. 31-35). Fatty acid/glucosamine amide derivatives, created by covalently linking an omega-3 fatty acid to glucosamine via an amine linker group, can have synergistic activity along both the PGE2 pathway and the anti-oxidative Nrf2 pathway.

[0008] Dexpramipexole is a low molecular weight, water-soluble compound that has recently been shown to be clinically effective in treating amyotrophic lateral sclerosis (ALS) (Cudkowicz et al *Nat. Med.* **2011**, 17, p. 1652-1657). In a phase 2 trial, ALS patients treated with Dexpramipexole showed a dose-related slowing of symptom progression as well as increased survival time. Preliminary studies into the mechanism of action appear to indicate that dexpramipexole can prevent mitochondrial ROS generation and thereby impart some neuroprotective effects (Ferrari-Toninelli et al *BMC Pharmacology* **2010**, 10, p. 1-6). Because of this anti-oxidant and neuroprotective effect, a covalent amide derivative between an omega-3 fatty acid and dexpramipexole can have a synergistic effect that cannot be duplicated by administering the individual components or a combination of the components.

[0009] Phenylketonuria (PKU) is metabolic disorder that results from lack of enzymes that are needed to convert phenylalanine to tyrosine. If left untreated, the excessive buildup of phenylalanine can lead to mental retardation, speech impediments, seizures and behavioral abnormalities. Children with PKU often need supplementation with DHA for cognitive function and development. In patients with PKU, treatment with sapropterin has been shown

to be effective in lowering blood level of phenylalanine. A fatty acid sapropterin amide can allow for more effective delivery of sapropterin to the liver where a high level of phenylalanine hydroxylase is expressed. In addition, with fatty acid sapropterin amides, DHA can also be delivered more effectively to cells to enhance cognitive function and development.

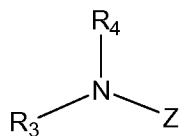
[0010] 4-Aminopyridine and fingolimod are amine containing compounds that have been found to be useful in treating relapsing remitting multiple sclerosis. A covalent omega-3 fatty acid conjugate of 4-aminopyridine or fingolimod will have additional anti-inflammatory and neuroprotective effects that cannot be replicated by administering the individual components or the combination of the components. N-acylated cysteine, tiopronin and penicillamine are some thiol containing compounds that have been used clinically to treat Wilson's disease, cystinuria and to thin the thick mucus present in cystic fibrosis patients. Fatty acid amide derivatives containing these thiol compounds will allow better tissue targeting and reduce side effects.

SUMMARY OF THE INVENTION

[0011] The invention is based in part on the discovery of fatty acid amides and their demonstrated effects in achieving improved treatment that cannot be achieved by administering the individual components (i.e. fatty acid and amine) or in noncovalent combination. Fatty acid amides and compositions comprising them are useful in the treatment and prevention of diseases and disorders associated with inflammation. For example, the fatty acid amides described herein are useful in the treatment or prevention of metabolic disorders including atherosclerosis, dyslipidemia, coronary heart disease, hypercholesterolemia, Type 2 diabetes, elevated cholesterol, metabolic syndrome, diabetic nephropathy, IgA nephropathy, chronic kidney disease (CKD), nephropathic cystinosis, and cardiovascular disease. In addition, they are useful in the treatment of autoimmune diseases such as rheumatoid arthritis, psoriasis, systemic lupus erythematosus, inflammatory bowel diseases (including colitis and Crohn's disease), respiratory diseases such as asthma, cystic fibrosis, COPD and neurodegenerative diseases such as multiple sclerosis, Huntington's disease, Parkinson's disease and Alzheimer's disease, Huntington's disease, amyotrophic lateral sclerosis (ALS) and muscular dystrophy. The compounds described herein are also useful in treating a variety of cancer such as carcinoma, sarcoma, lymphoma, leukemia, melanoma, mesothelioma, multiple myeloma, seminoma, and cancer of the bladder, blood,

bone, brain, breast, central nervous system, colon, endometrium, esophagus, genitourinary tract, head, larynx, liver, lung, neck, ovary, pancreas, prostate, testicle, spleen, small intestine, large intestine or stomach.

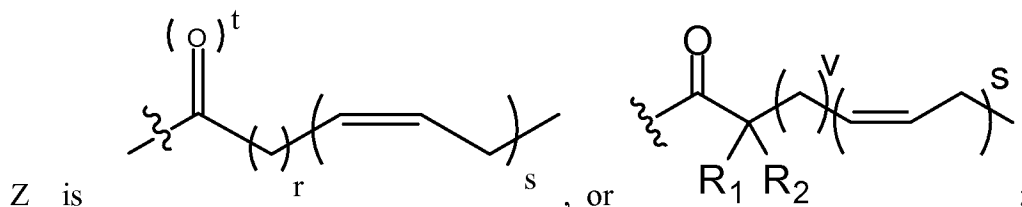
[0012] In one aspect, compounds of the **Formula I** are described:



Formula I

and pharmaceutically acceptable salts, hydrates, solvates, prodrugs, enantiomers and stereoisomers thereof;

wherein



each r is independently 2, 3, or 7;

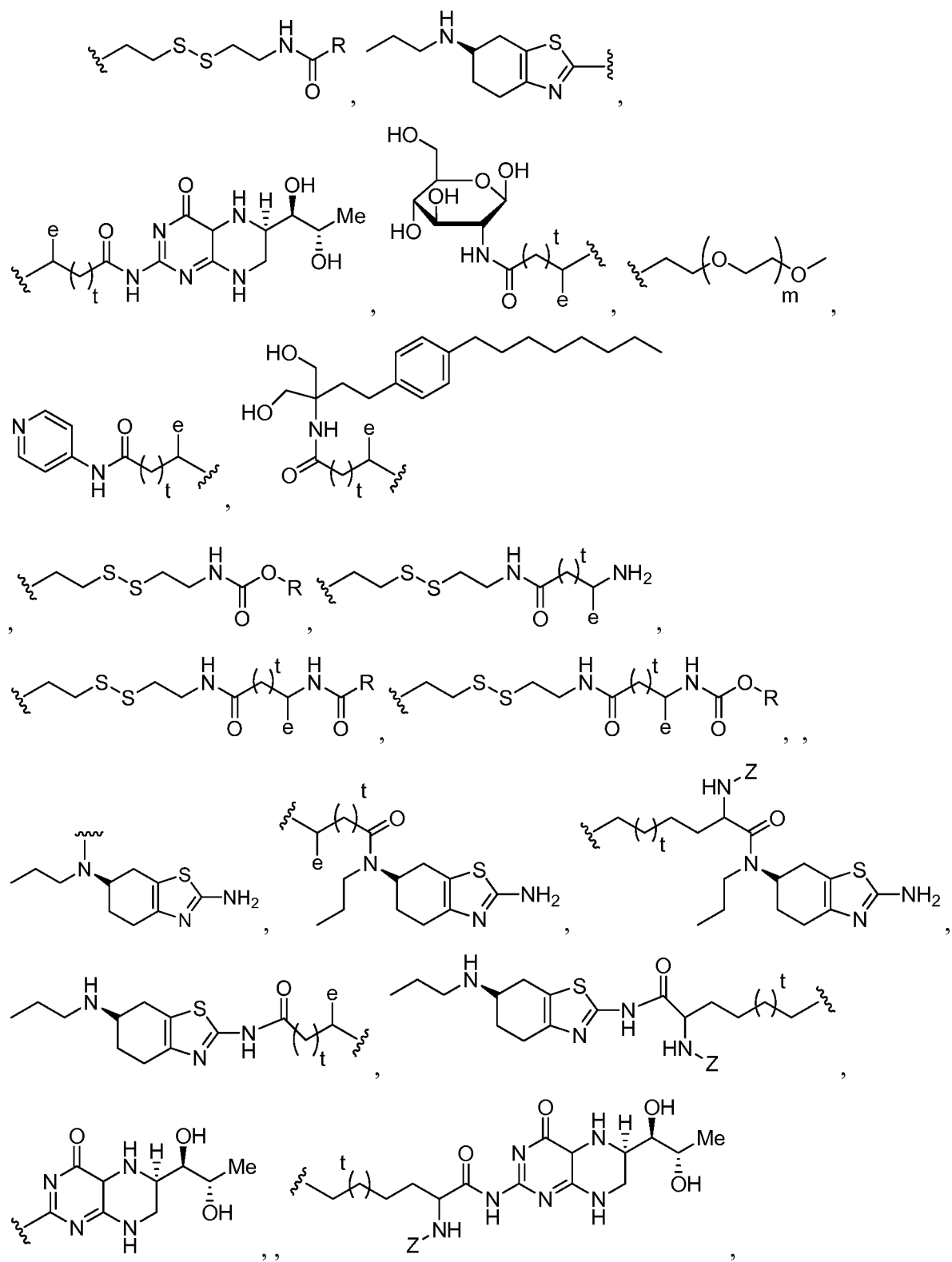
each s is independently 3, 5, or 6;

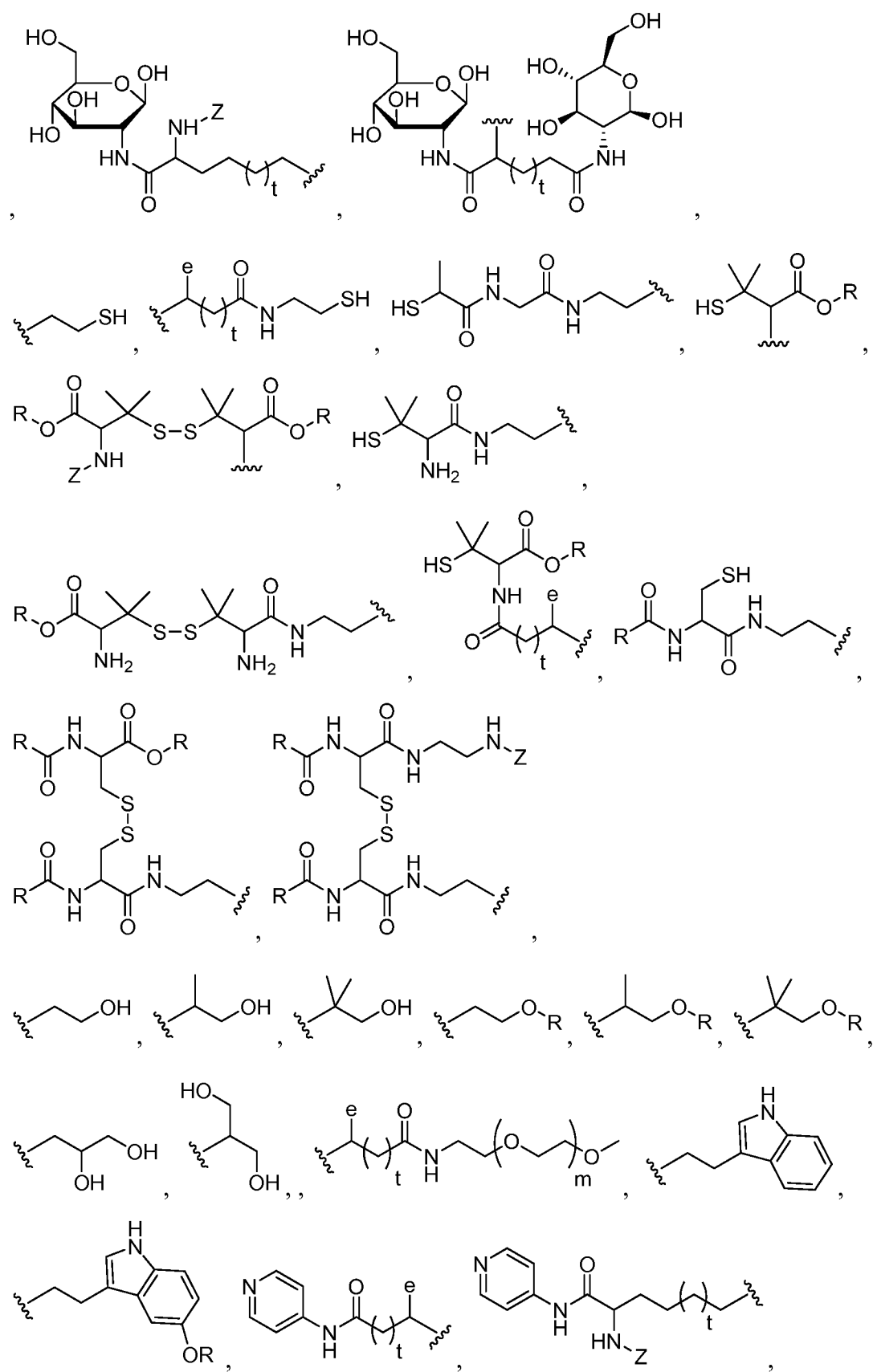
each t is independently 0 or 1;

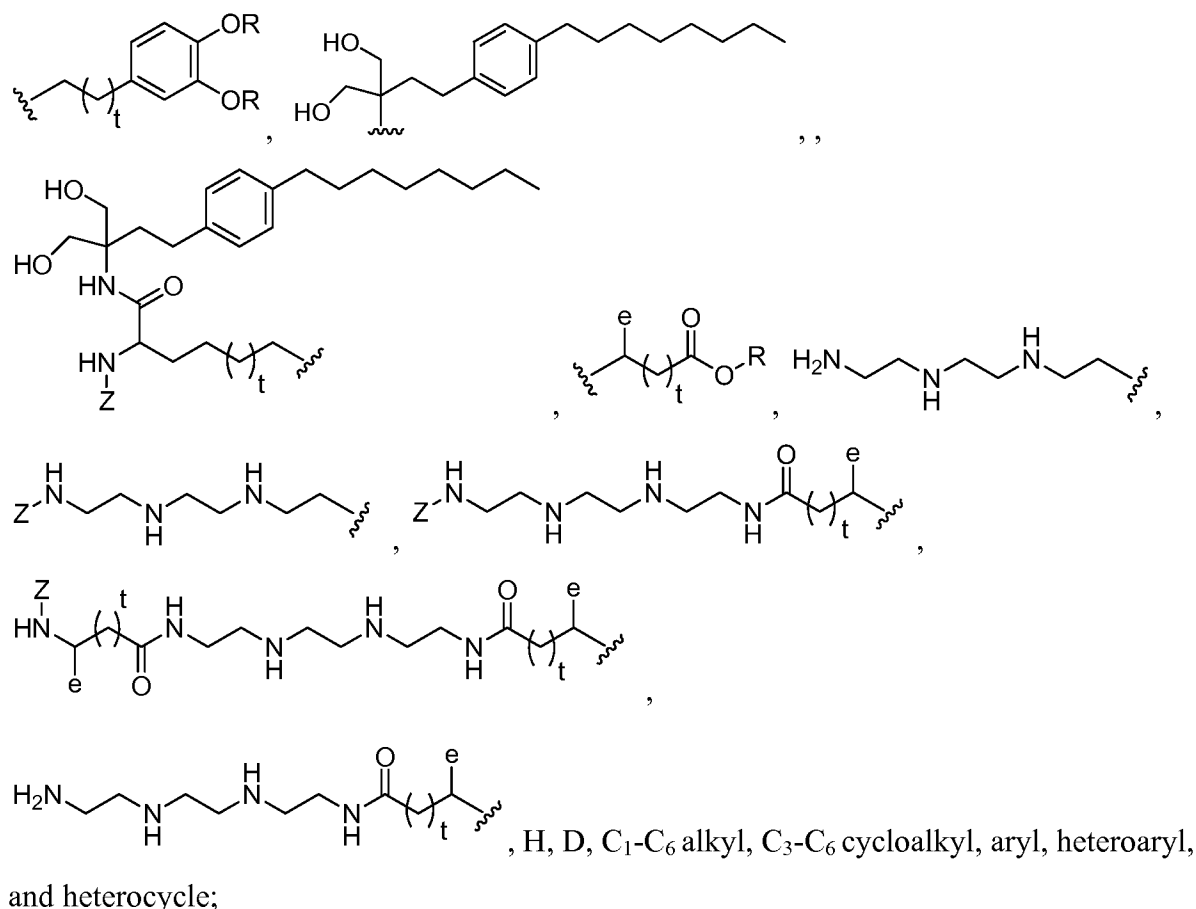
each v is independently 1, 2, or 6;

R₁ and R₂ are independently -H, -D, -C₁-C₄ alkyl, -halogen, -OH, -C(O)C₁-C₄ alkyl, -O-aryl, -O-benzyl, -OC(O)C₁-C₄ alkyl, -C₁-C₃ alkene, -C₁-C₃ alkyne, -C(O)C₁-C₄ alkyl, -NH₂, -NH(C₁-C₃ alkyl), -N(C₁-C₃ alkyl)₂, -NH(C(O)C₁-C₃ alkyl), -N(C(O)C₁-C₃ alkyl)₂, -SH, -S(C₁-C₃ alkyl), -S(O)C₁-C₃ alkyl, -S(O)₂C₁-C₃ alkyl;

R₃ and R₄ are independently selected from:





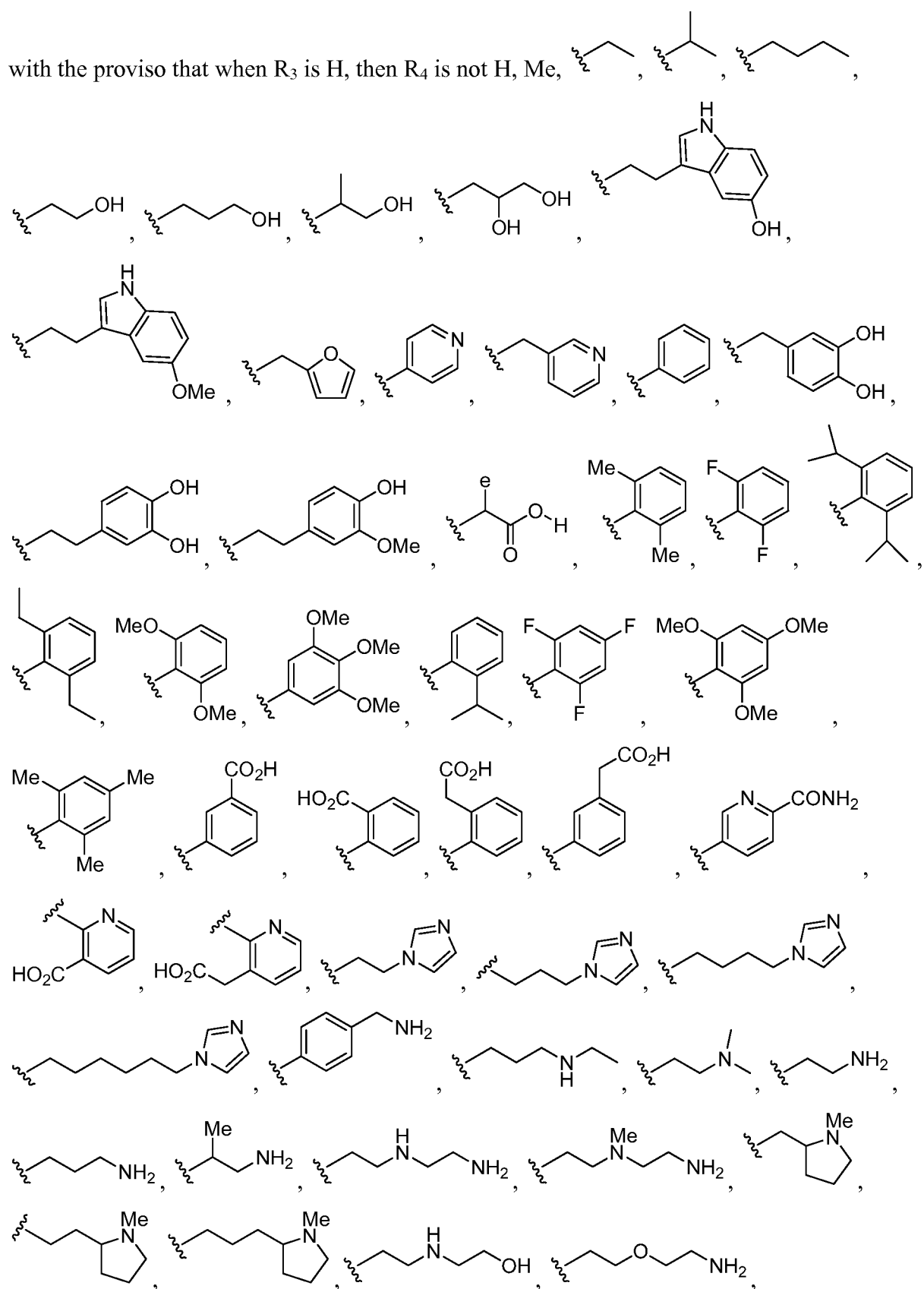


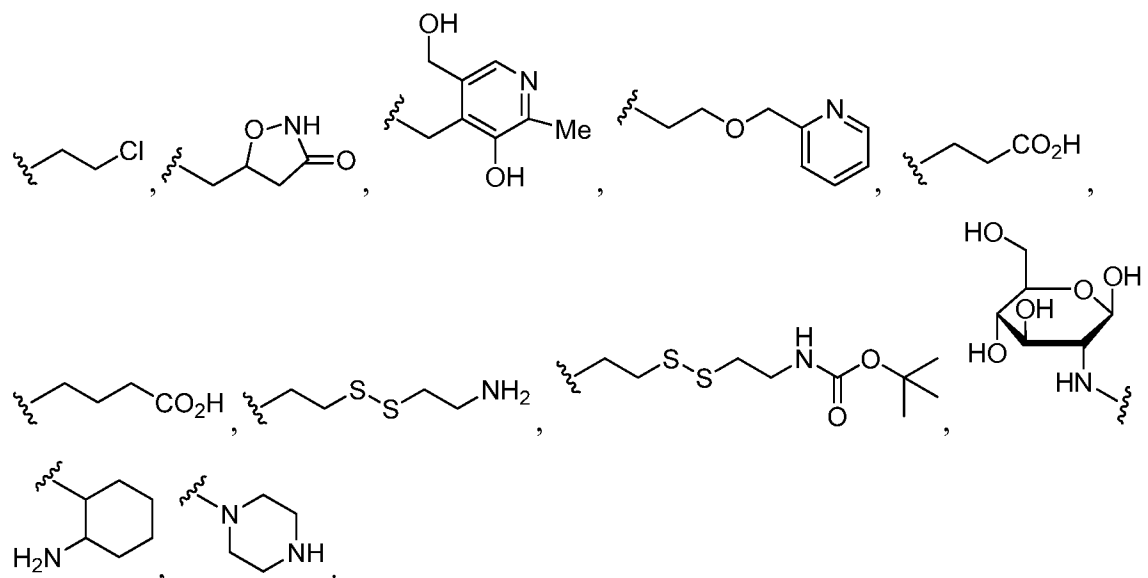
each e is independently H or any one of the side chains of the naturally occurring amino acids;

each m is independently 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

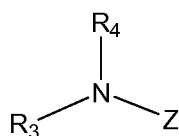
each R is independently -H, straight or branched -C₁-C₆ alkyl, -C₁-C₆ cycloalkyl, aryl, heteroaryl or heterocyclic that is optionally substituted with one, two, three, four or five groups selected from OH, CN, halogen, CO₂R₅, CONHR₅, CONR₅R₅, S(O)₂NR₅R₅, NR₅R₅, NR₅COR₅, -(OCH₂CH₂)_m-OCH₃;

each R₅ is independently -H, -C₁-C₃ alkyl, or straight or branched C₁-C₄ alkyl optionally substituted with OH, or halogen;





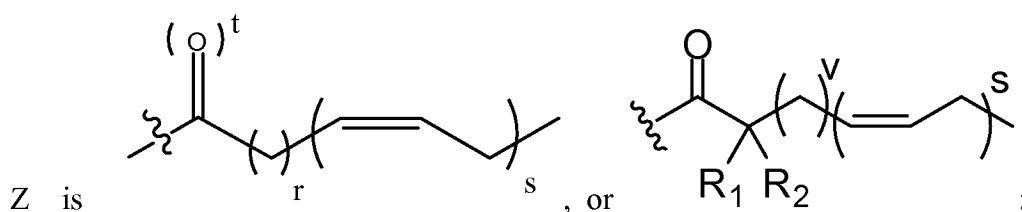
[0013] In another aspect, pharmaceutical compositions are described comprising a compound of **Formula I'**:



Formula I'

and pharmaceutically acceptable salts, hydrates, solvates, enantiomers and stereoisomers thereof;

wherein



each r is independently 2, 3, or 7;

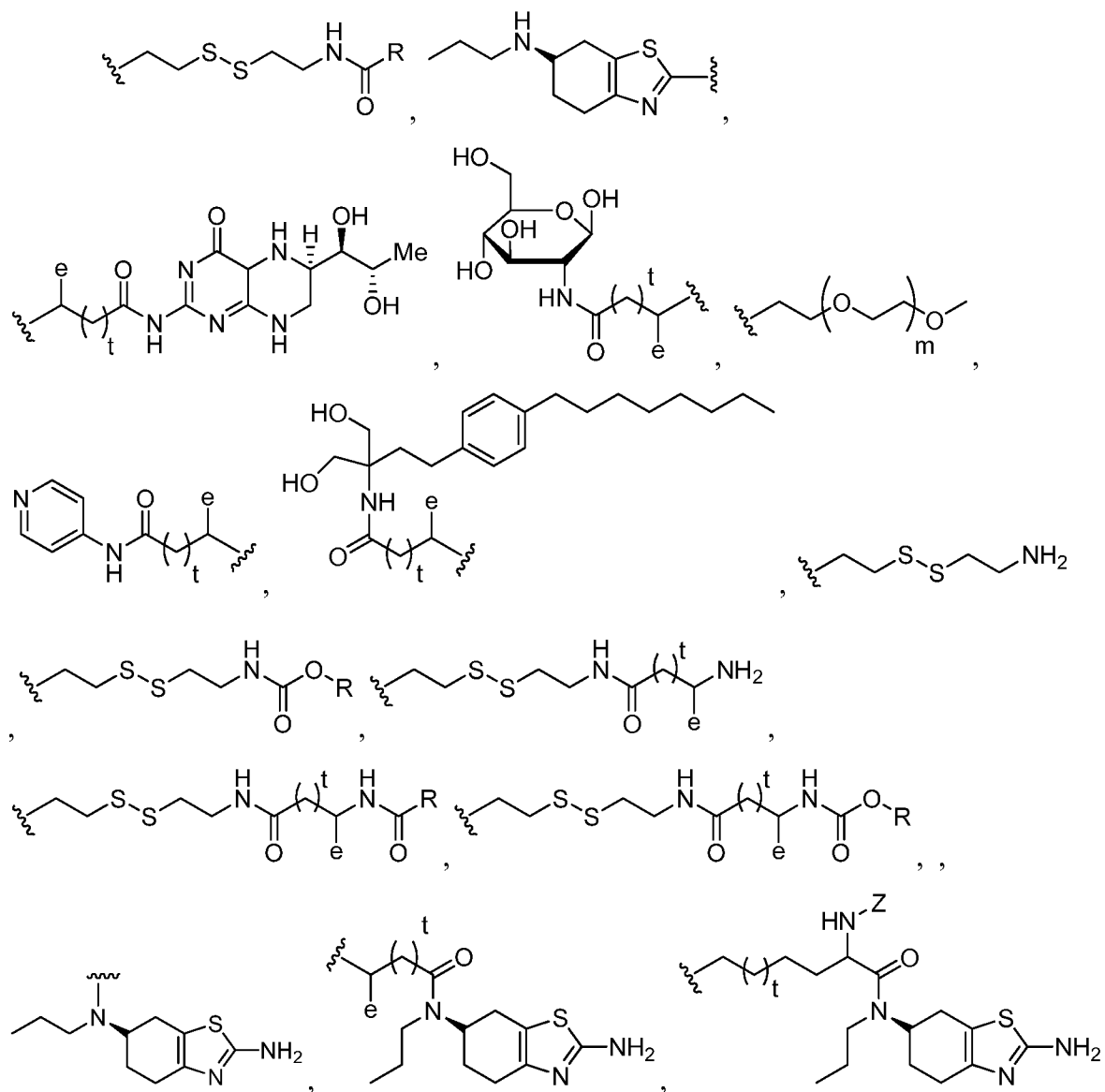
each s is independently 3, 5, or 6;

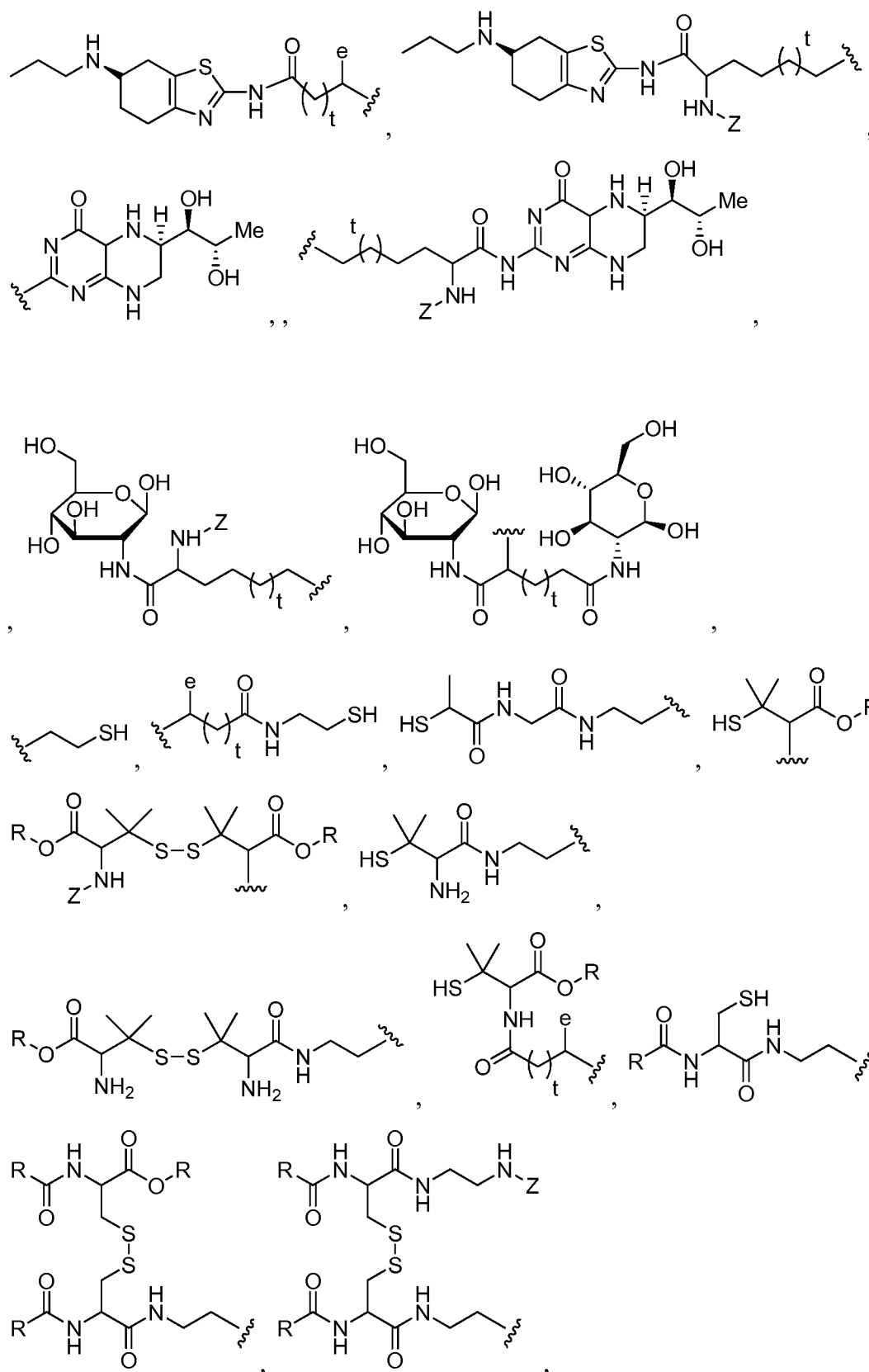
each t is independently 0 or 1;

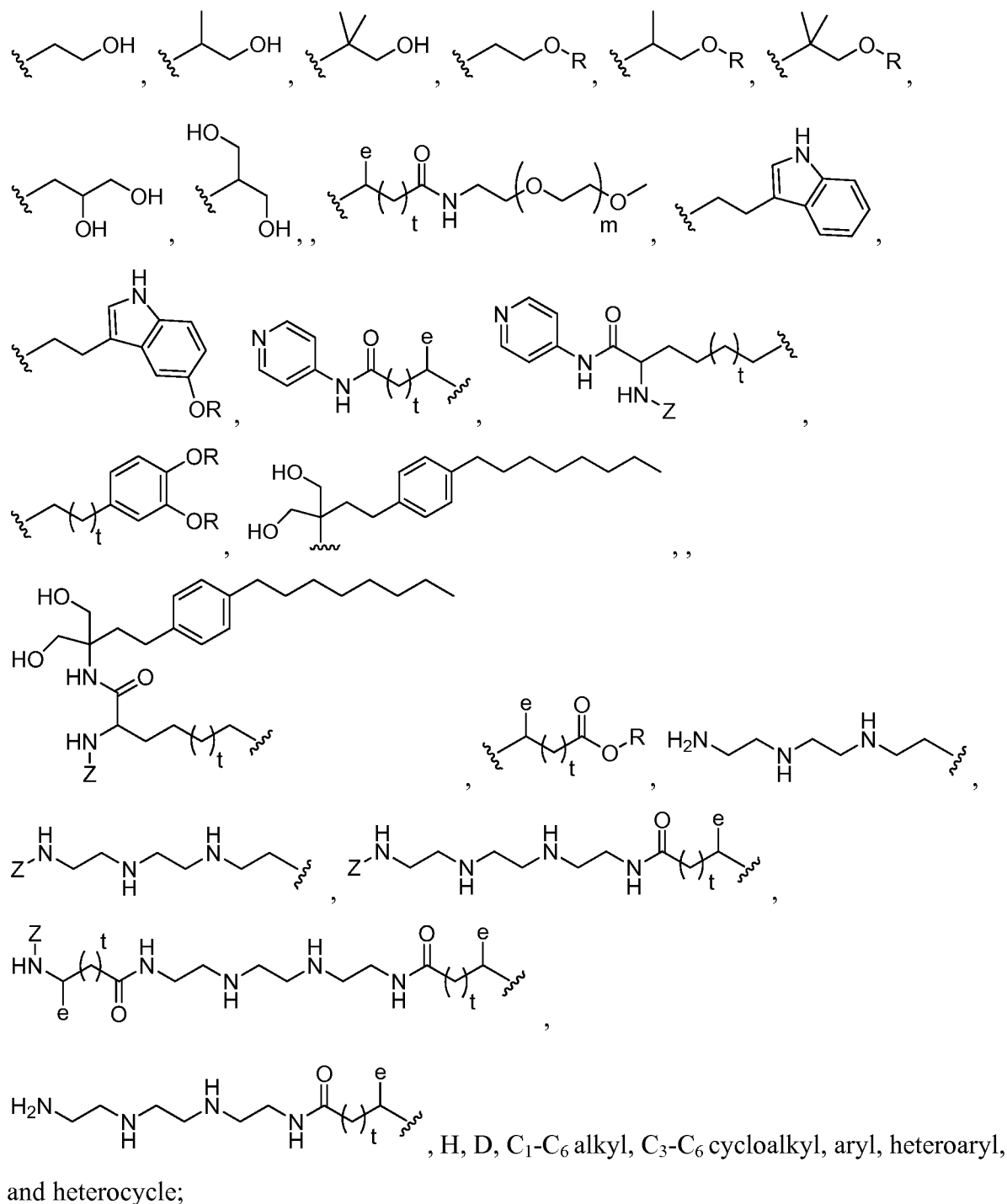
each v is independently 1, 2, or 6;

R₁ and R₂ are independently -H, -D, -C₁-C₄ alkyl, -halogen, -OH, -C(O)C₁-C₄ alkyl, -O-aryl, -O-benzyl, -OC(O)C₁-C₄ alkyl, -C₁-C₃ alkene, -C₁-C₃ alkyne, -C(O)C₁-C₄ alkyl, -NH₂, -NH(C₁-C₃ alkyl), -N(C₁-C₃ alkyl)₂, -NH(C(O)C₁-C₃ alkyl), -N(C(O)C₁-C₃ alkyl)₂, -SH, -S(C₁-C₃ alkyl), -S(O)C₁-C₃ alkyl, -S(O)₂C₁-C₃ alkyl;

R_3 and R_4 are independently selected from:

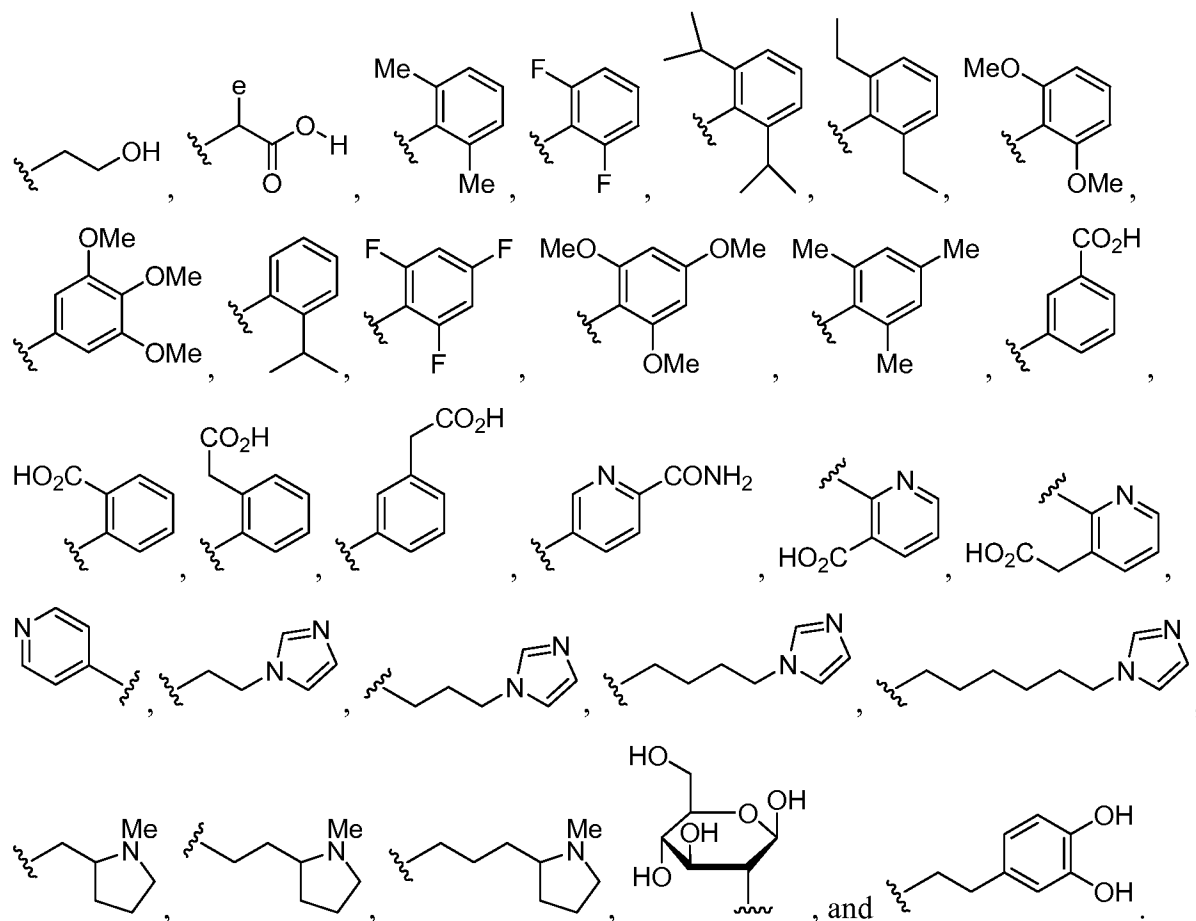






with the proviso that

when R_3 is H then R_4 is not



[0015] Also described herein are methods of treating a disease susceptible to treatment with a fatty acid amide in a patient in need thereof by administering to the patient an effective amount of a fatty acid amide.

[0016] Also described herein are methods of treating metabolic diseases, autoimmune disease, respiratory disease, or neurodegenerative diseases by administering to a patient in need thereof an effective amount of a fatty acid amide.

[0017] The invention also includes pharmaceutical compositions that comprise an effective amount of a fatty acid amide and a pharmaceutically acceptable carrier. The compositions are useful for treating or preventing a metabolic disease, autoimmune disease, respiratory disease, or neurodegenerative diseases. The invention includes a fatty acid amide provided as a pharmaceutically acceptable prodrug, a hydrate, a salt, such as a pharmaceutically acceptable salt, enantiomer, stereoisomer, or mixtures thereof.

[0018] The details of the invention are set forth in the accompanying description below. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, illustrative methods and materials are now described. Other features, objects, and advantages of the invention will be apparent from the description and from the claims. In the specification and the appended claims, the singular forms also include the plural unless the context clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. All patents and publications cited in this specification are incorporated herein by reference in their entireties.

DETAILED DESCRIPTION OF THE INVENTION

[0019] Metabolic disorders are a wide variety of medical disorders that interfere with a subject's metabolism. Metabolism is the process a subject's body uses to transform food into energy. Metabolism in a subject with a metabolic disorder is disrupted in some way. Autoimmune diseases arise from an overactive immune response of the body against tissues normally present in the body. Neurodegenerative diseases result from the deterioration of neurons or their myelin sheaths, which would eventually lead to a variety of CNS-related dysfunctions. The fatty acid amides possess the ability to treat or prevent metabolic disorders, autoimmune, respiratory diseases, or neurodegenerative diseases. In addition, the fatty acid amides can also be used to treat a variety of cancer such as carcinoma, sarcoma, lymphoma, leukemia, melanoma, mesothelioma, multiple myeloma, seminoma, and cancer of the bladder, blood, bone, brain, breast, central nervous system, colon, endometrium,

esophagus, genitourinary tract, head, larynx, liver, lung, neck, ovary, pancreas, prostate, testicle, spleen, small intestine, large intestine or stomach.

DEFINITIONS

[0020] The following definitions are used in connection with the fatty acid amides:

[0021] The term “fatty acid amides” includes any and all possible isomers, stereoisomers, enantiomers, diastereomers, tautomers, pharmaceutically acceptable salts, hydrates, solvates, and prodrugs of the fatty acid amide conjugates described herein.

[0022] The articles “a” and “an” are used in this disclosure to refer to one or more than one (*i.e.*, to at least one) of the grammatical object of the article. By way of example, “an element” means one element or more than one element.

[0023] The term “and/or” is used in this disclosure to mean either “and” or “or” unless indicated otherwise.

[0024] Unless otherwise specifically defined, the term “aryl” refers to cyclic, aromatic hydrocarbon groups that have 1 to 2 aromatic rings, including monocyclic or bicyclic groups such as phenyl, biphenyl or naphthyl. Where containing two aromatic rings (bicyclic, *etc.*), the aromatic rings of the aryl group may be joined at a single point (*e.g.*, biphenyl), or fused (*e.g.*, naphthyl). The aryl group may be optionally substituted by one or more substituents, *e.g.*, 1 to 5 substituents, at any point of attachment. The substituents can themselves be optionally substituted. It is understood that any of the substitutable hydrogens on an aryl can be substituted with halogen, C₁-C₃ alkyl, hydroxyl, alkoxy and cyano groups.

[0025] “C₁-C₃ alkyl” refers to a straight or branched chain saturated hydrocarbon containing 1-3 carbon atoms. Examples of a C₁-C₃ alkyl group include, but are not limited to, methyl, ethyl, propyl and isopropyl.

[0026] “C₁-C₄ alkyl” refers to a straight or branched chain saturated hydrocarbon containing 1-4 carbon atoms. Examples of a C₁-C₄ alkyl group include, but are not limited to, methyl, ethyl, propyl, butyl, isopropyl, isobutyl, *sec*-butyl and *tert*-butyl.

[0027] “C₁-C₅ alkyl” refers to a straight or branched chain saturated hydrocarbon containing 1-5 carbon atoms. Examples of a C₁-C₅ alkyl group include, but are not limited to, methyl, ethyl, propyl, butyl, pentyl, isopropyl, isobutyl, *sec*-butyl and *tert*-butyl, isopentyl and neopentyl.

[0028] “C₁-C₆ alkyl” refers to a straight or branched chain saturated hydrocarbon containing 1-6 carbon atoms. Examples of a C₁-C₆ alkyl group include, but are not limited to, methyl, ethyl, propyl, butyl, pentyl, hexyl, isopropyl, isobutyl, *sec*-butyl, *tert*-butyl, isopentyl, and neopentyl. It is understood that any of the substitutable hydrogens on a C₁-C₆ alkyl can be substituted with halogen, hydroxyl, alkoxy and cyano groups.

[0029] The term “cycloalkyl” refers to a cyclic hydrocarbon containing 3-6 carbon atoms. Examples of a cycloalkyl group include, but are not limited to, cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. It is understood that any of the substitutable hydrogens on a cycloalkyl can be substituted with halogen, C₁-C₃ alkyl, hydroxyl, alkoxy and cyano groups.

[0030] The term “heterocycle” as used herein refers to a cyclic hydrocarbon containing 3-6 atoms wherein at least one of the atoms is an O, N, or S. Examples of heterocycles include, but are not limited to, aziridine, oxirane, thiirane, azetidine, oxetane, thietane, pyrrolidine, tetrahydrofuran, tetrahydrothiophene, piperidine, tetrahydropyran, thiane, imidazolidine, oxazolidine, thiazolidine, dioxolane, dithiolane, piperazine, oxazine, dithiane and dioxane. It is understood that any of the substitutable hydrogens on a heterocycle can be substituted with halogen, C₁-C₃ alkyl, hydroxyl, alkoxy and cyano groups.

[0031] The term “heteroaryl” as used herein refers to a monocyclic or bicyclic ring structure having 5 to 12 ring atoms wherein one or more of the ring atoms is a heteroatom, e.g. N, O or S and wherein one or more rings of the bicyclic ring structure is aromatic. Some examples of heteroaryl are pyridyl, furyl, pyrrolyl, thienyl, thiazolyl, oxazolyl, imidazolyl, indolyl, tetrazolyl, benzofuryl, xanthenes and dihydroindole. It is understood that any of the substitutable hydrogens on a heteroaryl can be substituted with halogen, C₁-C₃ alkyl, hydroxyl, alkoxy and cyano groups.

[0032] The term “any one of the side chains of the naturally occurring amino acids” as used herein means a side chain of any one of the following amino acids: Isoleucine, Alanine, Leucine, Asparagine, Lysine, Aspartate, Methionine, Cysteine, Phenylalanine, Glutamate, Threonine, Glutamine, Tryptophan, Glycine, Valine, Proline, Arginine, Serine, Histidine and Tyrosine.

[0033] The term “fatty acid” as used herein means an omega-3 fatty acid and fatty acids that are metabolized *in vivo* to omega-3 fatty acids. Non-limiting examples of fatty acids are *all-cis*-7,10,13-hexadecatrienoic acid, α -linolenic acid (ALA or *all-cis*-9,12,15-

octadecatrienoic acid), stearidonic acid (STD or *all-cis*-6,9,12,15-octadecatetraenoic acid), eicosatrienoic acid (ETE or *all-cis*-11,14,17-eicosatrienoic acid), eicosatetraenoic acid (ETA or *all-cis*-8,11,14,17-eicosatetraenoic acid), eicosapentaenoic acid (EPA or *all-cis*-5,8,11,14,17-eicosapentaenoic acid), docosapentaenoic acid (DPA, clupanodonic acid or *all-cis*-7,10,13,16,19-docosapentaenoic acid), docosahexaenoic acid (DHA or *all-cis*-4,7,10,13,16,19-docosahexaenoic acid), tetracosapentaenoic acid (*all-cis*-9,12,15,18,21-docosahexaenoic acid), or tetracosahexaenoic acid (nisinic acid or *all-cis*-6,9,12,15,18,21-tetracosenoic acid).

[0034] A “subject” is a mammal, *e.g.*, a human, mouse, rat, guinea pig, dog, cat, horse, cow, pig, or non-human primate, such as a monkey, chimpanzee, baboon or rhesus, and the terms “subject” and “patient” are used interchangeably herein.

[0035] The invention also includes pharmaceutical compositions comprising an effective amount of a fatty acid amide and a pharmaceutically acceptable carrier. The invention includes a fatty acid amide provided as a pharmaceutically acceptable prodrug, hydrate, salt, such as a pharmaceutically acceptable salt, enantiomers, stereoisomers, or mixtures thereof.

[0036] Representative “pharmaceutically acceptable salts” include, *e.g.*, water-soluble and water-insoluble salts, such as the acetate, amsonate (4,4-diaminostilbene-2, 2 - disulfonate), benzenesulfonate, benzonate, bicarbonate, bisulfate, bitartrate, borate, bromide, butyrate, calcium, calcium edetate, camsylate, carbonate, chloride, citrate, clavulariate, dihydrochloride, edetate, edisylate, estolate, esylate, fiunarate, gluceptate, gluconate, glutamate, glycollylarsanilate, hexafluorophosphate, hexylresorcinate, hydrabamine, hydrobromide, hydrochloride, hydroxynaphthoate, iodide, isothionate, lactate, lactobionate, laurate, magnesium, malate, maleate, mandelate, mesylate, methylbromide, methylnitrate, methylsulfate, mucate, napsylate, nitrate, *N*-methylglucamine ammonium salt, 3-hydroxy-2-naphthoate, oleate, oxalate, palmitate, pamoate (1,1-methene-bis-2-hydroxy-3-naphthoate, einbonate), pantothenate, phosphate/diphosphate, picrate, polygalacturonate, propionate, *p*-toluenesulfonate, salicylate, stearate, subacetate, succinate, sulfate, sulfosalicylate, suramate, tannate, tartrate, teoclate, tosylate, triethiodide, and valerate salts.

[0037] The term “metabolic disease” as used herein refers to disorders, diseases and syndromes involving dyslipidemia, and the terms metabolic disorder, metabolic disease, and metabolic syndrome are used interchangeably herein.

[0038] An “effective amount” when used in connection with a fatty acid amide is an amount effective for treating or preventing a metabolic disease.

[0039] The term “carrier”, as used in this disclosure, encompasses carriers, excipients, and diluents and means a material, composition or vehicle, such as a liquid or solid filler, diluent, excipient, solvent or encapsulating material, involved in carrying or transporting a pharmaceutical agent from one organ, or portion of the body, to another organ, or portion of the body.

[0040] The term “treating”, with regard to a subject, refers to improving at least one symptom of the subject's disorder. Treating can be curing, improving, or at least partially ameliorating the disorder.

[0041] The term “disorder” is used in this disclosure to mean, and is used interchangeably with, the terms disease, condition, or illness, unless otherwise indicated.

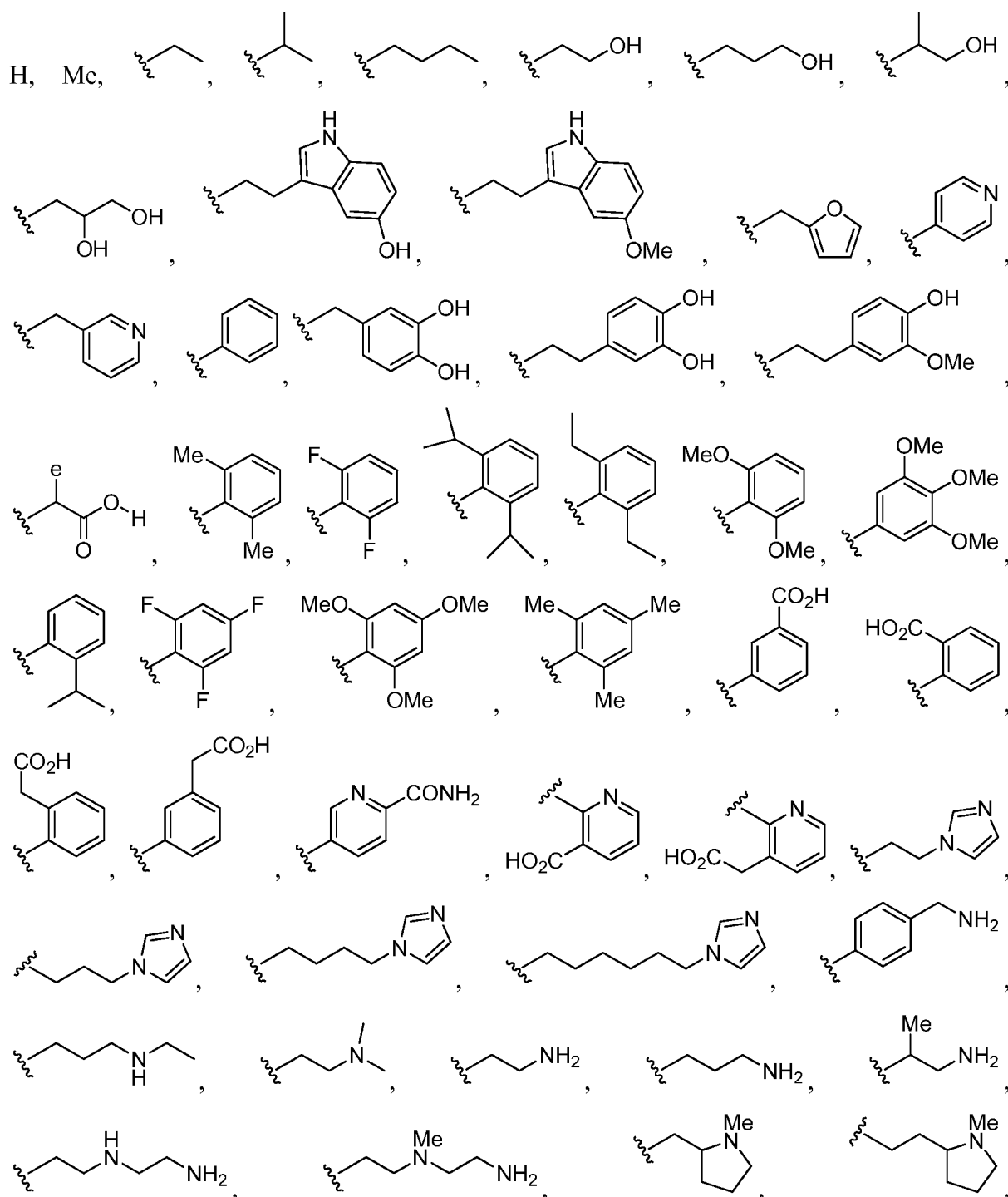
[0042] The term “administer”, “administering”, or “administration” as used in this disclosure refers to either directly administering a compound or pharmaceutically acceptable salt of the compound or a composition to a subject, or administering a prodrug derivative or analog of the compound or pharmaceutically acceptable salt of the compound or composition to the subject, which can form an equivalent amount of active compound within the subject's body.

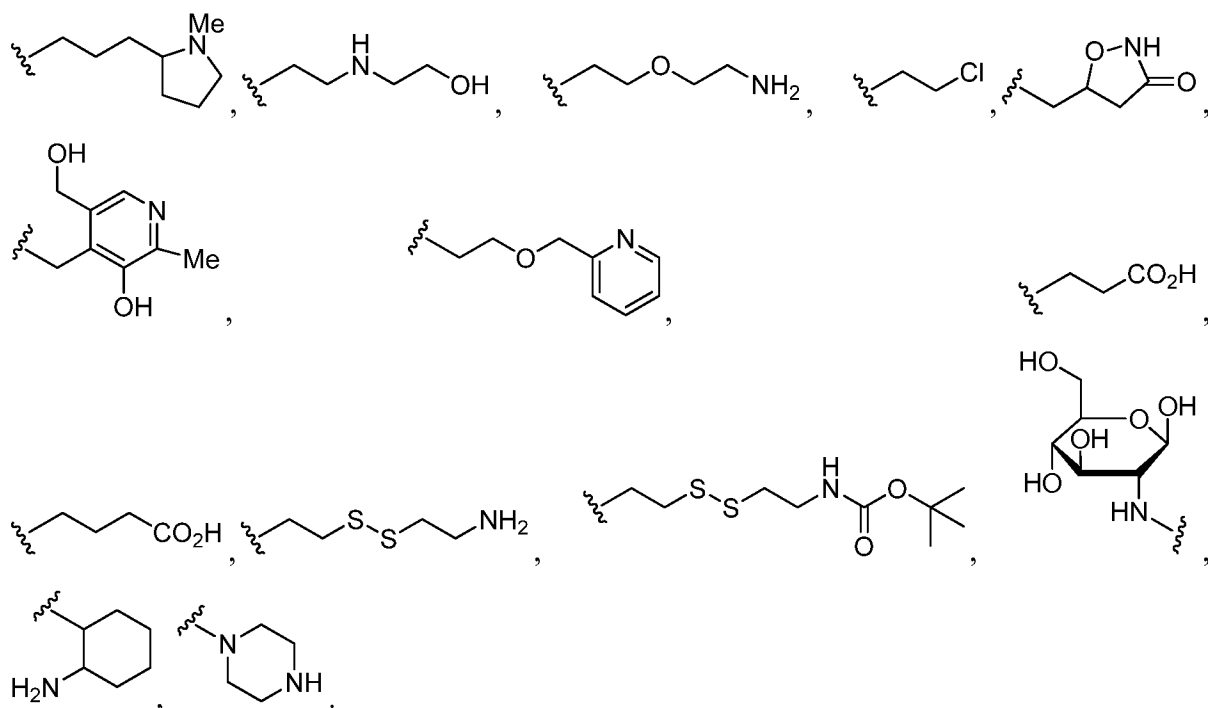
[0043] The term “prodrug,” as used in this disclosure, means a compound which is convertible *in vivo* by metabolic means (*e.g.*, by hydrolysis) to a fatty acid amide.

[0044] The following abbreviations are used herein and have the indicated definitions: Boc and BOC are *tert*-butoxycarbonyl, Boc₂O is di-*tert*-butyl dicarbonate, CDI is 1,1'-carbonyldiimidazole, DCC is *N,N'*-dicyclohexylcarbodiimide, DIEA is *N,N*-diisopropylethylamine, DMAP is 4-dimethylaminopyridine, DOSS is sodium dioctyl sulfosuccinate, EDC and EDCI are 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride, EtOAc is ethyl acetate, h is hour, HATU is 2-(7-aza-1*H*-benzotriazole-1-yl)-1,1,3,3-tetramethyluronium hexafluorophosphate, HPMC is hydroxypropyl methylcellulose, oxone is potassium peroxymonosulfate, Pd/C is palladium on carbon, TFA is trifluoroacetic acid, TGPS is tocopherol propylene glycol succinate, THF is tetrahydrofuran, and TNF is tumor necrosis factor.

COMPOUNDS

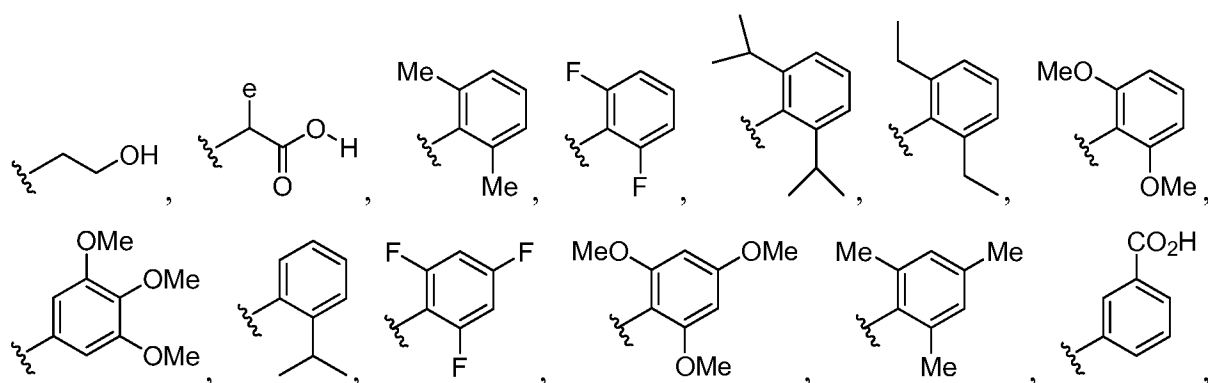
[0045] Accordingly in one aspect, a fatty acid amide is described which comprises a fatty acid covalently linked to an amine, wherein the fatty acids are selected from the group consisting of omega-3 fatty acids and fatty acids that are metabolized *in vivo* to omega-3 fatty acids, and the amide is capable of hydrolysis to produce free fatty acids with the proviso that when the amine is a primary amine then the amine cannot be:

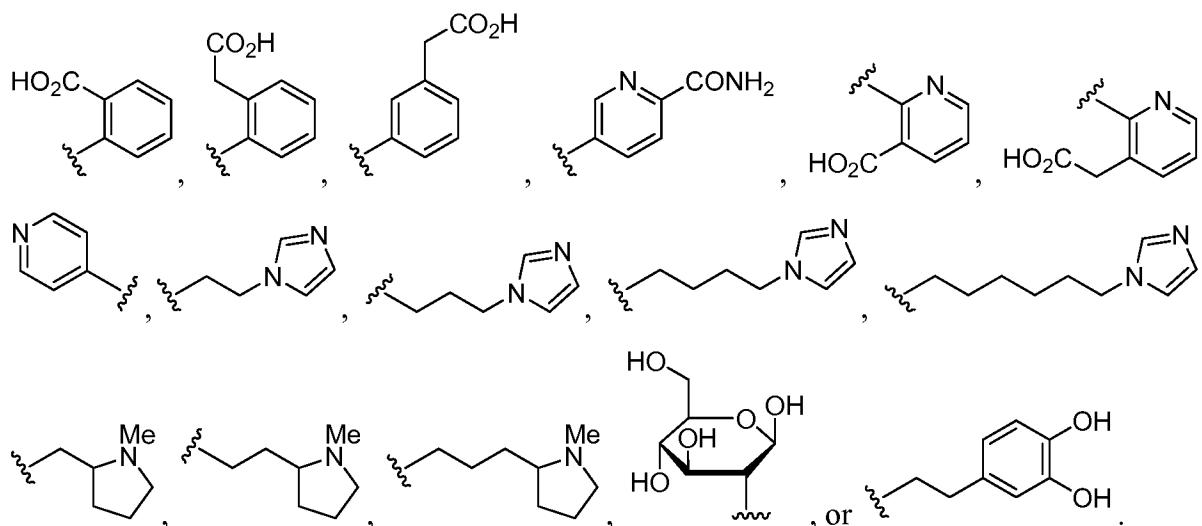




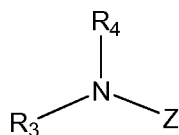
[0046] In some embodiments, the fatty acids are selected from the group consisting of *all-cis*-7,10,13-hexadecatrienoic acid, α -linolenic acid, stearidonic acid, eicosatrienoic acid, eicosatetraenoic acid, eicosapentaenoic acid (EPA), docosapentaenoic acid, docosahexaenoic acid (DHA), tetracosapentaenoic acid, tetracosahexaenoic acid, and lipoic acid. In other embodiments, the fatty acid is selected from eicosapentaenoic acid, docosahexaenoic acid, and lipoic acid. In other embodiments, the fatty acid is selected from eicosapentaenoic acid and docosahexaenoic acid. In some embodiments, the hydrolysis is enzymatic.

[0047] In another aspect pharmaceutical formulations a fatty acid amide is described which comprises a fatty acid covalently linked to an amine, wherein the fatty acids are selected from the group consisting of omega-3 fatty acids and fatty acids that are metabolized *in vivo* to omega-3 fatty acids, and the amide is capable of hydrolysis to produce free fatty acids with the proviso that when the amine is a primary amine then the amine cannot be





[0048] In another aspect, the present invention provides fatty acid amides according to **Formula I**:

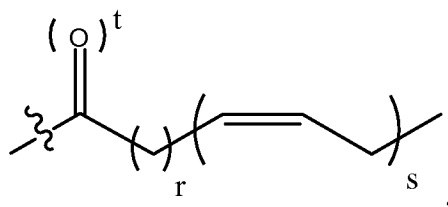


Formula I

and pharmaceutically acceptable salts, hydrates, solvates, prodrugs, enantiomers and stereoisomers thereof;

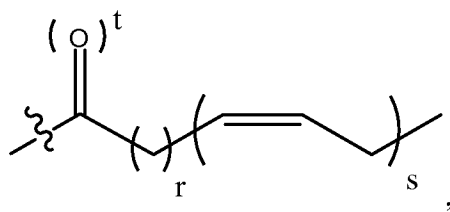
wherein m, e, r, s, t, v, z, R₁, R₂, R₃, R₄, are as defined above for **Formula I**,

[0049] In some embodiments, one Z is



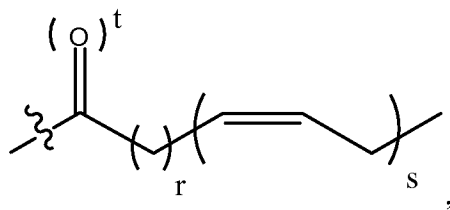
and r is 2.

[0050] In some embodiments, one Z is



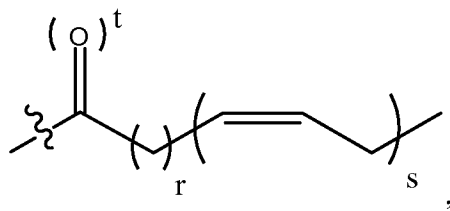
and r is 3.

[0051] In some embodiments, one Z is



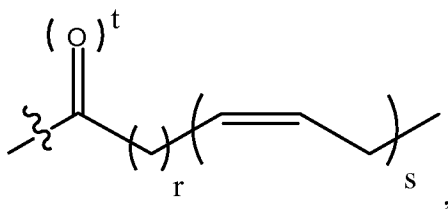
and r is 7.

[0052] In other embodiments, one Z is



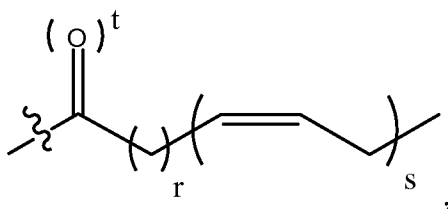
and s is 3.

[0053] In some embodiments, one Z is



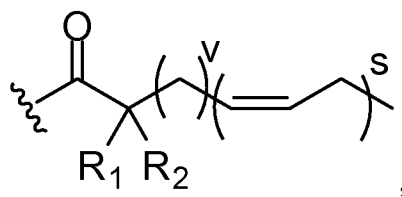
and s is 5.

[0054] In some embodiments, one Z is



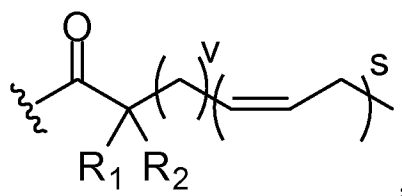
and s is 6.

[0055] In some embodiments, one Z is



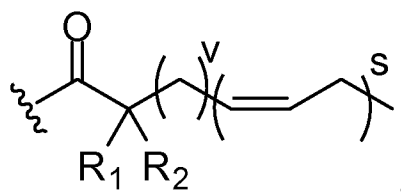
and v is 1.

[0056] In other embodiments, one Z is



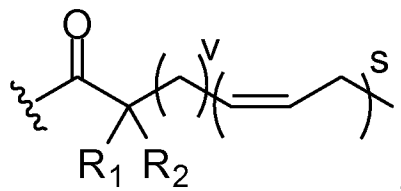
and v is 2.

[0057] In some embodiments, one Z is



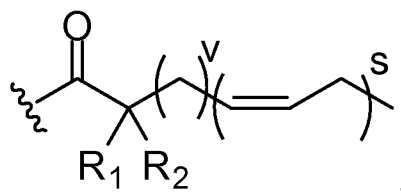
and v is 6.

[0058] In some embodiments, one Z is



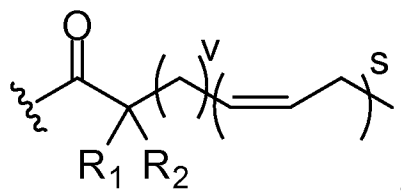
and s is 3.

[0059] In some embodiments, one Z is



and s is 5.

[0060] In other embodiments, one Z is



and s is 6.

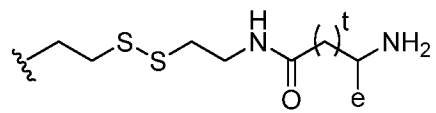
[0061] In some embodiments, r is 2 and s is 6.

[0062] In some embodiments, r is 3 and s is 5.

[0063] In some embodiments, t is 1.

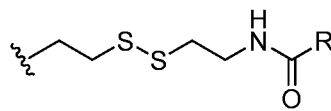
[0064] In some embodiments, R₃ is H and R₄ is

[0065] In some embodiments, R_3 is H and R_4 is



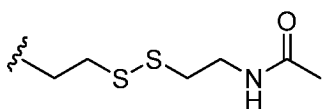
wherein t is 0 and e is the side chain of naturally occurring amino acids.

[0066] In some embodiments, R_3 is H and R_4 is

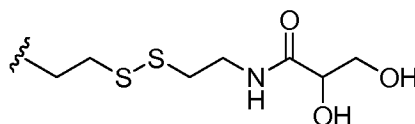


, wherein R is straight or branched $-C_1-C_6$ alkyl that is optionally substituted with one, two, three, four or five groups selected from OH, CN, halogen, CO_2R_5 , $CONHR_5$, $CONR_5R_5$, $S(O)_2NR_5R_5$, NR_5R_5 , NR_5COR_5 , $-(OCH_2CH_2)_m-OCH_3$.

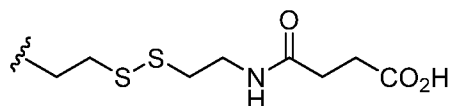
[0067] In some embodiments, R_3 is H and R_4 is



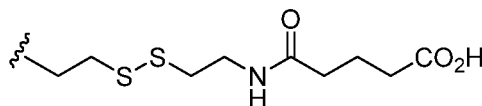
[0068] In some embodiments, R_3 is H and R_4 is



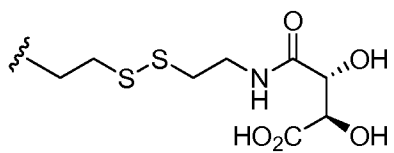
[0069] In some embodiments, R_3 is H and R_4 is



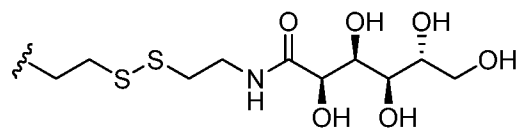
[0070] In some embodiments, R_3 is H and R_4 is



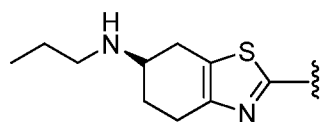
[0071] In some embodiments, R_3 is H and R_4 is



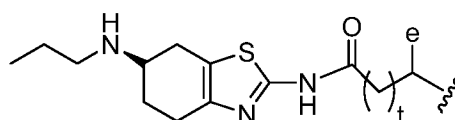
In some embodiments, R_3 is H and R_4 is



[0072] In some embodiments, R_3 is H and R_4 is

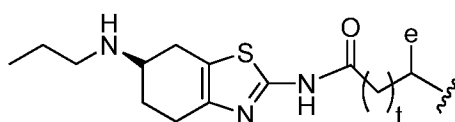


[0073] In some embodiments, R_3 is H and R_4 is



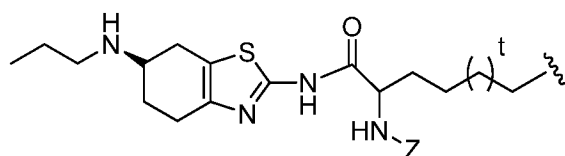
wherein t is 0 and e is the side chain of naturally occurring amino acids.

[0074] In some embodiments, R_3 is H and R_4 is



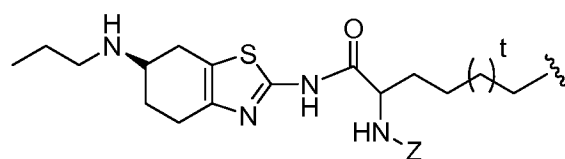
wherein t is 1 and e is the side chain of naturally occurring amino acid.

[0075] In some embodiments, R_3 is H and R_4 is



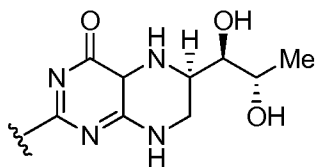
wherein t is 0 and Z is as defined above.

[0076] In some embodiments, R_3 is H and R_4 is

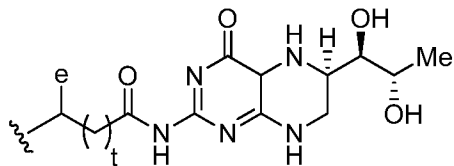


wherein t is 1 and Z is as defined above.

[0077] In some embodiments, R₃ is H and R₄ is

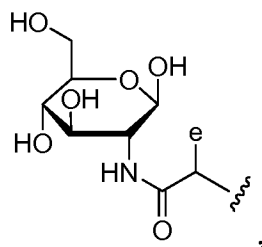


[0078] In some embodiments, R₃ is H and R₄ is



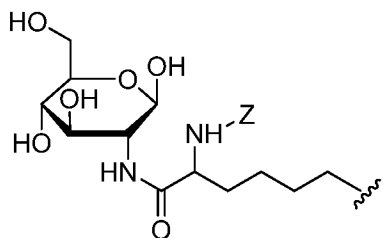
wherein t is 0 and e is the side chain of naturally occurring amino acids.

[0079] In some embodiments, R₃ is H and R₄ is

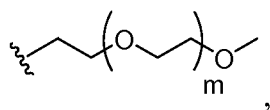


wherein e is the side chain of naturally occurring amino acids.

[0080] In some embodiments, R₃ is H and R₄ is

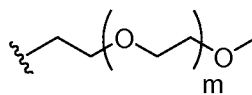


[0081] In some embodiments, R₃ is H and R₄ is



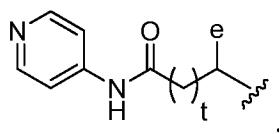
wherein m is 1.

[0082] In some embodiments, R₃ is H and R₄ is



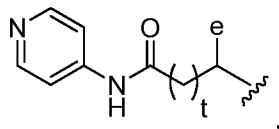
, wherein m is 2.

[0089] In some embodiments, R3 is H and R4 is



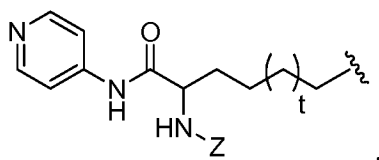
wherein t is 0 and e is the side chain of naturally occurring amino acids.

[0090] In some embodiments, R3 is H and R4 is



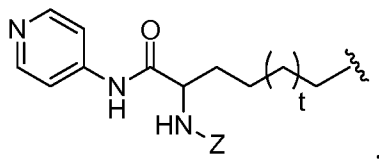
wherein t is 1 and e is the side chain of naturally occurring amino acids.

[0091] In some embodiments, R3 is H and R4 is



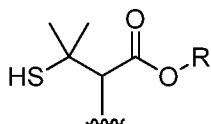
wherein t is 1 and Z is as defined above.

[0092] In some embodiments, R3 is H and R4 is



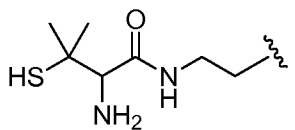
wherein t is 0 and Z is as defined above.

[0093] In some embodiments, R3 is H and R4 is

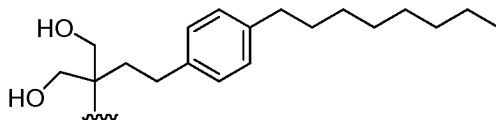


wherein R is H.

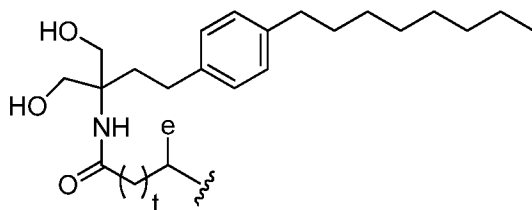
[0094] In some embodiments, R3 is H and R4 is



[0095] In some embodiments, R3 is H and R4 is

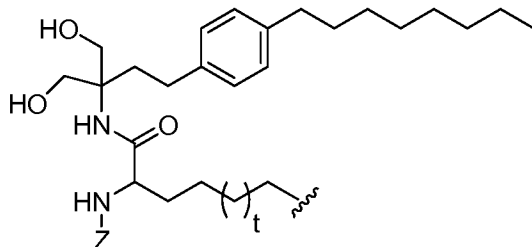


[0096] In some embodiments, R₃ is H and R₄ is



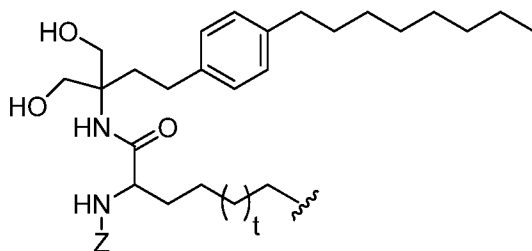
wherein t is 1 and e is the side chain of naturally occurring amino acid.

[0097] In some embodiments, R3 is H and R4 is



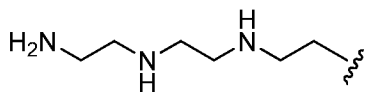
wherein t is 1 and Z is as defined above.

[0098] In some embodiments, R3 is H and R4 is



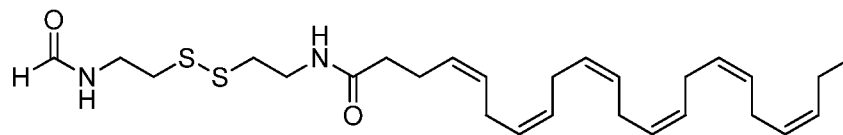
wherein t is 0 and Z is as defined above.

[0099] In some embodiments, R3 is H and R4 is

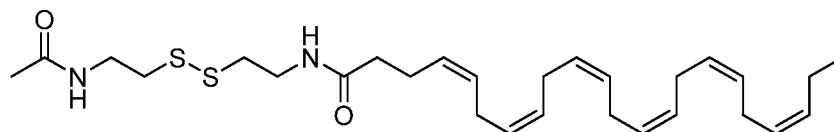


[00100] In **Formula I** and **I'**, any one or more of H may be substituted with a deuterium. It is also understood in **Formula I** and **I'** that a methyl substituent can be substituted with a C₁-C₆ alkyl.

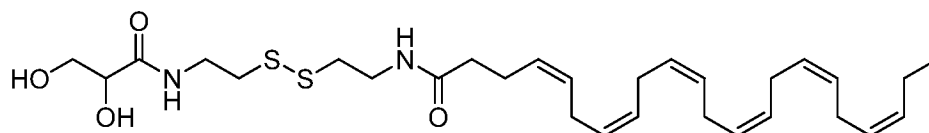
[00101] In other illustrative embodiments, compounds of **Formula I** are as set forth below:



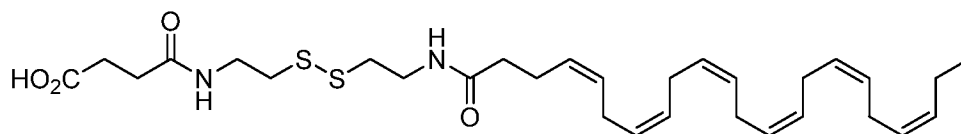
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-formamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-1**);



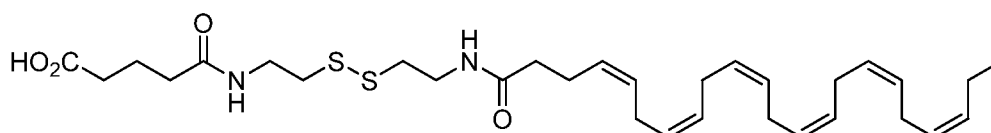
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-2**);



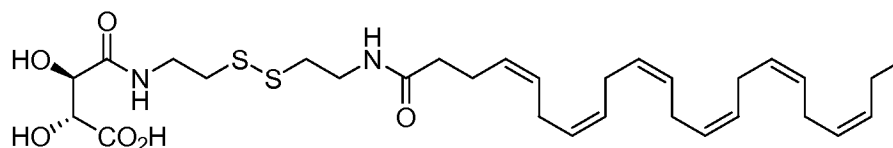
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-3**);



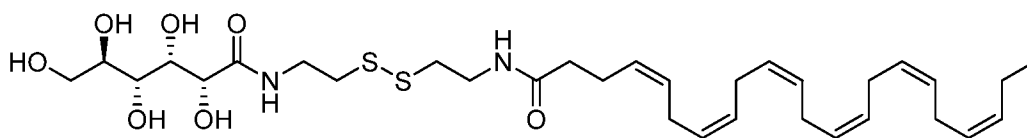
4-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-4**);



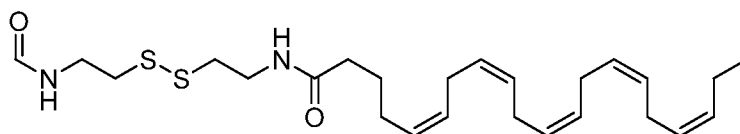
5-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-5-oxopentanoic acid (**I-5**);



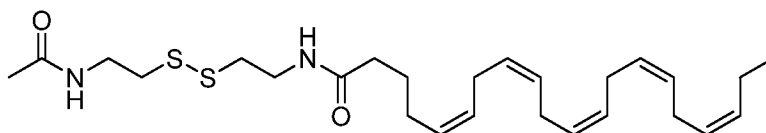
(2R,3R)-4-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-2,3-dihydroxy-4-oxobutanoic acid (**I-6**);



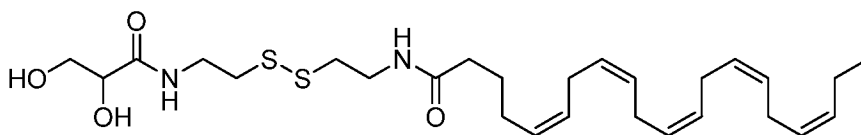
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-((2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanamido)ethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-7**);



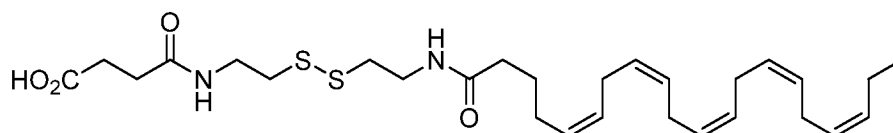
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-formamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-8**);



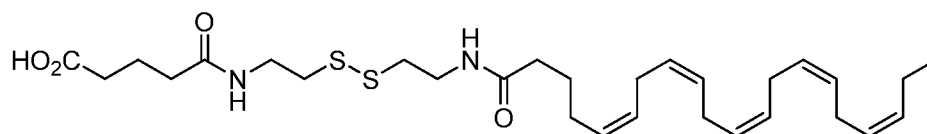
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-9**);



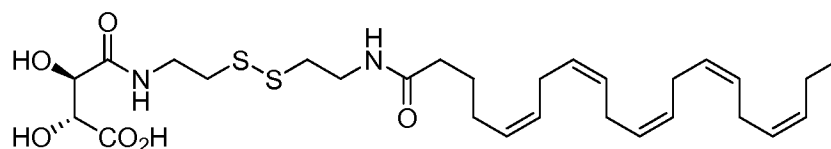
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-10**);



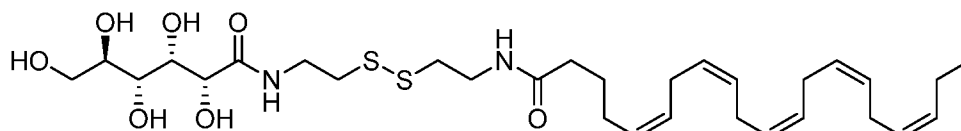
4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-11**);



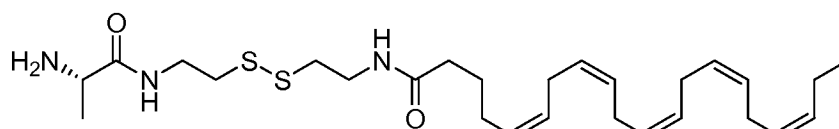
5-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-5-oxopentanoic acid (**I-12**);



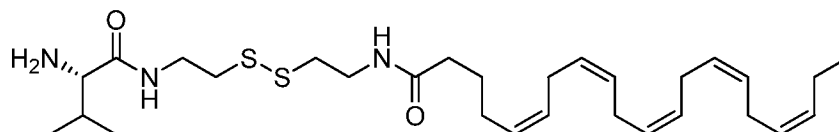
(2R,3R)-2,3-dihydroxy-4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-13**);



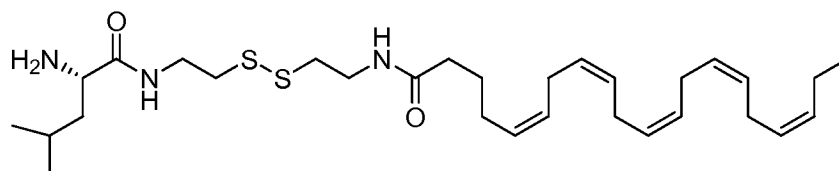
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-14**);



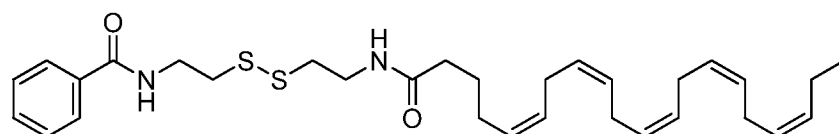
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((S)-2-aminopropanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-15**);



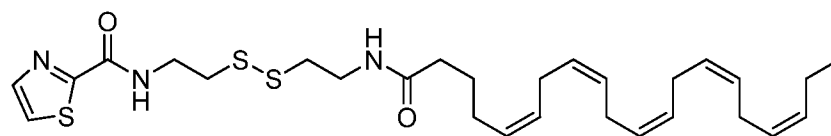
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((S)-2-amino-3-methylbutanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-16**);



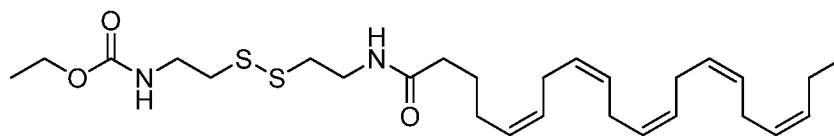
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((S)-2-amino-4-methylpentanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-17**);



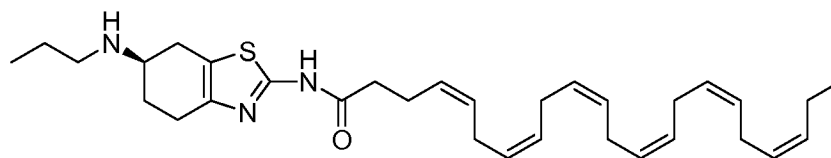
N-(2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)benzamide (**I-18**);



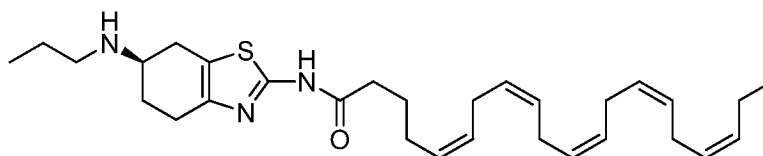
N-(2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)thiazole-2-carboxamide (**I-19**);



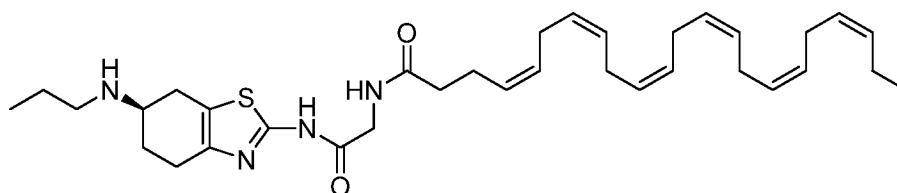
ethyl (2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)carbamate (**I-20**);



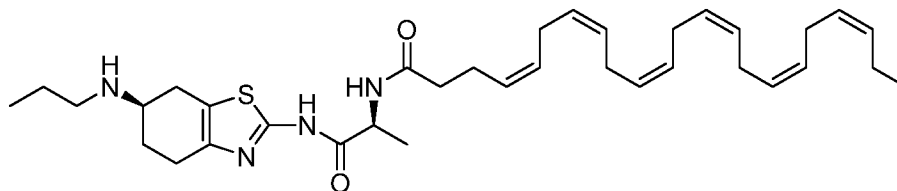
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-21**);



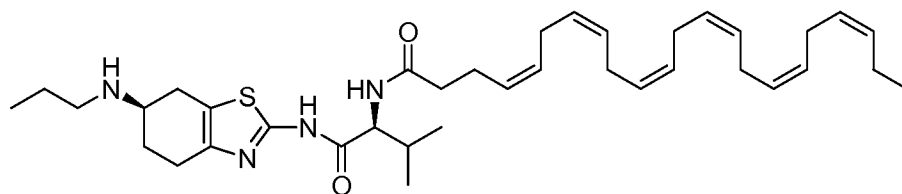
(5Z,8Z,11Z,14Z,17Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-22**);



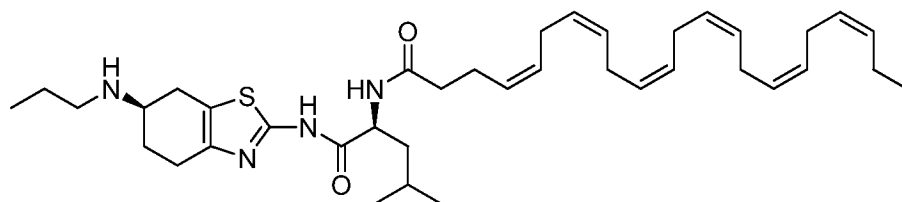
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-oxo-2-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-23**);



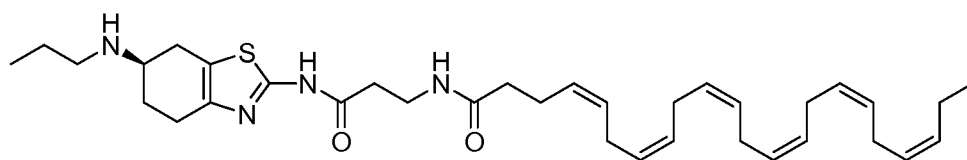
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-24**);



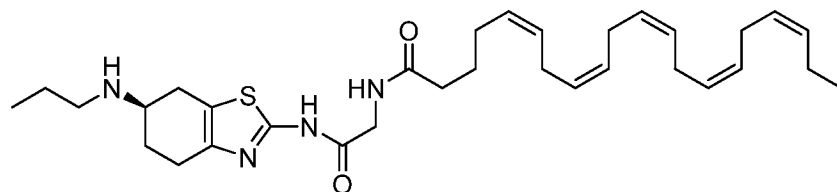
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-3-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)butan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-25**);



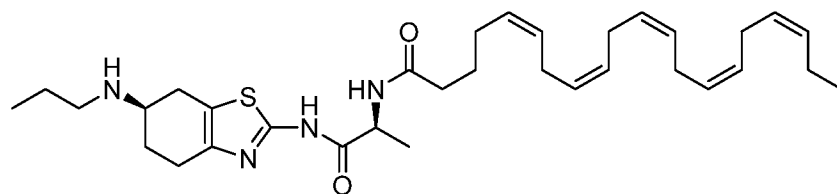
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-4-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)pentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-26**);



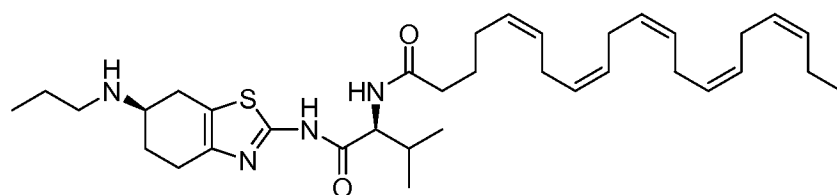
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)docosa-4,7,10,13,16,19-hexaenamide (**I-27**);



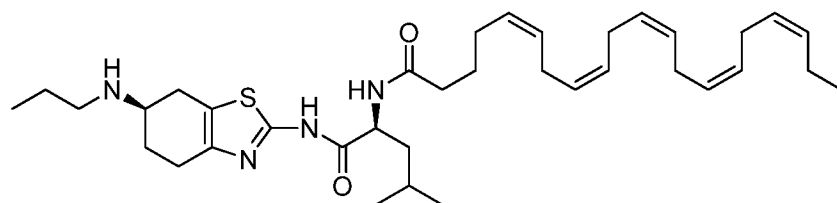
(5Z,8Z,11Z,14Z,17Z)-N-(2-oxo-2-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-28**);



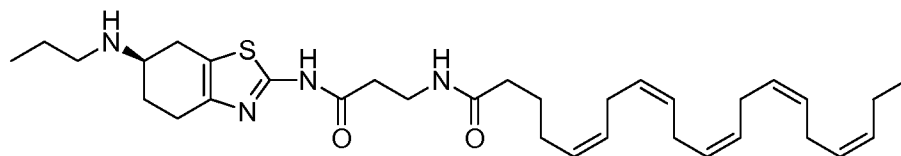
(5Z,8Z,11Z,14Z,17Z)-N-((S)-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-29**);



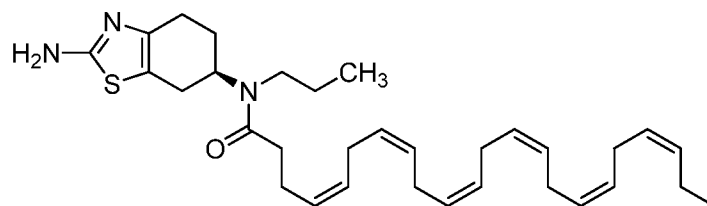
(5Z,8Z,11Z,14Z,17Z)-N-((S)-3-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)butan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-30**);



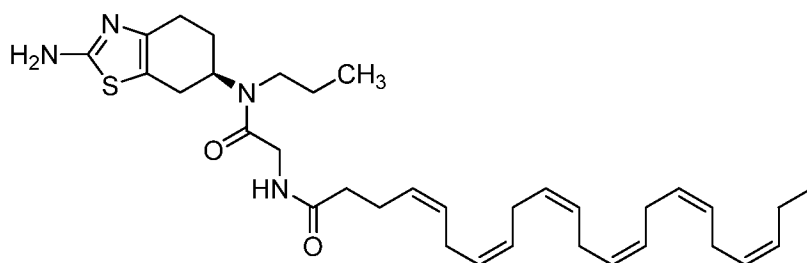
(5Z,8Z,11Z,14Z,17Z)-N-((S)-4-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)pentan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-31**);



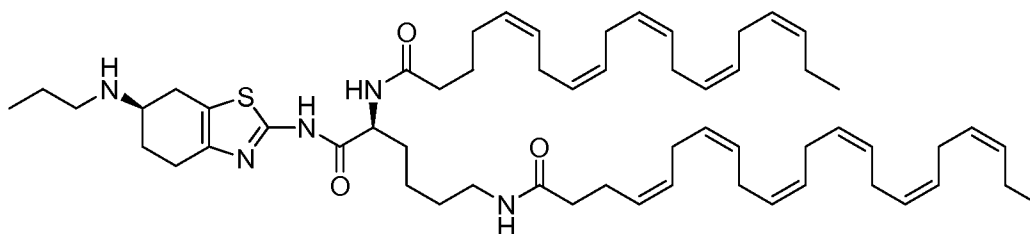
(5Z,8Z,11Z,14Z,17Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)icosa-5,8,11,14,17-pentaenamide (**I-32**);



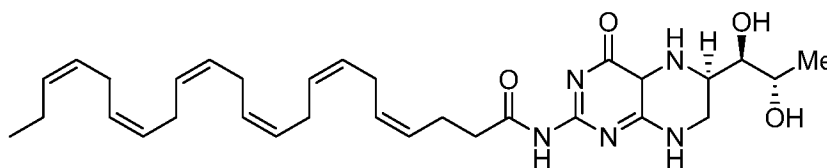
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((R)-2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)-N-propyldocosa-4,7,10,13,16,19-hexaenamide (**I-33**);



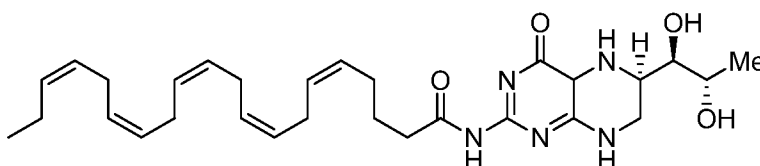
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(((R)-2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)amino)-2-oxoethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-34**);



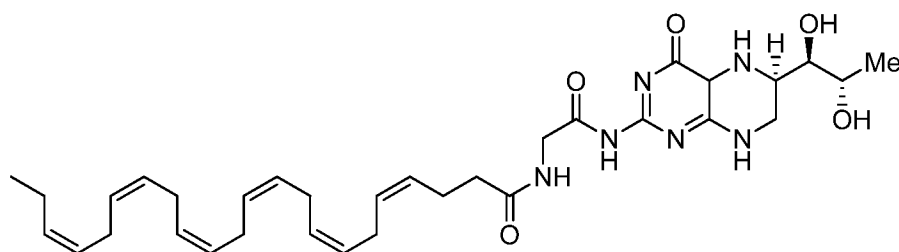
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxo-6-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (**I-35**);



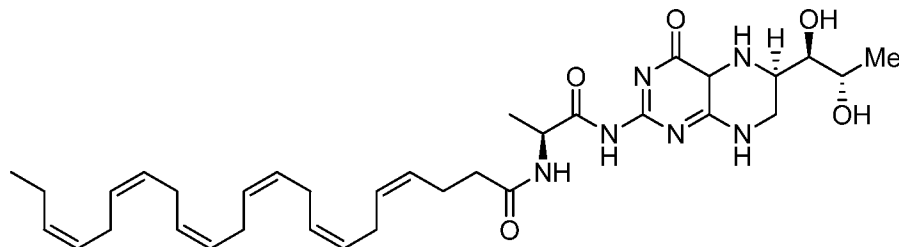
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-36**);



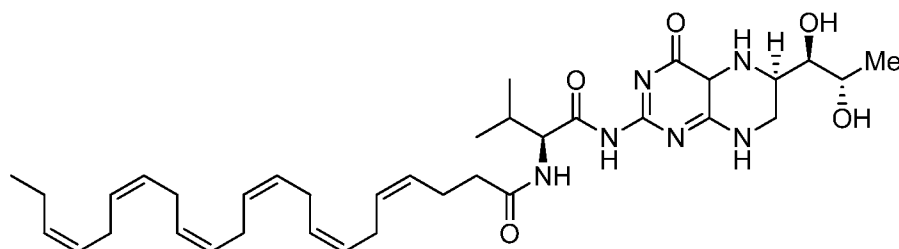
(5Z,8Z,11Z,14Z,17Z)-N-((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-37**);



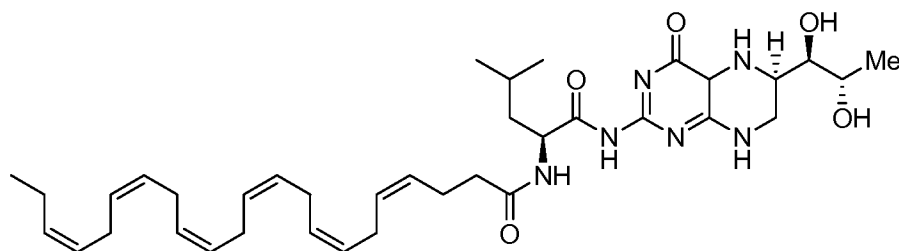
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-2-oxoethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-38**);



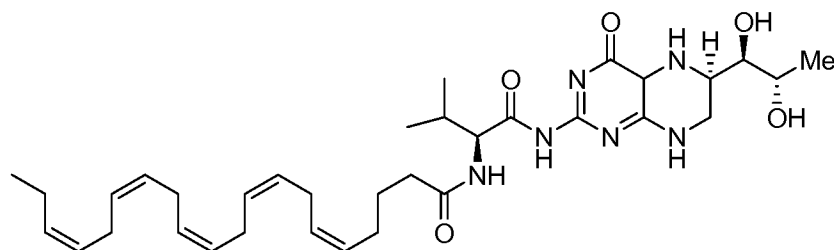
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-1-oxopropan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-39**);



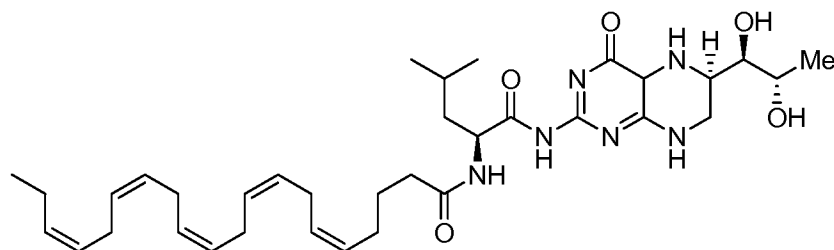
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-3-methyl-1-oxobutan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-40**);



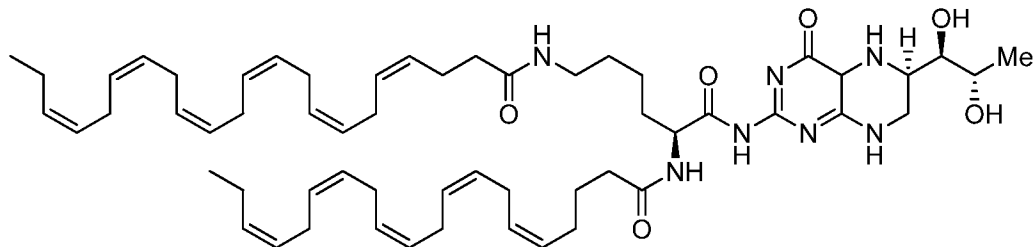
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-4-methyl-1-oxopentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-41**);



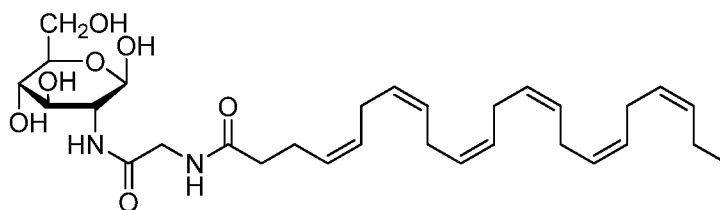
(5Z,8Z,11Z,14Z,17Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-3-methyl-1-oxobutan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-42**);



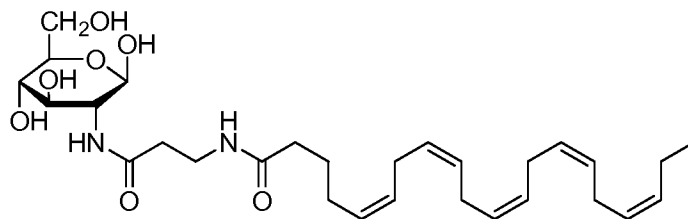
(5Z,8Z,11Z,14Z,17Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-4-methyl-1-oxopentan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-43**);



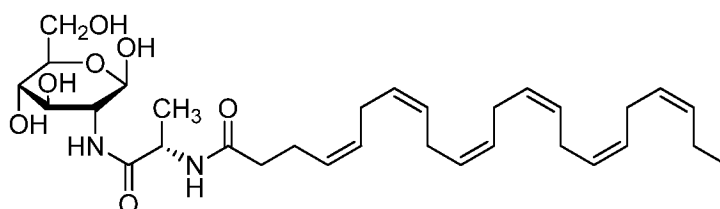
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((5S)-6-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxohexyl)docosa-4,7,10,13,16,19-hexaenamide (**I-44**);



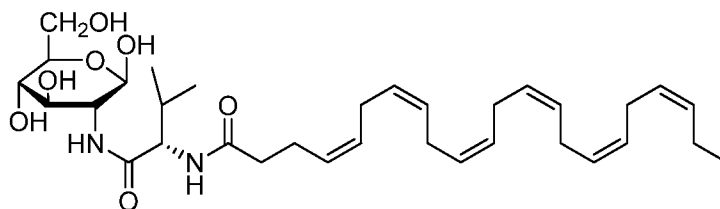
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-oxo-2-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-45**);



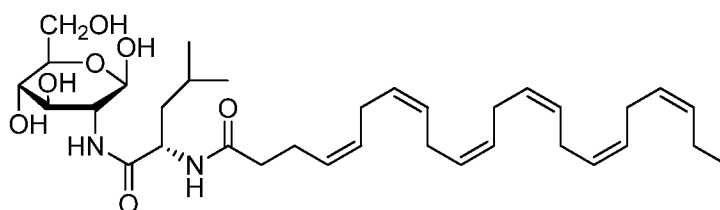
(5Z,8Z,11Z,14Z,17Z)-N-(3-oxo-3-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propyl)icosa-5,8,11,14,17-pentaenamide (**I-46**);



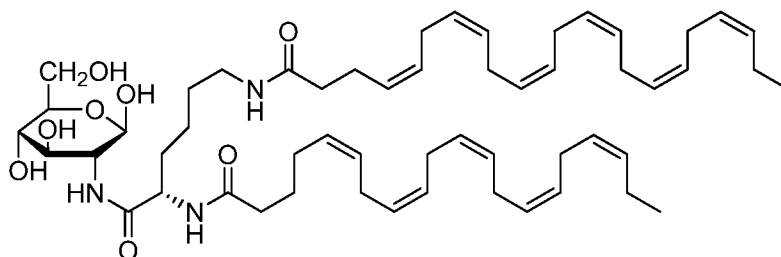
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-47**);



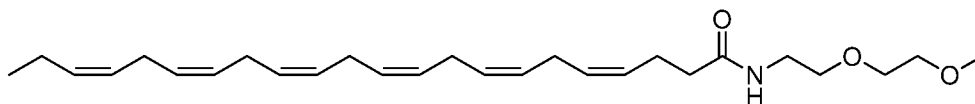
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-3-methyl-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)butan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-48**);



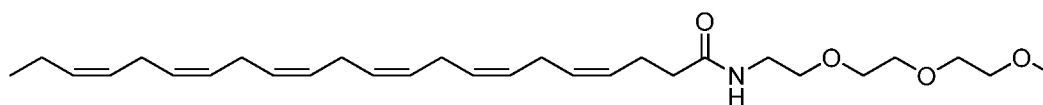
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-4-methyl-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)pentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-49**);



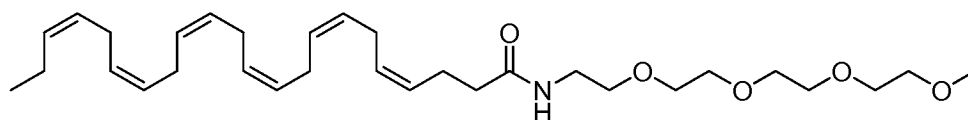
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (**I-50**);



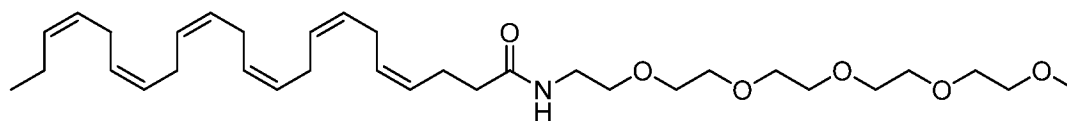
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-methoxyethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-51**);



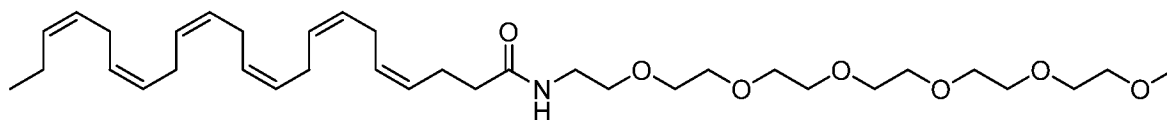
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-52**);



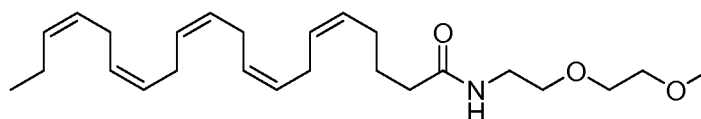
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-53**);



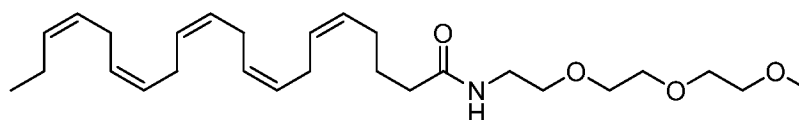
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-54**);



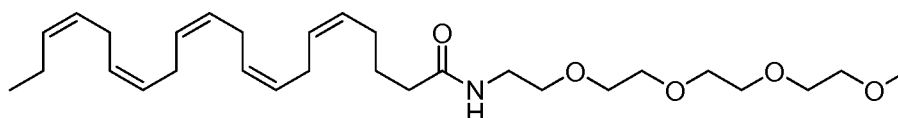
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-55**);



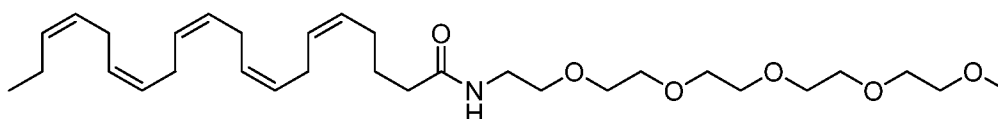
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-methoxyethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-56**);



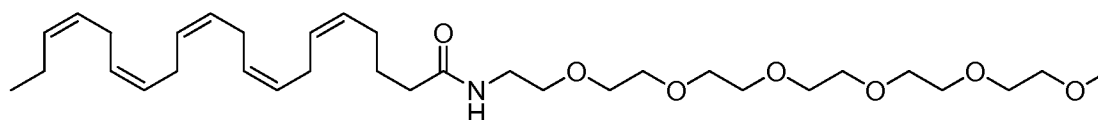
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-57**);



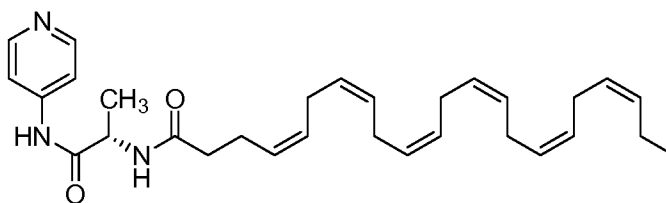
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-58**);



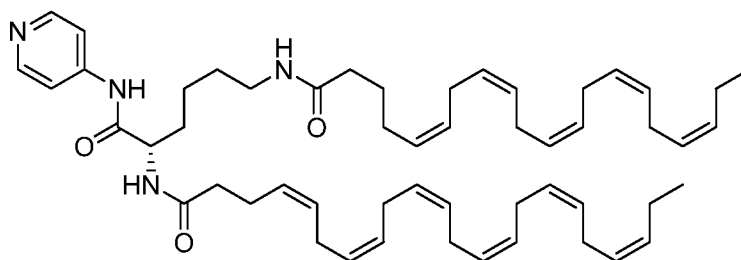
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-59**);



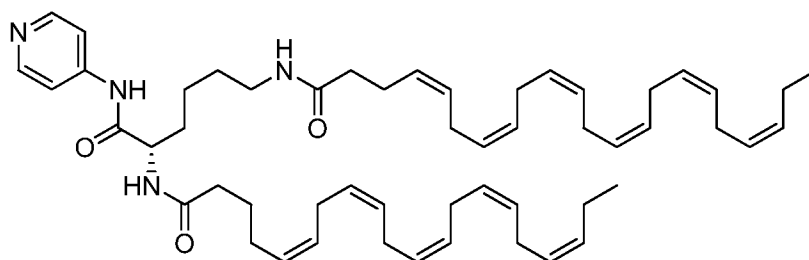
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-60**).



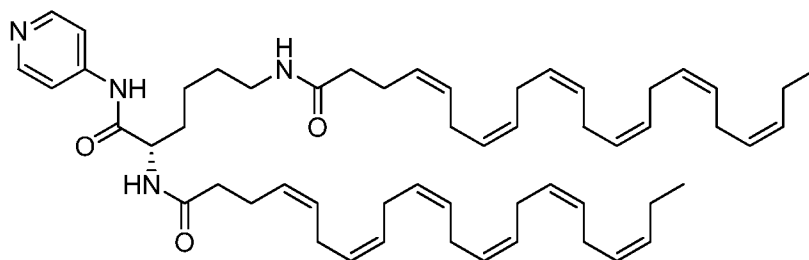
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(pyridin-4-ylamino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-61**);



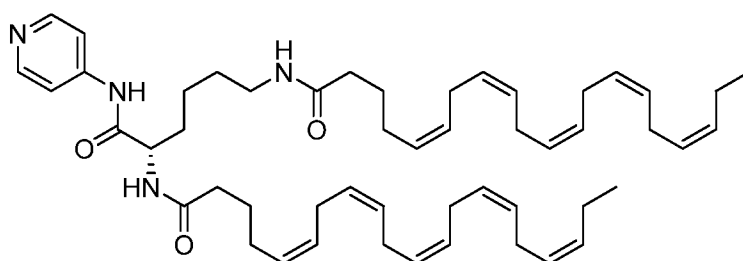
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-6-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-1-oxo-1-(pyridin-4-ylamino)hexan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-62**);



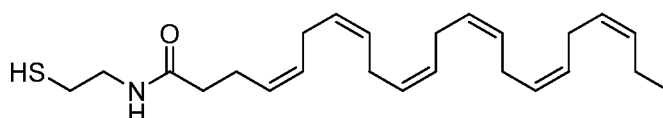
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxo-6-(pyridin-4-ylamino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (**I-63**);



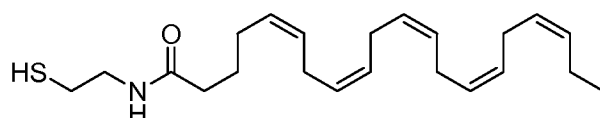
(4Z,4'Z,7Z,7'Z,10Z,10'Z,13Z,13'Z,16Z,16'Z,19Z,19'Z)-N,N'-((S)-6-oxo-6-(pyridin-4-ylamino)hexane-1,5-diyl)bis(docosa-4,7,10,13,16,19-hexaenamide) (**I-64**);



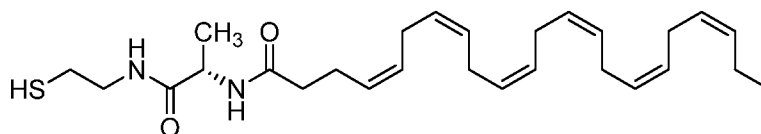
(5Z,5'Z,8Z,8'Z,11Z,11'Z,14Z,14'Z,17Z,17'Z)-N,N'-((S)-6-oxo-6-(pyridin-4-ylamino)hexane-1,5-diyl)bis(icosa-5,8,11,14,17-pentaenamide) (**I-65**);



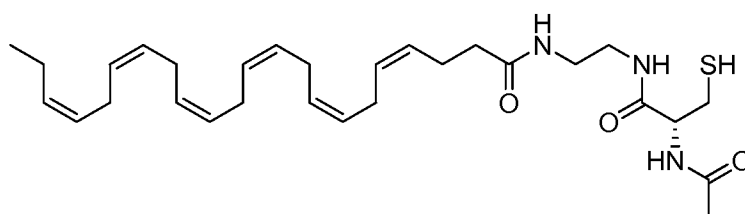
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-mercaptoethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-66**);



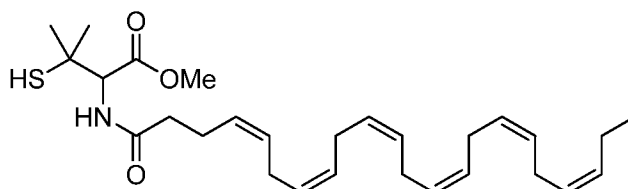
(5Z,8Z,11Z,14Z,17Z)-N-(2-mercaptoethyl)icosa-5,8,11,14,17-pentaenamide (**I-67**)



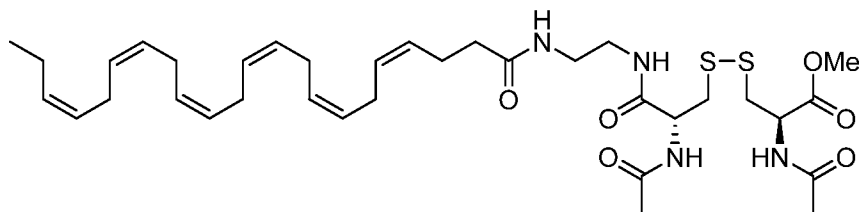
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-((2-mercaptoethyl)amino)-1-oxopropan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-68**);



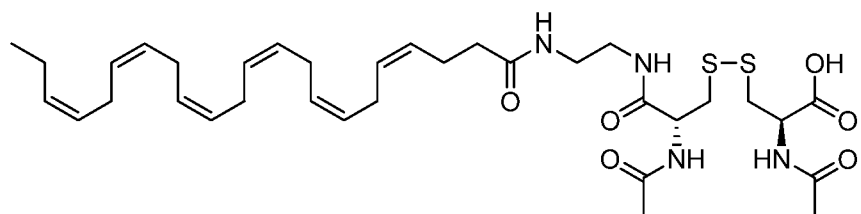
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((R)-2-acetamido-3-mercaptopropanamido)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-69**);



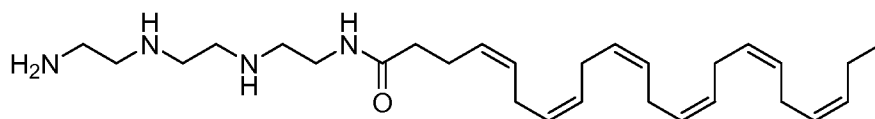
methyl 2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)-3-mercapto-3-methylbutanoate (**I-70**);



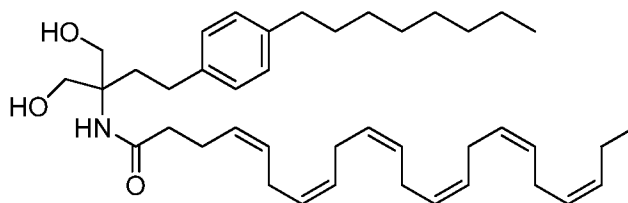
(R)-methyl 2-acetamido-3-(((R)-2-acetamido-3-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)amino)-3-oxopropyl)disulfanyl)propanoate (**I-71**)



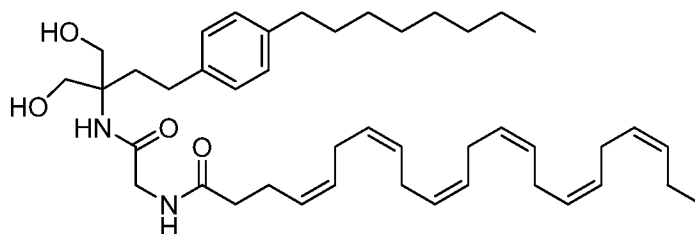
(R)-2-acetamido-3-(((R)-2-acetamido-3-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)amino)-3-oxopropyl)disulfanyl)propanoic acid (**I-72**);



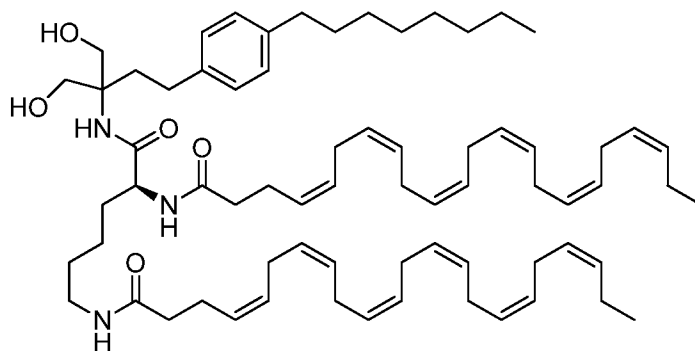
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-((2-aminoethyl)amino)ethyl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-73**);



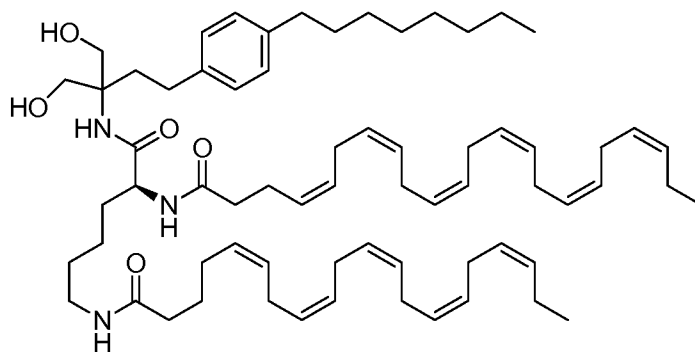
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-74**);



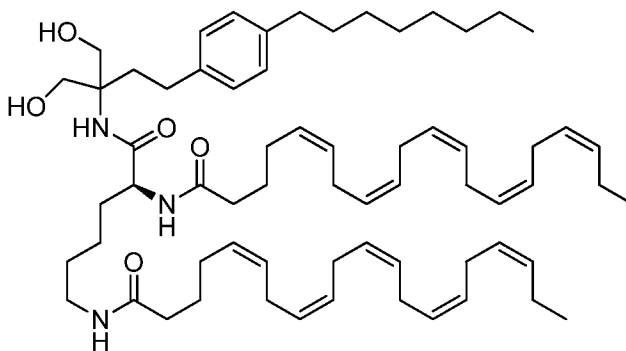
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(((1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)amino)-2-oxoethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-75**);



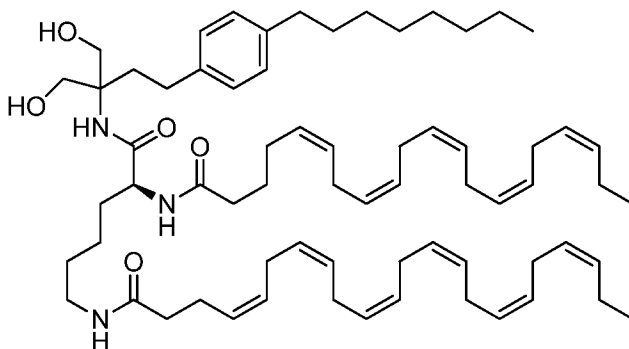
(4Z,4'Z,7Z,7'Z,10Z,10'Z,13Z,13'Z,16Z,16'Z,19Z,19'Z)-N,N'-((S)-6-(((1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)amino)-6-oxohexane-1,5-diyl)bis(docosa-4,7,10,13,16,19-hexaenamide) (**I-76**);



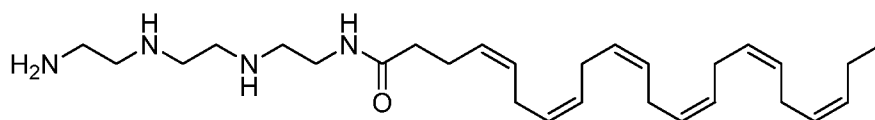
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-(((1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)amino)-6-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-1-oxohexan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-77**);



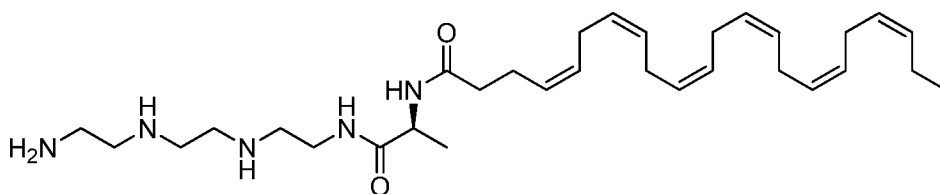
(5Z,5'Z,8Z,8'Z,11Z,11'Z,14Z,14'Z,17Z,17'Z)-N,N'-((S)-6-((1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)amino)-6-oxohexane-1,5-diyl)bis(icos-5,8,11,14,17-pentaenamide) (**I-78**);



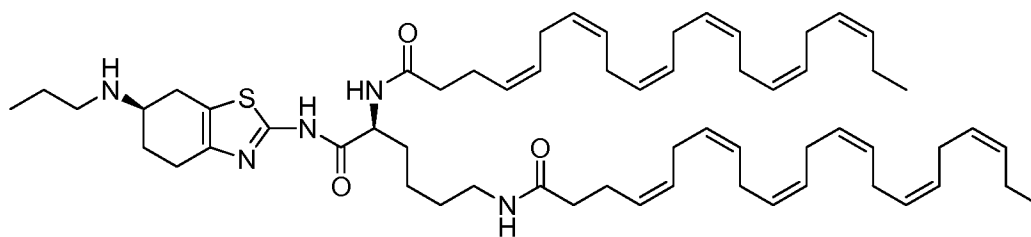
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-6-((1-hydroxy-2-(hydroxymethyl)-4-(4-octylphenyl)butan-2-yl)amino)-5-((5Z,8Z,11Z,14Z,17Z)-icos-5,8,11,14,17-pentaenamido)-6-oxohexyl)docosa-4,7,10,13,16,19-hexaenamide (**I-79**);



(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-((2-aminoethyl)amino)ethyl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-80**);



(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-((2-((2-((2-aminoethyl)amino)ethyl)amino)ethyl)amino)-1-oxopropan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-81**).



(4Z,4'Z,7Z,7'Z,10Z,10'Z,13Z,13'Z,16Z,16'Z,19Z,19'Z)-N,N'-((S)-6-oxo-6-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)hexane-1,5-diyl)bis(docosa-4,7,10,13,16,19-hexaenamide) (**I-82**)

Methods for using fatty acid amides

[00102] Also provided in the invention is a method for inhibiting, preventing, or treating inflammation or an inflammatory disease in a subject. The inflammation can be associated with an inflammatory disease or a disease where inflammation contributes to the disease. Inflammatory diseases can arise where there is an inflammation of the body tissue. These include local inflammatory responses and systemic inflammation. Examples of such diseases include, but are not limited to: organ transplant rejection; reoxygenation injury resulting from organ transplantation (see Grupp *et al.*, J. Mol. Cell Cardiol. 31: 297-303 (1999)) including, but not limited to, transplantation of the following organs: heart, lung, liver and kidney; chronic inflammatory diseases of the joints, including arthritis, rheumatoid arthritis, osteoarthritis and bone diseases associated with increased bone resorption; inflammatory bowel diseases such as ileitis, ulcerative colitis, Barrett's syndrome, and Crohn's disease; inflammatory lung diseases such as asthma, adult respiratory distress syndrome, chronic obstructive airway disease, and cystic fibrosis; inflammatory diseases of the eye including corneal dystrophy, trachoma, onchocerciasis, uveitis, sympathetic ophthalmitis and endophthalmitis; chronic inflammatory diseases of the gum, including gingivitis and periodontitis; chronic kidney disease (CKD); IgA nephropathy; nephropathic cystinosis, inflammatory diseases of the kidney including uremic complications, glomerulonephritis and nephrosis; inflammatory diseases of the skin including sclerodermatitis, psoriasis and eczema; inflammatory diseases of the central nervous system, including chronic demyelinating diseases of the nervous system, multiple sclerosis, AIDS-related neurodegeneration and Alzheimer's disease, infectious meningitis, encephalomyelitis, Parkinson's disease, Huntington's disease, amyotrophic lateral sclerosis and viral or autoimmune encephalitis. Metabolic disease such as type II diabetes mellitus; the prevention of type I diabetes; dyslipidemia; hypertriglyceridemia; severe hypertriglyceridemia, hypercholesterolemia, familial hypercholesterolemia, diabetic complications, including, but not limited to glaucoma, retinopathy, macula edema, nephropathy, such as microalbuminuria and progressive diabetic nephropathy, polyneuropathy, diabetic neuropathy, atherosclerotic

coronary arterial disease, peripheral arterial disease, nonketotic hyperglycemic hyperosmolar coma, mononeuropathies, autonomic neuropathy, joint problems, and a skin or mucous membrane complication, such as an infection, a shin spot, a candidal infection or necrobiosis lipoidica diabetorum; immune-complex vasculitis, systemic lupus erythematosus; inflammatory diseases of the heart such as cardiomyopathy, ischemic heart disease hypercholesterolemia, and atherosclerosis; as well as various other diseases that can have significant inflammatory components, including preeclampsia; chronic liver failure, brain and spinal cord trauma, and cancer. The inflammatory disease can also be a systemic inflammation of the body, exemplified by gram-positive or gram negative shock, hemorrhagic or anaphylactic shock, or shock induced by cancer chemotherapy in response to proinflammatory cytokines, *e.g.*, shock associated with proinflammatory cytokines. Such shock can be induced, *e.g.*, by a chemotherapeutic agent that is administered as a treatment for cancer. Other disorders include depression, obesity, allergic diseases, acute cardiovascular events, arrhythmia, prevention of sudden death.

[00103] In some embodiments, other diseases susceptible to treatment with Fatty Acid Amide Derivative are muscle wasting diseases such as Muscular Dystrophy including but not limited to Duchenne's Muscular Dystrophy, Becker Muscular Dystrophy, Emery-Dreifuss Muscular Dystrophy, Limb-Girdle Muscular Dystrophy, Facioscapulohumeral Muscular Dystrophy, Myotonic Dystrophy, Oculopharyngeal Muscular Dystrophy, Distal Muscular Dystrophy, Congenital Muscular Dystrophy, Spinal Muscular Atrophy, and Spinal Bulbar Muscular Dystrophy. Other diseases that can be treated with Fatty Acid Amides include inflammatory myopathies such as dermatomyositis, inclusion body myositis, and polymyositis, and cancer cachexia. Also inflammation that results from surgery and trauma can be treated with a Fatty Acid Amide. The compounds described herein are also useful in treating a variety of cancer such as carcinoma, sarcoma, lymphoma, leukemia, melanoma, mesothelioma, multiple myeloma, seminoma, and cancer of the bladder, blood, bone, brain, breast, central nervous system, colon, endometrium, esophagus, genitourinary tract, head, larynx, liver, lung, neck, ovary, pancreas, prostate, testicle, spleen, small intestine, large intestine or stomach. Still other diseases that can be treated with fatty acid amides include phenylketonuria, fatty liver disease, non-alcoholic fatty liver disease, NASH (non-alcoholic steatohepatitis), Sarcopenia, Sjogren syndrome, chronic kidney disease, Myasthenia gravis, xerophthalmia, Wilson's disease, cystinuria, and scleroderma.

[00104] In some embodiments, the subject is administered an effective amount of a fatty acid amide.

[00105] The invention also includes pharmaceutical compositions useful for treating or preventing a metabolic disease, or for inhibiting a metabolic disease. The compositions can be suitable for internal use and comprise an effective amount of a fatty acid amide described herein and a pharmaceutically acceptable carrier. The fatty acid amides are especially useful in that they demonstrate very low peripheral toxicity or no peripheral toxicity.

[00106] The fatty acid amides can each be administered in amounts that are sufficient to treat or prevent a metabolic disease or prevent the development thereof in subjects.

[00107] Administration of the fatty acid amides can be accomplished via any mode of administration for therapeutic agents. These modes include systemic or local administration such as oral, nasal, parenteral, transdermal, subcutaneous, vaginal, buccal, rectal or topical administration modes.

[00108] Depending on the intended mode of administration, the compositions can be in solid, semi-solid or liquid dosage form, such as, for example, injectables, tablets, suppositories, pills, time-release capsules, elixirs, tinctures, emulsions, syrups, powders, liquids, suspensions, or the like, sometimes in unit dosages and consistent with conventional pharmaceutical practices. Likewise, they can also be administered in intravenous (both bolus and infusion), intraperitoneal, subcutaneous or intramuscular form, all using forms well known to those skilled in the pharmaceutical arts.

[00109] Illustrative pharmaceutical compositions are tablets and gelatin capsules comprising a fatty acid amide and a pharmaceutically acceptable carrier, such as: a) a diluent, *e.g.*, purified water, triglyceride oils, such as hydrogenated or partially hydrogenated vegetable oil, or mixtures thereof, corn oil, olive oil, sunflower oil, safflower oil, fish oils, such as EPA or DHA, or their esters or triglycerides or mixtures thereof, omega-3 fatty acids or derivatives thereof, lactose, dextrose, sucrose, mannitol, sorbitol, cellulose, sodium, saccharin, glucose and/or glycine; b) a lubricant, *e.g.*, silica, talcum, stearic acid, its magnesium or calcium salt, sodium oleate, sodium stearate, magnesium stearate, sodium benzoate, sodium acetate, sodium chloride and/or polyethylene glycol; for tablets also; c) a binder, *e.g.*, magnesium aluminum silicate, starch paste, gelatin, tragacanth, methylcellulose, sodium carboxymethylcellulose, magnesium carbonate, natural sugars such as glucose or beta-lactose, corn sweeteners, natural and synthetic gums such as acacia, tragacanth or

sodium alginate, waxes and/or polyvinylpyrrolidone, if desired; d) a disintegrant, *e.g.*, starches, agar, methyl cellulose, bentonite, xanthan gum, alginic acid or its sodium salt, or effervescent mixtures; e) absorbent, colorant, flavorant and sweetener; f) an emulsifier or dispersing agent, such as Tween 80, Labrasol, HPMC, DOSS, caproyl 909, labrafac, labrafil, peceol, transcutool, capmul MCM, capmul PG-12, captex 355, gelucire, vitamin E TGPS or other acceptable emulsifier; and/or g) an agent that enhances absorption of the compound such as cyclodextrin, hydroxypropyl-cyclodextrin, PEG400, PEG200.

[00110] Liquid, particularly injectable, compositions can, for example, be prepared by dissolution, dispersion, *etc.* For example, the fatty acid amide is dissolved in or mixed with a pharmaceutically acceptable solvent such as, for example, water, saline, aqueous dextrose, glycerol, ethanol, and the like, to thereby form an injectable isotonic solution or suspension. Proteins such as albumin, chylomicron particles, or serum proteins can be used to solubilize the fatty acid amides.

[00111] The fatty acid amides can be also formulated as a suppository that can be prepared from fatty emulsions or suspensions; using polyalkylene glycols such as propylene glycol, as the carrier.

[00112] The fatty acid amides can also be administered in the form of liposome delivery systems, such as small unilamellar vesicles, large unilamellar vesicles and multilamellar vesicles. Liposomes can be formed from a variety of phospholipids, containing cholesterol, stearylamine or phosphatidylcholines. In some embodiments, a film of lipid components is hydrated with an aqueous solution of drug to form a lipid layer encapsulating the drug, as described in United States Patent No. 5,262,564, the contents of which are hereby incorporated in their entirety.

[00113] Fatty acid amides can also be delivered by the use of monoclonal antibodies as individual carriers to which the fatty acid amides are coupled. The fatty acid amides can also be coupled with soluble polymers as targetable drug carriers. Such polymers can include polyvinylpyrrolidone, pyran copolymer, polyhydroxypropylmethacrylamide-phenol, polyhydroxyethylaspanamidephenol, or polyethyleneoxidepolylysine substituted with palmitoyl residues. Furthermore, the fatty acid amide conjugates can be coupled to a class of biodegradable polymers useful in achieving controlled release of a drug, for example, polylactic acid, polyepsilon caprolactone, polyhydroxy butyric acid, polyorthoesters, polyacetals, polydihydropyrans, polycyanoacrylates and cross-linked or amphipathic block

copolymers of hydrogels. In one embodiment, fatty acid amides are not covalently bound to a polymer, *e.g.*, a polycarboxylic acid polymer, or a polyacrylate.

[00114] Parenteral injectable administration is generally used for subcutaneous, intramuscular or intravenous injections and infusions. Injectables can be prepared in conventional forms, either as liquid solutions or suspensions or solid forms suitable for dissolving in liquid prior to injection.

[00115] Compositions can be prepared according to conventional mixing, granulating or coating methods, respectively, and the present pharmaceutical compositions can contain from about 0.1 % to about 80 %, from about 5 % to about 60 %, or from about 1 % to about 20 % of the fatty acid amide conjugate by weight or volume.

[00116] The dosage regimen utilizing the fatty acid amide is selected in accordance with a variety of factors including type, species, age, weight, sex and medical condition of the patient; the severity of the condition to be treated; the route of administration; the renal or hepatic function of the patient; and the particular fatty acid amide conjugate employed. A physician or veterinarian of ordinary skill in the art can readily determine and prescribe the effective amount of the drug required to prevent, counter or arrest the progress of the condition.

[00117] Effective dosage amounts of the present invention, when used for the indicated effects, range from about 20 mg to about 5,000 mg of the fatty acid amides per day. Compositions for *in vivo* or *in vitro* use can contain about 20, 50, 75, 100, 150, 250, 500, 750, 1,000, 1,250, 2,500, 3,500, or 5,000 mg of the fatty acid amide. In one embodiment, the compositions are in the form of a tablet that can be scored. Effective plasma levels of the fatty acid amide can range from about 5 ng/mL to 5000 ng/mL per day. Appropriate dosages of the fatty acid amides can be determined as set forth in Goodman, L. S.; Gilman, A. *The Pharmacological Basis of Therapeutics*, 5th ed.; MacMillan: New York, 1975, pp. 201-226.

[00118] Fatty acid amides can be administered in a single daily dose, or the total daily dosage can be administered in divided doses of two, three or four times daily. Furthermore, fatty acid amides can be administered in intranasal form via topical use of suitable intranasal vehicles, or via transdermal routes, using those forms of transdermal skin patches well known to those of ordinary skill in that art. To be administered in the form of a transdermal delivery system, the dosage administration can be continuous rather than intermittent throughout the dosage regimen. Other illustrative topical preparations include creams, ointments, lotions,

aerosol sprays and gels, wherein the concentration of the fatty acid amide conjugate ranges from about 0.1 % to about 15 %, w/w or w/v.

Combination Therapies

[00119] Fatty acid amides may also be administered with other therapeutic agents such as cholesterol-lowering agents, fibrates and hypolipidemic agents, DPP-IV inhibitors as anti-diabetic agents, anti-diabetic agents, antiepileptic agents, antiglaucoma agents, antihypertensive agents, anti-inflammatory agents, TNF- α inhibitors, anti-depressant agents, anti-cancer agents, immunosuppressant agents, agents to treat osteoporosis, and agents to treat multiple sclerosis. In some embodiments, the fatty acid amide can be co-administered with the other therapeutic agent. In some embodiments, the fatty acid amide can be administered before the other therapeutic agent. In some embodiments, the fatty acid amide can be administered after the other therapeutic agent.

[00120] In some embodiments, the other therapeutic agent is a cholesterol-lowering agent. Non limiting examples of cholesterol-lowering agents are atorvastatin, cerivastatin, fluvastatin, lovastatin, pitavastatin, pravastatin, rosuvastatin, simvastatin, ezetimibe, and the combination of ezetimibe/simvastatin (Vytorin®).

[00121] In some embodiments, the other therapeutic agent is a fibrate or hypolipidemic agent. Non-limiting examples of fibrates or hypolipidemic agents are acifran, acipimox, beclobrate, bezafibrate, binifibrate, ciprofibrate, clofibrate, colessevelam, gemfibrozil, fenofibrate, melinamide, niacin, and ronafibrate.

[00122] In some embodiments, the other therapeutic agent is a DPP-IV inhibitor as anti-diabetic agent. Non-limiting examples of DPP-IV inhibitors as anti-diabetic agents are sitagliptin, saxagliptin, vildagliptin, linagliptin, dutogliptin, gemigliptin and alogliptin.

[00123] In some embodiments, the other therapeutic agent is an Anti-diabetic agent. Non-limiting examples of anti-diabetic agents are acarbose, epalrestat, exenatide, glimepiride, liraglutide, metformin, miglitol, mitiglinide, nateglinide, pioglitazone, pramlintide, repaglinide, rosiglitazone, tolrestat, troglitazone, and voglibose.

[00124] In some embodiments, the other therapeutic agent is an antiepileptic agent. Non-limiting examples of antiepileptic agents include Gabapentin, pregabalin.

[00125] In some embodiments, the other therapeutic agent is an Antiglaucoma agents. Non-limiting examples of antiglaucoma agents include apraclonidine, befunolol,

bimatoprost, brimonidine, brinzolamide, dapiprazole, dorzolamide, latanoprost, levobunolol, tafluprost, travoprost, and unoprostone isopropyl ester.

[00126] In some embodiments, the other therapeutic agent is an antihypertensive agents. Non-limiting examples of antihypertensive agents include alacepril, alfuzosin, aliskiren, amlodipine besylate, amosulalol, aranidipine, arotinolol HCl, azelnidipine, barnidipine hydrochloride, benazepril hydrochloride, benidipine hydrochloride, betaxolol HCl, bevantolol HCl, bisoprolol fumarate, bopindolol, bosentan, budralazine, bunazosin HCl, candesartan cilexetil, captopril, carvedilol, celiprolol HCl, cicletanine, cilazapril, cinildipine, clevidipine, delapril, dilevalol, doxazosin mesylate, efonidipine, enalapril maleate, enalaprilat, eplerenone, eprosartan, felodipine, fenoldopam mesylate, fosinopril sodium, guanadrel sulfate, imidapril HCl, irbesartan, isradipine, ketanserin, lacidipine, lercanidipine, lisinopril, losartan, manidipine hydrochloride, mebefradil hydrochloride, moxonidine, nebivolol, nilvadipine, nipradilol, nisoldipine, olmesartan medoxomil, perindopril, pinacidil, quinapril, ramipril, rilmedidine, spirapril HCl, telmisartan, temocarpil, terazosin HCl, tertatolol HCl, tiamenidine HCl, tilisolol hydrochloride, trandolapril, treprostinil sodium, trimazosin HCl, valsartan, and zofenopril calcium.

[00127] In some embodiments, the other therapeutic agent is an anti-inflammatory agent. Non-limiting examples of anti-inflammatory agents include celecoxib, rofecoxib, ibuprofen, naproxen, indomethacin, salicylic acid, salsalate, 5-aminosalicylic acid, dimethylfumarate, monomethyl fumarate, methotrexate, prednisone, prednisolone, abatecept, aceclofenac, AF-2259, alefacept, amfenac sodium, ampiroxicam, amtolmetin guacil, arformoterol, bambuterol, bardoxolone methyl, butibufen, cankinumab, ciclesonide, deflazacort, doxofylline, dexibuprofen, droxicam, etodolac, flunoxaprofen, fluticasone propionate, fomoterol fumarate, golimumab, indacaterol, interferon-gamma, isofezolac, isoxicam, lobenzarit sodium, lornoxicam, loxoprofen sodium, lumiracoxib, mabuterol HCl, nabumetone, nepafenac, nimesulide, oxaprozin, oxitropium bromide, piroxicam cinnamate, rimexolone, sivelestat, tenoxicam, zaltoprofen, fisalamine, and osalazine.

[00128] In some embodiments, the other therapeutic agent is a TNF- α inhibitor. Non-limiting examples of TNF- α inhibitors include infliximab, adalimumab, certolizumab, golimumab, and etanercept.

[00129] In some embodiments, the other therapeutic agent is an anti-depressant agents. Non-limiting examples of anti-depressant agents include bupropion HCl, citalopram,

desvenlafaxine, fluoxetine HCl, fluvoxamine maleate, metapramine, milnacipran, mirtazapine, moclobemide, nefazodone, paroxetine, pivagabine, reboxetine, setiptiline, sertraline HCl, tianeptine sodium, toloxatone and venlafaxine.

[00130] In some embodiments, the other therapeutic agent is an anti-cancer agent. Non-limiting examples of anti-cancer agents include abarelix, alemtuzumab, alitretinoin, amrubicin HCl, amsacrine, anastrozole, arglabin, azacitidine, belotecan, bevacizumab, bexarotene, bicalutamide, bisantrene HCl, bortezomib, camostat mesylate, capecitabine, catumaxomab, cetuximab, cladribine, clofarabine, cytarabine ocfosfate, dasatinib, degarelix acetate, denileukin diftitox, doxetaxel, doxilfluridine, enocitabine, epirubicin HCl, erlotinib, exemestane, fludarabine phosphate, flutamide, formestane, fotemustine, fulvestrant, gefitinib, gemcitabine HCl, gemtuzumab ozogamicin, ibritumomab tiuxetan, idarubicin HCl, imatibib mesylate, interferon gamma-1a, interleukin-2, irinotecan, INCB18424, ixabepilone, lapatinib, lenalidomide, letrozole, lonidamine, mitoxantrone HCl, nelarabine, nedaplatin, nilutamide, nimotuzumab, OCT-43, ofatumumab, oxaliplatin, paclitaxal, panitumumab, pazopanib, pegaspargase, pemetrexed, pentostatin, pirarubicin, pralatrexate, raltitrexed, ranimustine, ridaforolimus, SKI-2053R, sobuzoxane, sorafenib, sunitinib, talaporfin sodium, tamibarotene, tasonermin, temoporfin, temozolomide, temsirolimus, topotecan HCl, toremifene, tosimomab, trabectedin, valrubicin, vinorelbine, vorinostat and zinostatin stimalamer.

[00131] In some embodiments, the other therapeutic agent is an immunosuppressant agent. Non-limiting examples of immunosuppressant agents include cyclosporine, everolimus, gusperimus, mizoribine, muromonab-CD3, mycophenolate sodium, mycophenolate mofeti, pimecrolimus, tacrolimus.

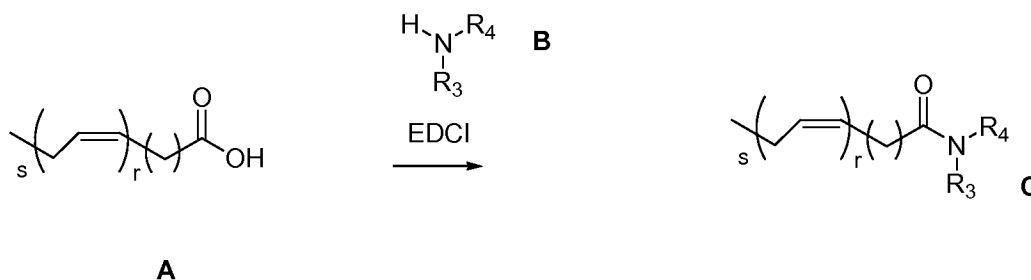
[00132] In some embodiments, the other therapeutic agent is an agents to treat osteoporosis. Non-limiting examples of agents to treat osteoporosis include alendronate sodium, ibandronic acid, incadronic acid, raloxifene HCl, risdronate sodium, strontium ranelate.

[00133] In some embodiments, the other therapeutic agent is an agent to treat multiple sclerosis. Non-limiting examples of agents to treat multiple sclerosis include dimethyl fumarate, mono methyl fumarate, fingolimod, teriflunomide, laquinimod, cladribine, interferon beta-1a, betaseron, glatimer acetate, natalizumab.

METHODS OF MAKING

[00134] Examples of synthetic pathways useful for making Fatty Acid Conjugates of Formula **I** are set forth in the Examples below and generalized in **Schemes 1-6**.

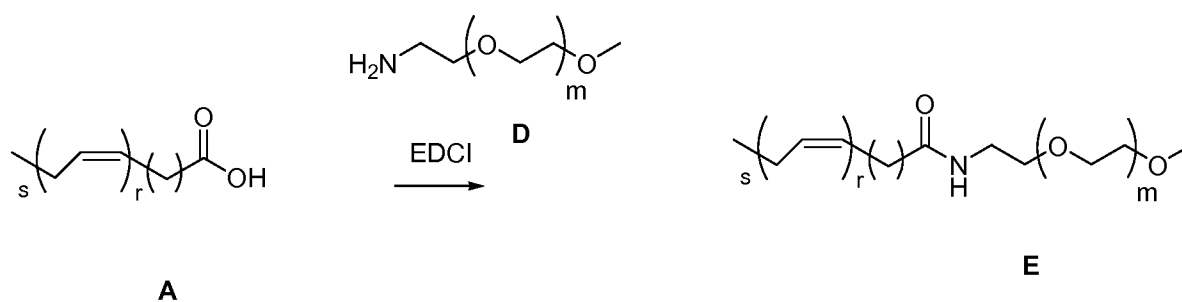
Scheme 1



wherein r , s , R_3 and R_4 are as defined above.

[00135] A fatty acid of the general formula **A** can be coupled directly with an amine of the general formula **B** using any standard amide coupling reagent such as EDCI, HATU or DCC, in an organic solvent such as CH_2Cl_2 or acetonitrile. A large variety of amines of the formula **B** is commercially available.

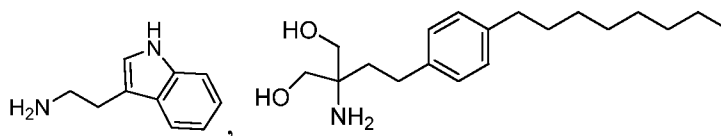
Scheme 2



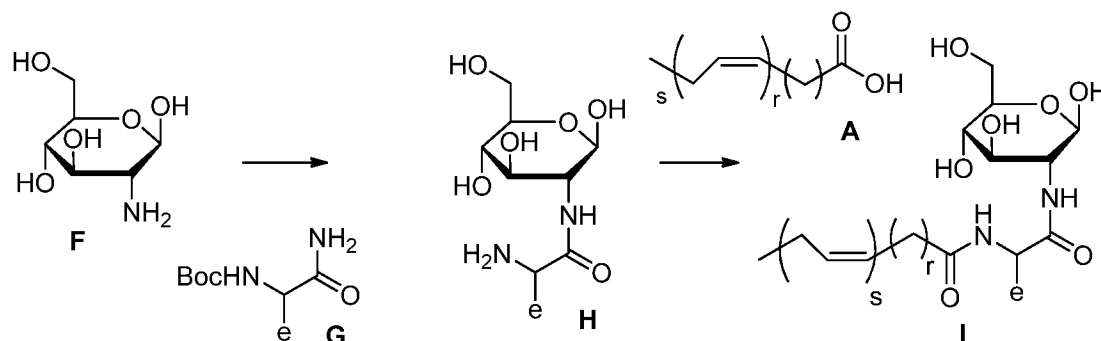
wherein r , s and m are as defined above.

[00136] A fatty acid of the general formula **A** can be coupled directly with an amine of the general formula **D** using any standard amide coupling reagent such as EDCI, HATU or DCC, in an organic solvent such as CH_2Cl_2 or acetonitrile. A number of these polyether amines (wherein m is 1, 2, 3, 4, 5 and 6) are commercially available. To those familiar in the

art, instead of the amine D, primary amines such as the ones shown below (all commercially available) can be used for the same amide coupling reaction:



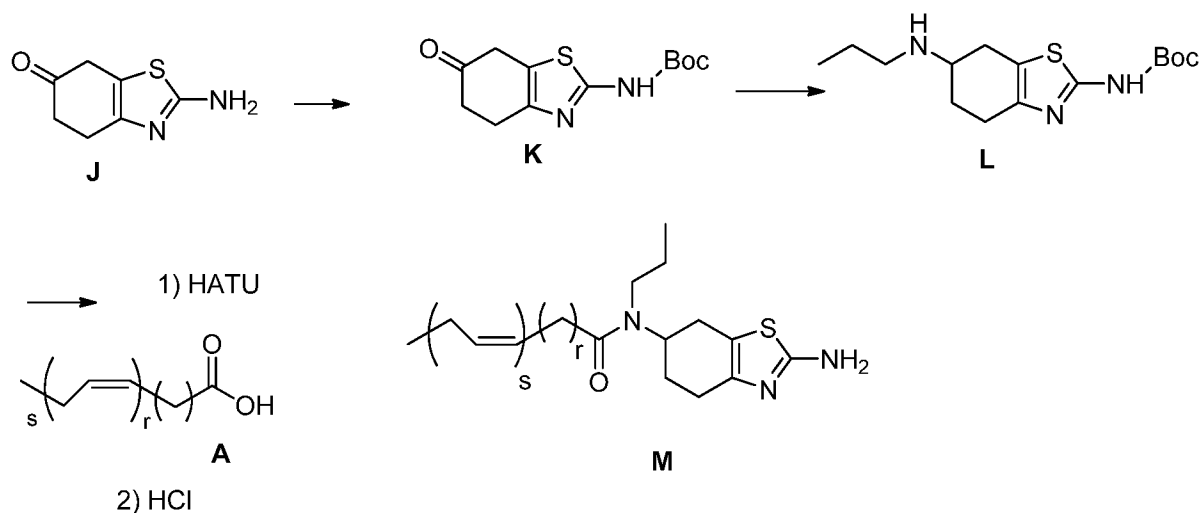
Scheme 3



wherein e, r, and s are as defined above.

[00137] The commercially available amine **F** can be coupled with a BOC-protected amino acid of the formula **G** using EDC or HATU to afford an intermediate amide. The BOC protecting group can be removed by treatment with acid such TFA or HCl to afford compounds of the general formula **H**. This amine can be coupled with a fatty acid of the general formula **A** to obtain compounds of the general formula **I**. To those familiar in the art, any other amines such as the ones shown in Scheme 3 can be used for the same sequence of reactions.

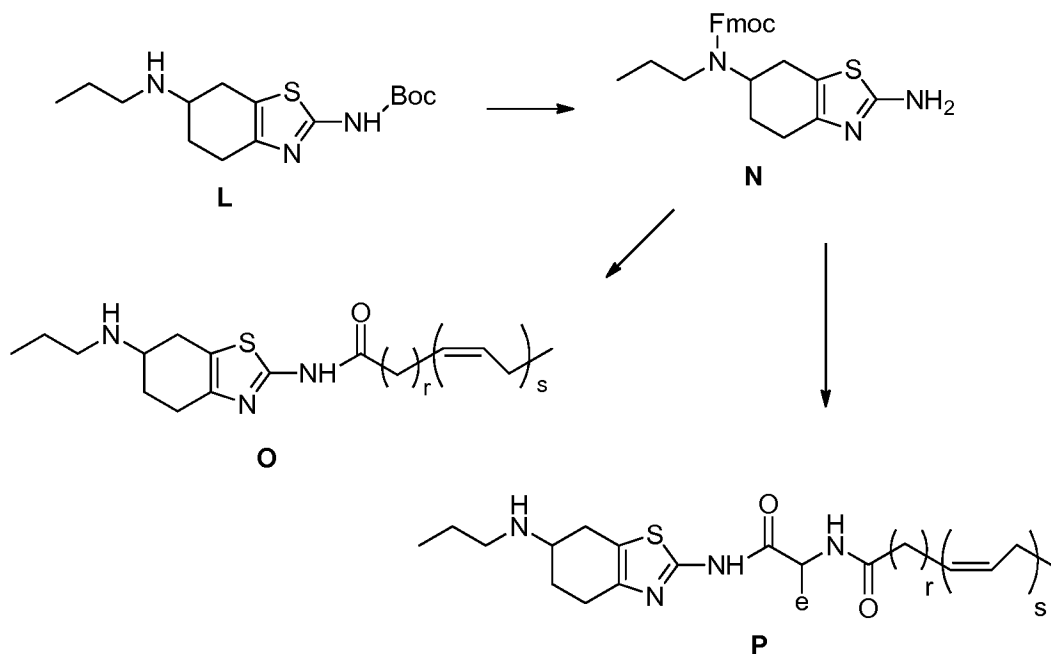
Scheme 4



wherein r and s are as defined above.

[00138] The commercially available amine **J** is treated with a reagent such as BOC-anhydride to obtain the BOC-protected derivative **K**. A reductive amination using propylamine in the presence of either sodium triacetoxyborohydride or sodium cyanoborohydride affords compound **L**, a differentially protected diamine intermediate. Intermediate **L** can be coupled with a fatty acid of the formula **A** in the presence of HATU and a tertiary amine such as DIEA or Et₃N, followed by treatment with HCl to afford compound **M**.

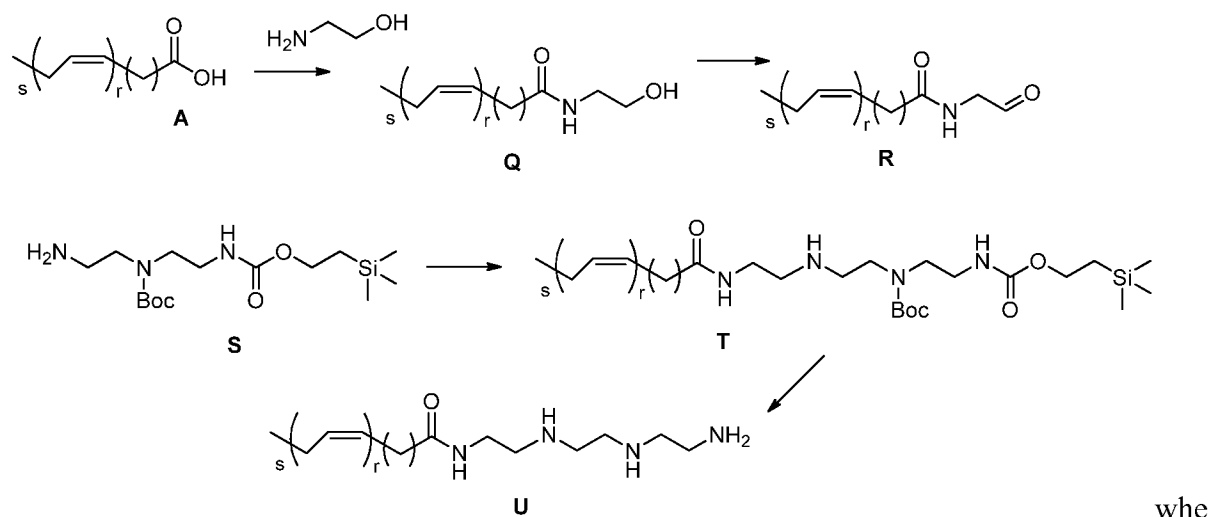
Scheme 5



wherein e, r and s are as defined above.

[00139] To those familiar in the art, this scheme illustrates the use of differential protecting group to enable amide coupling reaction at one of the two amino sites. The BOC-protected amine **L** can be treated with a reagent such as Fmoc-Cl according to the procedures outlined in Greene's *Protective Groups in Organic Synthesis*, Wiley, 3rd Edition. The resulting Fmoc-protected compound can be treated with acids such as TFA or HCl to afford compound **N**. Compound **N** can be coupled with a fatty acid of the formula **A**, followed by treatment with a base such as morpholine or diethylamine to obtain compounds of the general formula **O**. To those familiar in the art, compound **N** can also be subjected to the same reaction sequence outlined in Scheme 3 using the BOC-protected amino acid of the formula **G** to eventually obtain compounds of the general formula **P**.

Scheme 6



[00140] To those familiar in the art, Scheme 6 illustrates the use of protecting groups to differentiate a polyamine. The fatty acid of the formula **A** is coupled with ethanolamine to obtain compounds of the general formula **Q**. The alcohol group can be oxidized to the corresponding aldehyde using reagents such as pyridinium dichromate or Dess-Martin reagent to obtain compounds of the general formula **R**. The acylated amine of the formula **S** can be prepared using the procedures outlined in Andruszkiewicz et al. *Synthetic Commun.* **2008**, 38, 905-913. Compound **R** and **S** can be reacted under reductive amination conditions using either sodium borohydride or sodium cyanoborohydride to obtain compounds of the

general formula **T**. Treatment of **T** with a fluoride reagent will selectively remove the silyl protecting group and treatment with an acid such as TFA or HCl will remove the remaining BOC protecting group to afford compounds of the general formula **U**.

EXAMPLES

[00141] The disclosure is further illustrated by the following examples, which are not to be construed as limiting this disclosure in scope or spirit to the specific procedures herein described. It is to be understood that the examples are provided to illustrate certain embodiments and that no limitation to the scope of the disclosure is intended thereby. It is to be further understood that resort may be had to various other embodiments, modifications, and equivalents thereof which may suggest themselves to those skilled in the art without departing from the spirit of the present disclosure and/or scope of the appended claims.

[00142] The following non-limiting compound examples serve to illustrate further embodiments of the fatty acid amides. It is to be understood that any embodiments listed in the Examples section are embodiments of the fatty acid amides and, as such, are suitable for use in the methods and compositions described above.

Example 1

Effect of the compounds of the invention in cystinotic fibroblasts

[00143] Nephropathic cystinosis is an orphan genetic lysosomal storage disorder characterized by a massive accumulation of crystalline cystine within cells. Affected individuals develop a proximal renal tubulopathy and progress, if untreated, to end-stage renal failure. Omran et al (*Bioorg. Med. Chem.* **2011**, p, 3492) described a convenient in vitro system to quickly evaluate compounds that could deplete levels of cystine in cultured fibroblasts. Cystinotic fibroblasts (cell line GM00008, Coriell Cell Repository) were seeded in a 6-well plate and grown in DMEM/15% FBS until confluent. The compound of the invention was formulated in 100% ethanol at a concentration of 50 mM; prior to addition to cells, drugs were further diluted in 100% FBS and sonicated for one hour. Cells were incubated with drug for 24 hours, then harvested via trypsinization. Cells were subsequently washed in PBS and suspended in a 3:1 solution of 5.2 mM N-ethylmaleimide (Sigma) to 12% sulfosalicylic acid (Sigma) in order to derivatize free cysteine and precipitate protein respectively. To lyse cells, samples were then frozen at -80 degrees Celsius, thawed, and

sonicated twice for 1 minute. Lysates were cleared of precipitated protein via centrifugation and samples were subsequently processed for LC-MS/MS analysis.

[00144] Protein quantification was accomplished by dissolving precipitated protein in 0.25 M NaOH and 1 M Tris (pH 7.5), and spectrophotometric measurement using the Bradford method.

[00145] Compound **I-9** was evaluated in this cystinotic fibroblast assay. The level of cystine in this cystinotic cell line was quantitated by LC-MS/MS. A depletion of cystine was observed when cystinotic fibroblasts were treated with 50 μ M of compound **I-9**. The level of cystine was expressed as the percentage of control (POC). Using this method, compound **I-9** showed a 68% reduction in the cystine level at 50 μ M, whereas the control compound cysteamine showed a 45% reduction in the cystine level at 50 μ M. The cystine level was determined as follows: To the 50 μ L of supernatant, acetonitrile (400 μ L) containing 200ng/ml Internal standard (deuterated cystine) was added and mixture was vortexed for 1 min followed by centrifugation for 10 minutes. Supernatant was transferred to a clean LC vials and 10 μ L of the sample was injected on LC-MS/MS for the measurement of Cystine.

LC-MS analysis

[00146] The concentration of Cystine was measured by LC-MS/MS. 10 μ L of the sample was injected into the column (Luna, HILIC, 150X4.60mm, 3 μ Phenomenex). Cystine and deuterated cystine was eluted from the column by a stepwise gradient of 10% mobile phase B at 0 min, 10% B at 2.5 min, 50% B at 2.7 min and 10% B at 3 min. Mobile phase A contained Acetonitrile/Water/Ammonium acetate (20mM) with 0.1% Formic acid and mobile phase B contained Acetonitrile/Ammonium acetate (20mM) with 0.1% formic acid. The column elute was directly injected into a Agilent triple quad, which was maintained in electrospray positive mode. The retention times for Cystine and the internal standard (deuterated cystine) was 2.25 min. Cystine was monitored via the transition m/z 241.3-152 with a fragmentor of 75 and collision energy of 7Ev and duterated cystine was monitored via the transition m/z 247.3-124.1 with a fragmentor 126 and collision energy of 9eV. The column was maintained at 25⁰C.

Example 2

Effect of the compounds of the invention in a genetic mouse model lacking cystinosin, the protein defective in nephropathic cystinosis.

[00147] Nephropathic cystinosis is an orphan genetic lysosomal storage disorder characterized by a massive accumulation of crystalline cystine within cells. The accumulation of cysteine is due to a defective lysosomal cystine transporter called cystinosin. A genetic mouse model lacking cystinosin has recently been described (Cherqui et al *Molecular and Cellular Biology* **2002**, 22, p. 7622-7632). Mice lacking cystinosin have been shown to have a substantial increase in cystine level in numerous tissues including liver, kidney, spleen, muscle, brain and heart. Treatment of mice lacking cystinosin with cysteamine at 200 or 400 mg/kg orally for 7, 30 or 60 days has been shown to reduce cystine levels of all tissues tested, with the greatest effect observed in the liver and kidney, after 60 days. Compounds described herein can be evaluated in a similar fashion for their ability to reduce cystine levels in certain tissues using this genetic mouse model lacking cystinosin.

Example 3

Effect of the compounds of the invention in the transgenic YAC128 mouse model for Huntington disease

[00148] Transgenic Huntington disease mice expressing highly expanded human huntingin (YAC128) and their wild type littermates can be used to assess the effect of bis-fatty acid conjugates containing cystamine on transglutamine levels. Three-month old YAC mice are treated with the desired conjugate for a period of two weeks before being sacrificed. Mice are asphyxiated with carbon dioxide and the brains are immediately removed, separated into forebrain and hindbrain, frozen in isopentane on dry ice and stored at -80 °C. Tissues are then processed to measure transglutaminase activity as well as to assess striatal neuropathology according to the detailed procedure outlined in Van Raamsdock, J. M. et al, *J. Neurochemistry* **2005**, 95, p. 210-220. Transgenic animals that are 7 months of age can also be used to assess for motor functions (such as time on rotarod) when administered with compounds of this invention over a period of 4 months.

Example 4

Effect of fatty acid amides on ApoB secretion in HepG2 cells

[00149] HepG2 cells (ATCC) are seeded at 25,000 cells per well in collagen-coated 96-well plates in growth media (DMEM with 10% fetal bovine serum). The following day, fatty acid amides are complexed to lipoprotein-deficient fetal bovine serum at the appropriate concentration. Growth media is then removed from and the HepG2 cells are washed once with PBS. The lipoprotein-deficient FBS with the complexed fatty acid amide conjugates is added to DMEM for a final 10% concentration. Each concentration of fatty acid amide is tested in triplicate. Cells are incubated for 16 hours with the fatty acid amide. Alamar Blue® (Invitrogen) is then added to the media to determine cell viability per the manufacturer's instructions. Two hours after Alamar Blue® addition, the media is removed and placed in a black 96-well plate. The plate is then read at 550nm/590nm to determine cell viability. The media is then used to determine ApoB concentrations using ELISA kits (Mabtech AB). Percent inhibition of ApoB secretion is determined by normalizing data to vehicle treated wells. For a given compound, an IC₅₀ (concentration at which 50% of ApoB secretion is inhibited) can also be determined by using a 4 parameter-fit inhibition curve model (Graph Pad Prism®).

Example 5

Effect of fatty acid amides on SREBP-1c target genes

[00150] HepG2 cells (ATCC) are seeded at 20,000 cells per well in 96 well plates. After adhering overnight, growth media (10% FBS in DMEM) is removed and cells are serum starved for 24 hours in DMEM containing 1% fatty acid free bovine serum albumin (BSA, Sigma). Cells are then treated with the fatty acid amides at a final concentration of 50 µM in 1% BSA or 0.1 oleate complexed to fatty acid free BSA in a 5:1 molar ratio. Cells are incubated for 6 hours and then washed with PBS. RNA was reverse-transcribed using the cells II cDNA reagents according to standard protocols (outlined in Applied Biosystem StepOne Real-time PCR protocols). Real time PCR of transcripts can be performed with Tagman assays for the three specific genes FASN (fatty acid synthase), SCD (steroyl CoA desaturase) and ApoA1(apolipoprotein A1). In all three cases, 18S-VIC® is used as a normalization control.

Example 6

Effect of fatty acid amides in the Zucker fa/fa rat model

[00151] Male Zucker rats (*HsdHlr:ZUCKER-Lepr^{fa}*) between 8-10 weeks of age are purchased from Harlan. Zucker rats are maintained on Teklad Global Rodent Diet (2018S) during the acclimation period and for the duration of study. The Zucker rats are weighed and randomly assigned to treatment arms based on body weight and plasma TG levels (n is 8). Inclusion criteria for the study include body weight >300 grams and fed TG levels in plasma >800 mg/dL. Rats are randomized into treatment arms based on pre-dose (day -1) body weights and plasma levels (fed) of triglycerides. Dosing is initiated on day 1 and continue through day 5. Dosing is daily (qd) by oral gavage (po) for all treatment arms. Body weights are measured for all rats on days 1 through 5. On day 4, a blood sample (fed) are collected from each rat, processed for plasma and stored at -80°C. At 8pm on day 4 food are removed from all rats to initiate fasting state. On day 5 rats are dosed at 8am according to treatment arm. Two hours later (10am) two blood draws from each rat are collected and processed for plasma. Triglyceride levels are then analyzed by standard protocols using commercially available kits.

Example 7**Effect of fatty acid amides in the Golden Syrian Hamster model of dyslipidemia.**

[00152] Golden Syrian Hamster (Strain: HsdHanTM:AURA, from Harlan Laboratories), 5-6 weeks of age, with a body weight of approximately 80 g, are used for the study. The Hamsters are maintained on high fat diet D12492 (Research Diets, New Brunswick NJ) during the acclimation period and throughout the study. Animals will then receive drinking water supplemented with 10% fructose (Sigma, supplied by Catabasis) starting on day -8 and continuing throughout the study. The hamsters will be randomized into treatment arms based on pre-dose (day -1) body weights and plasma levels (fed) of triglycerides (TG). Dosing will be initiated on day 1 and continue through day 28. Dosing will be daily (qd) by oral gavage (po) for all treatment arms. On day 27, hamsters will be fasted at the beginning of the dark cycle. Hamsters will be dosed at 8am on day 28 according to the treatment arm. Two hours later (10am) a blood sample will be collected from each hamster, processed to plasma and stored at -80°C. Triglyceride and HDL cholesterol levels will be determined using standard protocols and the commercially available kits from Abcam, Cayman or Sigma-Aldrich.

Example 8

Effects of compounds of the invention on NF- κ B Levels in RAW 264.7 Macrophages

[00153] RAW 264.7 cells stably expressing a 3x NF- κ B response element-driven luciferase reporter were seeded into 96 well plates in serum-free medium (Optimem) 18 hours prior to compound application. Compounds of the invention were prepared by first making 100 mM stock solutions in EtOH. Stock solutions were then diluted 1:100 in low LPS FBS (Gemini BenchMark 100-106), mixed vigorously and allowed to incubate at room temperature for 30 minutes. 1:2 serial dilutions were then made in FBS supplemented with 1% EtOH, mixed vigorously, and again allowed to incubate at room temperature for 30 minutes before adding to RAW 264.7 reporter cells (final concentrations: 10% FBS, 100 μ M highest compound dilution, 0.1% EtOH) for a 2 hour pretreatment prior to stimulation with LPS. Cells were then stimulated with 200 ng/ml LPS or vehicle control for 3 hours in the presence of the compounds of the invention. A set of six vehicles was left unstimulated with LPS in order to measure the assay floor. AlamarBlue viability dye (Invitrogen) was added to cells simultaneously with the delivery of LPS (final AlamarBlue concentration of 10%). After the 3 h incubation period with LPS, cell viability was measured by reading fluorescence (excitation 550 nm, emission 595 nm) with a Perkin Elmer Victor V plate reader. Then cell media was aspirated from each well. Luciferase signal was then developed by addition of the Britelite Plus reagent (Perkin Elmer). Luciferase activity was measured with the Perkin Elmer Victor V plate reader. NF- κ B activity was expressed as a percent of the vehicle control wells (stimulated with LPS). Compounds were tested at 6 dose point titrations in triplicate to determine IC₅₀ values. Table 1 summarizes the IC₅₀ values for a number of fatty acid amides in this NF- κ B luciferase reporter assay. A (–) indicates that the compound showed no inhibitory activity up to 200 μ M. A (+) indicates that the compound showed inhibitory activity of less than 200 μ M. A (+ +) indicates that the compound showed inhibitory activity of less than 50 μ M.

Table 1. Summary of IC₅₀ values for fatty acid amides in the NF- κ B luciferase reporter assay.

Compound	NF-κB inhibitory activity IC₅₀ μM
DHA	—
EPA	—
I-21	+
I-47	—
I-48	++
I-49	++
I-52	++
I-57	++

Example 9

Effect of fatty acid amides on IL-1 β

[00154] RAW264.7 macrophages were seeded at a density of 100,000 cells/well in a 96-well plate in DMEM supplemented with 10% FBS and Penn/strep. 16 hours later, medium was aspirated and replaced with 90 μ L/well of serum-free DMEM. Fatty acid amides were brought up in 100% EtOH to a concentration of 100mM and then diluted 1:100 in 100% FBS for a stock solution consisting of 1mM compound and 1% EtOH. These stock solutions were then diluted 1:10 in FBS supplemented with 1% EtOH to generate a 100 μ M of the fatty acid amide. 10 μ L was then added to the RAW264.7 cells to generate final concentrations 10 μ M of the fatty acid amide or 10 μ M each DHA and MMF, along with vehicle only control. The compounds were allowed to pre-incubate for 2 hours before stimulation of 100ng/ml LPS (10 μ L of 1 μ g/ml LPS was added to each well). Following 3 hours of LPS stimulation, cells were washed once in 1x PBS, aspirated dry, and flash frozen in liquid nitrogen. RNA was then isolated and converted to cDNA using the Cells to cDNA kit (Ambion) according to the manufacturer's protocol. IL-1 β transcript levels were then measured using Taqman primer/probe assay sets (Applied Biosystems), normalized to GAPDH using the deltaCt

method, and the data expressed relative to vehicle only control. Figure 1 summarizes the IL-1 β gene expression data on compound **I-57** (cellular toxicity was assessed using alamar blue as indicator, abbreviated in the figure as AB). As shown in this figure, upon dosing with compound **I-57**, there was a decrease in the gene expression of the inflammatory cytokine IL-1 β .

Example 10

Effect of fatty acid amides on the target gene Hmox1 in RAW macrophages

[00155] RAW264.7 macrophages were seeded at a density of 100,000 cells/well in a 96-well plate in DMEM supplemented with 10% FBS and Penn/strep. 16 hours later, medium was aspirated and replaced with 90uL/well of serum-free DMEM. Fatty acid amides were brought up in 100% EtOH to a concentration of 100mM and then diluted 1:100 in 100% FBS for a 20x stock solution consisting of 1mM compound and 1% EtOH. The fatty acid amide 20x stock solutions were diluted 1:2 in FBS supplemented with 1% EtOH for a 500uM 10x stock solution. The 10x stock solutions were then serially diluted 1:2 in FBS supplemented with 1% EtOH and 10 μ L of each dilution was added to the RAW246.7 cells to generate final concentrations of 50, 25, 12.5, 6.25, 3.12 and 1.6 μ M. The compounds were allowed to pre-incubate for 2 hours before stimulation of 100ng/ml LPS (10 μ L of 1 μ g/ml LPS is added to each well). Following 3 hours of LPS stimulation, cells were washed once in 1x PBS, aspirated dry, and flash frozen in liquid nitrogen. RNA was then isolated and converted to cDNA using the Cells to cDNA kit (Ambion) according to the manufacturer's protocol. Transcript levels were then measured using ABI Taqman primer/probe assay kits, normalized to GAPDH using the deltaCt method, and the data expressed relative to vehicle only control. Figure 2 summarizes the Hmox data on compound **I-57** (cellular toxicity was assessed using alamar blue as indicator, abbreviated in the figure as AB). As shown in this figure, upon dosing with compound **I-57**, there was an upregulation of Hmox gene expression.

Example 11

Effect of fatty acid amides conjugates in the streptozotocin-diabetic rat

[00156] Female Sprague-Dawley rats (8 weeks old, with an average weight of 150 g) are used for the study. Diabetes is induced by a single tail vein injection of streptozotocin (STZ) in 0.1 mol/L sodium citrate buffer, pH 4.5. Diabetes is then confirmed by measuring blood glucose levels at two and three days after the STZ treatment. Diabetic animals are classified as those with plasma glucose higher than 16 nmol/L. The diabetic animals are then divided into the vehicle control group and the treatment group (each group having 12 animals). All animals are housed individually with a light dark cycle of 12 hours each, with animals having free access to food and water. In order to maintain body weight and to limit hyperglycemia, diabetic animals are treated with 3 IU of ultralente insulin three times per week in the afternoon (at approximately 3 to 4 pm). In order to maintain glycemic control as the animals gain weight, the dose of insulin is increased to 5 IU at week 15. Animals are dosed with the vehicle or the fatty acid amide over a 28 week period (Examples of vehicles that can be used include combinations of solvents such as polyethylene glycol and propyleneglycol, lipids such as glycerol monooleate and soybean oil, and surfactants such as polysorbate 80 and cremophor EL). Progression of renal disease can be assessed by monthly measurements of urinary albumin and plasma creatinine concentrations. For urinary measurements, rats are housed in metabolic rat cages for 24 hrs. Urinary albumin can be quantified by a competitive ELISA assay according to the protocols outlined in Degenhardt et al, *Kidney International* **2002**, 61, p. 939-950. Plasma creatinine concentrations can be measured by the Jaffé picric acid procedure, using the standard kit from Sigma (Sigma cat # 555-A). Statistical analyses can be performed using SigmaStat for Windows V1.00. *P* values can be calculated by non-parametric Mann-Whitney Rank Sum analysis. On week 28, dyslipidemia can also be assessed by measuring plasma triglycerides and total cholesterol. These plasma lipids can be measured by enzymatic, colorimetric, end-point assays using standardized, commercially available kits. Total cholesterol can be analyzed using the Sigma kit (cat # 352) and triglycerides can be analyzed by the Sigma kit (cat # 37, GOP Grinder).

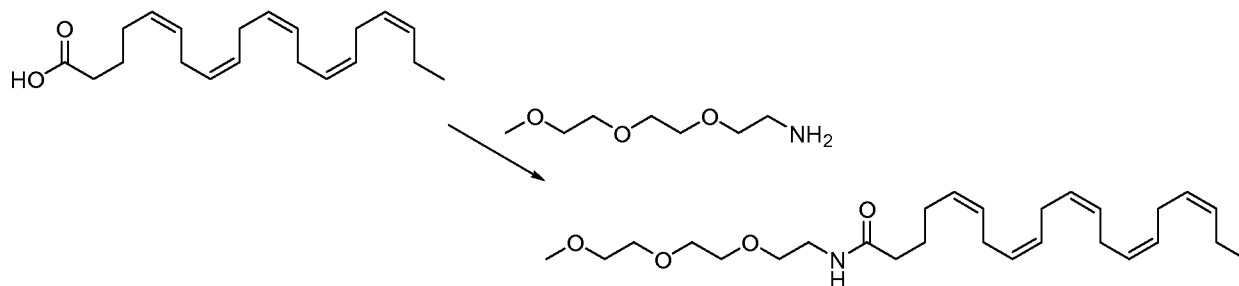
Example 12

Effect of fatty acid amides in the cisplatin-induced nephrotoxicity mouse model

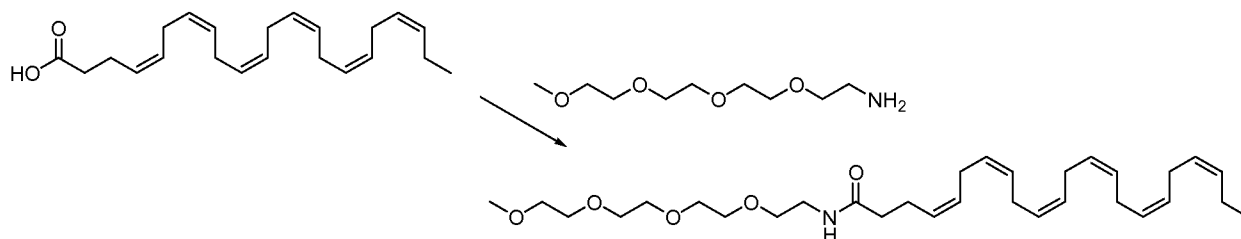
[00157] For this study, 10 to 12-week old male C57BL/6 mice of approximately 30 g in body weight are used. After the normal acclimation period, the animals are maintained on a standard diet and water is freely available. Mice are then given a single intraperitoneal injection of either the vehicle or cisplatin (20 mg/kg, at a concentration of 1 mg/mL in saline). Ten animals are used per treatment group. For the drug treatment group, beginning 24 hours prior to the cisplatin injection, animals are dosed with a fatty acid amide (formulated in combinations of solvents such as polyethylene glycol and propyleneglycol, lipids such as glycerol monooleate and soybean oil, and surfactants such as polysorbate 80 and cremophor EL). Dosing is then continued over a period of 72 hours. At this point, animals are sacrificed and blood and kidney tissues are collected. Blood urea nitrogen (BUN) and creatinine are measured. Levels of TNF- α in serum can be determined using a commercially available enzyme-linked immunosorbent assay (ELISA). Tissues are processed for histology and RNA isolation. Tubular injury can be assessed in PAS-stained sections using a semi-quantitative scale described in “G. Ramesh and W. B. Reeves, *Kidney International*, **2004**, 65, p. 490-498”.

Compounds

[00158] The following non-limiting compound examples serve to illustrate further embodiments of the fatty acid amides. It is to be understood that any embodiments listed in the Examples section are embodiments of the fatty acid amides and, as such, are suitable for use in the methods and compositions described above.

Example 13**Preparation of (5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (I-57):**

[00159] In a typical run, (5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenoic acid (1 mmol) was taken up in 50 mL of CH_2Cl_2 along with 2-(2-(2-methoxyethoxy)ethoxy)ethanamine (1 mmol) and EDC (1.1 mmol). The resulting reaction mixture is stirred at room temperature for 6 h and then diluted with CH_2Cl_2 (100 mL). The organic layer is washed with saturated aqueous NH_4Cl , brine, dried (Na_2SO_4) and concentrated under reduced pressure. The resulting residue was purified by chromatography (95% CH_2Cl_2 , 5% MeOH) to afford (5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide. MS (EI) calcd for $\text{C}_{27}\text{H}_{45}\text{NO}_4$ 447.33; found 448 ($\text{M} + 1$).

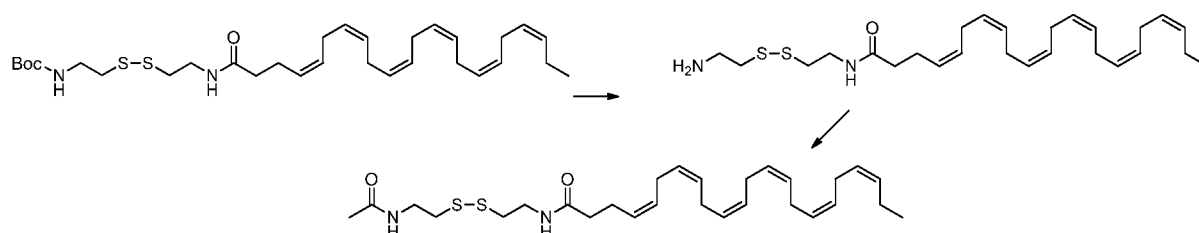
Example 14**Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (I-53):**

[00160] The same procedure outlined in example 13 was used. (4Z,7Z,10Z,13Z,16Z,19Z)-Docosa-4,7,10,13,16,19-hexaenoic acid and 2-(2-(2-(2-

methoxyethoxy)ethoxy)ethoxy)ethanamine were used as the appropriate starting materials for the amide coupling step. MS (EI) calcd for $C_{31}H_{51}NO_5$ 517.38; found 518 $[M+H]^+$.

Example 15

Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (I-2):



[00161] The starting material, tert-butyl (2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)carbamate, was prepared according to the procedures outlined in WO 2011106688.

[00162] To the solution of tert-butyl (2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)carbamate (10 g, 17.8 mmol) in 20 mL of EtOAc was added a 4 N HCl solution in EtOAc (100 mL) at 0 °C. The resulting reaction mixture was stirred at room temperature for 2 h. A saturated aqueous solution of Na_2CO_3 was added to the stirred mixture in order to adjust the pH is 8. The organic layer was separated and evaporated under reduced pressure to afford 8.2 g of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-aminoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide. Yield: 100%.

MS calculated for $C_{26}H_{42}N_2OS_2$: 462.75; Found: 463.5 $[M+H]^+$.

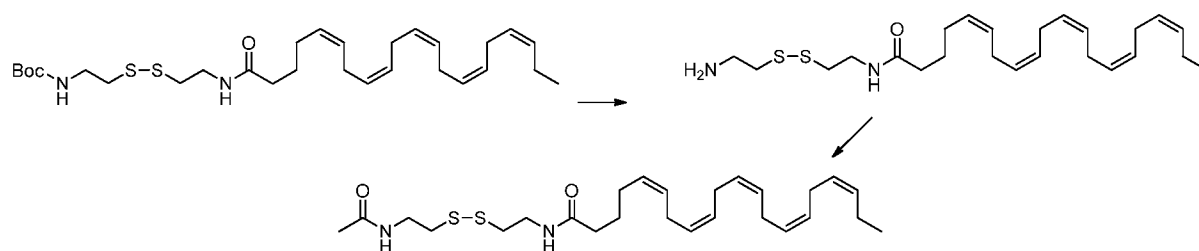
A mixture of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (8.2 g, 17.8 mmol) in CH_2Cl_2 (200 mL) was cooled to 0 °C, and acetic anhydride (2.2 g, 21.3 mmol) and triethylamine (5.4 g, 53.4 mmol) was added. The resulting reaction mixture was allowed to slowly warm to room temperature over a period of 30 min under N_2 . The organic layer was then washed with aq. NH_4Cl (100 mL x 3), brine (100 mL x 3), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography to afford 5.7 g of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide. Yield: 64%.

[00163] MS calculated for $C_{28}H_{44}N_2O_2S_2$: 504.8; found: 505.2 $[M+H]^+$.

^1H NMR (400 MHz, CDCl_3) δ 0.95-1.00 (t, J is 7.4 Hz, 3H), 2.02 (s, 3H), 2.03-2.10 (m, 2H), 2.25-2.29 (m, 2H), 2.39-2.45 (m, 2H), 2.78-2.85 (m, 14H), 3.54-3.60 (m, 4H), 5.29-5.44 (m, 12H), 6.25 (s, 1H), 6.41 (s, 1H).

Example 16

Preparation of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (I-9):



[00164] The starting material, tert-butyl (2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)carbamate was prepared according to the procedures outlined in WO 2011106688.

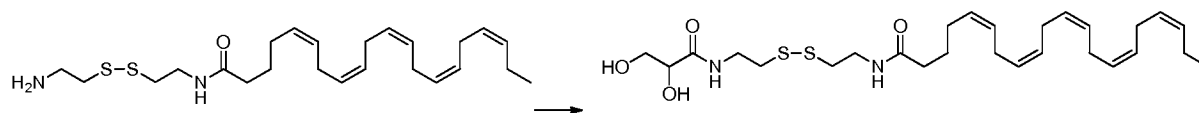
[00165] This material was then subjected to the same reaction sequence outlined in example 15 to prepare (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide. This fatty acid/cystamine derivative, (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (12 g, 27.5 mmol), was then subjected to the same reaction conditions outlined in example 15. The final product was purified by silica gel chromatography to afford 6.7 g of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide. Yield: 51%.

MS calculated for $\text{C}_{26}\text{H}_{42}\text{N}_2\text{O}_2\text{S}_2$: 478.8; found: 479.3 $[\text{M}+\text{H}]^+$.

^1H NMR (400 MHz, CDCl_3) δ 0.95-1.00 (t, J is 7.6 Hz, 3 H), 1.68-1.76 (m, 2 H), 2.02 (s, 3 H), 2.04-2.15 (m, 4 H), 2.20-2.24 (m, 2 H), 2.80-2.85 (m, 12 H), 3.53-3.60 (m, 4 H), 5.30-5.42 (m, 10 H), 6.25 (s, 1 H), 6.48 (s, 1 H).

Example 17

Preparation of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (I-10):



[00166] Glyceric acid was readily available commercially as an aqueous solution. The calcium salt of glyceric acid was isolated as follows: to a mixture of glyceric acid (20% in water) (50 g, 94.33 mmol) in H₂O (20 mL) was added Ca(OH)₂ (3.49 g, 47.16 mmol). The mixture was stirred at room temperature for 2 hours and then lyophilized to afford 11.8 g of the calcium salt of glyceric acid.

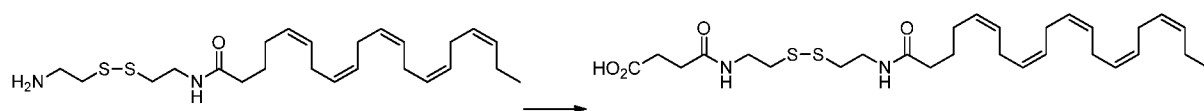
[00167] The calcium salt of glyceric acid (4.81 g, 38.53 mmol) was taken up in 100 mL of DMF along with HOBt (6.5 g, 48.16 mmol), EDCI (9.23 g, 48.16 mmol), (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (14 g, 32.11 mmol) and DMAP (7.77 g, 64.22 mmol). The resulting reaction mixture was stirred at room temperature overnight. It was then diluted with ethyl acetate (500 mL) and washed with saturated aqueous NH₄Cl (100 mL x 3) and brine (100 mL x 3). The organic layer was dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography to afford 3.4 g of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide. Yield: 20 %.

MS calculated for C₂₇H₄₄N₂O₄S₂: 524.7; found: 525.3 [M+H]⁺.

¹H NMR (400 MHz, CDCl₃) δ 0.88-0.92 (t, *J* is 8 Hz, 3 H), 1.60-1.67 (m, 2 H), 1.97-2.15 (m, 6 H), 2.70-2.89 (m, 13 H), 3.43-3.57 (m, 4 H), 3.78-3.83 (m, 2 H), 4.11-4.23 (m, 2 H), 5.23-5.36 (m, 10 H), 6.04 (s, 1 H), 7.31 (s, 1 H).

Example 18

Preparation of 4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (I-11):



[00168] A mixture of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (14 g, 32.11 mmol) in CH₂Cl₂ (200 mL) was cooled down to 0 °C with stirring. Succinic anhydride (3.85 g, 38.53 mmol) and Et₃N (9.72 g, 96.33 mmol) were then added. The resulting reaction mixture was allowed to warm to room temperature and stirred for 18 h. It was then diluted with CH₂Cl₂ (200 mL) and acidified with some 1 N HCl (50 mL). The aqueous layer was discarded and the organic layer was washed with saturated NH₄Cl (300 mL x 3), brine (300 mL x 3), dried over anhydrous Na₂SO₄ and concentrated

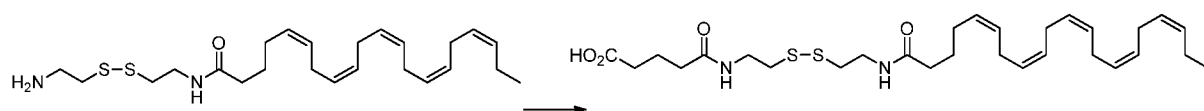
under reduced pressure. The resulting residue was purified by silica gel chromatography to afford 7.6 g of 4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid. Yield: 44%.

MS calculated for $C_{28}H_{44}N_2O_4S_2$: 536.7; found: 537.1 $[M+H]^+$.

1H NMR (400 MHz, $CDCl_3$) δ 0.88-0.92 (t, J is 7.6 Hz, 3 H), 1.62-1.68 (m, 2 H), 1.99-2.07 (m, 4 H), 2.13-2.17 (m, 2 H), 2.49-2.52 (m, 2 H), 2.62-2.64 (m, 2 H), 2.71-2.80 (m, 12 H), 3.47-3.52 (m, 4 H), 5.23-5.36 (m, 10 H), 6.13 (s, 1 H), 6.90 (s, 1 H).

Example 19

Preparation of 5-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-5-oxopentanoic acid (I-12):



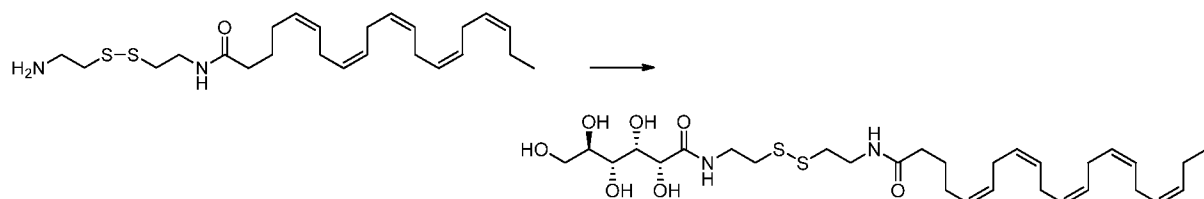
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-Aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (14 g, 32.11 mmol) was subjected to the same reaction conditions detailed in example 18, substituting glutaric anhydride for succinic anhydride. The resulting final product was purified by silica gel chromatography. Yield: 30%.

MS calculated for $C_{29}H_{46}N_2O_4S_2$: 550.8; found: 551.2 $[M+H]^+$.

1H NMR (400 MHz, $CDCl_3$) δ 0.88-0.92 (t, J is 7.6 Hz, 3 H), 1.62-1.68 (m, 2 H), 1.89-2.07 (m, 6 H), 2.13-2.17 (m, 2 H), 2.26-2.29 (m, 2 H), 2.34-2.38 (m, 2 H), 2.72-2.79 (m, 12 H), 3.47-3.52 (m, 4 H), 5.23-5.34 (m, 10 H), 6.16 (s, 1 H), 6.60 (s, 1 H).

Example 20

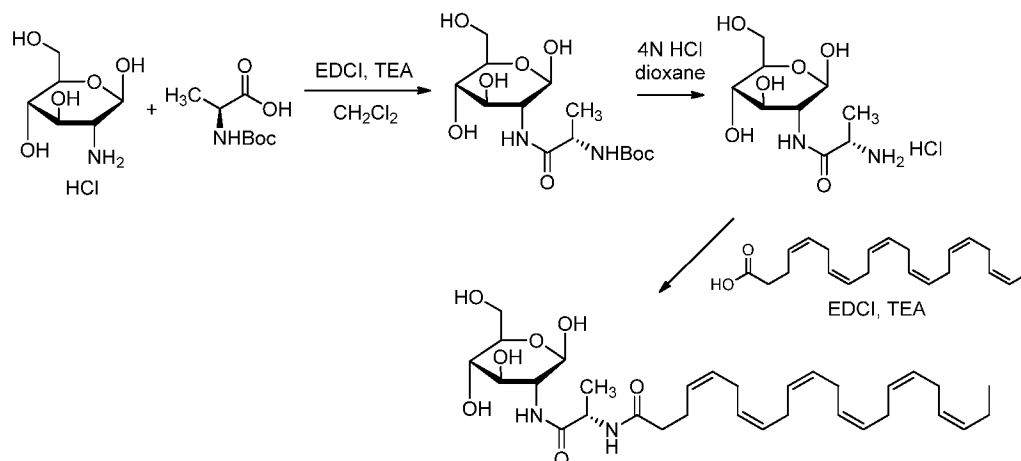
Preparation of (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (I-14)



[00169] (5Z,8Z,11Z,14Z,17Z)-N-(2-((2-Aminoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide was subjected to the same reaction conditions detailed in example 17, substituting D-gluconic acid for glyceric acid. MS calculated for $C_{30}H_{50}N_2O_7S_2$: 614.31; found: 615 $[M+H]^+$.

Example 21

Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (



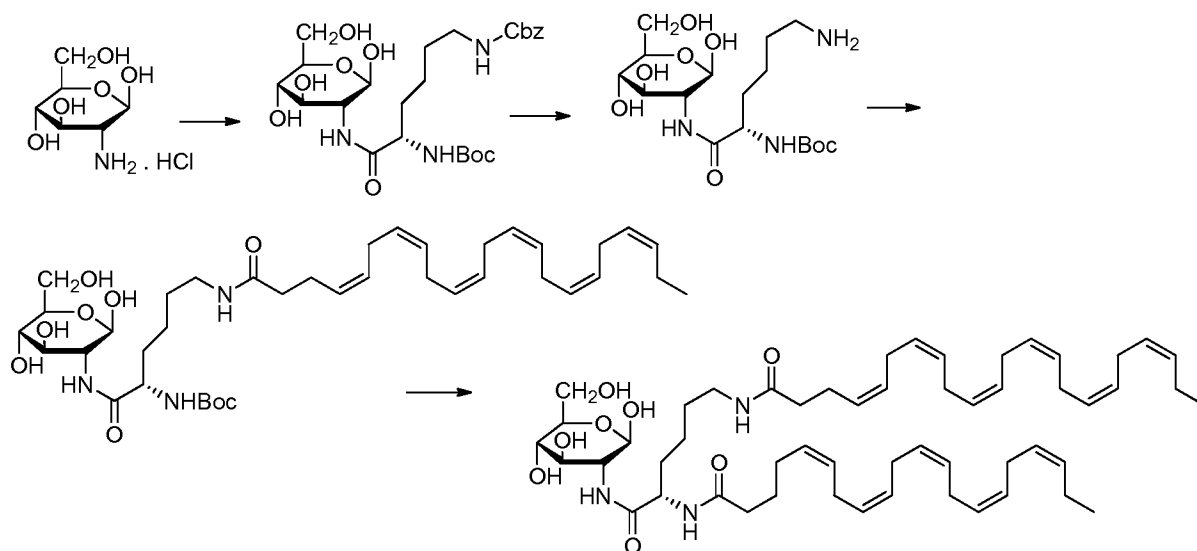
[00170] Glucosamine-HCl salt ((2R,3R,4R,5S,6R)-3-amino-6-(hydroxymethyl)tetrahydro-2H-pyran-2,4,5-triol hydrochloride, 500mg, 2.32 mmol) was pre-stirred in 3 mL CH_2Cl_2 and triethylamine (468 ul, 1.5 equivalents). Next, N-Boc-L-alanine ((S)-2-((tert-butoxycarbonyl)amino)propanoic acid, 439 mg, 1.0 equivalents) and EDC (672 mg, 1.5 equivalents) were added. The reaction was stirred at room temperature overnight under N_2 until completion. Upon completion, the crude reaction was filtered and washed with 2 mL CH_2Cl_2 ; the filtrate was dried under high vacuum to give an opaque waxy solid. The opaque solid was re-dissolved in hot EtOAc where white salt by-products remain undissolved. The heterogenous mixture was filtered, with EtOAc. The filtrate was collected, dried over Na_2SO_4 , and dried under high vacuum to give tert-butyl ((S)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propan-2-yl)carbamate, which was used in the next step without further purification.

[00171] To tert-butyl ((S)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propan-2-yl)carbamate, was added 3 equivalents of 4N HCl in dioxane and stirred for 30 minutes, followed by azeotrope with EtOAc to give the (L)-alanine linked glucosamine-HCl salt, (S)-2-amino-N-((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)propanamide hydrochloride. The (L)-alanine linked glucosamine-HCl salt (605 mg, 2.11 mmol) was pre-stirred in 3 mL CH_2Cl_2 and triethylamine (426 ul, 1.5 equivalents). Next, (4Z,7Z,10Z,13Z,16Z,19Z)-docosa-

4,7,10,13,16,19-hexaenoic acid (623 mg, 0.90 equivalents) and EDC (529 mg, 1.3 equivalents) were added and the reaction was stirred overnight at room temperature under N_2 , until completion. Upon completion, the crude reaction was dried under high vacuum, then re-dissolved in EtOAc; next pentanes was added to form a 50% pentane-EtOAc mixture upon which salt-by products of the reaction crashes out. The crude product was filtered and the filtrate was concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (gradient elution, 0-10% MeOH in CH_2Cl_2). MS calculated for $C_{31}H_{48}N_2O_7$: 560.72; found 563.5 $[M+Na]^+$.

Example 22

Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (I-50):



[00172] To a solution of (S)-benzyl tert-butyl (6-amino-6-oxohexane-1,5-diyl)dicarbamate (23 g, 60.52 mmol) in 150 mL of DMF was added successively Et_3N (18.31 g, 181.28 mmol), HATU (37.90 g 99.73 mmol), and glucosamine hydrochloride (14.33 g, 66.45 mmol) in portions at 0 °C. The resulting reaction mixture was stirred at room temperature for 2 hours and then concentrated under reduced pressure to remove the DMF.

The resulting residue was purified by silica gel chromatography (gradient elution: CH₂Cl₂/MeOH is 30:1 to 15:1) to afford 27 g of benzyl tert-butyl ((S)-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexane-1,5-diyl)dicarbamate (Yield: 84%). MS calculated for C₂₅H₃₈N₂O₁₀: 540.58; found: 541.2 [M+H]⁺.

[00173] To a solution of benzyl tert-butyl ((S)-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexane-1,5-diyl)dicarbamate (27 g, 49.9 mmol) in 300mL of methanol was added 10% Pd-C (3 g) and H₂ gas was introduced. The suspension was stirred at room temperature under 1 atm of H₂ for 18 h. The resulting reaction mixture was filtered through a pad of Celite and the filtrate was concentrated under reduced pressure to afford 20 g of tert-butyl ((S)-6-amino-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexan-2-yl)carbamate (yield: 99%) as a yellow oil. This material was used for the next step without further purification. MS calculated for C₁₇H₃₂N₃O₈: 406.45; found: 407.1 [M+H]⁺.

[00174] To a solution of DHA (5.31 g, 16.21 mmol) in 100 mL of DMF was added Et₃N (2.23 g, 22.11 mmol), EDC (4.23 g, 22.11 mmol), then ((S)-6-amino-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexan-2-yl)carbamate (6.0 g, 14.74 mmol) in portions at 0 °C. The reaction mixture was stirred at room temperature for 18 h and then concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (gradient elution: CH₂Cl₂: MeOH is 40:1 to 15:1) to afford 2.8 g of tert-butyl ((S)-6-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexan-2-yl)carbamate (Yield: 26%). MS calculated for C₃₉H₈₆N₃O₉: 716.9; found: 717.1 [M+H]⁺.

[00175] tert-Butyl ((S)-6-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexan-2-yl)carbamate (2.8 g, 3.90 mmol) was taken up in 20 mL of 4 N HCl in ethyl acetate and allowed to stir at room temperature for 30 min. The reaction mixture was diluted with 20 mL of ethyl acetate and concentrated under reduced pressure to afford the HCl salt of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-amino-6-oxo-6-

((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide.

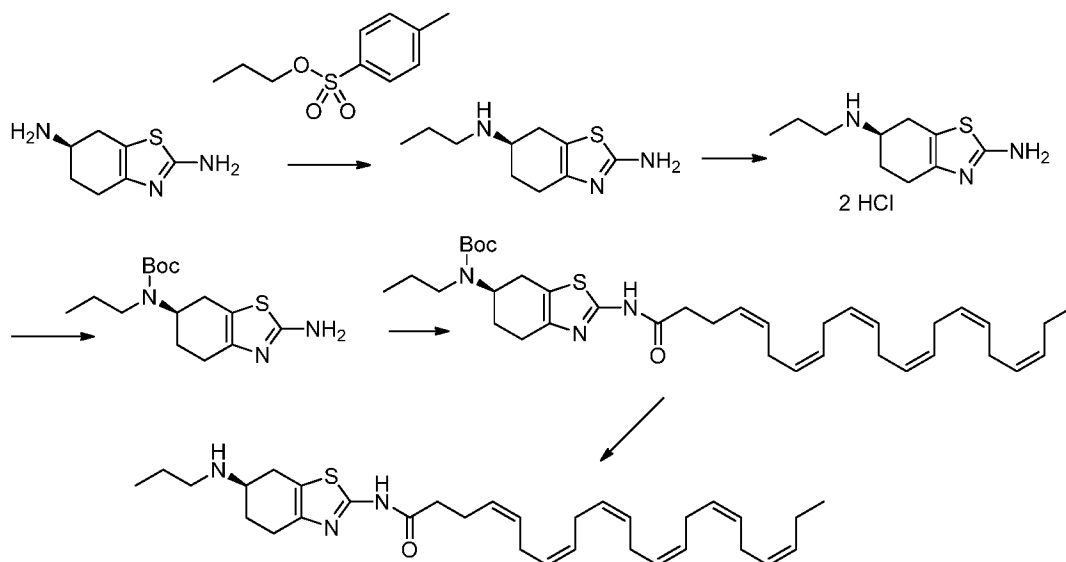
[00176] To a solution of compound EPA (1.29 g, 4.29 mmol) in 50 mL of DMF was added Et₃N (0.59 g, 5.85 mmol), HATU (2.22 g, 0.85 mmol), and the HCl salt of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-amino-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (2.54 g, 3.90 mmol) in portions at 0 °C. The resulting reaction mixture was stirred at room temperature overnight. Then the reaction mixture was removed under reduced pressure. The residue was purified by silica gel chromatography (gradient elution: CH₂Cl₂: MeOH is 50:1 to 15:1) to afford 120 mg of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-5-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)-6-oxo-6-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)hexyl)docosa-4,7,10,13,16,19-hexaenamide (Yield: 3.1%).

MS calculated for C₅₄H₈₃N₃O₈: 902.25; found: 884 [M-18]⁺.

¹H NMR (400MHz, CDCl₃) δ 0.86-0.93 (m, 6H), 1.20-1.35 (m, 7H), 1.51-1.58 (m, 3H), 1.99-2.26 (m, 12H), 2.76-2.81 (m, 18H), 2.95-2.98 (m, 3H), 3.47-3.59 (m, 3H), 4.39-4.42 (m, 2H), 4.57-4.59 (m, 1H), 4.90-4.91 (m, 1H), 5.26-5.39 (m, 22H), 6.41-6.42 (m, 1H), 7.59-7.61 (m, 1H), 7.72-7.73 (m, 1H), 7.81-7.83 (m, 1H).

Example 23

Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)docosa-4,7,10,13,16,19-hexaenamide (I-21):



[00177] A mixture of the commercially available compound (R)-4,5,6,7-tetrahydrobenzo[d]thiazole-2,6-diamine (61 g, 351 mmol) in n-propanol (800 mL) was stirred at 95 °C under N₂ for 15 min. A solution containing n-propyl 4-methylbenzenesulfonate (100 g, 467 mmol) and DIEA (80 mL) in 300 mL n-propanol was then added dropwise at room temperature. The resulting reaction mixture was stirred at 95 °C for 18 h. It was then cooled to room temperature, and stirring was continued for an additional 4 h. The precipitated material was collected by filtration and washed with reagent grade alcohol (120 mL), followed by heptanes (100 mL). The resulting solids were dried under high vacuum for 2 h and then taken up in 50 mL of ethanol and cooled to between 0 and 5 °C. With continuous stirring, concentrated HCl (45 mL) was slowly added to the reaction while maintaining the temperature at between 0 and 5 °C, and the mixture was stirred for an additional 15 min. Methyl t-butyl ether (MTBE, 270 mL) was added to mixture, and stirring was continued for additional 1.5 h at this temperature. The mixture was filtered, washed twice with an MTBE/ethanol solution (2:1; 2 × 70 mL), and dried under high vacuum at room temperature for 18 h to afford 38.5 g of the dihydrochloride salt of (R)-N6-propyl-4,5,6,7-tetrahydrobenzo[d]thiazole-2,6-diamine (Yield: 51%). MS calculated for C₁₀H₁₇N₃S: 211.11; found: 212.1 [M+H]⁺.

[00178] The dihydrochloride salt of (R)-N6-propyl-4,5,6,7-tetrahydrobenzo[d]thiazole-2,6-diamine (12 g, 42.2 mmol) and Et₃N (12.7 g, 126.6 mmol) were taken up in 500 mL of MeOH. A solution of Boc-anhydride (79.14 g, 0.665 mmol) in MeOH (70 mL) was then added dropwise at room temperature over a period of about 1 h. The resulting reaction

mixture was stirred at room temperature for 18 h and then concentrated under reduced pressure. It was then diluted with water (100 mL) and extracted with CH₂Cl₂. The combined organic layers were dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (using a mixture of pentane/EtOAc) to afford 6.3 g of (R)-tert-butyl (2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (Yield: 49%).

[00179] (R)-tert-Butyl (2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (4 g, 12.8 mmol) was taken up in 100 mL of CH₂Cl₂ along with DHA (4 g, 12.2 mmol), HATU (5.9 g, 15.4 mmol) and DIEA (4.96 g, 38.4 mmol). The resulting reaction mixture was stirred at room temperature for 18 h. It was then diluted with CH₂Cl₂ (100 mL) and washed with aq. HCl (5%, 3 x 200 mL) and brine (3 x 200 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (pentane/EtOAc) to afford 5 g of tert-butyl ((R)-2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (Yield: 66%).

MS calculated for C₃₇H₅₅N₃O₃S: 621.9; found: 622.4 [M+H]⁺.

¹H NMR (400 MHz, CDCl₃) δ 0.87-0.91 (t, *J* is 7.4 Hz, 3H), 0.94-0.99 (t, *J* is 7.4 Hz, 3H), 1.47 (s, 9H), 1.52-1.63 (m, 2H), 1.82-2.11 (m, 4H), 2.40-2.48 (m, 4H), 2.72-2.77 (m, 20H), 3.00-3.10 (m, 2H), 5.27-5.45 (m, 12H).

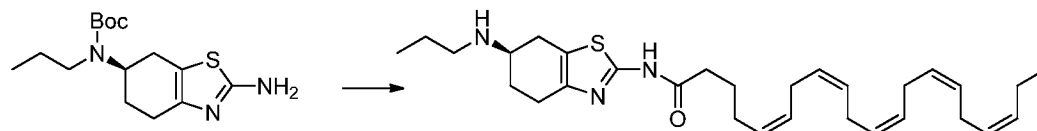
[00180] tert-Butyl ((R)-2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (2.1 g, 3.43 mmol) was taken up in 20 mL of 4 N HCl in ethyl acetate and allowed to stir at room temperature for 2 h. The reaction mixture was diluted with 40 mL of ethyl acetate and concentrated under reduced pressure. The resulting residue was diluted with EtOAc and washed with aq. NaHCO₃ (3 x 30 mL) brine (3 x 30 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by preparative HPLC to afford 1.5 g of (4Z,7Z,10Z,13Z,16Z,19Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)docosa-4,7,10,13,16,19-hexaenamide (Yield: 85%).

MS calculated for C₃₂H₄₇N₃OS: 521.8; found: 522.3 [M+H]⁺.

¹H NMR (400 MHz, CDCl₃) δ 0.92-0.99 (m, 6H), 1.50-1.56 (m, 2H), 1.72-1.74 (m, 2H), 2.03-2.09 (m, 4H), 2.46-2.51 (m, 5H), 2.64-2.73 (m, 3H), 2.79-2.85 (m, 11H), 2.97-3.02 (m, 2H), 5.32-5.43 (m, 12H).

Example 24

Preparation of (5Z,8Z,11Z,14Z,17Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)icosa-5,8,11,14,17-pentaenamide (I-22):



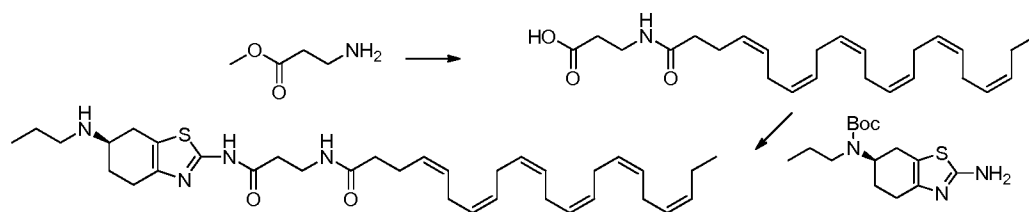
[00181] (R)-tert-Butyl (2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (300 mg, 0.96 mmol) was subjected to the same reaction conditions detailed in example 23, substituting EPA for DHA. After preparative HPLC purification, 180 mg of (5Z,8Z,11Z,14Z,17Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)icosa-5,8,11,14,17-pentaenamide.

MS calculated for $C_{30}H_{45}N_3OS$: 495.33; found: 496.3 $[M+H]^+$.

1H NMR (400 MHz, $CDCl_3$) δ 0.98-1.04 (m, 6H), 1.50-1.70 (s, 3H), 1.71-1.84 (m, 3H), 2.03-2.07 (m, 3H), 2.12-2.18 (m, 2H), 2.39-2.43 (t, J is 3.6 Hz, 3H), 2.49-2.51 (m, 1H), 2.64-2.67 (t, J is 7.4 Hz, 3H), 2.71-2.74 (m, 8H), 2.95-3.03 (m, 2H), 5.29-5.43 (m, 10H).

Example 25

Preparation of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)docosa-4,7,10,13,16,19-hexaenamide (I-27):



[00182] To a suspension of β -alanine methyl ester (1.39 g, 10 mmol), EDC (2.88 g, 15 mmol), HOBt (2.03 g, 15 mmol) and Et_3N (3.03 g, 30 mmol) in 30 mL of CH_2Cl_2 was added DHA (3.12 g, 9.5 mmol). The mixture was stirred at room temperature for 18 h. The reaction mixture was then washed with saturated aqueous NH_4Cl (3 x 30 mL), brine (3 x 30 mL), dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The resulting residue

was purified by silica gel chromatography (EtOAc/pentane) to afford 3.2 g of methyl 3-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)propanoate (Yield: 82%).

¹H NMR (400 MHz, CDCl₃) δ 0.95-0.99 (t, *J* is 7.6 Hz, 3H), 2.03-2.11 (m, 2H), 2.21-2.25 (t, *J* is 7.6 Hz, 2H), 2.37-2.43 (m, 2H), 2.52-2.56 (t, *J* is 6.0 Hz, 2H), 2.79-2.86 (m, 10H), 2.37-2.43 (m, 2H), 3.70 (s, 3H), 5.29-5.42 (m, 12H), 6.06 (s, 1H).

[00183] To a solution of methyl 3-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)propanoate (0.7 g, 1.69 mmol) in 10 mL of THF was added 10 mL of 5 N NaOH. The resulting reaction mixture was stirred at room temperature for 2h and acidified to pH is 2 with 6 N HCl. The aqueous phase was extracted with EtOAc. The combined organic layers were washed with brine, dried over Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography to afford 532 mg of 3-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)propanoic acid (Yield: 80%).

¹H NMR (400 MHz, CDCl₃) δ 0.95-0.99 (t, *J* is 7.4 Hz, 3H), 2.03-2.08 (m, 2H), 2.21-2.25 (t, *J* is 7.2 Hz, 2H), 2.37-2.43 (m, 2H), 2.58-2.62 (t, *J* is 5.4 Hz, 2H), 2.79-2.90 (m, 10H), 3.52-3.54 (3, 2H), 5.29-5.43 (m, 12H), 6.08 (s, 1H).

3-((4Z,7Z,10Z,13Z,16Z,19Z)-Docosa-4,7,10,13,16,19-hexaenamido)propanoic acid (200 mg, 0.50 mmol) was taken up in 10 mL of CH₂Cl₂ along with (R)-tert-butyl (2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (156 mg, 0.50 mmol), HATU (229 mg, 0.60 mmol) and DIEA (194 mg, 1.50 mmol). The resulting reaction mixture was stirred at room temperature for 18 h. It was then diluted with CH₂Cl₂ (10 mL) and washed with aq. HCl (5%, 3 x 20 mL) and brine (3 x 20 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (EtOAc/pentane) to afford 200 mg of tert-butyl ((R)-2-(3-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)propanamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (Yield: 57%).

[00184] tert-Butyl ((R)-2-(3-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)propanamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (200 mg, 0.29 mmol) was taken up in 10 mL of 4 N HCl in EtOAc and allowed to stir at room temperature for 2 h. The reaction mixture was diluted with 10 mL of EtOAc and concentrated under reduced pressure. The resulting residue was purified by preparative HPLC to afford 120 mg of (4Z,7Z,10Z,13Z,16Z,19Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-

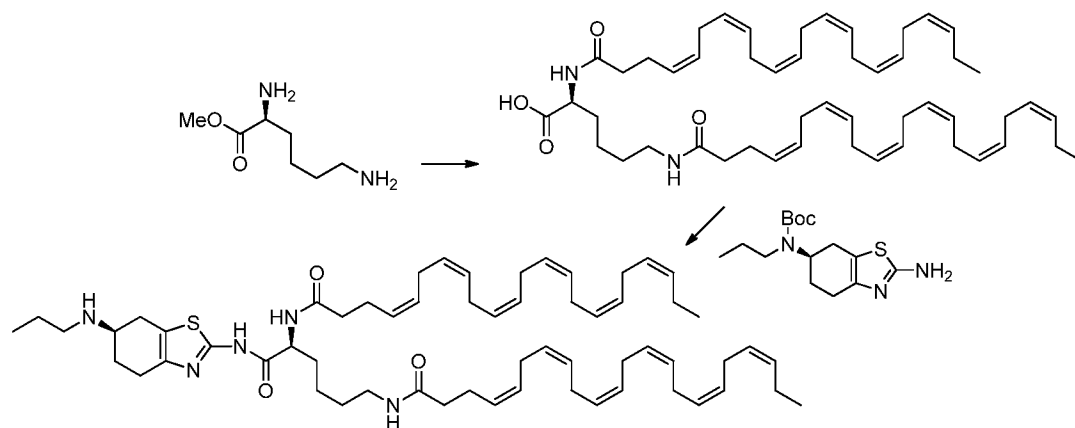
tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)docosa-4,7,10,13,16,19-hexaenamide (Yield: 70%)

MS calculated for $C_{35}H_{52}N_4O_2S$: 592.9; found: 593.4 $[M+H]^+$.

1H NMR (400 MHz, $CDCl_3$) δ 0.88-0.97 (m, 6H), 1.50-1.56 (m, 2H), 1.71-1.82 (m, 2H), 2.00-2.09 (m, 4H), 2.20-2.24 (m, 2H), 2.36-2.40 (m, 2H), 2.41-2.60 (m, 1H), 2.65-2.68 (m, 5H), 2.69-2.73 (m, 1H), 2.80-2.86 (m, 10H), 2.95-3.03 (m, 2H), 3.58-3.63 (m, 2H), 5.30-5.42 (m, 12H), 6.22-5.24 (m, 1H).

Example 26

Preparation of (4Z,4'Z,7Z,7'Z,10Z,10'Z,13Z,13'Z,16Z,16'Z,19Z,19'Z)-N,N'-((S)-6-oxo-6-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)hexane-1,5-diyl)bis(docosa-4,7,10,13,16,19-hexaenamide) (I-82):



[00185] To a suspension of L-lysine methyl ester dihydrochloride (2.33 g, 10 mmol), EDC (2.88 g, 15 mmol), HOBt (2.03 g, 15 mmol) and Et_3N (3.03 g, 30 mmol) in 30 mL of CH_2Cl_2 was added DHA (3.12 g, 9.5 mmol). The resulting reaction mixture was stirred at room temperature for 18 h. The reaction mixture was washed with saturated aqueous NH_4Cl (3 x 30 mL) and brine (3 x 30 mL). The organic layer was dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (pentane/ $EtOAc$) to afford 4.67 g of (S)-methyl 2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)hexanoate (Yield: 60%).

1H NMR (400 MHz, $CDCl_3$) δ 0.95 -1.01 (m, 6H), 1.26 - 1.40 (m, 2H), 1.48 - 1.55 (m, 2H), 1.65 - 1.73 (m, 1H), 1.79 - 1.85 (m, 2H), 2.03 - 2.13 (m, 4H), 2.19 - 2.24 (m, 2H), 2.27 - 2.32 (m, 2H), 2.37 - 2.45 (m, 4H), 2.80 - 2.85 (m, 20H), 3.20 - 3.27 (m, 2H), 3.74 - 3.75 (d, J is

2.4 Hz, 3H), 4.56 - 4.60 (m, 1H), 5.27 - 5.46 (m, 24H), 5.68 (s, 1H), 6.18 - 6.21 (d, *J* is 7.5 Hz, 1H).

[00186] To the solution of (S)-methyl 2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)hexanoate (2.5 g, 3.2 mmol) in 20 mL of THF was added 50 mL of 5 N NaOH. The resulting reaction mixture was stirred at room temperature for 2h and then acidified to pH is 2 with 6 N HCl. The aqueous phase was extracted with EtOAc. The combined organic layers were washed with brine, dried over Na₂SO₄, and concentrated under reduced pressure to afford 2.22 g of (S)-2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)hexanoic acid (Yield: 90%).

[00187] (S)-2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-Docosa-4,7,10,13,16,19-hexaenamido)hexanoic acid (500 mg, 0.70 mmol) was taken up in 20 mL of CH₂Cl₂ along with (R)-tert-butyl (2-amino-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (204 mg, 0.70 mmol), HATU (319 mg, 0.84 mmol) and DIEA (226 mg, 1.75 mmol). The resulting reaction mixture was stirred at room temperature for 18 h. It was then diluted with CH₂Cl₂ (20 mL) and washed with aq. HCl (5%, 3 x 40 mL) and brine (3 x 40 mL). The organic layer was dried over anhydrous Na₂SO₄ and concentrated under reduced pressure. The resulting residue was purified by silica gel chromatography (pentane/EtOAc) to afford 300 mg of tert-butyl ((R)-2-((S)-2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)hexanamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (Yield: 72%).

[00188] tert-Butyl ((R)-2-((S)-2,6-di((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)hexanamido)-4,5,6,7-tetrahydrobenzo[d]thiazol-6-yl)(propyl)carbamate (500 mg, 0.47 mmol) was taken up in 20 mL of 4 N HCl in ethyl acetate and allowed to stir at room temperature for 90 min. The reaction mixture was diluted with 10 mL of ethyl acetate and concentrated under reduced pressure to afford 300 mg of (4Z,4'Z,7Z,7'Z,10Z,10'Z,13Z,13'Z,16Z,16'Z,19Z,19'Z)-N,N'-((S)-6-oxo-6-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)hexane-1,5-diyl)bis(docosa-4,7,10,13,16,19-hexaenamide) (Yield: 70%).

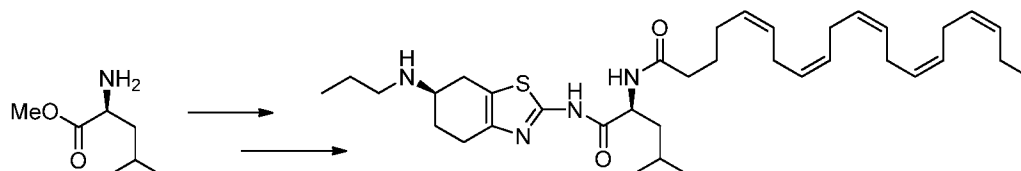
MS calculated for C₆₀H₈₉N₅O₃S: 960.4; found: 961.4 [M+H]⁺.

¹H NMR (400 MHz, CDCl₃) δ 0.94 - 0.99 (m, 9H), 1.40-1.46 (m, 2H), 1.50 - 1.54 (m, 2H), 1.61 - 1.67 (m, 2H), 1.74 -1.86 (m, 2H), 1.90 -1.95 (m, 2H), 2.03 - 2.10 (m, 4H), 2.20 - 2.29 (m, 3H), 2.32 - 2.43 (m, 7H), 2.46 - 2.66 (m, 2H), 2.74 - 2.84 (m, 23H), 3.01 - 3.05 (m, 1H),

3.17 - 3.32 (m, 3H), 4.59 - 4.62 (m, 1H), 5.27 - 5.44 (m, 24H), 5.80 - 5.82 (m, 1H), 6.74 - 6.76 (m, 1H).

Example 27

Preparation of (5Z,8Z,11Z,14Z,17Z)-N-((S)-4-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)pentan-2-yl)icosa-5,8,11,14,17-pentaenamide (I-31)



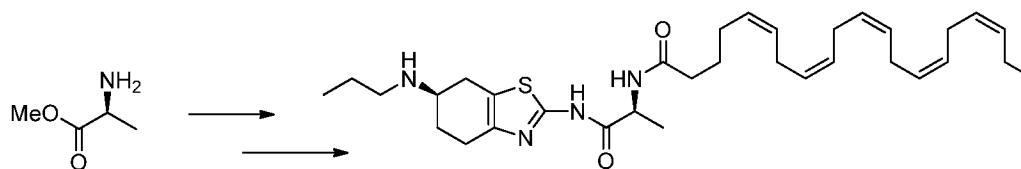
[00189] The same experimental procedure outlined in example 25 was employed, using L-Leucine methyl ester as the appropriate starting material.

MS calculated for $C_{38}H_{58}N_4O_2S$: 634.4; found: 635.4 $[M+H]^+$.

1H NMR (400 MHz, $CDCl_3$) δ 0.86 - 1.01 (m, 12H), 1.47 - 1.55 (m, 2H), 1.57 - 1.69 (m, 2H), 1.71 - 1.80 (m, 2H), 2.04 - 2.13 (m, 4H), 2.23 - 2.29 (m, 3H), 2.33 - 2.40 (m, 3H), 2.65 - 2.69 (t, J is 13.8 Hz, 3H), 2.82 - 2.87 (m, 10H), 2.96-3.04 (m, 2H), 4.66 - 4.73 (m, 1H), 5.30 - 5.45 (m, 12H), 5.95 - 5.98 (d, J is 7.5 Hz, 1H).

Example 28

Preparation of (5Z,8Z,11Z,14Z,17Z)-N-((S)-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propan-2-yl)icosa-5,8,11,14,17-pentaenamide (I-29):



[00190] The same experimental procedure outlined in example 25 was employed, using L-Alanine methyl ester as the appropriate starting material.

MS calculated for $C_{35}H_{52}N_4O_2S$: 592.9; found: 593.4 $[M+H]^+$.

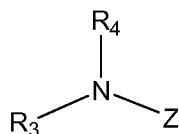
¹H NMR (400 MHz, CDCl₃) δ 0.98-1.05 (m, 6H), 1.46-1.49 (d, *J* is 6.8 Hz, 3H), 1.91-2.15 (m, 5H), 2.34-2.46 (m, 5H), 2.59-2.74 (m, 2H), 2.81-2.88 (m, 10H), 3.01-3.10 (m, 3H), 3.20-3.53 (m, 2H), 4.80-4.89 (m, 1H), 5.27-5.43 (m, 12H), 6.85-6.98 (m, 1H).

EQUIVALENTS

[00191] Those skilled in the art will recognize, or be able to ascertain, using no more than routine experimentation, numerous equivalents to the specific embodiments described specifically herein. Such equivalents are intended to be encompassed in the scope of the following claims.

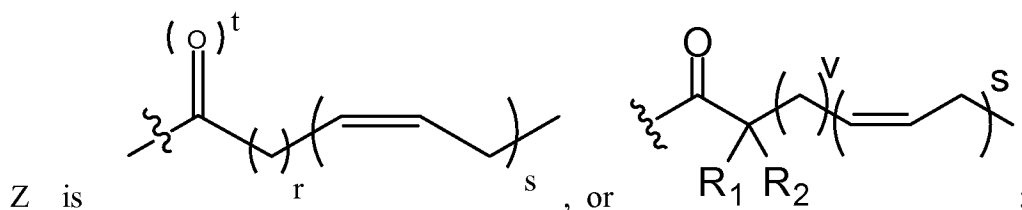
CLAIMS

1. A compound of the **Formula I**:

**Formula I**

or a pharmaceutically acceptable salt, hydrate, solvate, prodrug, enantiomer or stereoisomer thereof;

wherein



each r is independently 2, 3, or 7;

each s is independently 3, 5, or 6;

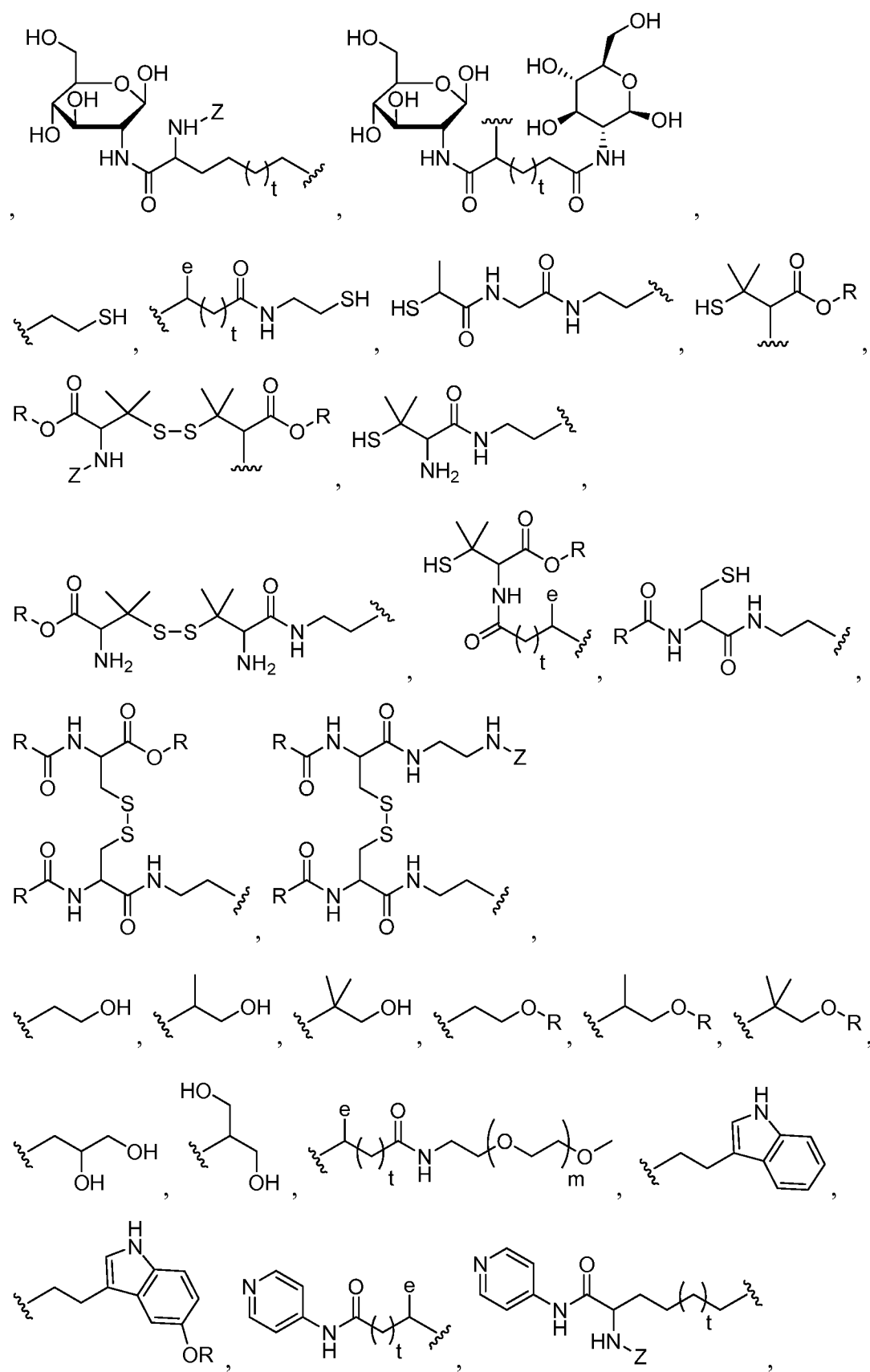
each t is independently 0 or 1;

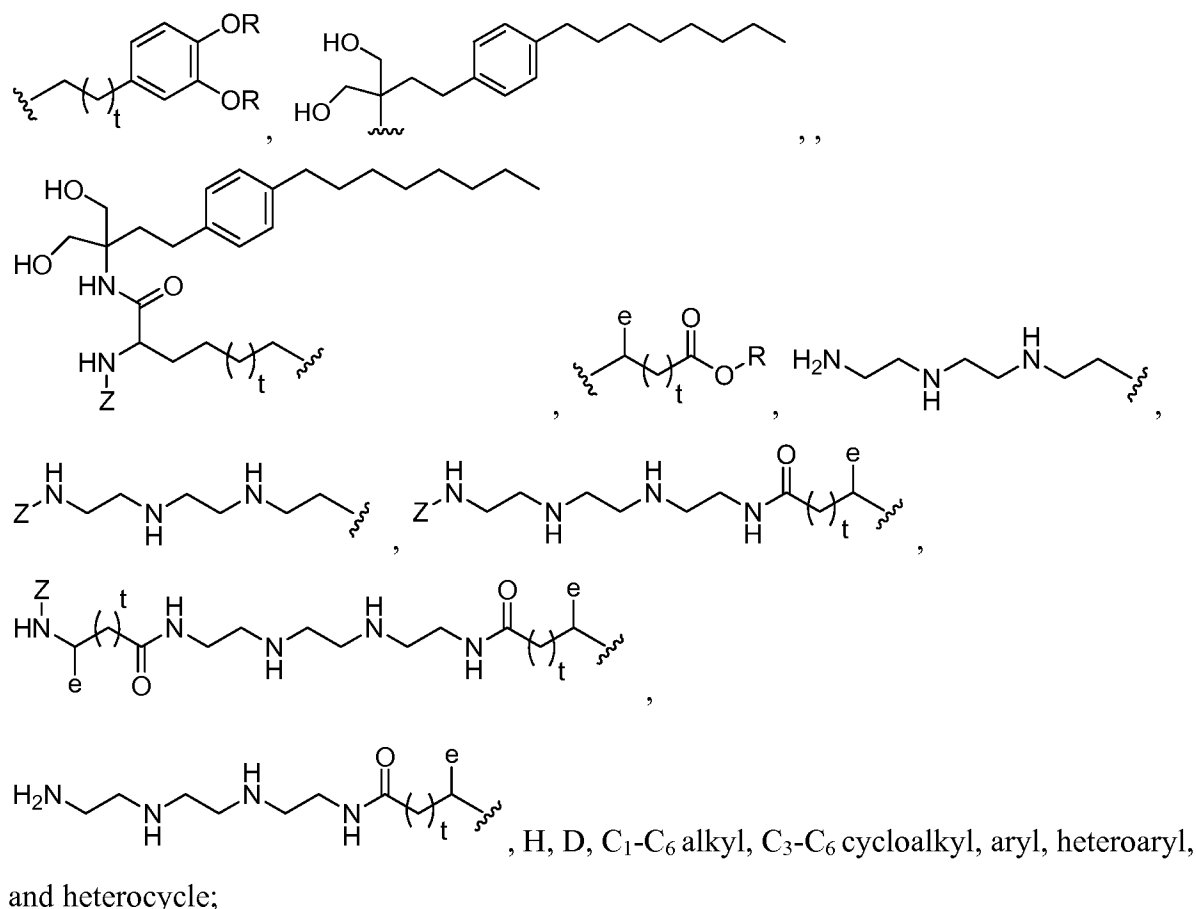
each v is independently 1, 2, or 6;

R_1 and R_2 are independently -H, -D, -C₁-C₄ alkyl, -halogen, -OH, -C(O)C₁-C₄ alkyl, -O-aryl, -O-benzyl, -OC(O)C₁-C₄ alkyl, -C₁-C₃ alkene, -C₁-C₃ alkyne, -C(O)C₁-C₄ alkyl, -NH₂, -NH(C₁-C₃ alkyl), -N(C₁-C₃ alkyl)₂, -NH(C(O)C₁-C₃ alkyl), -N(C(O)C₁-C₃ alkyl)₂, -SH, -S(C₁-C₃ alkyl), -S(O)C₁-C₃ alkyl, -S(O)₂C₁-C₃ alkyl;

R_3 and R_4 are independently





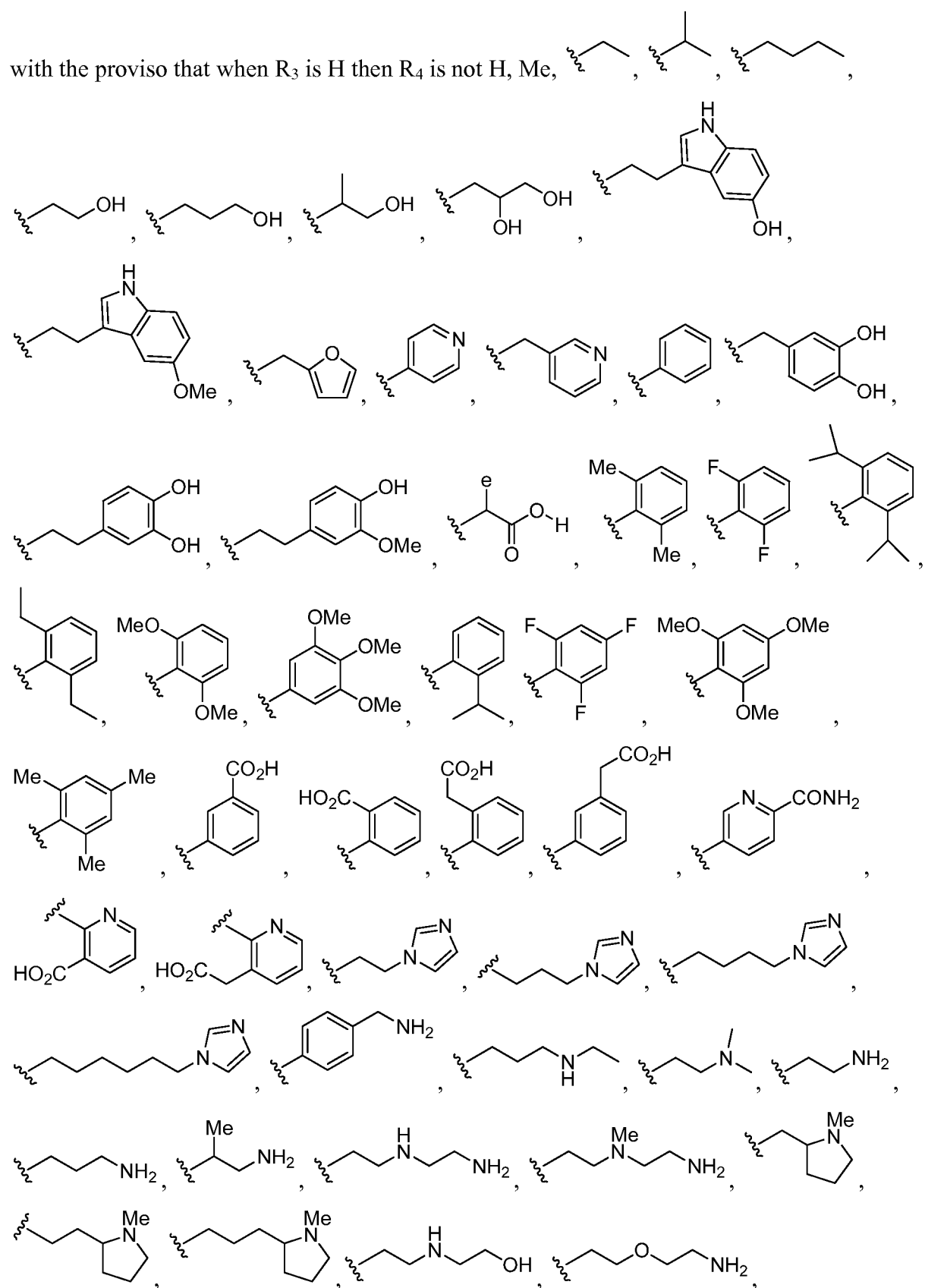


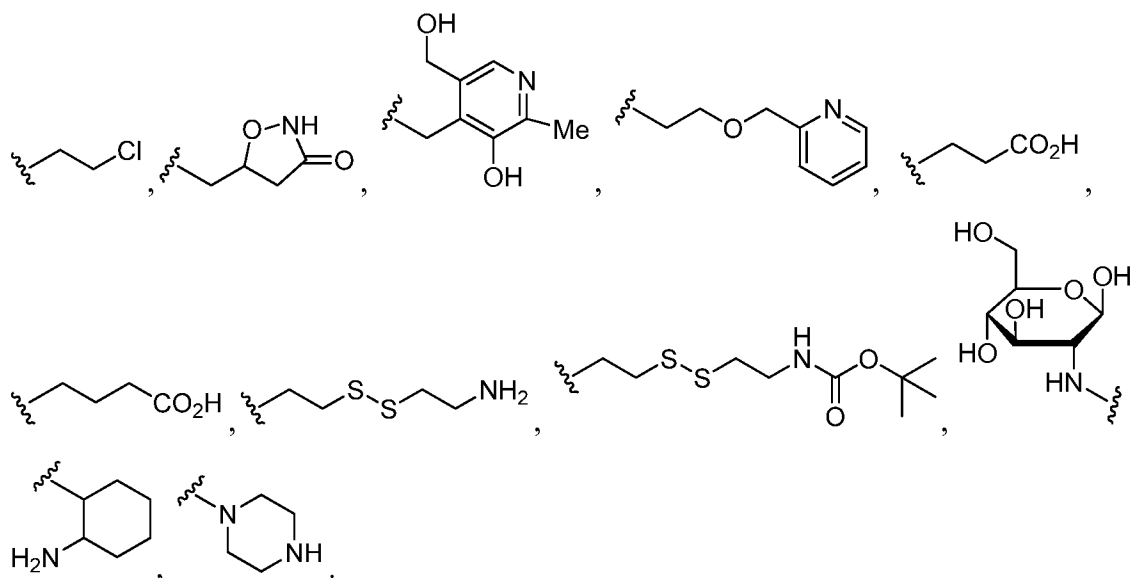
each e is independently H or any one of the side chains of the naturally occurring amino acids;

each m is independently 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

each R is independently -H, straight or branched -C₁-C₆ alkyl, -C₁-C₆ cycloalkyl, aryl, heteroaryl or heterocyclic that is optionally substituted with one, two, three, four or five groups selected from OH, CN, halogen, CO₂R₅, CONHR₅, CONR₅R₅, S(O)₂NR₅R₅, NR₅R₅, NR₅COR₅, -(OCH₂CH₂)_m-OCH₃;

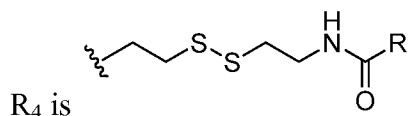
each R₅ is independently -H, -C₁-C₃ alkyl, or straight or branched C₁-C₄ alkyl optionally substituted with OH, or halogen;





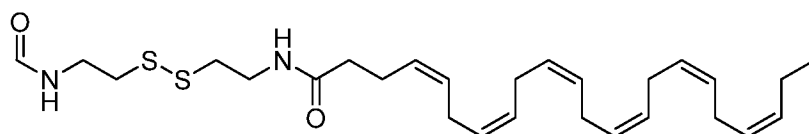
2. The compound of claim 1, wherein

R_3 is H;

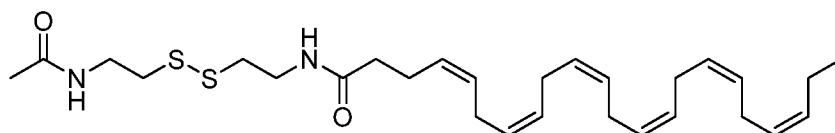


; and R is selected from straight or branched $-C_1-C_6$ alkyl that is optionally substituted with one, two, three, four or five groups selected from OH, CN, halogen, CO_2R_5 , $CONHR_5$, $CONR_5R_5$, $S(O)_2NR_5R_5$, NR_5R_5 , NR_5COR_5 , $-(OCH_2CH_2)_m-OCH_3$.

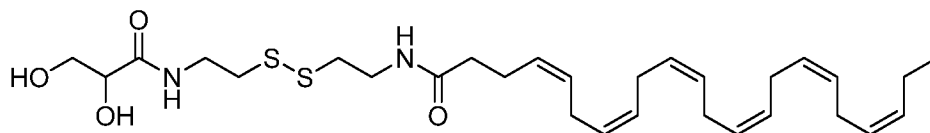
3. The compound of claim 2, wherein the compound is selected from the group consisting of



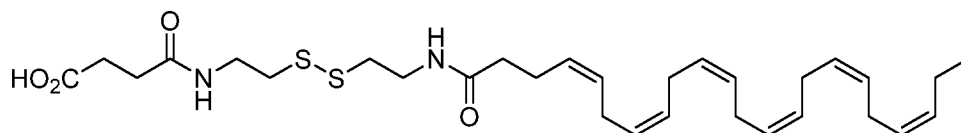
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-formamidoethyl)disulfany)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-1**);



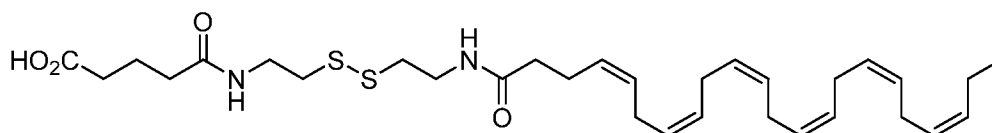
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-2**);



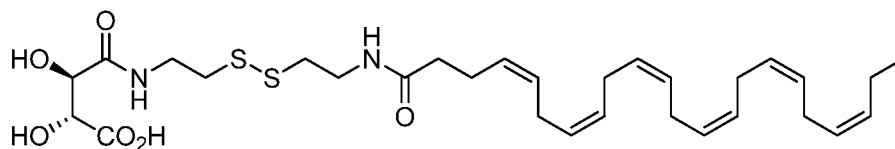
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-3**);



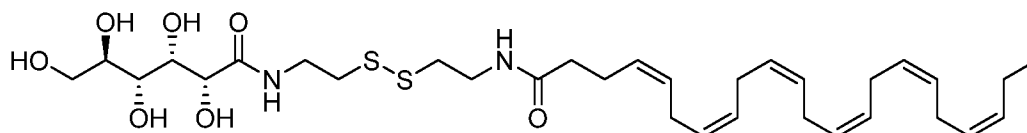
4-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-4**);



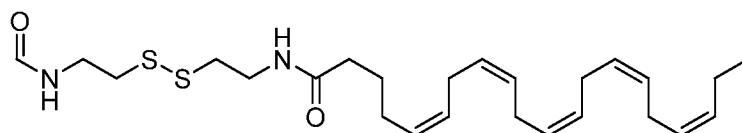
5-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-5-oxopentanoic acid (**I-5**);



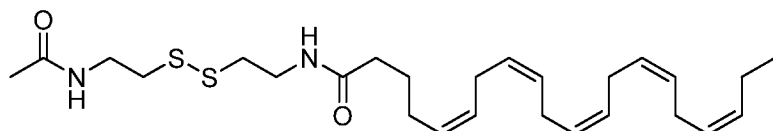
(2R,3R)-4-((2-((2-((4Z,7Z,10Z,13Z,16Z,19Z)-docosa-4,7,10,13,16,19-hexaenamido)ethyl)disulfanyl)ethyl)amino)-2,3-dihydroxy-4-oxobutanoic acid (**I-6**);



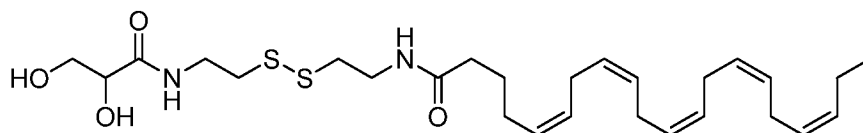
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-((2-((2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanamido)ethyl)disulfanyl)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-7**);



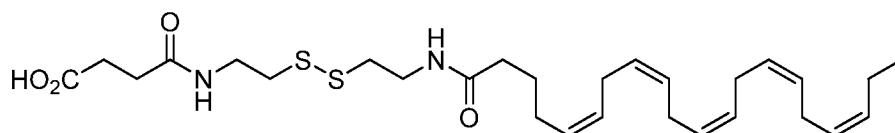
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-formamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-8**);



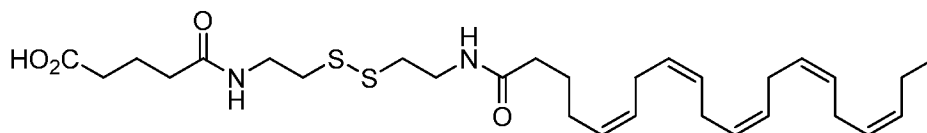
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-acetamidoethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-9**);



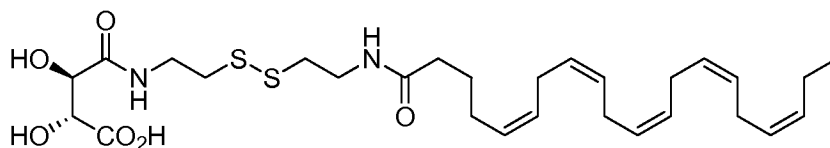
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-(2,3-dihydroxypropanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-10**);



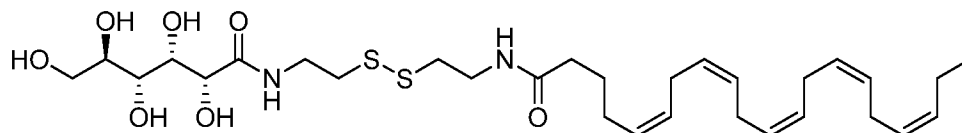
4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-11**);



5-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-5-oxopentanoic acid (**I-12**);



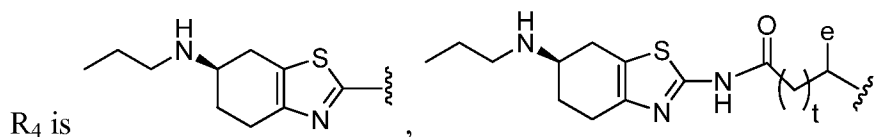
(2R,3R)-2,3-dihydroxy-4-((2-((2-((5Z,8Z,11Z,14Z,17Z)-icosa-5,8,11,14,17-pentaenamido)ethyl)disulfanyl)ethyl)amino)-4-oxobutanoic acid (**I-13**);



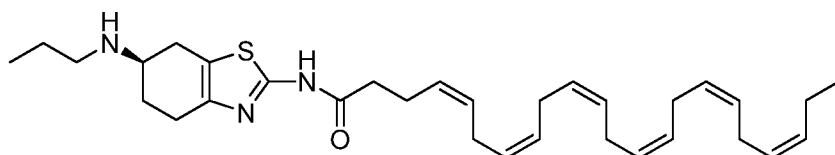
(5Z,8Z,11Z,14Z,17Z)-N-(2-((2-((2R,3S,4R,5R)-2,3,4,5,6-pentahydroxyhexanamido)ethyl)disulfanyl)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-14**).

4. The compound of claim 1, wherein

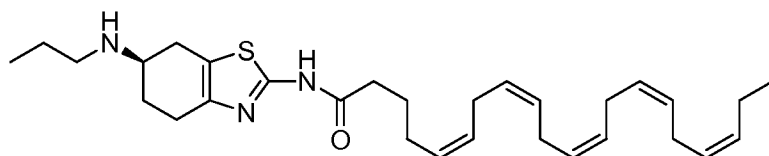
R₃ is H;



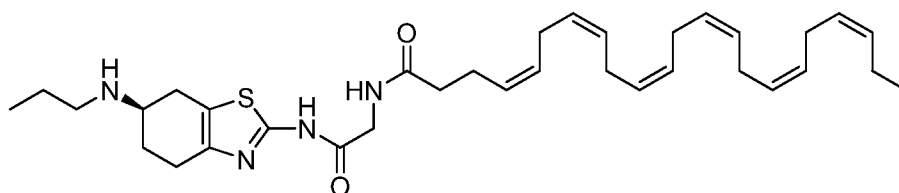
5. The compound of claim 4, wherein the compound is selected from the group consisting of



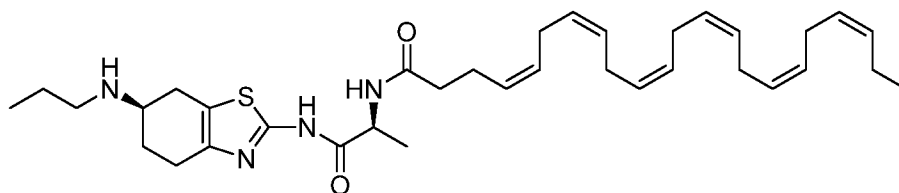
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-21**);



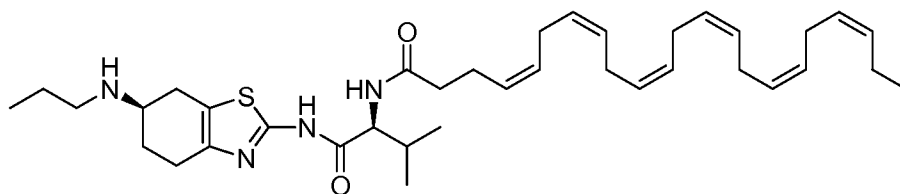
(5Z,8Z,11Z,14Z,17Z)-N-((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-22**);



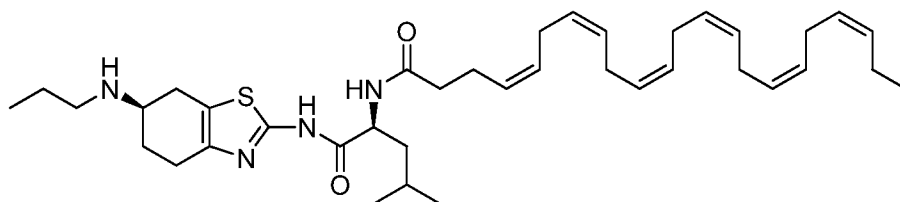
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-oxo-2-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-23**);



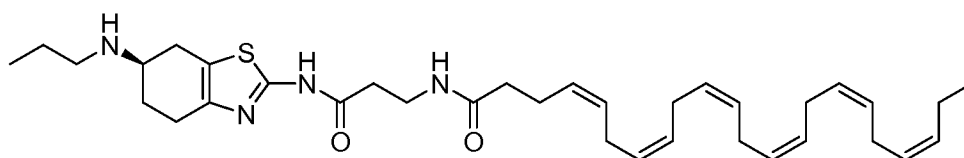
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-24**);



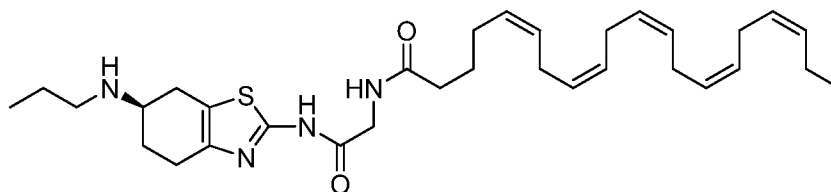
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-3-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)butan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-25**);



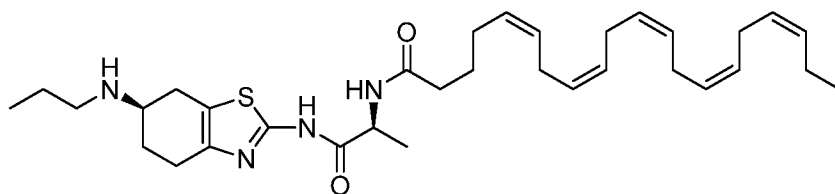
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-4-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)pentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-26**);



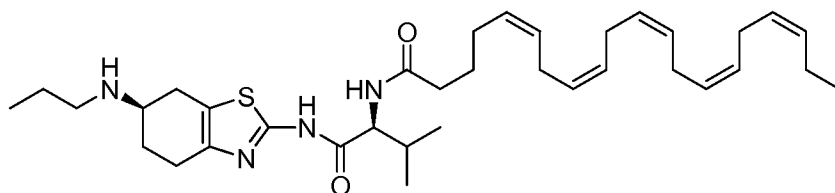
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)docosa-4,7,10,13,16,19-hexaenamide (**I-27**);



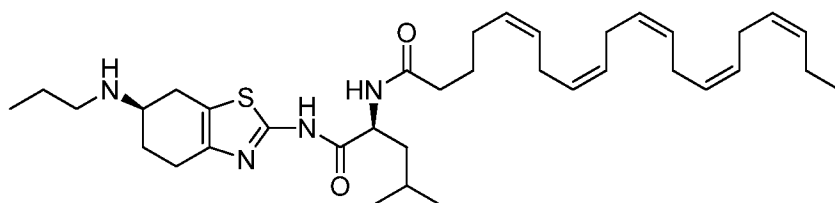
(5Z,8Z,11Z,14Z,17Z)-N-(2-oxo-2-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-28**);



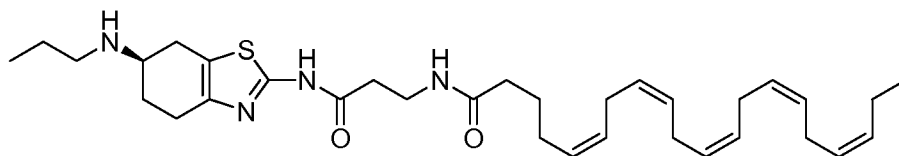
(5Z,8Z,11Z,14Z,17Z)-N-((S)-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-29**);



(5Z,8Z,11Z,14Z,17Z)-N-((S)-3-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)butan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-30**);



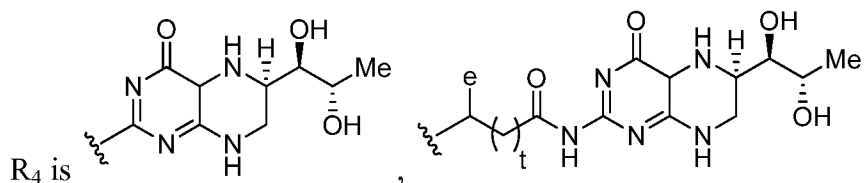
(5Z,8Z,11Z,14Z,17Z)-N-((S)-4-methyl-1-oxo-1-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)pentan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-31**);



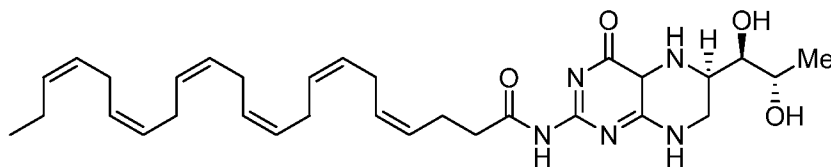
(5Z,8Z,11Z,14Z,17Z)-N-(3-oxo-3-(((R)-6-(propylamino)-4,5,6,7-tetrahydrobenzo[d]thiazol-2-yl)amino)propyl)icosa-5,8,11,14,17-pentaenamide (**I-32**).

6. The compound of claim 1, wherein

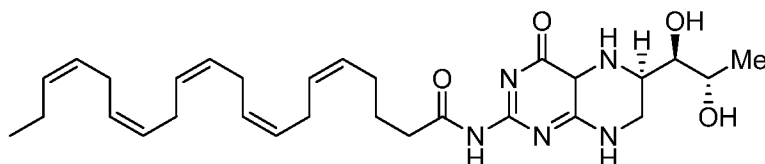
R₃ is H;



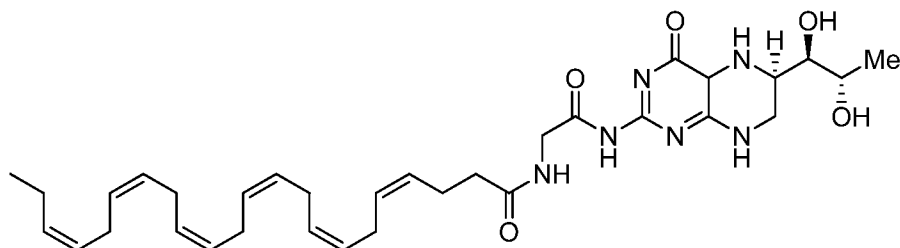
7. The compound of claim 6, wherein the compound is selected from the group consisting of



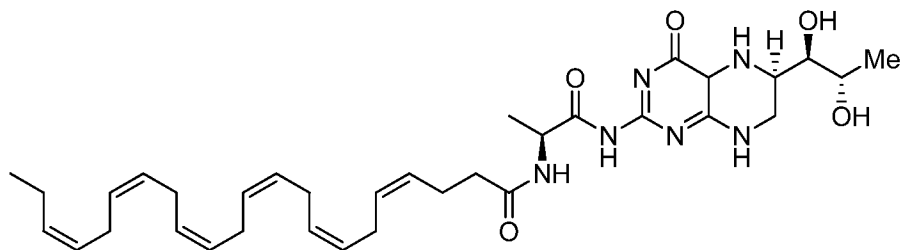
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-36**);



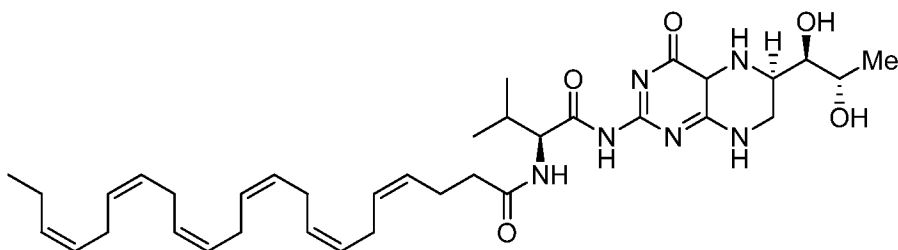
(5Z,8Z,11Z,14Z,17Z)-N-((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-37**);



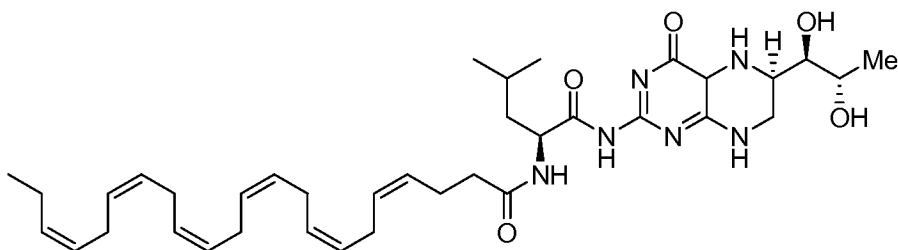
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-2-oxoethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-38**);



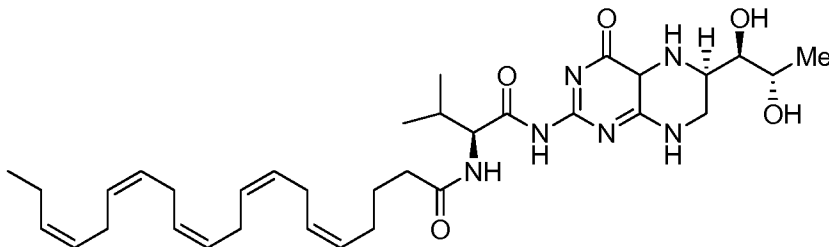
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-1-oxopropan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-39**);



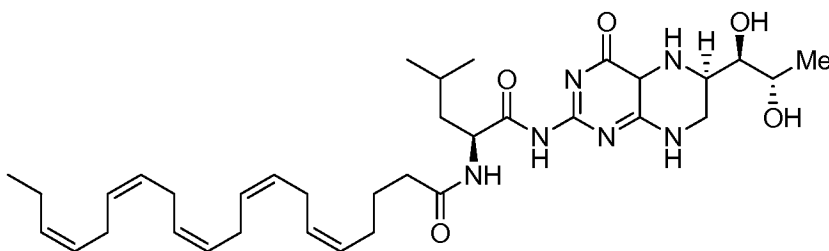
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-3-methyl-1-oxobutan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-40**);



(4Z,7Z,10Z,13Z,16Z,19Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-4-methyl-1-oxopentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-41**);



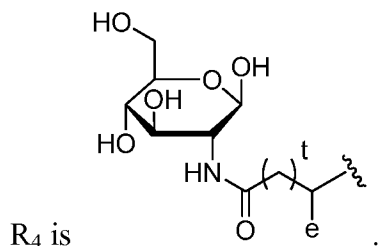
(5Z,8Z,11Z,14Z,17Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-3-methyl-1-oxobutan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-42**);



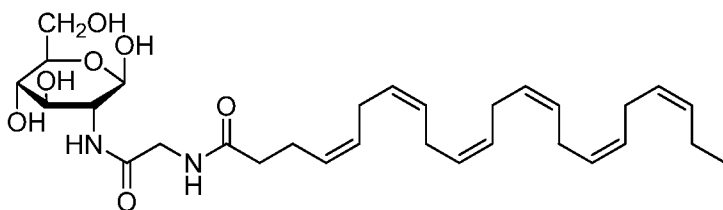
(5Z,8Z,11Z,14Z,17Z)-N-((2S)-1-(((6R)-6-((1R,2S)-1,2-dihydroxypropyl)-4-oxo-4,4a,5,6,7,8-hexahydropteridin-2-yl)amino)-4-methyl-1-oxopentan-2-yl)icosa-5,8,11,14,17-pentaenamide (**I-43**);

8. The compound of claim 1, wherein

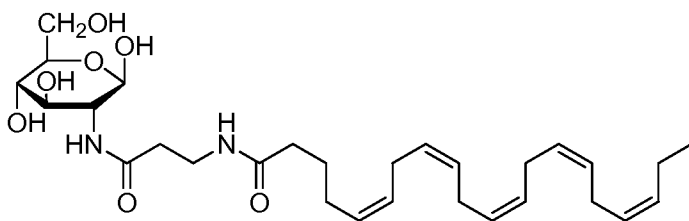
R_3 is H;



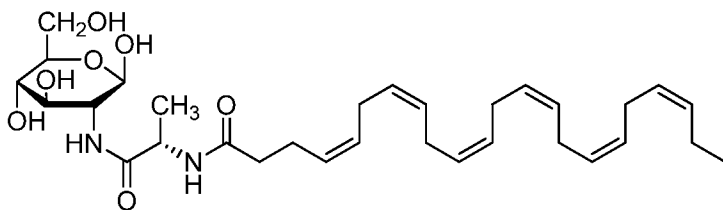
9. The compound of claim 8, wherein the compound is selected from the group consisting of



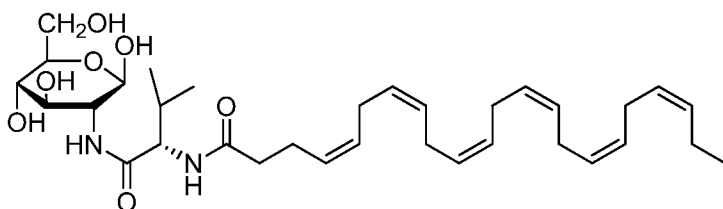
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-oxo-2-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-45**):



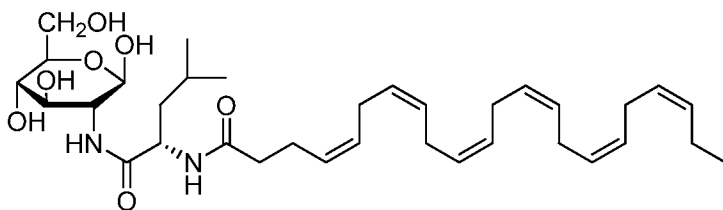
(5Z,8Z,11Z,14Z,17Z)-N-(3-oxo-3-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propyl)icosa-5,8,11,14,17-pentaenamide (**I-46**):



(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)propan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-47**);



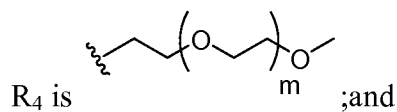
(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-3-methyl-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)butan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-48**);



(4Z,7Z,10Z,13Z,16Z,19Z)-N-((S)-4-methyl-1-oxo-1-(((2R,3R,4R,5S,6R)-2,4,5-trihydroxy-6-(hydroxymethyl)tetrahydro-2H-pyran-3-yl)amino)pentan-2-yl)docosa-4,7,10,13,16,19-hexaenamide (**I-49**).

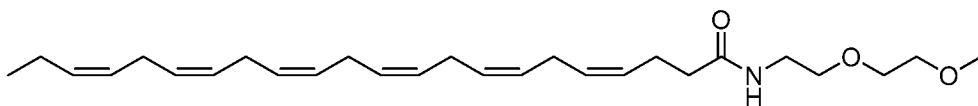
10. The compound of claim 1, wherein

R₃ is H;

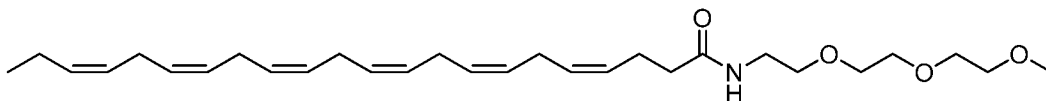


m is 1, 2, 3, 4, 5 or 6.

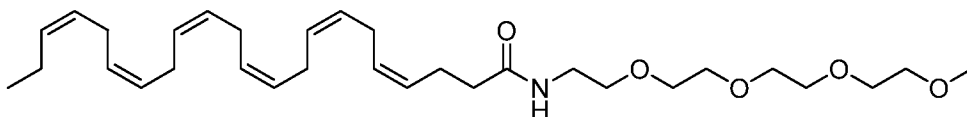
11. A compound of claim 2, wherein the compound is selected from the group consisting of



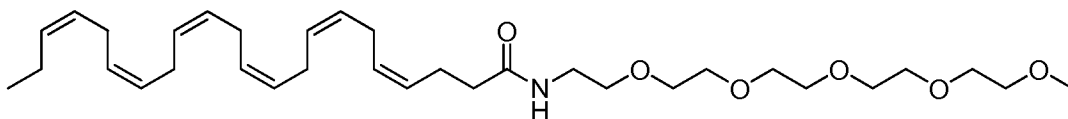
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-methoxyethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-51**);



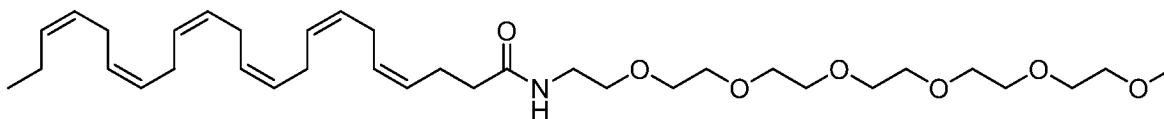
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-52**);



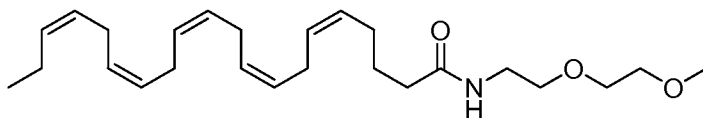
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-53**);



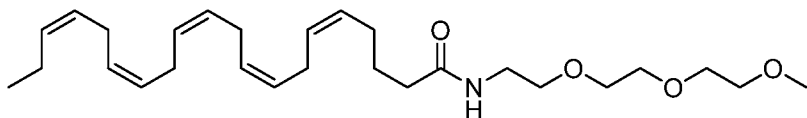
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-54**);



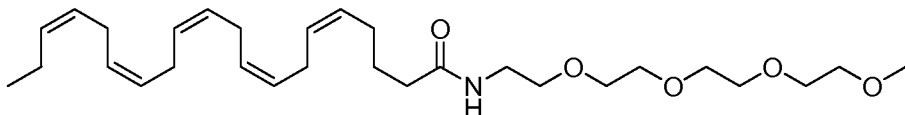
(4Z,7Z,10Z,13Z,16Z,19Z)-N-(2-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethoxy)ethyl)docosa-4,7,10,13,16,19-hexaenamide (**I-55**);



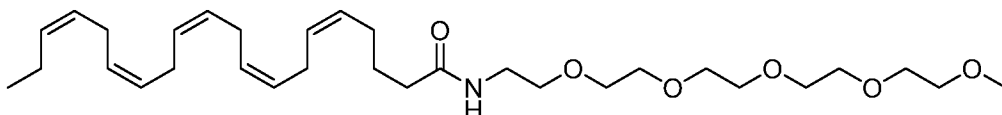
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-methoxyethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-56**);



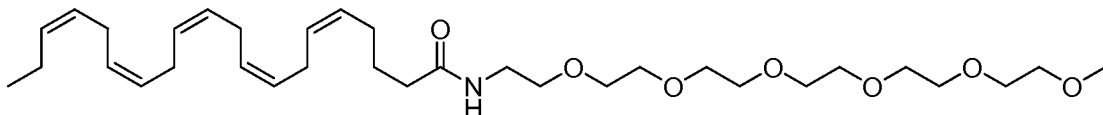
(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-methoxyethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-57**);



(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-58**);

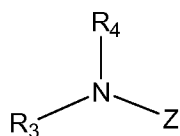


(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-59**);



(5Z,8Z,11Z,14Z,17Z)-N-(2-(2-(2-(2-(2-(2-methoxyethoxy)ethoxy)ethoxy)ethoxy)ethoxy)ethyl)icosa-5,8,11,14,17-pentaenamide (**I-60**).

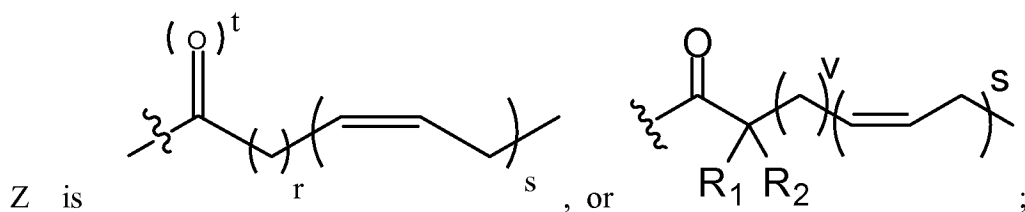
12. A pharmaceutical composition comprising a compound of **Formula I'**:



Formula I'

or a pharmaceutically acceptable salt, hydrate, solvate, enantiomer or a stereoisomer thereof;

wherein



each r is independently 2, 3, or 7;

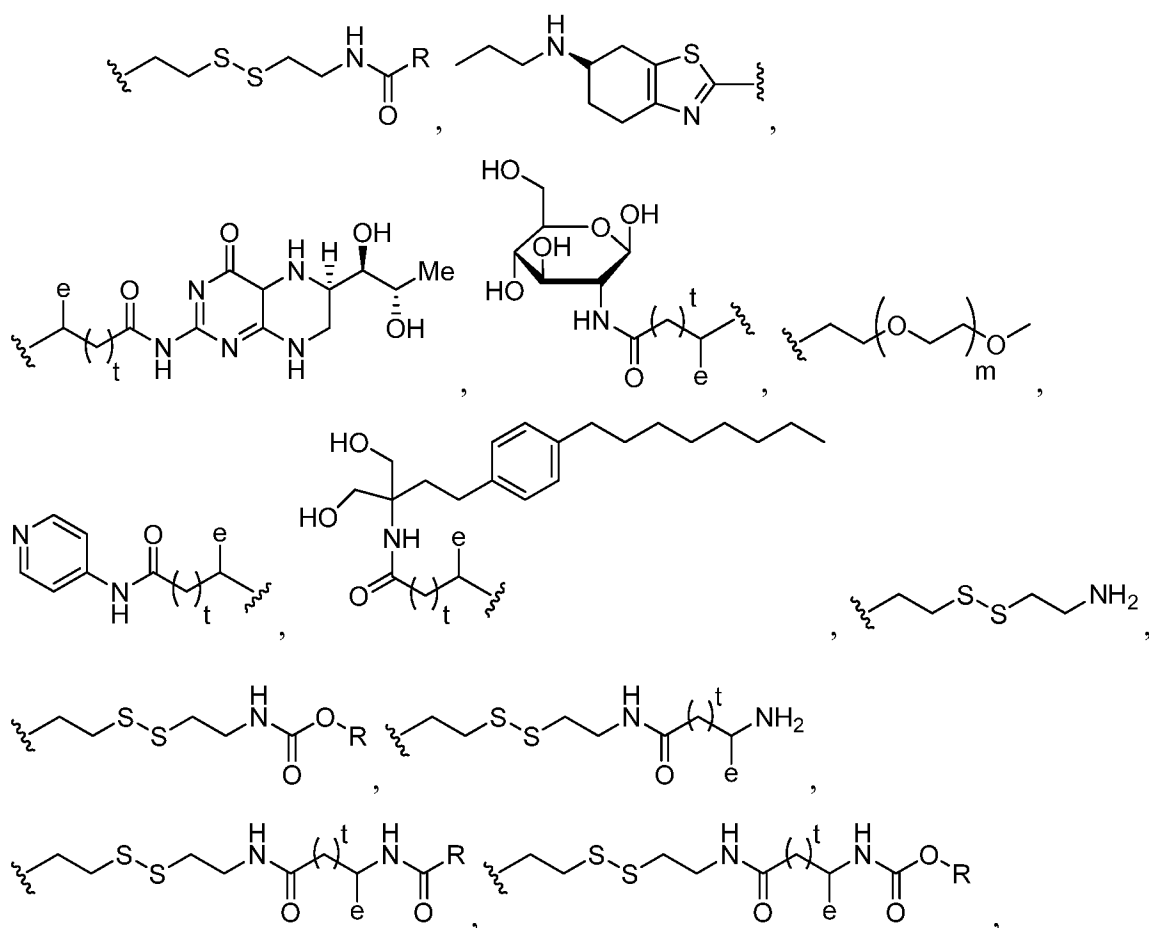
each s is independently 3, 5, or 6;

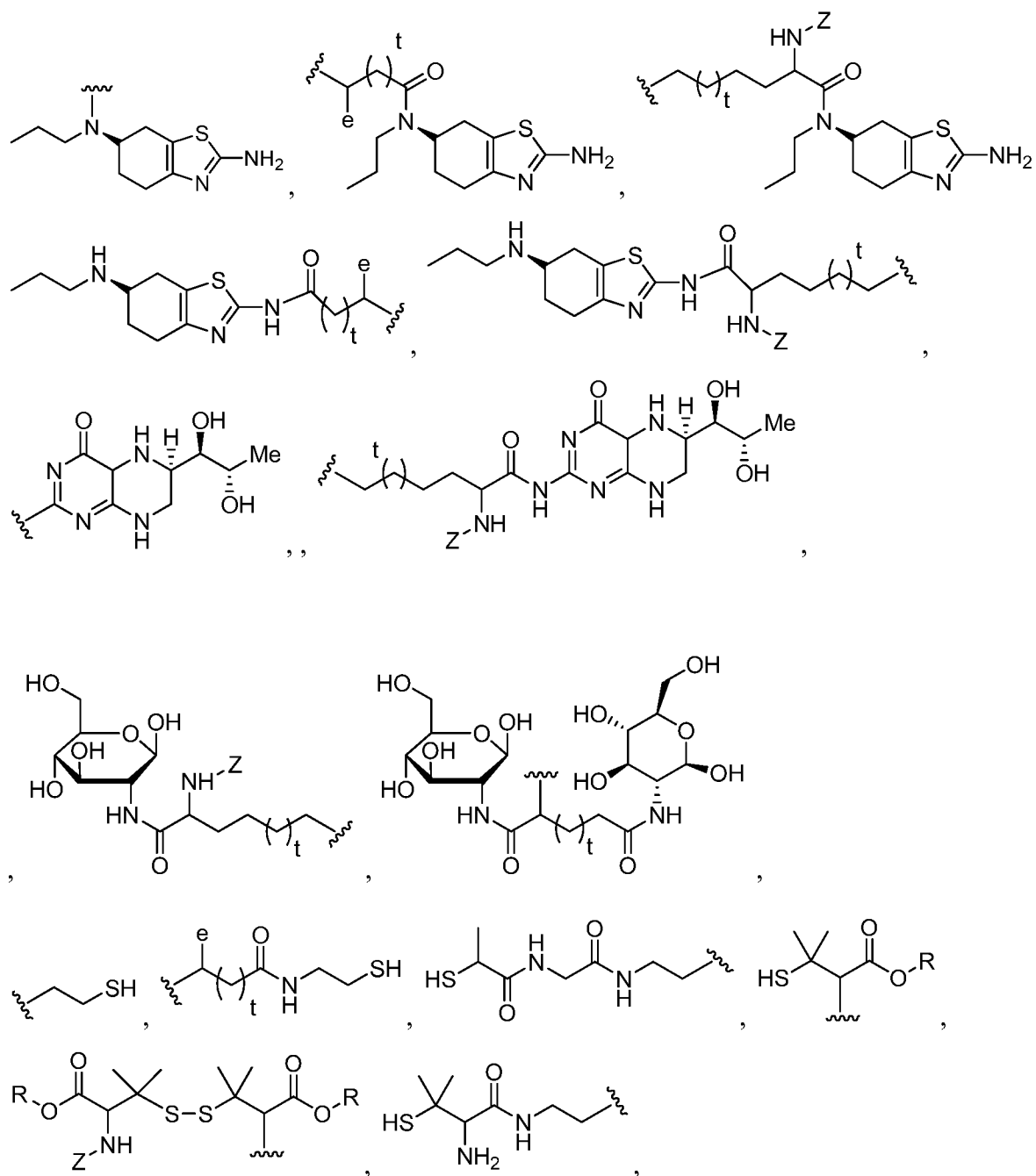
each t is independently 0 or 1;

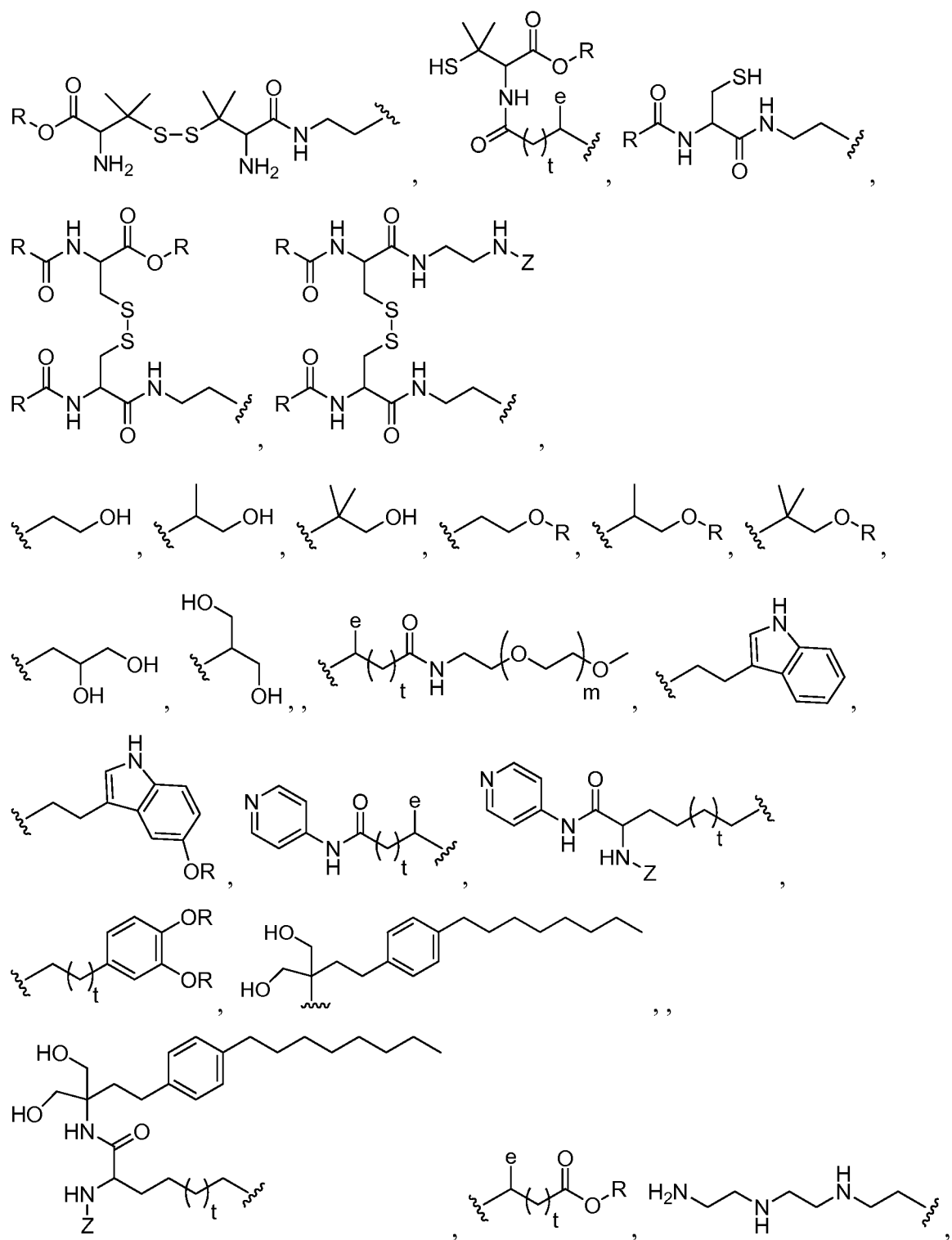
each v is independently 1, 2, or 6;

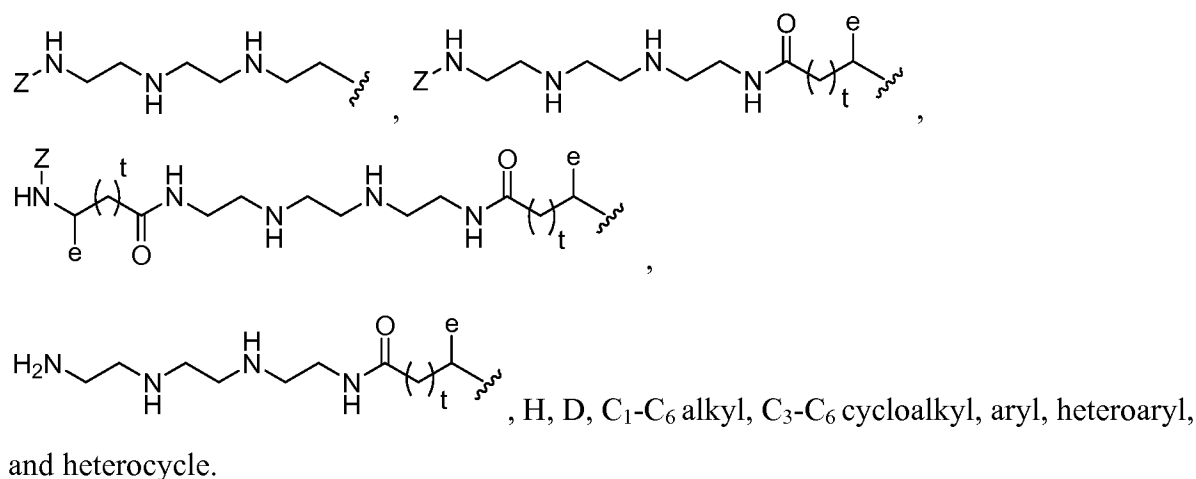
R₁ and R₂ are independently -H, -D, -C₁-C₄ alkyl, -halogen, -OH, -C(O)C₁-C₄ alkyl, -O-aryl, -O-benzyl, -OC(O)C₁-C₄ alkyl, -C₁-C₃ alkene, -C₁-C₃ alkyne, -C(O)C₁-C₄ alkyl, -NH₂, -NH(C₁-C₃ alkyl), -N(C₁-C₃ alkyl)₂, -NH(C(O)C₁-C₃ alkyl), -N(C(O)C₁-C₃ alkyl)₂, -SH, -S(C₁-C₃ alkyl), -S(O)C₁-C₃ alkyl, -S(O)₂C₁-C₃ alkyl;

R₃ and R₄ are independently









each e is independently H or any one of the side chains of the naturally occurring amino acids;

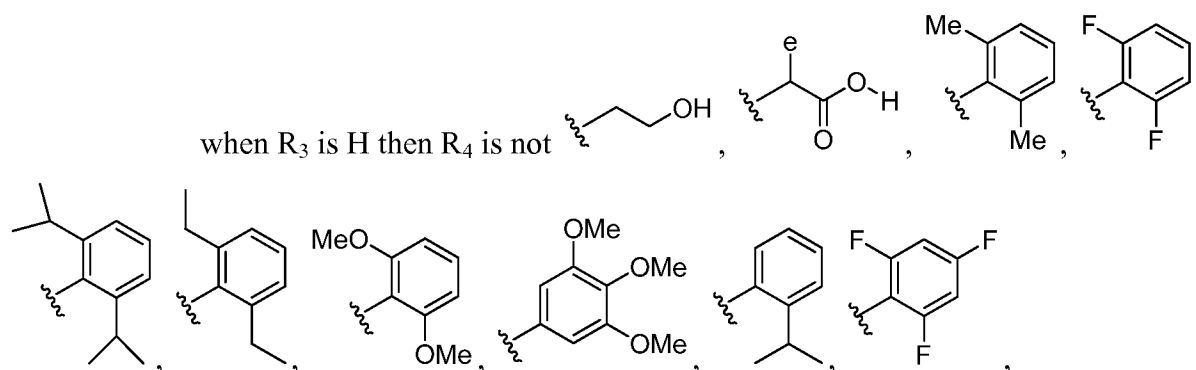
each m is independently 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12;

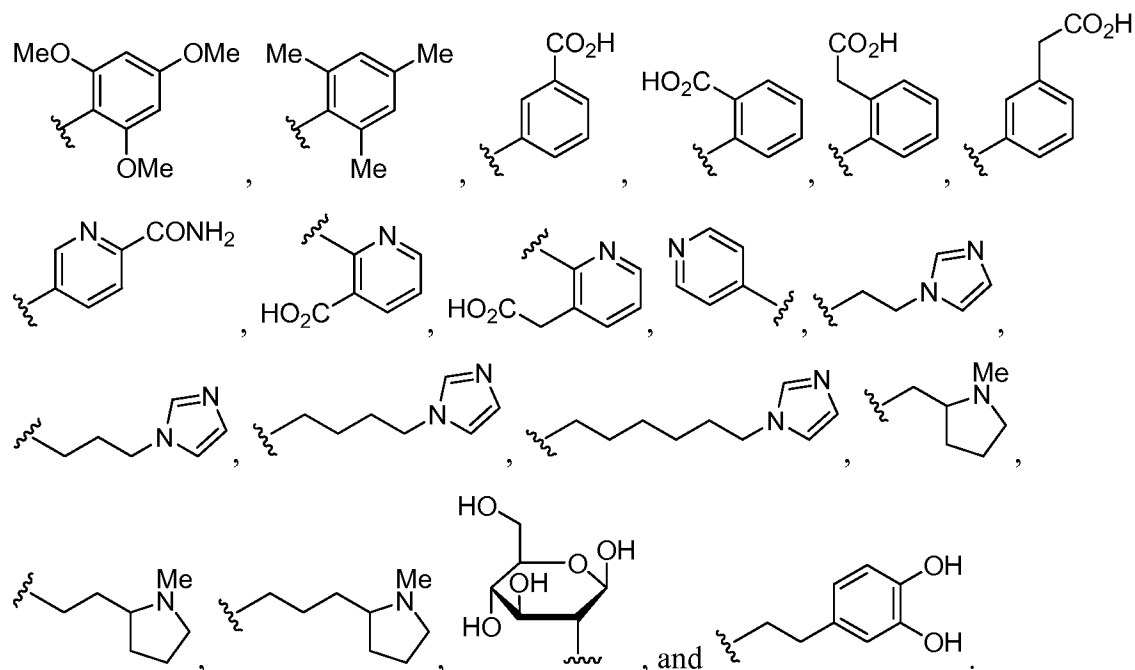
each R is independently -H, straight or branched -C₁-C₆ alkyl, -C₁-C₆ cycloalkyl, aryl, heteroaryl or heterocyclic that is optionally substituted with one, two, three, four or five groups selected from OH, CN, halogen, CO₂R₅, CONHR₅, CONR₅R₅, S(O)₂NR₅R₅, NR₅R₅, NR₅COR₅, -(OCH₂CH₂)_m-OCH₃;

each R₅ is independently -H, -C₁-C₃ alkyl, or straight or branched C₁-C₄ alkyl optionally substituted with OH, or halogen;

and a pharmaceutically acceptable carrier;

with the proviso that





13. A method for treating a disease with inflammation as the underlying etiology, the method comprising administering to a patient in need thereof an effective amount of a pharmaceutical composition of Claim 12.

14. The method of claim 13, wherein the disease is metabolic disease.

15. The method of Claim 14, wherein the metabolic disease is selected from atherosclerosis, dyslipidemia, coronary heart disease, hypertriglyceridemia, hypercholesterolemia, Type 2 diabetes, elevated cholesterol, metabolic syndrome, diabetic nephropathy, progressive diabetic nephropathy, IgA nephropathy, nephropathic cystinosis, chronic kidney disease (CKD) and cardiovascular disease, fatty liver disease, diabetic neuropathy, diabetic retinopathy, or metabolic syndrome.

16. A method for treating autoimmune disease, inflammatory respiratory disease, or neurodegenerative disease, the method comprising administering to a patient in need thereof an effective amount of a pharmaceutical composition of claim 12.

17. The method of claim 16, wherein the autoimmune disease is selected from cystic fibrosis, rheumatoid arthritis, psoriasis, systemic lupus erythematosus, and inflammatory bowel disease.
18. The method of claim 16, wherein the inflammatory lung disease is selected from asthma, adult respiratory distress syndrome, chronic obstructive airway disease, COPD and cystic fibrosis.
19. The method of claim 16, wherein the disease is neurodegenerative disease.
20. The method of claim 14, wherein the neurodegenerative disease is selected from multiple sclerosis, Parkinson's disease, Alzheimer's disease, Huntington's disease, amyotrophic lateral sclerosis (ALS) and muscular dystrophy.
21. The method of claim 12, wherein the composition further comprises another therapeutic agent selected from the group consisting of salicylic acid, monomethyl fumarate, dimethylfumarate, raloxifene, mycophenolic acid, ibuprofen, naproxen, niacin, ezetimibe, a statin, and a fibrate.
22. The method of claim 21, wherein the statin is selected from the group consisting of atorvastatin, cerivastatin, fluvastatin, lovastatin, pitavastatin, pravastatin, rosuvastatin, and simvastatin.
23. The method of claim 22, wherein the pharmaceutical composition comprises at least two compounds of **Formula I'**, wherein the Z group can be the same or different.

24. The method of claim 23, wherein one compound of the **Formula I'** has a Z group in which t is 1, r is 2 and s is 6 and the second compound of the **Formula I'** has a Z group in which t is 1, r is 3 and s is 5.
25. A pharmaceutical composition comprising a compound of claim 3 and a pharmaceutically acceptable carrier.
26. A pharmaceutical composition comprising a compound of claim 5 and a pharmaceutically acceptable carrier.
27. A pharmaceutical composition comprising a compound of claim 7 and a pharmaceutically acceptable carrier.
28. A pharmaceutical composition comprising a compound of claim 9 and a pharmaceutically acceptable carrier.
29. A pharmaceutical composition comprising a compound of claim 11 and a pharmaceutically acceptable carrier.
30. A method of claim 25, wherein the disease is nephropathic cystinosis, Huntington's disease or fatty liver disease, including non-alcoholic fatty liver disease (NAFLD) and non-alcoholic steatohepatitis (NASH).
31. A method of claim 26, wherein the disease is a neurodegenerative disease selected from multiple sclerosis, Parkinson's disease, Alzheimer's disease, Huntington's disease, amyotrophic lateral sclerosis (ALS) and muscular dystrophy.

32. A method of claim 27, wherein the disease is phenylketonuria (PKU).
33. A method of claim 28, wherein the disease is an inflammatory condition selected from from rheumatoid arthritis and osteoarthritis.
34. A method for treating a disease with inflammation as the underlying etiology, the method comprising administering to a patient in need thereof an effective amount of a pharmaceutical composition of Claim 29.
35. A method of claim 34, wherein the disease is a metabolic disease is selected from atherosclerosis, dyslipidemia, coronary heart disease, hypertriglyceridemia, hypercholesterolemia, Type 2 diabetes, elevated cholesterol, metabolic syndrome, diabetic nephropathy, progressive diabetic nephropathy, IgA nephropathy, chronic kidney disease (CKD) and cardiovascular disease, fatty liver disease (including non-alcoholic fatty liver disease and non-alcoholic steatohepatitis), diabetic neuropathy, diabetic retinopathy, or metabolic syndrome.
36. The method of claim 11, wherein the composition further comprises another therapeutic agent selected from the group consisting of salicylic acid, monomethyl fumarate, dimethylfumarate, raloxifene, mycophenolic acid, ibuprofen, naproxen, niacin, ezetimibe, a statin, and a fibrate.
37. The method of claim 36, wherein the statin is selected from the group consisting of atorvastatin, cerivastatin, fluvastatin, lovastatin, pitavastatin, pravastatin, rosuvastatin, and simvastatin.
38. The method of claim 37, wherein the pharmaceutical composition comprises at least two compounds of **Formula I'**, wherein the Z group can be the same or different.

39. The method of claim 38, wherein one compound of the **Formula I'** has a Z group in which t is 1, r is 2 and s is 6 and the second compound of the **Formula I'** has a Z group in which t is 1, r is 3 and s is 5.

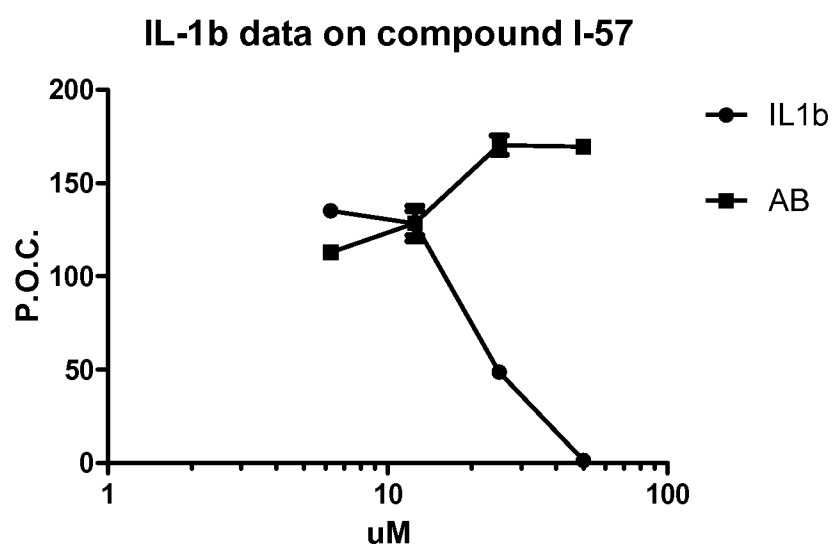


FIG. 1

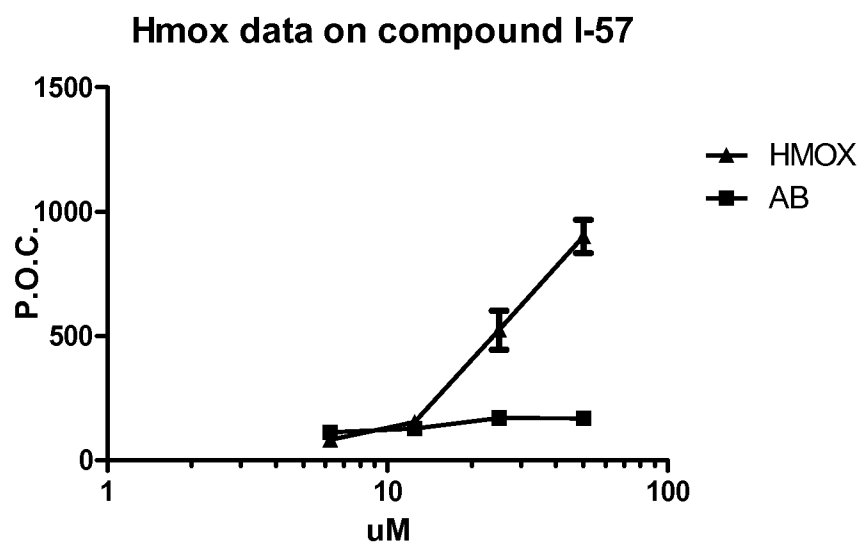


FIG. 2