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(54) Title: COMPOSITIONS AND METHODS FOR TREATING CARDIOVASCULAR RELATED DISORDERS

(57) Abstract: The present invention relates to nanoparticles complexed with therapeutic agents configured for treating cardiovascular related disorders, and methods of synthesizing the same. In particular, the present invention is directed to compositions comprising synthetic HDL (sHDL) nanoparticles carrying therapeutic agents configured for treating cardiovascular related disorders, methods for synthesizing such sHDL nanoparticles, as well as systems and methods utilizing such sHDL nanoparticles (e.g., in diagnostic and/or therapeutic settings (e.g., for the delivery of therapeutic agents, imaging agents, and/or targeting agents (e.g., in cardiovascular disease diagnosis and/or therapy, etc.))).



COMPOSITIONS AND METHODS FOR TREATING CARDIOVASCULAR RELATED DISORDERS

CROSS REFERENCE TO RELATED APPLICATIONS

5 The present invention claims the priority benefit of U.S. Provisional Patent Application 62/138,193, filed March 25, 2015, which is incorporated by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR 10 DEVELOPMENT

 This invention was made with government support under GM008353, HL068878 and HL117491 awarded by the National Institutes of Health. The government has certain rights in the invention.

15 FIELD OF THE INVENTION

 The present invention relates to nanoparticles complexed with therapeutic agents configured for treating cardiovascular related disorders, and methods of synthesizing the same. In particular, the present invention is directed to compositions comprising synthetic HDL (sHDL) nanoparticles carrying therapeutic agents configured for treating cardiovascular
20 related disorders, methods for synthesizing such sHDL nanoparticles, as well as systems and methods utilizing such sHDL nanoparticles (e.g., in diagnostic and/or therapeutic settings (e.g., for the delivery of therapeutic agents, imaging agents, and/or targeting agents (e.g., in cardiovascular disease diagnosis and/or therapy, etc.))).

25 BACKGROUND OF THE INVENTION

 The target of action on many cardiovascular medicines or preventive substances is in the vascular wall. Increase of cholesterol efflux, reduction of inflammation, reduction of oxidation and thrombosis at the vascular wall prevent or alleviate many pathologies (e.g., atherosclerosis, thrombosis, vascular disease) and will reduce heart attacks, strokes and other
30 acute disease manifestation. Yet, there are only select vehicles or particles that accumulate at the vascular wall, enter through endothelial cell layer and are capable of delivery drugs/nutrients to the local vascular areas where they are needed.

Improved compositions and techniques for delivering therapeutic agents targeting vascular regions for therapeutic purposes are needed.

SUMMARY

5 Experiments conducted during the course of developing embodiments for the present invention demonstrated that sHDL nanoparticles selectively accumulate at specific vascular tissue regions (e.g., macrophages associated with atheromatous plaque regions), and improve the efficacy of therapeutic agents delivered to such vascular tissue regions with such sHDL nanoparticles. For example, increased sphingosine-1-phosphate (S1P) related nitric oxide
10 release was demonstrated through its delivery within sHDL nanoparticles (see, Examples I and II). LXR, RXR, and PPAR γ agonist-encapsulated sHDL nanoparticles were shown to induce significant upregulation of ABC transporters, resulting in increased cholesterol efflux in macrophage (see, Examples XVI, XVII, XVIII and XIX). RXR and LXR agonist-encapsulated sHDL nanoparticles were shown to attenuate atherosclerosis development *in*
15 *vivo* at a low dosage (Examples XX and XXI). In addition, LXR agonist-encapsulated sHDL nanoparticles were shown to induce *in vivo* atherosclerosis regression while avoiding liver toxicity (e.g., hepatic steatosis) (Examples III and IV).

Accordingly, the present invention relates to nanoparticles complexed with therapeutic agents configured for treating cardiovascular related disorders, and methods of
20 synthesizing the same. In particular, the present invention is directed to compositions comprising synthetic HDL (sHDL) nanoparticles carrying therapeutic agents configured for treating cardiovascular related disorders, methods for synthesizing such sHDL nanoparticles, as well as systems and methods utilizing such sHDL nanoparticles (e.g., in diagnostic and/or therapeutic settings (e.g., for the delivery of therapeutic agents, imaging agents, and/or
25 targeting agents (e.g., in cardiovascular disease diagnosis and/or therapy, etc.))).

In certain embodiments, the present invention provides methods for preparing a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA). The present invention is not limited to particular methods for preparing a sHDL-TA. In some embodiments, such methods comprise combining at least one phospholipid having a transition temperature, at least one
30 therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture; lyophilizing the mixture to produce a dried mixture; hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture; and heating (e.g., thermocycling or incubating) the aqueous mixture above and below the phospholipid transition temperature to

produce a sHDL-TA. In some embodiments, the therapeutic agent is configured to treat a cardiovascular disorder. In some embodiments, the HDL apolipoprotein is an HDL apolipoprotein mimetic.

In some embodiments, the solvent is glacial acetic acid. In some embodiments, the aqueous buffer PBS. In some embodiments, the heating is thermocycling. In some
5 embodiments, the thermocycling occurs between 25 and 50°C.

The sHDL-TA nanoparticles are not limited to a particular size. In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

Such methods are not limited to a particular HDL apolipoprotein. For example, in
10 some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I,
15 preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof.

In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic as
20 described in Srinivasa, et al., 2014 Curr. Opinion Lipidology Vol. 25(4): 304-308, U.S. Patent No. 6,743,778, 7,566,695, and/or U.S. Patent Application Publication Nos. 2003/0171277, 2006/0069030, 2009/0081293, 20110046056, 20130231459. In some embodiments, the the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336. In some embodiments, the ApoA-I mimetic is an ApoA-I mimetic having the following amino acid
25 sequence (PVLDFRELLNELLEALKQKLLK) (SEQ ID NO: 4) (the “22A” ApoA-I mimetic).

Such methods are not limited to a particular phospholipid. In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate]
30 (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-

maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

5 Such methods are not limited to a particular therapeutic agent. In some embodiments, the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz,

10 labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), antiocoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine,

15 cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nocardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide),

20 potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol

25 absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate,

30 nitroglycerin).

In some embodiments, the liver X receptor agonist is selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-

cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX).

In some embodiments, the retinoid X receptor agonist is selected from Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

In some embodiments, the combined LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

In some embodiments, the methods further comprise combining an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In certain embodiments, the present invention provides compositions comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA). In some embodiments, the sHDL-TA comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein. In some embodiments, the therapeutic agent is configured to treat a cardiovascular disorder. In some embodiments, the HDL apolipoprotein is an HDL apolipoprotein mimetic.

Such compositions are not limited to a particular HDL apolipoprotein. In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano, ApoA-IMilano, preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof.

Such compositions are not limited to a particular phospholipid. In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyl)thio] propionate]

(DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

Such compositions are not limited to a therapeutic agent. For example, in some embodiments, the therapeutic agent is as disclosed herein. In some embodiments, the therapeutic agent is a liver X receptor agonist (e.g., TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3β-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)-anthrabenzoxocinone and (-)-bischloroanthrabenzoxocinone ((-)-BABX). In some embodiments, the therapeutic agent is a liver X receptor agonist (e.g., CD3254, Bexarotene, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506). In some embodiments, the therapeutic agent is a combination of LXR and RXR agonists.

The sHDL-TA nanoparticles are not limited to a particular size. In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

In some embodiments, an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) is contained within the sHDL-TA mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In certain embodiments, the present invention provides methods of treating a subject having a cardiovascular related disorder, comprising administering to the subject a therapeutically effective amount of a composition comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA), wherein the sHDL-TA comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein, wherein the

therapeutic agent is configured to treat a cardiovascular disorder, wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

Such methods are not limited to treating a particular cardiovascular related disorder. In some embodiments, the cardiovascular related disorder is one or more disorders selected from the group consisting of atherosclerosis, coronary artery disease, cardiomyopathy, hypertensive heart disease, heart failure, pulmonary heart disease, cardiac dysrhythmias, inflammatory heart disease (e.g., endocarditis, inflammatory cardiomegaly, myocarditis), valvular heart disease, cerebrovascular disease, peripheral arterial disease, congenital heart disease, and rheumatic heart disease.

In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof.

In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridylidithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 8-10 nm).

Such methods are not limited to a therapeutic agent. For example, in some embodiments, the therapeutic agent is as disclosed herein. In some embodiments, the

therapeutic agents are liver X receptor agonists (e.g., TO901317) and/or retinoid X receptor agonists (e.g., CD3254).

In some embodiments, the methods further comprise an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) within the sHDL-TA
5 mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In certain embodiments, the present invention provides methods of targeting a therapeutic agent to an atheromatous plaque region within a biological sample comprising
10 producing a therapeutic agent encapsulated within a synthetic HDL (sHDL) nanoparticle, wherein the sHDL nanoparticle accumulates at atheromatous plaque regions, and exposing the therapeutic agent encapsulated within the sHDL nanoparticle to the biological sample such that the therapeutic agent encapsulated within the sHDL nanoparticle accumulates at atheromatous plaque regions within the biological sample.

Such methods are not limited to a particular manner of producing the therapeutic
15 agent encapsulated within a synthetic HDL (sHDL) nanoparticle. In some embodiments, such producing comprises combining at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture; lyophilizing the mixture to produce a dried mixture; hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture; heating (e.g., thermocycling or incubating)
20 the aqueous mixture above and below the phospholipid transition temperature to produce a therapeutic agent encapsulated within a sHDL nanoparticle. In some embodiments, the solvent is glacial acetic acid. In some embodiments, the aqueous buffer PBS. In some embodiments, the heating is thermocycling. In some embodiments, the thermocycling occurs between 25 and 50°C. In some embodiments, the average particle size of the therapeutic
25 agent encapsulated within the sHDL nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm). In some embodiments, the producing further comprises combining an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture. In
30 some embodiments, the lipophilic near infrared fluorescent dye is DiD.

Such methods are not limited to a particular therapeutic agent. In some embodiments, the therapeutic agent is configured to treat a cardiovascular disorder. In some embodiments, the therapeutic agent is as disclosed herein. In some embodiments, the therapeutic agents are

liver X receptor agonists (e.g., TO901317) and/or retinoid X receptor agonists (e.g., CD3254).

Such methods are not limited to a particular HDL apolipoprotein. In some embodiments, the HDL apolipoprotein is an HDL apolipoprotein mimetic. the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

Such methods are not limited to a particular type of phospholipid. In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

Such methods are not limited a particular type of biological sample. In some embodiments, the biological sample is an *in vivo*, *in vitro* or an *ex vivo* sample. In some embodiments, the biological sample is a living mammal.

In certain embodiments, the present invention provides methods of upregulating ABCA1 and ABCG1 expression within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the exposing results in upregulation of ABCA1 and ABCG1 expression within the biological sample. In some embodiments, the sHDL-TA nanoparticle comprises a mixture of at least

one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein. In some embodiments, the therapeutic agent is a liver X receptor agonist and/or a retinoid X receptor agonist. In some embodiments, the HDL apolipoprotein is an HDL apolipoprotein mimetic. In some embodiments, the therapeutic agents are liver X receptor agonists (e.g.,
 5 TO901317) and retinoid X receptor agonists (e.g., CD3254).

Such methods are not limited a particular type of biological sample. In some embodiments, the biological sample is an *in vivo*, *in vitro* or an *ex vivo* sample. In some embodiments, the biological sample is a living mammal.

Such methods are not limited to a particular HDL apolipoprotein. In some
 10 embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE,
 15 proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic.

Such methods are not limited to a particular phospholipid. In some embodiments, the
 20 phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

25 In some embodiments, the methods further comprise an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) within the sHDL-TA mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor agonist, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

30 In some embodiments, the upregulation of ABCA1 and ABCG1 expression within the biological sample occurs within macrophages associated with atheromatous plaque regions within the biological sample. In some embodiments, the upregulation of ABCA1 and ABCG1

expression further induces cholesterol efflux from the macrophages associated with atheromatous plaque regions within the biological sample.

In certain embodiments, the present invention provides methods of inducing cholesterol efflux within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the biological sample comprises cells comprising macrophages, wherein the exposing results in cholesterol efflux from the macrophages within the biological sample, wherein the sHDL-TA nanoparticle comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein, wherein the therapeutic agent is a liver X receptor agonist;
 10 wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof.

In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

In some embodiments, the liver X receptor agonist is TO901317.

In some embodiments, the retinoid X receptor agonist is CD3254.

In some embodiments, the methods further comprise an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) within the sHDL-TA
5 mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor agonist, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In some embodiments, the cholesterol efflux from the macrophages within the biological sample occurs within macrophages associated with atheromatous plaque regions
10 within the biological sample. In some embodiments, the cholesterol efflux coincides with upregulation of ABCA1 and ABCG1 expression within the macrophages associated with atheromatous plaque regions within the biological sample.

Such methods are not limited a particular type of biological sample. In some embodiments, the biological sample is an *in vivo*, *in vitro* or an *ex vivo* sample. In some
15 embodiments, the biological sample is a living mammal.

In certain embodiments, the present invention provides methods for treating atherosclerotic lesions within a subject, comprising administering to the subject a composition comprising a therapeutically effective amount of a composition comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA), wherein the sHDL-TA
20 comprises a mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor, and at least one HDL apolipoprotein, wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic, wherein the administering results in accumulation of the sHDL-TA at atherosclerotic lesions within the subject, wherein accumulation of the sHDL-TA at the atherosclerotic lesions within the subject results in
25 cholesterol efflux from macrophages at the atherosclerotic lesions. In some embodiments, the Liver X Receptor agonist is TO901317. In some embodiments, the retinoid X receptor agonist is CD3254.

In some embodiments, administering the composition comprising a sHDL-TA nanoparticle results in reduced liver related lipogenesis in comparison to administration of a
30 liver X receptor agonist not encapsulated within a sHDL nanoparticle. In some embodiments, the liver related lipogenesis is measured by SREBP1c expression.

In some embodiments, the cholesterol efflux from macrophages at the atherosclerotic lesions further involves upregulation of ABCA1 and ABCG1 expression within the macrophages.

Such methods are not limited to a particular HDL apolipoprotein. In some
 5 embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE,
 10 proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

Such methods are not limited to a particular phospholipid. In some embodiments, the
 15 phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-
 20 dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine,
 25 and combinations thereof.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

In some embodiments, the methods further comprise an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) within the sHDL-TA
 30 mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor agonist, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In certain embodiments, the present invention provides methods of inducing nitric oxide efflux within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the biological sample comprises cells comprising endothelial cells, wherein the exposing results in nitric oxide efflux from the endothelial cells within the biological sample, wherein the sHDL-TA nanoparticle comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein, wherein the therapeutic agent is sphingosine-1-phosphate; wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

Such methods are not limited to a particular HDL apolipoprotein. In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic.

Such methods are not limited to a particular phospholipid. In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

In some embodiments, the methods further comprise an imaging agent (e.g., a lipophilic near infrared fluorescent dye or a nuclear imaging agent) within the sHDL-TA

mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor agonist, and at least one HDL apolipoprotein. In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

Such methods are not limited a particular type of biological sample. In some
 5 embodiments, the biological sample is an *in vivo*, *in vitro* or an *ex vivo* sample. In some
 embodiments, the biological sample is a living mammal.

In certain embodiments, the present invention provides methods of detecting the
 presence of atherosclerotic lesions in a subject, comprising administering to the subject
 compositions comprising synthetic HDL – imaging agent (sHDL-IA) nanoparticles, wherein
 10 the synthetic HDL-IA nanoparticles are known to accumulate at atherosclerotic lesions,
 wherein the sHDL-IA nanoparticles comprise a mixture of at least one phospholipid, at least
 one imaging agent, and at least one HDL apolipoprotein, imaging the amount and location of
 the sHDL-IA within the subject, wherein determination of imaging within vascular regions
 indicates the presence of atherosclerotic lesions within the subject, wherein the HDL
 15 apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I),
 apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and
 apolipoprotein E (apo E), wherein the phospholipid is selected from the group consisting of
 dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-
 (2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-
 20 phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-
 maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-
 [4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-
 phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-
 octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-
 25 carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine,
 phosphatidylethanolamine, and combinations thereof.

In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In
 some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the
 ApoA-I mimetic is described by any of SEQ ID NOs: 1-336. In some embodiments, the
 30 average particle size of the sHDL-IA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10
 nm).

In some embodiments, the methods further comprise combining a therapeutic agent with the mixture of at least one phospholipid, at least one imaging agent, and at least one HDL apolipoprotein. In some embodiments, the therapeutic agent is as disclosed herein.

In some embodiments, the imaging agent is a lipophilic near infrared fluorescent dye.

5 In some embodiments, the lipophilic near infrared fluorescent dye is DiD.

In certain embodiments, the present invention provides kits comprising at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein. In some embodiments, the kits further comprise at least one imaging agent.

In some embodiments, the therapeutic agent is as disclosed herein.

10 In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is 22A ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

20 In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridylthio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

30 In certain embodiments, the present invention provides methods for preparing a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA) comprising combining at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture; lyophilizing the mixture to

produce a dried mixture; hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture; incubating the aqueous mixture above and below the phospholipid transition temperature to produce a sHDL-TA; wherein the therapeutic agent is configured to treat a cardiovascular disorder; wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

In some embodiments, the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). In some embodiments, the HDL apolipoprotein mimetic is an ApoA-I mimetic. In some embodiments, the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

In some embodiments, the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, the therapeutic agent is as disclosed herein.

In some embodiments, the solvent is organic solvent. In some embodiments, the aqueous buffer PBS. In some embodiments, the incubating occurs between 35 and 55°C.

In some embodiments, the average particle size of the sHDL-TA nanoparticle is between 6-20 nm (e.g., 6-14) (e.g., 8-10 nm).

In some embodiments, the methods further comprise combining an imaging agent with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture. In some embodiments, the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

In certain embodiments, the present invention provides compositions comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA), wherein the sHDL comprises at

least one HDL apolipoprotein and at least one phospholipid, wherein the sHDL-TA has a therapeutic agent to sHDL ratio of 0.1-10% wt/wt, 60-66% wt/wt, or 30/33% wt/wt.

In certain embodiments, the present invention provides compositions comprising a synthetic HDL – therapeutic agent / imaging agent nanoparticle (sHDL-TA/IA), wherein the sHDL comprises at least one HDL apolipoprotein and at least one phospholipid, wherein the
5 sHDL-TA/IA has a (therapeutic agent / imaging agent) to (sHDL) ratio of 0.1-10% wt/wt, 60-66% wt/wt, or 30/33% wt/wt.

In certain embodiments, the present invention provides compositions comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA), wherein the sHDL comprises at least one HDL apolipoprotein and at least one phospholipid, wherein the therapeutic agent is
10 between 0.01 – 20% by weight of the sHDL-TA, wherein the sHDL is between 80-99.99% by weight of the sHDL-TA. In some embodiments, the therapeutic agent is between 1-10% by weight of the sHDL-TA.

In certain embodiments, the present invention provides compositions comprising a synthetic HDL – therapeutic agent-imaging agent nanoparticle (sHDL-TA/IA), wherein the sHDL comprises at least one HDL apolipoprotein and at least one phospholipid, wherein the therapeutic agent-imaging agent is between 0.01 – 20% by weight of the sHDL-TA/IA,
15 wherein the sHDL is between 80-99.99% by weight of the sHDL-TA/IA. In some embodiments, the therapeutic agent-imaging agent is between 1-10% by weight of the sHDL-TA/IA.
20

Additional embodiments will be apparent to persons skilled in the relevant art based on the teachings contained herein.

BRIEF DESCRIPTION OF THE DRAWINGS

25 FIG. 1: GPC analysis of S1P-HDL—22A:DPPC containing 10 nmol S1P; detection wavelength of A) 220 nm and B) 280 nm; peak at 8.12 minutes corresponds to HDL particle (Example 1).

FIG. 2: HUVECs were treated with 1.0 mg/ mL HDL (22A:DPPC, 1:2 w/w) containing different concentrations of S1P and released nitric oxide was measured in supernatants by ozone chemiluminescence. Blank 22A:DPPC HDL (1.0 mg/mL) and PBS
30 were used as controls (Example 2).

FIG. 3: (A) Homogeneous size distribution of LXR-sHDL measured by GPC; (B) SEM images of LXR-sHDL at 150,000-fold magnification; (C-D) qRT-PCR analysis of

ABCA1 expression (C) and AGCG1 expression (D) in J774.1 macrophages treated with DMSO control, TO901317-LXR agonist in DMSO solution, blank sHDL made from DMPC, TO901317-sHDL made from DMPC, blank sHDL made from POPC/DMPC mixture, and TO901317-sHDL made from POPC/DMPC; (E) TO901317-DMPC-sHDL and TO901317-DMPC/POPC-sHDL induced more cholesterol efflux in macrophages compared to the blank HDL and buffer controls.

FIG. 4: (A) DiD-sHDL can accumulate in the plaque of ApoE-deficient mouse with atherosclerosis. 1 = No treatment; 2 = blank sHDL; 3 = fluorescent labeled DiD-sHDL. (B) Quantitative RT-PCR of the liver lysate showed that LXR agonist-sHDL (sHDL-TO) had much less effects on the SREBP1c expression relative to free LXR agonist (TO) at all TO concentrations 0.5, 1.5 and 10 mg/mL.

FIG. 5 shows regulation of LXR-target gene expression by TO901317-encapsulated sHDL particles in macrophages.

FIG. 6 shows westernblot analysis for the expression of ABCA1 in TO901317-encapsulated sHDL particles treated macrophages.

FIG. 7 shows the effects of TO901317-encapsulated sHDL particles on cholesterol efflux in macrophage.

FIG. 8A and 8B shows the effects of TO901317-encapsulated sHDL particles on plasma lipids in C57BL/6J Mice.

FIG. 9 shows an RT-PCR analysis for the expression of SREBP1c in the liver.

FIG. 10 shows sHDL nanoparticle can deliver compound to atherosclerotic lesions.

FIG. 11 shows TO901317-encapsulated sHDL nanoparticles can activate ABCA1 and ABCG1 expression in monocytes *in vivo*.

FIG. 12 shows TO901317-encapsulated sHDL nanoparticles induced less triglyceride accumulation in the liver.

FIG. 13 shows TO901317-encapsulated sHDL nanoparticles induced less SREBP-1c and FAS expression in the liver.

FIG. 14 shows that TO901317-encapsulated sHDL nanoparticles induces atherosclerosis regression *in vivo*.

FIG. 15: Schematic for the preparation of LXR agonist-loaded sHDL using the co-lyophilization method.

FIG. 16 shows compound-encapsulated sHDL nanoparticles can enhance ABCA1 expression compared to sHDL nanoparticle-treated and free compound-treated macrophages.

FIG. 17 shows compound-encapsulated sHDL nanoparticles can enhance ABCG1 expression compared to sHDL nanoparticle-treated and free compound-treated macrophages.

FIG. 18 shows compound-encapsulated sHDL nanoparticles can enhance SR-BI expression compared to sHDL nanoparticle-treated and free compound-treated macrophages.

5 FIG. 19 shows compound-encapsulated sHDL nanoparticles can enhance cholesterol efflux compared to sHDL nanoparticle-treated and free compound-treated macrophages.

FIG. 20 shows TO901317-encapsulated sHDL nanoparticles can attenuate atherosclerotic lesion formation compared to sHDL nanoparticle-treated and TO901317-treated apoE-deficient mice.

10 FIG. 21 shows CD3254-encapsulated sHDL nanoparticles can attenuate atherosclerotic lesion formation compared to sHDL nanoparticle-treated and CD3254-treated apoE-deficient mice.

FIG. 22 shows TO901317 treatment induced increased triglyceride levels, whereas TO901317-encapsulated sHDL nanoparticles treatment did not induce triglyceride increase in apoE-deficient mice.

FIG. 23 shows RXR agonist treatment did not affect lipid profile in indicated groups of apoE-deficient mice.

FIG. 24: Schematic for the preparation of drug-loaded sHDL. All components were dissolved in acetic acid and lyophilized, followed by hydration with PBS and thermal cycling to form drug-loaded sHDL.

FIG. 25: Transmission electron microscopy of different sHDL nanoparticles. (a) Blank sHDL (DMPC:POPC:22A = 10mg: 10 mg: 10 mg; (b) TO-loaded sHDL (DMPC:POPC:22A: TO901317 = 10mg: 10 mg: 10 mg:0.45 mg); (c) Blank sHDL (DMPC:22A = 20mg : 10 mg; (d) TO-loaded sHDL (DMPC:22A: TO901317 = 20mg: 10 mg:0.45 mg).

FIG. 26: Characterization of drug-loaded sHDL nanoparticles. (a) Sizes of different drug-loaded sHDL nanoparticles; (b) Encapsulation efficiency of different drug-loaded sHDL nanoparticles

FIG. 27: Drug release from sHDL nanoparticles. (a) The percent of drug (TO901317) retained in sHDL nanoparticles over time. (b) The percent of drug (TO901317) released into the release medium over time.

DEFINITIONS

To facilitate an understanding of the present invention, a number of terms and phrases are defined below:

As used here, the term “lipids” refer to fatty substances that are insoluble in water and include fats, oils, waxes, and related compounds. They may be either made in the blood
5 (endogenous) or ingested in the diet (exogenous). Lipids are essential for normal body function and whether produced from an exogenous or endogenous source, they must be transported and then released for use by the cells. The production, transportation and release of lipids for use by the cells is referred to as lipid metabolism. While there are several classes of lipids, two major classes are cholesterol and triglycerides. Cholesterol may be ingested in
10 the diet and manufactured by the cells of most organs and tissues in the body, primarily in the liver. Cholesterol can be found in its free form or, more often, combined with fatty acids as what is called cholesterol esters.

As used herein the term, “lipoproteins” refer to spherical compounds that are structured so that water-insoluble lipids are contained in a partially water-soluble shell.
15 Depending on the type of lipoprotein, the contents include varying amounts of free and esterified cholesterol, triglycerides and apoproteins or apolipoproteins. There are five major types of lipoproteins, which differ in function and in their lipid and apoprotein content and are classified according to increasing density: (i) chylomicrons and chylomicron remnants, (ii) very low density lipoproteins (“VLDL”), (iii) intermediate-density lipoproteins (“IDL”),
20 (iv) low-density lipoproteins (“LDL”), and (v) high-density lipoproteins (“HDL”). Cholesterol circulates in the bloodstream as particles associated with lipoproteins.

As used herein, the term “HDL” or “high density lipoprotein” refers to high-density lipoprotein. HDL comprises a complex of lipids and proteins in approximately equal amounts that functions as a transporter of cholesterol in the blood. HDL is mainly synthesized in and
25 secreted from the liver and epithelial cells of the small intestine. Immediately after secretion, HDL is in a form of a discoidal particle containing apolipoprotein A-I (also called apoA-I) and phospholipid as its major constituents, and also called nascent HDL. This nascent HDL receives, in blood, free cholesterol from cell membranes of peripheral cells or produced in the hydrolysis course of other lipoproteins, and forms mature spherical HDL while holding, at its
30 hydrophobic center, cholesterol ester converted from said cholesterol by the action of LCAT (lecithin cholesterol acyltransferase). HDL plays an extremely important role in a lipid metabolism process called “reverse cholesterol transport”, which takes, in blood, cholesterol out of peripheral tissues and transports it to the liver. High levels of HDL are associated with

a decreased risk of atherosclerosis and coronary heart disease (CHD) as the reverse cholesterol transport is considered one of the major mechanisms for HDL's prophylactic action on atherosclerosis.

As used herein, the terms "synthetic HDL," "sHDL," "reconstituted HDL", or
5 "rHDL" refer to a particle structurally analogous to native HDL, composed of a lipid or lipids in association with at least one of the proteins of HDL, preferably Apo A-I or a mimetic thereof, and which exhibits all of the known physiological functions of HDL. Typically, the components of sHDL may be derived from blood, or produced by recombinant technology.

As used herein, the term "atherosclerosis" refers to a cardiovascular related disorder.
10 Generally, atherosclerosis begins with an injury to the inner wall of an artery (endothelium or endothelial cells). Once the inner wall is damaged, a combination of biological processes can lead to the accumulation of the plaque. In response to the injury, macrophages accumulate at the site and migrate beneath the inner layer. The macrophages then begin to absorb fatty substances from the blood and become foam cells. An accumulation of foam cells and other
15 substances, such as proliferating smooth muscle cells, contribute to the formation of plaque and eventually forms bulges in the artery wall. Over time, as the bulges continue to absorb fatty substances, plaque accumulations (atheromatous plaque regions or atherosclerotic plaques) narrow the vessel lumen and occlude the blood flow. Further, plaque accumulation may cause blood vessel walls to harden and lose their elasticity, which can increase resistance
20 to blood flow and raise blood pressure. As a result, vascular diseases are considered a progressive illness with symptoms often not evident until people are middle aged or older.

As used herein, the term "atheroma," "atheromatous plaque region," "atherosclerotic plaque," or "atherosclerotic lesion" refers to an accumulation of degenerative material in the tunica intima (inner layer) of artery walls. The material consists of (mostly) macrophage
25 cells, or debris, containing lipids (cholesterol and fatty acids), calcium and a variable amount of fibrous connective tissue. The accumulated material forms a swelling in the artery wall, which may intrude into the channel of the artery, narrowing it and restricting blood flow. Atheroma occurs in atherosclerosis.

As used herein, the term "liver X receptor" or "LXR" refers to a member of the
30 nuclear receptor family of transcription factors and is closely related to nuclear receptors such as the PPARs, FXR and RXR. Liver X receptors (LXRs) are important regulators of cholesterol, fatty acid, and glucose homeostasis.

As used herein, the term “retinoid X receptors” or “RXR” refers to members of the nuclear receptor family of transcription factors and are common binding partners to many other nuclear receptors, including PPARs, LXRs and FXR. RXR heterodimers act as ligand-dependent transcriptional regulators and increase the DNA-binding efficiency of its partner.

5 As used herein, the term "subject" refers to any animal (*e.g.*, a mammal), including, but not limited to, humans, non-human primates, rodents, and the like, which is to be the recipient of a particular treatment. Typically, the terms "subject" and "patient" are used interchangeably herein in reference to a human subject.

10 As used herein, the term "sample" is used in its broadest sense. In one sense, it is meant to include a specimen or culture obtained from any source, as well as biological and environmental samples. Biological samples may be obtained from animals (including humans) and encompass fluids, solids, tissues, and gases. Biological samples include blood products, such as plasma, serum and the like. Environmental samples include environmental material such as surface matter, soil, water, crystals and industrial samples. Such examples
15 are not however to be construed as limiting the sample types applicable to the present invention.

As used herein, the term "drug" or “therapeutic agent” is meant to include any molecule, molecular complex or substance administered to an organism for diagnostic or therapeutic purposes, including medical imaging, monitoring, contraceptive, cosmetic,
20 nutraceutical, pharmaceutical and prophylactic applications. The term "drug" is further meant to include any such molecule, molecular complex or substance that is chemically modified and/or operatively attached to a biologic or biocompatible structure.

As used herein, the term “solvent” refers to a medium in which a reaction is conducted. Solvents may be liquid but are not limited to liquid form. Solvent categories
25 include but are not limited to nonpolar, polar, protic, and aprotic.

DETAILED DESCRIPTION OF THE INVENTION

Experiments conducted during the course of developing embodiments for the present invention demonstrated that sHDL nanoparticles selectively accumulate at specific vascular
30 tissue regions (*e.g.*, macrophages associated with atheromatous plaque regions), and improve the efficacy of therapeutic agents delivered to such vascular tissue regions with such sHDL nanoparticles. For example, increased sphingosine-1-phosphate (S1P) related nitric oxide release was demonstrated through its delivery within sHDL nanoparticles (see, Examples I

and II). In addition, LXR agonist-encapsulated sHDL nanoparticles were shown to induce *in vivo* atherosclerosis regression while avoiding liver toxicity (e.g., hepatic steatosis) (Examples III and IV). In addition, LXR agonist-encapsulated sHDL nanoparticles and RXR agonist-encapsulated sHDL nanoparticles were shown to attenuate *in vivo* atherosclerosis development (Example VI).

Accordingly, the present invention relates to nanoparticles complexed with therapeutic agents configured for treating cardiovascular related disorders, and methods of synthesizing the same. In particular, the present invention is directed to compositions comprising synthetic HDL (sHDL) nanoparticles carrying therapeutic agents configured for treating cardiovascular related disorders, methods for synthesizing such sHDL nanoparticles, as well as systems and methods utilizing such sHDL nanoparticles (e.g., in diagnostic and/or therapeutic settings (e.g., for the delivery of therapeutic agents, imaging agents, and/or targeting agents (e.g., in cardiovascular disease diagnosis and/or therapy, etc.))).

The present invention is not limited to specific types or kinds of sHDL nanoparticles carrying a therapeutic agent (e.g., sHDL-TA nanoparticles). Generally, sHDL-TA nanoparticles are composed of a mixture of HDL apolipoprotein, an amphipathic lipid, and a therapeutic agent.

HDL apolipoproteins include, for example apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E). Preferably, the carrier particles are composed of Apo A-I or Apo A-II, however the use of other lipoproteins including apolipoprotein A4, apolipoprotein Cs or apolipoprotein E may be used alone or in combination to formulate carrier particle mixtures for delivery of therapeutic agents. In some embodiments, the HDL apolipoprotein is selected from preproapolipoprotein, preproApoA-I, proApoA-I, ApoA-I, preproApoA-II, proApoA-II, ApoA-II, preproApoA-IV, proApoA-IV, ApoA-IV, ApoA-V, preproApoE, proApoE, ApoE, preproApoA-IMilano, proApoA-IMilano ApoA-IMilano preproApoA-IParis, proApoA-IParis, and ApoA-IParis and peptide mimetics of these proteins mixtures thereof. In some embodiments, mimetics of such HDL apolipoproteins are used.

ApoA-I is synthesized by the liver and small intestine as preproapolipoprotein which is secreted as a proprotein that is rapidly cleaved to generate a mature polypeptide having 243 amino acid residues. ApoA-I consists mainly of 6 to 8 different 22 amino acid repeats spaced by a linker moiety which is often proline, and in some cases consists of a stretch made up of several residues. ApoA-I forms three types of stable complexes with lipids: small, lipid-poor

complexes referred to as pre-beta-1 HDL; flattened discoidal particles containing polar lipids (phospholipid and cholesterol) referred to as pre-beta-2 HDL; and spherical particles containing both polar and nonpolar lipids, referred to as spherical or mature HDL (HDL₃ and HDL₂). Most HDL particles in the circulating population contain both ApoA-I and ApoA-II (the second major HDL protein). However, the fraction of HDL containing only ApoA-I (referred to herein as the AI-HDL fraction) is more effective in reverse cholesterol transport.

In some embodiments, ApoA-I agonists or mimetics are provided. In some embodiments, such ApoA-I mimetics are capable of forming amphipathic α -helices that mimic the activity of ApoA-I, and have specific activities approaching or exceeding that of the native molecule. In some, the ApoA-I mimetics are peptides or peptide analogues that form amphipathic helices (in the presence of lipids), bind lipids, form pre- β -like or HDL-like complexes, activate lecithin:cholesterol acyltransferase (LCAT), increase serum levels of HDL fractions, and promote cholesterol efflux.

The present invention is not limited to use of a particular ApoA-I mimetic. In some embodiments, any of the ApoA-I mimetics described in Srinivasa, et al., 2014 Curr. Opin. Lipidology Vol. 25(4): 304-308 are utilized. In some embodiments, any of the ApoA-I mimetics described in U.S. Patent Application Publication Nos. 20110046056 and 20130231459 are utilized.

In some embodiments, the “22A” ApoA-I mimetic is used (PVLDFRELLNELLEALKQKQK) (SEQ ID NO: 4) (see, Examples I-IV) (see, e.g., U.S. Patent No. 7,566,695). In some embodiments, any of the following ApoA-I mimetics shown in Table 1 as described in U.S. Patent No. 7,566,695 are utilized:

Table 1. ApoA-I mimetics

SEQ ID NO	AMINO ACID SEQUENCE
(SEQ ID NO:1)	PVLDFRELLNELLEZLKQKQK
(SEQ ID NO:2)	GVLDFRELLNELLEALKQKQK
(SEQ ID NO:3)	PVLDFRELLNELLEWLKQKQK
(SEQ ID NO:4)	PVLDFRELLNELLEALKQKQK
(SEQ ID NO:5)	pVLDFRELLNELLEALKQKQK
(SEQ ID NO:6)	PVLDFRELLNEXLEALKQKQK
(SEQ ID NO:7)	PVLDFKELLNELLEALKQKQK
(SEQ ID NO:8)	PVLDFRELLNEGLEALKQKQK
(SEQ ID NO:9)	PVLDFRELGNELLEALKQKQK
(SEQ ID NO:10)	PVLDFRELLNELLEAZKQKQK

(SEQ ID NO:11)	PVLDLKFELLQELLEALKQKLK
(SEQ ID NO:12)	PVLDLFRELLNELLEAGKQKLK
(SEQ ID NO:13)	GVLDLFRELLNEGLEALKQKLK
(SEQ ID NO:14)	PVLDLFRELLNELLEALOQOLO
(SEQ ID NO:15)	PVLDLFRELWNELLEALKQKLK
(SEQ ID NO:16)	PVLDLLRELLNELLEALKQKLK
(SEQ ID NO:17)	PVLELFKELLQELLEALKQKLK
(SEQ ID NO:18)	GVLDLFRELLNELLEALKQKLK
(SEQ ID NO:19)	pVLDLFRELLNEGLEALKQKLK
(SEQ ID NO:20)	PVLDLFREGLNELLEALKQKLK
(SEQ ID NO:21)	pVLDLFRELLNELLEALKQKLK
(SEQ ID NO:22)	PVLDLFRELLNELLEGLKQKLK
(SEQ ID NO:23)	PLLELFKELLQELLEALKQKLK
(SEQ ID NO:24)	PVLDLFRELLNELLEALQKKLK
(SEQ ID NO:25)	PVLDFFRELLNEXLEALKQKLK
(SEQ ID NO:26)	PVLDLFRELLNELLELLKQKLK
(SEQ ID NO:27)	PVLDLFRELLNELZEALKQKLK
(SEQ ID NO:28)	PVLDLFRELLNELWEALKQKLK
(SEQ ID NO:29)	AVLDLFRELLNELLEALKQKLK
(SEQ ID NO:30)	PVLDLPRELLNELLEALKQKLK ¹
(SEQ ID NO:31)	PVLDLFLELLNEXLEALKQKLK
(SEQ ID NO:32)	XVLDLFRELLNELLEALKQKLK
(SEQ ID NO:33)	PVLDLFREKLNELLEALKQKLK
(SEQ ID NO:34)	PVLDZFRELLNELLEALKQKLK
(SEQ ID NO:35)	PVLDWFRELLNELLEALKQKLK
(SEQ ID NO:36)	PLLELLKELLQELLEALKQKLK
(SEQ ID NO:37)	PVLDLFWELNELLEALKQKLK
(SEQ ID NO:38)	PVLDLFRELLNEXLEAWKQKLK
(SEQ ID NO:39)	PVLDLFRELLLEELLKALKKKLK
(SEQ ID NO:40)	PVLDLFNELLRELLEALQKKLK
(SEQ ID NO:41)	PVLDLWRELLNEXLEALKQKLK
(SEQ ID NO:42)	PVLDEFREKLNEXWEALKQKLK
(SEQ ID NO:43)	PVLDEFREKLWEXLEALKQKLK
(SEQ ID NO:44)	pvldefreklneXlealkqklk
(SEQ ID NO:45)	PVLDEFREKLNEXLEALKQKLK
(SEQ ID NO:46)	PVLDLFREKLNEXLEALKQKLK
(SEQ ID NO:47)	~VLDLFRELLNEGLEALKQKLK
(SEQ ID NO:48)	pVLDLFRELLNELLEALKQKLK
(SEQ ID NO:49)	PVLDLFRNLLEKLLEALEQKLK
(SEQ ID NO:50)	PVLDLFRELLWEXLEALKQKLK
(SEQ ID NO:51)	PVLDLFWELLNEXLEALKQKLK

(SEQ ID NO:52)	PVWDEFREKLNEXLEALKQKCLK
(SEQ ID NO:53)	VVLDLFRELLNELLEALKQKCLK
(SEQ ID NO:54)	PVLDLFRELLNEWLEALKQKCLK
(SEQ ID NO:55)	P~~~LFRELLNELLEALKQKCLK
(SEQ ID NO:56)	PVLDLFRELLNELLEALKQKKK
(SEQ ID NO:57)	PVLDLFRNLLLEELLKALEQKCLK
(SEQ ID NO:58)	PVLDEFREKLNEXLEALKQKL~
(SEQ ID NO:59)	LVLDLFRELLNELLEALKQKCLK
(SEQ ID NO:60)	PVLDLFRELLNELLEALKQ~~~
(SEQ ID NO:61)	PVLDEFRWKLNEXLEALKQKCLK
(SEQ ID NO:62)	PVLDEWREKLNEXLEALKQKCLK
(SEQ ID NO:63)	PVLDDFREKLNEXLEALKQKCLK
(SEQ ID NO:64)	PWLDEFREKLNEXLEALKQKCLK
(SEQ ID NO:65)	~VLDEFREKLNEXLEALKQKCLK
(SEQ ID NO:66)	PVLDLFRNLLLEELLEALQKKCLK
(SEQ ID NO:67)	~VLDLFRELLNELLEALKQKCLK
(SEQ ID NO:68)	PVLDEFRELLKEXLEALKQKCLK
(SEQ ID NO:69)	PVLDEFRKKLNEXLEALKQKCLK
(SEQ ID NO:70)	PVLDEFRELLYEXLEALKQKCLK
(SEQ ID NO:71)	PVLDEFREKLNELXEALKQKCLK
(SEQ ID NO:72)	PVLDLFRELLNEXLWALKQKCLK
(SEQ ID NO:73)	PVLDEFWEKLNEXLEALKQKCLK
(SEQ ID NO:74)	PVLDKFREKLNEXLEALKQKCLK
(SEQ ID NO:75)	PVLDEFREKLNEELEALKQKCLK
(SEQ ID NO:76)	PVLDEFRELLFEXLEALKQKCLK
(SEQ ID NO:77)	PVLDEFREKLNKXLEALKQKCLK
(SEQ ID NO:78)	PVLDEFRDKLNEXLEALKQKCLK
(SEQ ID NO:79)	PVLDEFRELLNELLEALKQKCLK
(SEQ ID NO:80)	PVLDLFRLLNELLEALQKKCLK
(SEQ ID NO:81)	PVLDEFREKLNWXLEALKQKCLK
(SEQ ID NO:82)	~~LDEFREKLNEXLEALKQKCLK
(SEQ ID NO:83)	PVLDEFREKLNEXLEALWQKCLK
(SEQ ID NO:84)	PVLDEFREKLNELLEALKQKCLK
(SEQ ID NO:85)	P~LDLFRELLNELLEALKQKCLK
(SEQ ID NO:86)	PVLELFRLLDELLNALQKKCLK
(SEQ ID NO:87)	pllellkellqellealkqclk
(SEQ ID NO:88)	PVLDKFRELLNEXLEALKQKCLK
(SEQ ID NO:89)	PVLDEFREKLNEXLWALKQKCLK
(SEQ ID NO:90)	~~~DEFREKLNEXLEALKQKCLK
(SEQ ID NO:91)	PVLDEFRELLNEXLEALKQKCLK
(SEQ ID NO:92)	PVLDEFRELYNEXLEALKQKCLK

(SEQ ID NO:93)	PVLDEFREKLNEXLKALKQKCLK
(SEQ ID NO:94)	PVLDEFREKLNEALEALKQKCLK
(SEQ ID NO:95)	PVLDFRELLNLXLEALKQKCLK
(SEQ ID NO:96)	pvl dfrellneXlealkqclk
(SEQ ID NO:97)	PVLDFRELLNELLE~~~~~
(SEQ ID NO:98)	PVLDFRELLNEELEALKQKCLK
(SEQ ID NO:99)	KLKQKLAELLENLLERFLDLVP
(SEQ ID NO:100)	pvl dfrellnellealkqclk
(SEQ ID NO:101)	PVLDFRELLNWXLEALKQKCLK
(SEQ ID NO:102)	PVLDFRELLNLXLEALKECLK
(SEQ ID NO:103)	PVLDEFRELLNEELEALKQKCLK
(SEQ ID NO:104)	P~~~~~LLNELLEALKQKCLK
(SEQ ID NO:105)	PAADAFREAA NEAAEAAKQKAK
(SEQ ID NO:106)	PVLDFREKLNEELEALKQKCLK
(SEQ ID NO:107)	klkqklaellenllerfldlvp
(SEQ ID NO:108)	PVLDFRWLLNEXLEALKQKCLK
(SEQ ID NO:109)	PVLDEFREKLNERLEALKQKCLK
(SEQ ID NO:110)	PVLDEFREKLNEXXEALKQKCLK
(SEQ ID NO:111)	PVLDEFREKLWEXWEALKQKCLK
(SEQ ID NO:112)	PVLDEFREKLNEXSEALKQKCLK
(SEQ ID NO:113)	PVLDEFREKLNEPLEALKQKCLK
(SEQ ID NO:114)	PVLDEFREKLNEXMEALKQKCLK
(SEQ ID NO:115)	PKLDEFREKLNEXLEALKQKCLK
(SEQ ID NO:116)	PHLDEFREKLNEXLEALKQKCLK
(SEQ ID NO:117)	PELDEFREKLNEXLEALKQKCLK
(SEQ ID NO:118)	PVLDEFREKLNEXLEALEQKCLK
(SEQ ID NO:119)	PVLDEFREKLNEELEAXKQKCLK
(SEQ ID NO:120)	PVLDEFREKLNEELEXLKQKCLK
(SEQ ID NO:121)	PVLDEFREKLNEELEALWQKCLK
(SEQ ID NO:122)	PVLDEFREKLNEELEWLKQKCLK
(SEQ ID NO:123)	QVLDFRELLNELLEALKQKCLK
(SEQ ID NO:124)	PVLDFOELLNELLEALOQOLO
(SEQ ID NO:125)	NVLDFRELLNELLEALKQKCLK
(SEQ ID NO:126)	PVLDFRELLNELGEALKQKCLK
(SEQ ID NO:127)	PVLDFRELLNELLELLKQKCLK
(SEQ ID NO:128)	PVLDFRELLNELLEFLKQKCLK
(SEQ ID NO:129)	PVLELFNDLLRELLEALQKKCLK
(SEQ ID NO:130)	PVLELFNDLLRELLEALKQKCLK
(SEQ ID NO:131)	PVLELFKELLNELLDALRQKCLK
(SEQ ID NO:132)	PVLDFRELLNLEALQKKCLK
(SEQ ID NO:133)	PVLEL FERLLEDLLQALNKKCLK

(SEQ ID NO:134)	PVLELFFERLLEDLLKALNOKLK
(SEQ ID NO:135)	DVLDLFRELLNELLEALKQKCLK
(SEQ ID NO:136)	PALELFKDLLQELLEALKQKCLK
(SEQ ID NO:137)	PVLDLFRELLNEGLEAZKQKCLK
(SEQ ID NO:138)	PVLDLFRELLNEGLEWLKQKCLK
(SEQ ID NO:139)	PVLDLFRELWNEGLEALKQKCLK
(SEQ ID NO:140)	PVLDLFRELLNEGLEALOQOLO
(SEQ ID NO:141)	PVLDFFRELLNEGLEALKQKCLK
(SEQ ID NO:142)	PVLELFRELLNEGLEALKQKCLK
(SEQ ID NO:143)	PVLDLFRELLNEGLEALKQKCLK*
(SEQ ID NO:144)	pVLELFENLLERLLDALQKKCLK
(SEQ ID NO:145)	GVLELFENLLERLLDALQKKCLK
(SEQ ID NO:146)	PVLELFENLLERLLDALQKKCLK
(SEQ ID NO:147)	PVLELFENLLERLFDALQKKCLK
(SEQ ID NO:148)	PVLELFENLLERLGDALQKKCLK
(SEQ ID NO:149)	PVLELFENLWERLLDALQKKCLK
(SEQ ID NO:150)	PLLELFENLLERLLDALQKKCLK
(SEQ ID NO:151)	PVLELFENLGERLLDALQKKCLK
(SEQ ID NO:152)	PVFELFENLLERLLDALQKKCLK
(SEQ ID NO:153)	AVLELFENLLERLLDALQKKCLK
(SEQ ID NO:154)	PVLELFENLLERGLDALQKKCLK
(SEQ ID NO:155)	PVLELFNLWERLLDALQKKCLK
(SEQ ID NO:156)	PVLELFNLLERLLDALQKKCLK
(SEQ ID NO:157)	PVLEFFENLLERLLDALQKKCLK
(SEQ ID NO:158)	PVLELFNLLERLLDWLQKKCLK
(SEQ ID NO:159)	PVLDLFENLLERLLDALQKKCLK
(SEQ ID NO:160)	PVLELFENLLERLLDWLQKKCLK
(SEQ ID NO:161)	PVLELFENLLERLLEALQKKCLK
(SEQ ID NO:162)	PVLELFENWLERLLDALQKKCLK
(SEQ ID NO:163)	PVLELFENLLERLWDALQKKCLK
(SEQ ID NO:164)	PVLELFENLLERLLDAWQKKCLK
(SEQ ID NO:165)	PVLELFENLLERLLDLLQKKCLK
(SEQ ID NO:166)	PVLELFNLLLEKLLDALQKKCLK
(SEQ ID NO:167)	PVLELFENGLERLLDALQKKCLK
(SEQ ID NO:168)	PVLELFEQLLEKLLDALQKKCLK
(SEQ ID NO:169)	PVLELFENLLEKLLDALQKKCLK
(SEQ ID NO:170)	PVLELFENLLEOLLDALQOOLLO
(SEQ ID NO:171)	PVLELFENLLEKLLDLLQKKCLK
(SEQ ID NO:172)	PVLELFNLLERLGDALQKKCLK
(SEQ ID NO:173)	PVLDLFDNLLDRLLDLLNKKCLK
(SEQ ID NO:174)	pvlelfenllerlldalqkkk

(SEQ ID NO:175)	PVLELFENLLERLLELLNKKLK
(SEQ ID NO:176)	PVLELWENLLERLLDALQKKLK
(SEQ ID NO:177)	GVLELFLNLLERLLDALQKKLK
(SEQ ID NO:178)	PVLELFDNLLLEKLLLEALQKKLR
(SEQ ID NO:179)	PVLELFDNLLERLLDALQKKLK
(SEQ ID NO:180)	PVLELFDNLLDKLLDALQKKLR
(SEQ ID NO:181)	PVLELFENLLERWLDALQKKLK
(SEQ ID NO:182)	PVLELFENLLEKLLLEALQKKLK
(SEQ ID NO:183)	PLLELFENLLEKLLDALQKKLK
(SEQ ID NO:184)	PVLELFLNLLERLLDAWQKKLK
(SEQ ID NO:185)	PVLELFENLLERLLDALQOOLO
(SEQ ID NO:186)	PVLELFEQLLERLLDALQKKLK
(SEQ ID NO:187)	PVLELFENLLERLLDALNKKLK
(SEQ ID NO:188)	PVLELFENLLDRLLDALQKKLK
(SEQ ID NO:189)	DVLELFENLLERLLDALQKKLK
(SEQ ID NO:190)	PVLEFWDNLLDKLLDALQKKLR
(SEQ ID NO:191)	PVLDLLRELLEELKQK*KLK*
(SEQ ID NO:192)	PVLDLKFELLEELKQK*KLK*
(SEQ ID NO:193)	PVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:194)	PVLELFFRELLEELKQK*KLK*
(SEQ ID NO:195)	PVLELKFELLEELKQK*KLK*
(SEQ ID NO:196)	PVLDLFFRELLEELKNK*KLK*
(SEQ ID NO:197)	PLLDLFFRELLEELKQK*KLK*
(SEQ ID NO:198)	GVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:199)	PVLDLFFRELWEELKQK*KLK*
(SEQ ID NO:200)	NVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:201)	PLLDLKFELLEELKQK*KLK*
(SEQ ID NO:202)	PALELFDLLEELRQK*LR*
(SEQ ID NO:203)	AVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:204)	PVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:205)	PVLDLFFREWLEELKQK*KLK*
(SEQ ID NO:206)	PLLELLKELLEELKQK*KLK*
(SEQ ID NO:207)	PVLELLKELLEELKQK*KLK*
(SEQ ID NO:208)	PALELFDLLEELRQRLK*
(SEQ ID NO:209)	PVLDLFFRELLNELLQK*KLK
(SEQ ID NO:210)	PVLDLFFRELLEELKQK*KLK
(SEQ ID NO:211)	PVLDLFFRELLEELOQO*LO*
(SEQ ID NO:212)	PVLDLFFOELLEELOQO*LK*
(SEQ ID NO:213)	PALELFDLLEEFQR*RLK*
(SEQ ID NO:214)	pVLDLFFRELLEELKQK*KLK*
(SEQ ID NO:215)	PVLDLFFRELLEEWKQK*KLK*

(SEQ ID NO:216)	PVLELFKELLEELKQKLK
(SEQ ID NO:217)	PVLDLFRELLELLKQKLK
(SEQ ID NO:218)	PVLDLFRELLNELLQKLK*
(SEQ ID NO:219)	PVLDLFRELLNELWQKLK
(SEQ ID NO:220)	PVLDLFRELLEELQKKLK
(SEQ ID NO:221)	DVLDLFRELLEELKQKLK*
(SEQ ID NO:222)	PVLDAFRELLEALLQLKK
(SEQ ID NO:223)	PVLDAFRELLEALAQLKK
(SEQ ID NO:224)	PVLDLFREGWEELKQKLK
(SEQ ID NO:225)	PVLDAFRELAELAQLKK
(SEQ ID NO:226)	PVLDAFRELGEALLQLKK
(SEQ ID NO:227)	PVLDLFRELGEELKQKLK*
(SEQ ID NO:228)	PVLDLFREGLEELKQKLK*
(SEQ ID NO:229)	PVLDLFRELLEEGKQKLK*
(SEQ ID NO:230)	PVLELFFERLLEDLQKKLK
(SEQ ID NO:231)	PVLDLFRELLEKLEQKLK
(SEQ ID NO:232)	PLLELFKELLEELKQKLK*
(SEQ ID NO:233)	LDDLLQKWAEAFNQLLKK
(SEQ ID NO:234)	EWLKAFYEKVLKELKELF*
(SEQ ID NO:235)	EWLEAFYKKVLEKLKELF*
(SEQ ID NO:236)	DWLKAFYDKVAEKLKEAF*
(SEQ ID NO:237)	DWFKAFYDKVFEKFKEFF
(SEQ ID NO:238)	GIKKFLGSIWKFIKAFVG
(SEQ ID NO:239)	DWFKAFYDKVAEKFKEAF
(SEQ ID NO:240)	DWLKAFYDKVAEKLKEAF
(SEQ ID NO:241)	DWLKAFYDKVFEKFKEFF
(SEQ ID NO:242)	EWLEAFYKKVLEKLKELP
(SEQ ID NO:243)	DWFKAFYDKFFEKFKEFF
(SEQ ID NO:244)	EWLKAFYEKVLKELKELF
(SEQ ID NO:245)	EWLKAIEYEKVEEKLKELF*
(SEQ ID NO:246)	EWLKAIEYEKVLKELKELF*
(SEQ ID NO:247)	EWLKAFYKKVLEKLKELF*
(SEQ ID NO:248)	PVLDLFRELLEQKLK*
(SEQ ID NO:249)	PVLDLFRELLEELKQK*
(SEQ ID NO:250)	PVLDLFRELLEKLKQK*
(SEQ ID NO:251)	PVLDLFRELLEKLQK*
(SEQ ID NO:252)	PVLDLFRELLEALKQK*
(SEQ ID NO:253)	PVLDLFENLLERLKQK*
(SEQ ID NO:254)	PVLDLFRELLNELKQK*

* indicates peptides that are N-terminal acetylated and C-terminal amidated;

indicates peptides that are N-terminal dansylated; sp indicates peptides that exhibited solubility problems under the experimental conditions; X is Aib; Z is Nal; O is Orn; He (%) designates percent helicity; mics designates micelles; and ~ indicates deleted amino acids.

5

In some embodiments, an ApoA-I mimetic having the following sequence as described in U.S. Patent No. 6,743,778 is utilized: Asp Trp Leu Lys Ala Phe Tyr Asp Lys Val Ala Glu Lys Leu Lys Glu Ala Phe (SEQ ID NO: 256).

10 In some embodiments, any of the following ApoA-I mimetics shown in Table 2 as described in U.S. Patent Application Publication No. 2003/0171277 are utilized:

Table 2.

SEQ ID NO	AMINO ACID SEQUENCE
(SEQ ID NO:256)	D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F
(SEQ ID NO:257)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:258)	Ac-D-W-F-K-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:259)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:260)	Ac-D-W-F-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:261)	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:262)	Ac-D-W-L-K-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:263)	Ac-D-W-F-K-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:264)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:265)	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:266)	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:267)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:268)	Ac-D-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:269)	Ac-E-W-L-K-L-F-Y-E-K-V-L-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:270)	Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:271)	Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:272)	Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:273)	Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:274)	Ac-E-W-L-K-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:275)	Ac-E-W-L-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:276)	AC-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH ₂

(SEQ ID NO:277)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:278)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:279)	Ac-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:280)	Ac-A-F-Y-D-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:281)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:282)	Ac-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:283)	Ac-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:284)	Ac-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:285)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:286)	Ac-K-A-F-Y-D-K-V-F-E-K-F-K-E-F-NH ₂
(SEQ ID NO:287)	Ac-L-F-Y-E-K-V-L-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:288)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:289)	Ac-A-F-Y-D-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:290)	Ac-A-F-Y-D-K-V-F-E-K-F-K-E-A-F-NH ₂
(SEQ ID NO:291)	Ac-A-F-Y-D-K-V-F-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:292)	Ac-A-F-Y-D-K-V-A-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:293)	Ac-A-F-Y-D-K-V-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:294)	Ac-D-W-L-K-A-L-Y-D-K-V-A-E-K-L-K-E-A-L-NH ₂
(SEQ ID NO:295)	Ac-D-W-F-K-A-F-Y-E-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:296)	Ac-D-W-F-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:297)	Ac-E-W-L-K-A-L-Y-E-K-V-A-E-K-L-K-E-A-L-NH ₂
(SEQ ID NO:298)	Ac-E-W-L-K-A-F-Y-E-K-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:299)	Ac-E-W-F-K-A-F-Y-E-K-V-A-E-K-L-K-E-F-F-NH ₂
(SEQ ID NO:300)	Ac-E-W-L-K-A-F-Y-E-K-V-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:301)	Ac-E-W-L-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:302)	Ac-E-W-F-K-A-F-Y-E-K-F-F-E-K-F-K-E-F-F-NH ₂
(SEQ ID NO:303)	Ac-D-F-L-K-A-W-Y-D-K-V-A-E-K-L-K-E-A-W-NH ₂
(SEQ ID NO:304)	Ac-E-F-L-K-A-W-Y-E-K-V-A-E-K-L-K-E-A-W-NH ₂
(SEQ ID NO:305)	Ac-D-F-W-K-A-W-Y-D-K-V-A-E-K-L-K-E-W-W-NH ₂
(SEQ ID NO:306)	Ac-E-F-W-K-A-W-Y-E-K-V-A-E-K-L-K-E-W-W-NH ₂
(SEQ ID NO:307)	Ac-D-K-L-K-A-F-Y-D-K-V-F-E-W-A-K-E-A-F-NH ₂
(SEQ ID NO:308)	Ac-D-K-W-K-A-V-Y-D-K-F-A-E-A-F-K-E-F-L-NH ₂
(SEQ ID NO:309)	Ac-E-K-L-K-A-F-Y-E-K-V-F-E-W-A-K-E-A-F-NH ₂

(SEQ ID NO:310)	Ac-E-K-W-K-A-V-Y-E-K-F-A-E-A-F-K-E-F-L-NH ₂
(SEQ ID NO:311)	Ac-D-W-L-K-A-F-V-D-K-F-A-E-K-F-K-E-A-Y-NH ₂
(SEQ ID NO:312)	Ac-E-K-W-K-A-V-Y-E-K-F-A-E-A-F-K-E-F-L-NH ₂
(SEQ ID NO:313)	Ac-D-W-L-K-A-F-V-Y-D-K-V-F-K-L-K-E-F-F-NH ₂
(SEQ ID NO:314)	Ac-E-W-L-K-A-F-V-Y-E-K-V-F-K-L-K-E-F-F-NH ₂
(SEQ ID NO:315)	Ac-D-W-L-R-A-F-Y-D-K-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:316)	Ac-E-W-L-R-A-F-Y-E-K-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:317)	Ac-D-W-L-K-A-F-Y-D-R-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:318)	Ac-E-W-L-K-A-F-Y-E-R-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:319)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-R-L-K-E-A-F-NH ₂
(SEQ ID NO:320)	Ac-E-W-L-K-A-F-Y-E-K-V-A-E-R-L-K-E-A-F-NH ₂
(SEQ ID NO:321)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-K-L-R-E-A-F-NH ₂
(SEQ ID NO:322)	Ac-E-W-L-K-A-F-Y-E-K-V-A-E-K-L-R-E-A-F-NH ₂
(SEQ ID NO:323)	Ac-D-W-L-K-A-F-Y-D-R-V-A-E-R-L-K-E-A-F-NH ₂
(SEQ ID NO:324)	Ac-E-W-L-K-A-F-Y-E-R-V-A-E-R-L-K-E-A-F-NH ₂
(SEQ ID NO:325)	Ac-D-W-L-R-A-F-Y-D-K-V-A-E-K-L-R-E-A-F-NH ₂
(SEQ ID NO:326)	Ac-E-W-L-R-A-F-Y-E-K-V-A-E-K-L-R-E-A-F-NH ₂
(SEQ ID NO:327)	Ac-D-W-L-R-A-F-Y-D-R-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:328)	Ac-E-W-L-R-A-F-Y-E-R-V-A-E-K-L-K-E-A-F-NH ₂
(SEQ ID NO:329)	Ac-D-W-L-K-A-F-Y-D-K-V-A-E-R-L-R-E-A-F-NH ₂
(SEQ ID NO:330)	Ac-E-W-L-K-A-F-Y-E-K-V-A-E-R-L-R-E-A-F-NH ₂
(SEQ ID NO:331)	Ac-D-W-L-R-A-F-Y-D-K-V-A-E-R-L-K-E-A-F-NH ₂
(SEQ ID NO:332)	Ac-E-W-L-R-A-F-Y-E-K-V-A-E-R-L-K-E-A-F-NH ₂

In some embodiments, an ApoA-I mimetic having the following sequence as described in U.S. Patent Application Publication No. 2006/0069030 is utilized: F-A-E-K-F-K-E-A-V-K-D-Y-F-A-K-F-W-D (SEQ ID NO: 333).

5 In some embodiments, an ApoA-I mimetic having the following sequence as described in U.S. Patent Application Publication No. 2009/0081293 is utilized: DWFKAFYDKVAEKFKEAF (SEQ ID NO: 334); DWLKAIFYDKVAEKLKEAF (SEQ ID NO: 335); PALEDLRQGLLPVLESFKVFLSALEEYTKKLNTQ (SEQ ID NO: 336).

Amphipathic lipids include, for example, any lipid molecule which has both a hydrophobic and a hydrophilic moiety. Examples include phospholipids or glycolipids.

10

Examples of phospholipids which may be used in the sHDL-TA nanoparticles include but are not limited to dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9*Z*-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-
 5 N-[4-(*p*-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(*p*-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(*p*-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9*Z*-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(*p*-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol,
 10 phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

In some embodiments, exemplary phospholipids include, but are not limited to, small alkyl chain phospholipids, egg phosphatidylcholine, soybean phosphatidylcholine, dipalmitoylphosphatidylcholine, dimyristoylphosphatidylcholine, distearoylphosphatidylcholine 1-myristoyl-2-palmitoylphosphatidylcholine, 1-palmitoyl-2-myristoylphosphatidylcholine, 1-palmitoyl-2-stearoylphosphatidylcholine, 1-stearoyl-2-palmitoylphosphatidylcholine, dioleoylphosphatidylcholine dioleophosphatidylethanolamine, dilauroylphosphatidylglycerol phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, phosphatidylinositol, phosphatidylglycerols, diphosphatidylglycerols such as dimyristoylphosphatidylglycerol,
 20 dipalmitoylphosphatidylglycerol, distearoylphosphatidylglycerol, dioleoylphosphatidylglycerol, dimyristoylphosphatidic acid, dipalmitoylphosphatidic acid, dimyristoylphosphatidylethanolamine, dipalmitoylphosphatidylethanolamine, dimyristoylphosphatidylserine, dipalmitoylphosphatidylserine, brain phosphatidylserine, brain sphingomyelin, egg sphingomyelin, milk sphingomyelin, palmitoyl sphingomyelin, phytosphingomyelin, dipalmitoylsphingomyelin, distearoylsphingomyelin,
 25 dipalmitoylphosphatidylglycerol salt, phosphatidic acid, galactocerebroside, gangliosides, cerebroside, dilaurylphosphatidylcholine, (1,3)-*D*-mannosyl-(1,3)diglyceride, aminophenylglycoside, 3-cholesteryl-6'-(glycosylthio)hexyl ether glycolipids, and cholesterol and its derivatives. Phospholipid fractions including SM and palmitoylsphingomyelin can
 30 optionally include small quantities of any type of lipid, including but not limited to lysophospholipids, sphingomyelins other than palmitoylsphingomyelin, galactocerebroside, gangliosides, cerebroside, glycerides, triglycerides, and cholesterol and its derivatives.

In some embodiments, the sHDL nanoparticles have a molar ratio of phospholipid/

HDL apolipoprotein from 2 to 250 (e.g., 10 to 200, 20 to 100, 20 to 50, 30 to 40).

Therapeutic agents include drugs and/or medicaments known to be useful in treating and/or preventing cardiovascular related disorders (e.g., atherosclerosis, heart failure, arrhythmia, atrial fibrillation, hypertension, coronary artery disease, angina pectoris, etc.).

- 5 Examples of therapeutic agents known to be useful in treating and/or preventing cardiovascular related disorders include, angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II
- 10 receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol,
- 15 penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide,
- 20 methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amilorone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide,
- 25 mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin), cholesteryl ester transfer protein inhibitors (e.g., anacetrapib, evacetrapib), PPAR agonists (e.g., K-877, CER-002, DSP-8658, INT131,
- 30 GFT505), and apoA-I activators (e.g., RVX-208).

In some embodiments, the therapeutic agent is sphingosine-1-phosphate (S1P) (see, Examples I and II). In some embodiments, the therapeutic agent is a S1P receptor agonist. In some embodiments, the therapeutic agent is a S1P analogue.

In some embodiments, the retinoid X receptor agonist is selected from Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

In some embodiments, the combined LXR and RXR agonists are selected from
5 TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-choleamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

10 In some embodiments, the therapeutic agent is a liver X receptor (LXR) agonist (see, Examples III and IV). Generally, during the development of atherosclerosis, cholesterol deposited in macrophages at sites of atherosclerotic plaques (e.g., atheromatous plaque regions) converts the macrophages into foam cells, which account for the major fraction of lesion deposited cholesterol (see, e.g., Tangirala, R. K.; et al., Proceedings of the National
15 Academy of Sciences of the United States of America 2002, 99 (18), 11896-11901; Rader, D. J.; et al., Cell Metabolism 2005, 1 (4), 223-230; Witztum, J. L.; et al., Journal of Clinical Investigation 1991, 88 (6), 1785-1792). In addition, macrophages produce proteolytic enzymes that can digest extracellular matrix, leading to plaque rupture, resulting in the recruitment of inflammatory cells (see, e.g., Libby, P.; et al., Nature 2011, 473 (7347), 317-
20 325; Vanderwal, A. C.; et al., Circulation 1994, 89 (1), 36-44; Weber, C.; et al., Nature Medicine 2011, 17 (11), 1410-1422). Therefore, both promoting reverse cholesterol transport (RCT) and inhibiting inflammation at the plaque area have been widely pursued as therapeutic strategies for atherosclerosis. Recently, LXR agonists have been found to inhibit the atherosclerosis by reversing the above two pathological processes (see, e.g., Im, S. S.; et al.,
25 Circulation Research 2011, 108 (8), 996-1001). Specifically, LXR agonists can up-regulate ABCA1/ABCG1 transporters on macrophages and remove cholesterol from macrophages by reverse cholesterol transport (see, e.g., Briand, F.; et al., Journal of Lipid Research 2010, 51 (4), 763-770; Cuchel, M.; et al., Circulation 2006, 113 (21), 2548-2555), which reduces the lesion cholesterol content directly and prevents the conversion of
30 macrophages into foam cells at sites of atherosclerotic lesions (see, e.g., Tangirala, R. K.; et al., Proceedings of the National Academy of Sciences of the United States of America 2002, 99 (18), 11896-11901). In addition, LXR agonists have been reported to attenuate the inflammatory response through a series of signaling cascades (see, e.g., Ghisletti, S.; et al.,

Genes & Development 2009, 23 (6), 681-693; Ghisletti, S.; Huang, W.; Ogawa, S.; Pascual, G.; Lin, M. E.; Willson, T. M.; Rosenfeld, M. G.; et al., Molecular Cell 2007, 25 (1), 57-70), which can also contribute to atherosclerosis inhibition (see, e.g., Joseph, S. B.; et al., Nature Medicine 2003, 9 (2), 213-219). However, treatment of experimental atherosclerotic mice
5 with LXR agonists leads to liver toxicity, owing to unrestrained lipogenesis (see, e.g., Repa, J. J.; et al., Genes & Development 2000, 14 (22), 2819-2830; Schultz, J. R.; et al., Genes & Development 2000, 14 (22), 2831-2838). The present invention overcomes such limitations through encapsulation of the LXR agonist within a sHDL nanoparticle thereby ensuring efficient targeting of the drug to the desired atheromatous plaque regions while avoiding liver
10 toxicity side effects.

Previously, high-density lipoproteins (HDLs) have been used for atherosclerotic plaque imaging and delivery of several different therapeutic molecules to the plaque (see, e.g., Skajaa, T.; et al., Biomaterials 2011, 32 (1), 206-213; Cormode, D. P.; et al., Nano Letters 2008, 8 (11), 3715-3723; Luthi, A. J.; et al., Acs Nano 2012, 6 (1), 276-285). HDL is
15 able to target the plaque through two main mechanisms (see, e.g., Kingwell, B. A.; et al., Nat Rev Drug Discov 2014, 13 (6), 445-64). Firstly, the vasculature around atherosclerosis lesions becomes leaky due severe inflammation and endothelial injury, which would facilitate the infiltration of HDL into the vascular tissue (see, e.g., Moulton, K. S.; et al., Circulation 2004, 110 (10), 1330-1336; Zhang, W. L.; et al., International Journal of Pharmaceutics 2011,
20 419 (1-2), 314-321). Secondly, HDL can be retained in the plaque through ingestion by macrophages and macrophage-derived foam cells, mediated by the SR-BI receptor, ABCA1 and ABCG1 receptors expressed on macrophage surfaces (see, e.g., Rader, D. J.; et al., Journal of Clinical Investigation 2006, 116 (12), 3090-3100; Tall, A. R.; et al., Cell Metabolism 2008, 7 (5), 365-375). In addition to the proven safety of HDL in previous
25 clinical trials, the above properties of HDL indicate HDL as an efficient delivery vehicle for LXR agonists to the plaque while minimizing severe side effects (e.g., liver toxicity side effects (e.g., hepatic steatosis)).

As described in Example III, experiments conducted during the course of developing embodiments for the present invention utilized synthetic HDL composed of ApoA1 mimetic
30 peptide and lipids to deliver LXR agonists to atherosclerotic plaques.

The present invention is not limited to the use of particular LXR agonists. In some embodiments, the LXR agonist is TO901317. Additional examples of LXR agonist include, but are not limited to, TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965,

N,N-dimethyl-3beta-hydroxy-choleamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX)).

The present invention is not limited to the use of particular RXR agonists. In some
5 embodiments, the RXR agonist is CD3254. Additional examples of RXR agonist include, but are not limited to, Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

The present invention is not limited to the use of particular LXR or RXR agonists. In
10 some embodiments, LXR and RXR agonists are combined. For example, in some embodiments, the combination of LXR and RXR agonists are from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-choleamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX)), Bexarotene, CD3254, Docosahexaenoic
15 acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

The present invention is not limited to a particular manner of generating sHDL-TA nanoparticles. In some embodiments, for example, such sHDL-TA nanoparticles are formed by mixing an amphipathic lipid and the therapeutic agent in a solvent. The solvent is then
20 removed and the dried lipid mixture is hydrated with an aqueous buffer. HDL apolipoprotein is then added and the composition is mixed vigorously to effect the formation of the sHDL-TA nanoparticles. Example I describes the formation of sHDL-TA nanoparticles wherein the therapeutic agent is sphingosine-1-phosphate (S1P). Example III describes the formation of sHDL-TA nanoparticles wherein the therapeutic agent is an LXR agonist (TO901317). As
25 described, phospholipids, apoA-I mimetic peptide (22A) and TO901317 were hydrated in an aqueous solution and the sHDL-TA nanoparticles were formed after three cycles of thermal cycling between 25 and 50°C.

In some embodiments, the sHDL-TA nanoparticles are prepared by co-lyophilization methods. For example, in some embodiments, lipids, ApoA mimetic peptides and a
30 therapeutic agent will be dissolved (e.g., in glacial acetic acid) and lyophilized. The obtained powder will be hydrated in PBS (e.g., pH 7.4) and thermocycled above and below the phospholipid transition temperature to form drug-loaded sHDL (see, Fig. 15 showing an LXR agonist as a therapeutic agent).

Generally, the sHDL-TA nanoparticles so formed are spherical and have a diameter of from about 5 nm to about 20 nm (e.g., 4 – 22 nm, 6 – 18 nm, 8 – 15 nm, 8- 10 nm, etc.). In some embodiments, the sHDL-TA nanoparticles are subjected to size exclusion chromatography to yield a more homogeneous preparation.

5 In some embodiments, the sHDL-TA nanoparticles are prepared by a thin-film dispersion method. For example, in some embodiments, lipid (e.g., approximately 15 mg lipid) is dissolved in chloroform (e.g., approximately 2 ml chloroform) and mixed with a drug stock DMSO solution (e.g., approximately 2.5 mg/mL drug stock DMSO solution). In some
10 embodiments, organic solvent is evaporated and buffer (50 mM acetate buffer, pH 5.0) added into the lipid/drug mixture to hydrate the film by probe sonication in intervals (e.g., 30 second intervals) using an ultrasonic processor (e.g., a VibraCell ultrasonic processor (Sonics, Newtown, CT)). In some embodiments, apolipoprotein is dissolved in buffer and mixed with the lipid suspension. Next, in some embodiments, the mixture is incubated in water bath (e.g., 50°C water bath for 5 min) and cooled (e.g., cooled at room temperature for
15 5 min). In some embodiments, the water bath / cooling is repeated (e.g., cycled three times) to form sHDL-TA nanoparticles.

In some embodiments, the sHDL-TA nanoparticles are prepared by mixing (e.g., vortexing) (e.g., ultraturrexing) buffer with powder formulations of peptide, lipid and therapeutic agent. In some embodiments, the mixture is further incubated at or about the lipid
20 phase transition temperature until sHDL-TA assembly is complete.

Generally, the sHDL-TA nanoparticles so formed are spherical and have a diameter of from about 5 nm to about 20 nm (e.g., 4 – 22 nm, 6 – 18 nm, 8 – 15 nm, 8- 10 nm, etc.). In some embodiments, the sHDL-TA nanoparticles are subjected to size exclusion chromatography to yield a more homogeneous preparation.

25 In some embodiments, the sHDL nanoparticles further encapsulate agents useful for determining the location of administered particles. Agents useful for this purpose include fluorescent tags, radionuclides and contrast agents.

Suitable imaging agents include, but are not limited to, fluorescent molecules such as those described by Molecular Probes (Handbook of fluorescent probes and research
30 products), such as Rhodamine, fluorescein, Texas red, Acridine Orange, Alexa Fluor (various), Allophycocyanin, 7-aminoactinomycin D, BOBO-1, BODIPY (various), Calciene, Calcium Crimson, Calcium green, Calcium Orange, 6-carboxyrhodamine 6G, Cascade blue, Cascade yellow, DAPI, DiA, DID, DiI, DiO, DiR, ELF 97, Eosin, ER Tracker Blue-White,

EthD-1, Ethidium bromide, Fluo-3, Fluo4, FM1-43, FM4-64, Fura-2, Fura Red, Hoechst 33258, Hoechst 33342, 7-hydroxy-4-methylcoumarin, Indo-1, JC-1, JC-9, JOE dye, Lissamine rhodamine B, Lucifer Yellow CH, LysoSensor Blue DND-167, LysoSensor Green, LysoSensor Yellow/Blu, LysoTracker Green FM, Magnesium Green, Marina Blue, Mitotracker Green FM, Mitotracker Orange CMTMRos, MitoTracker Red CMXRos, Monobromobimane, NBD amines, NeruoTrace 500/525 green, Nile red, Oregon Green, Pacific Blue. POP-1, Propidium iodide, Rhodamine 110, Rhodamine Red, R-Phycoerythrin, Resorfin, RH414, Rhod-2, Rhodamine Green, Rhodamine 123, ROX dye, Sodium Green, SYTO blue (various), SYTO green (Various), SYTO orange (various), SYTOX blue, SYTOX green, SYTOX orange, Tetramethylrhodamine B, TOT-1, TOT-3, X-rhod-1, YOYO-1, YOYO-3. In some embodiments, ceramides are provided as imaging agents. In some embodiments, S1P agonists are provided as imaging agents.

Additionally radionuclides can be used as imaging agents. Suitable radionuclides include, but are not limited to radioactive species of Fe(III), Fe(II), Cu(II), Mg(II), Ca(II), and Zn(II) Indium, Gallium and Technetium. Other suitable contrast agents include metal ions generally used for chelation in paramagnetic T1-type MIR contrast agents, and include di- and tri-valent cations such as copper, chromium, iron, gadolinium, manganese, erbium, europium, dysprosium and holmium. Metal ions that can be chelated and used for radionuclide imaging, include, but are not limited to metals such as gallium, germanium, cobalt, calcium, indium, iridium, rubidium, yttrium, ruthenium, yttrium, technetium, rhenium, platinum, thallium and samarium. Additionally metal ions known to be useful in neutron-capture radiation therapy include boron and other metals with large nuclear cross-sections. Also suitable are metal ions useful in ultrasound contrast, and X-ray contrast compositions.

Examples of other suitable contrast agents include gases or gas emitting compounds, which are radioopaque.

In some embodiments, the sHDL-TA nanoparticles further encapsulate a targeting agent. In some embodiments, targeting agents are used to assist in delivery of the sHDL-TA nanoparticles to desired body regions (e.g., bodily regions affected by a cardiovascular related disorder). Examples of targeting agents include, but are not limited to, an antibody, receptor ligand, hormone, vitamin, and antigen, however, the present invention is not limited by the nature of the targeting agent. In some embodiments, the antibody is specific for a disease-specific antigen. In some embodiments, the receptor ligand includes, but is not limited to, a ligand for CFTR, EGFR, estrogen receptor, FGR2, folate receptor, IL-2 receptor,

glycoprotein, and VEGFR. In some embodiments, the receptor ligand is folic acid.

In some embodiments, the sHDL-TA nanoparticles further encapsulate transgenes for delivery and expression to a target cell or tissue, *in vitro*, *ex vivo*, or *in vivo*. In such embodiments, rather than containing the actual protein, the sHDL-TA nanoparticles
5 encapsulate an expression vector construct containing, for example, a heterologous DNA encoding a gene of interest and the various regulatory elements that facilitate the production of the particular protein of interest in the target cells.

In some embodiments, the gene is a therapeutic gene that is used, for example, to treat cardiovascular related disorders, to replace a defective gene, or a marker or reporter gene that
10 is used for selection or monitoring purposes. In the context of a gene therapy vector, the gene may be a heterologous piece of DNA. The heterologous DNA may be derived from more than one source (i.e., a multigene construct or a fusion protein). Further, the heterologous DNA may include a regulatory sequence derived from one source and the gene derived from a different source. Tissue-specific promoters may be used to effect transcription in specific
15 tissues or cells so as to reduce potential toxicity or undesirable effects to non-targeted tissues. The nucleic acid may be either cDNA or genomic DNA. The nucleic acid can encode any suitable therapeutic protein.

The nucleic acid may be an antisense nucleic acid. In such embodiments, the antisense nucleic acid may be incorporated into the nanoparticle of the present invention
20 outside of the context of an expression vector.

In some embodiments, the sHDL-TA nanoparticles of the present invention may be delivered to local sites in a patient by a medical device. Medical devices that are suitable for use in the present invention include known devices for the localized delivery of therapeutic agents. Such devices include, but are not limited to, catheters such as injection catheters,
25 balloon catheters, double balloon catheters, microporous balloon catheters, channel balloon catheters, infusion catheters, perfusion catheters, etc., which are, for example, coated with the therapeutic agents or through which the agents are administered; needle injection devices such as hypodermic needles and needle injection catheters; needleless injection devices such as jet injectors; coated stents, bifurcated stents, vascular grafts, stent grafts, etc.; and coated
30 vaso-occlusive devices such as wire coils.

Exemplary devices are described in U.S. Pat. Nos. 5,935,114; 5,908,413; 5,792,105; 5,693,014; 5,674,192; 5,876,445; 5,913,894; 5,868,719; 5,851,228; 5,843,089; 5,800,519; 5,800,508; 5,800,391; 5,354,308; 5,755,722; 5,733,303; 5,866,561; 5,857,998; 5,843,003;

and 5,933,145; the entire contents of which are incorporated herein by reference. Exemplary stents that are commercially available and may be used in the present application include the RADIUS (SCIMED LIFE SYSTEMS, Inc.), the SYMPHONY (Boston Scientific Corporation), the Wallstent (Schneider Inc.), the PRECEDENT II (Boston Scientific Corporation) and the NIR (Medinol Inc.). Such devices are delivered to and/or implanted at target locations within the body by known techniques.

As noted, the sHDL-TA nanoparticles of the present invention are useful in treating cardiovascular related disorders. Examples of cardiovascular related disorders include, but are not limited to, atherosclerosis, coronary artery disease, cardiomyopathy, hypertensive heart disease, heart failure, pulmonary heart disease, cardiac dysrhythmias, inflammatory heart disease (e.g., endocarditis, inflammatory cardiomegaly, myocarditis), vulvular heart disease, cerebrovascular disease, peripheral arterial disease, congenital heart disease, and rheumatic heart disease.

The present invention is not limited to a particular method or technique for treating a cardiovascular related disorder. In some embodiments, the methods involve administering to a subject (e.g., a human subject suffering from or at risk for developing a cardiovascular related disorder) a therapeutically effective amount of a composition comprising a sHDL-TA nanoparticle as described herein. The utilized therapeutic agent will depend on the type of condition being treated. For example, if the cardiovascular related disorder is atherosclerosis, the therapeutic agent (in some embodiments) is an LXR agonist (e.g., TO901317) or a RXR agonist (e.g., CD3254).

In some embodiments, the present invention also provides kits comprising sHDL-TA nanoparticles as described herein. In some embodiments, the kits comprise one or more of the reagents and tools necessary to generate sHDL-TA nanoparticles, and methods of using such sHDL-TA nanoparticles.

The sHDL-TA nanoparticles of the present invention may be characterized for size and uniformity by any suitable analytical techniques. These include, but are not limited to, atomic force microscopy (AFM), electrospray-ionization mass spectroscopy, MALDI-TOF mass spectroscopy, ¹³C nuclear magnetic resonance spectroscopy, high performance liquid chromatography (HPLC) size exclusion chromatography (SEC) (equipped with multi-angle laser light scattering, dual UV and refractive index detectors), capillary electrophoresis and gel electrophoresis. These analytical methods assure the uniformity of the sHDL-TA

nanoparticle population and are important in the production quality control for eventual use in in vivo applications.

In some embodiments, gel permeation chromatography (GPC), which can separate sHDL nanoparticles from liposomes and free ApoA-I mimetic peptide, is used to analyze the sHDL-TA nanoparticles. In some embodiments, the size distribution and zeta-potential is
5 determined by dynamic light scattering (DLS) using, for example, a Malven Nanosizer instrument.

In some embodiments, the encapsulation efficiency of the therapeutic agent will be determined by a desalting column method. Briefly, a sHDL-TA nanoparticle will be passed
10 through a desalting column (cut off = 7000 Da) to remove any unencapsulated therapeutic agent, and an equal volume of a sHDL-TA nanoparticle that is not subject to desalting will be used as a comparison. All samples will be incubated with ethanol to break sHDL and subsequently analyzed by HPLC equipped with a C18 column³⁹. In some embodiments, an equation is used to calculate encapsulation efficiency. In some embodiments, the following
15 equation is used to calculate the encapsulation efficiency: Encapsulation efficiency (%) = (the content of drug in sHDL passed through the desalting column)/(the content of therapeutic agent in sHDL not passed through the desalting column) × 100%.

In some embodiments, to learn the release profile of therapeutic agent from sHDL, sHDL-TA nanoparticles and free therapeutic agent are placed into a dialysis bag (6-8kda),
20 which will be put in 200 ml PBS (pH 7.4) containing 0.1% Tween 80⁴⁰. The release media will be put in a 37°C air bath shaker at 100 rpm. In some embodiments, at predetermined time points, 2 ml of the medium will be sampled and replaced with an equal volume of fresh release media. The amount of therapeutic agent in the media will be quantified by reverse-phase HPLC.

25 In some embodiments, the sHDL-TA nanoparticles of the present invention are configured such that they are readily cleared from a subject (e.g., so that there is little to no detectable toxicity at efficacious doses).

Where clinical applications are contemplated, in some embodiments of the present invention, the sHDL-TA nanoparticles are prepared as part of a pharmaceutical composition
30 in a form appropriate for the intended application. Generally, this entails preparing compositions that are essentially free of pyrogens, as well as other impurities that could be harmful to humans or animals. However, in some embodiments of the present invention, a

straight sHDL-TA nanoparticle formulation may be administered using one or more of the routes described herein.

In preferred embodiments, the sHDL-TA nanoparticles are used in conjunction with appropriate salts and buffers to render delivery of the compositions in a stable manner to allow for uptake by target cells. Buffers also are employed when the sHDL-TA nanoparticles are introduced into a patient. Aqueous compositions comprise an effective amount of the sHDL-TA nanoparticles to cells dispersed in a pharmaceutically acceptable carrier or aqueous medium. Such compositions also are referred to as inocula. The phrase "pharmaceutically or pharmacologically acceptable" refer to molecular entities and compositions that do not produce adverse, allergic, or other untoward reactions when administered to an animal or a human. As used herein, "pharmaceutically acceptable carrier" includes any and all solvents, dispersion media, coatings, antibacterial and antifungal agents, isotonic and absorption delaying agents and the like. Except insofar as any conventional media or agent is incompatible with the vectors or cells of the present invention, its use in therapeutic compositions is contemplated. Supplementary active ingredients may also be incorporated into the compositions.

In some embodiments of the present invention, the active compositions include classic pharmaceutical preparations. Administration of these compositions according to the present invention is via any common route so long as the target tissue is available via that route. This includes oral, nasal, buccal, rectal, vaginal or topical. Alternatively, administration may be by orthotopic, intradermal, subcutaneous, intramuscular, intraperitoneal or intravenous injection.

The active sHDL-TA nanoparticles may also be administered parenterally or intraperitoneally or intratumorally. Solutions of the active compounds as free base or pharmacologically acceptable salts are prepared in water suitably mixed with a surfactant, such as hydroxypropylcellulose. Dispersions can also be prepared in glycerol, liquid polyethylene glycols, and mixtures thereof and in oils. Under ordinary conditions of storage and use, these preparations contain a preservative to prevent the growth of microorganisms.

In some embodiments, a therapeutic agent is released from the sHDL-TA nanoparticles within a target cell (e.g., within a vascular region) (e.g., within an atheroscleroma).

The pharmaceutical forms suitable for injectable use include sterile aqueous solutions or dispersions and sterile powders for the extemporaneous preparation of sterile injectable

solutions or dispersions. The carrier may be a solvent or dispersion medium containing, for example, water, ethanol, polyol (for example, glycerol, propylene glycol, and liquid polyethylene glycol, and the like), suitable mixtures thereof, and vegetable oils. The proper fluidity can be maintained, for example, by the use of a coating, such as lecithin, by the maintenance of the required particle size in the case of dispersion and by the use of surfactants. The prevention of the action of microorganisms can be brought about by various antibacterial and antifungal agents, for example, parabens, chlorobutanol, phenol, sorbic acid, thimerosal, and the like. In many cases, it may be preferable to include isotonic agents, for example, sugars or sodium chloride. Prolonged absorption of the injectable compositions can be brought about by the use in the compositions of agents delaying absorption, for example, aluminum monostearate and gelatin.

Sterile injectable solutions are prepared by incorporating the active sHDL-TA nanoparticles in the required amount in the appropriate solvent with various of the other ingredients enumerated above, as required, followed by filtered sterilization. Generally, dispersions are prepared by incorporating the various sterilized active ingredients into a sterile vehicle which contains the basic dispersion medium and the required other ingredients from those enumerated above. In the case of sterile powders for the preparation of sterile injectable solutions, the preferred methods of preparation are vacuum-drying and freeze-drying techniques which yield a powder of the active ingredient plus any additional desired ingredient from a previously sterile-filtered solution thereof.

Upon formulation, sHDL-TA nanoparticles are administered in a manner compatible with the dosage formulation and in such amount as is therapeutically effective. The formulations are easily administered in a variety of dosage forms such as injectable solutions, drug release capsules and the like. For parenteral administration in an aqueous solution, for example, the solution is suitably buffered, if necessary, and the liquid diluent first rendered isotonic with sufficient saline or glucose. These particular aqueous solutions are especially suitable for intravenous, intramuscular, subcutaneous and intraperitoneal administration. For example, one dosage could be dissolved in 1 ml of isotonic NaCl solution and either added to 1000 ml of hypodermoclysis fluid or injected at the proposed site of infusion, (see for example, "Remington's Pharmaceutical Sciences" 15th Edition, pages 1035-1038 and 1570-1580). In some embodiments of the present invention, the active particles or agents are formulated within a therapeutic mixture to comprise about 0.0001 to 1.0 milligrams, or about

0.001 to 0.1 milligrams, or about 0.1 to 1.0 or even about 10 milligrams per dose or so.

Multiple doses may be administered.

Additional formulations that are suitable for other modes of administration include vaginal suppositories and pessaries. A rectal pessary or suppository may also be used.

5 Suppositories are solid dosage forms of various weights and shapes, usually medicated, for insertion into the rectum, vagina or the urethra. After insertion, suppositories soften, melt or dissolve in the cavity fluids. In general, for suppositories, traditional binders and carriers may include, for example, polyalkylene glycols or triglycerides; such suppositories may be formed from mixtures containing the active ingredient in the range of 0.5% to 10%, preferably 1%-
10 2%. Vaginal suppositories or pessaries are usually globular or oviform and weighing about 5 g each. Vaginal medications are available in a variety of physical forms, e.g., creams, gels or liquids, which depart from the classical concept of suppositories. The sHDL-TA nanoparticles also may be formulated as inhalants.

The present invention also includes methods involving co-administration of the
15 sHDL-TA nanoparticles as described herein with one or more additional active agents. Indeed, it is a further aspect of this invention to provide methods for enhancing prior art therapies and/or pharmaceutical compositions by co-administering the sHDL-TA nanoparticles of this invention. In co-administration procedures, the agents may be administered concurrently or sequentially. In some embodiments, the sHDL-TA
20 nanoparticles described herein are administered prior to the other active agent(s). The agent or agents to be co-administered depends on the type of condition being treated. For example, when the condition being treated is a cardiovascular related disorder, the additional agent includes angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist
25 medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel,
30 eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine),

diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g.,
5 cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g.,
10 alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin). The additional agents to be co-administered can be any of the well-known agents in the art, including, but not limited to, those that are currently in clinical use.

EXPERIMENTAL

The following examples are provided in order to demonstrate and further illustrate certain preferred embodiments and aspects of the present invention and are not to be construed as limiting the scope thereof.

Example I.

This example describes S1P-sHDL compositions.

Sphingosine-1-phosphate (S1P, CAS 26993-30-6) was obtained from Cayman Chemical Company (Ann Arbor, MI). 22A mimetic peptide (SEQ?) and
25 dipalmitoylphosphatidylcholine (DPPC) was obtained from NOF (Japan). Cell culture reagents were obtained from Lonza (Walkersville, MD).

S1P stock solution was prepared in methanol, heating to 55°C and using bath sonication to help dissolve. 22A mimetic peptide and DPPC were weighed and added to separate vials, followed by the addition of acidified methanol (containing 10-20% glacial
30 acetic acid) to fully dissolve both peptide and lipid. Various amounts (1-500 nmol) of S1P was then added to DPPC solution, followed by the addition of peptide solution to create a 1:2 peptide:lipid ratio by weight. Samples were flash frozen in liquid nitrogen and lyophilized for 24 hours to remove solvents. Once the solvents evaporated, samples were removed from

lyophilizer and hydrated to desired concentrations using 1X PBS (pH 7.4). The solutions were vortexed and thermocycled above and below the lipid glass transition temperature (between 25°C and 50°C for DPPC). Thermocycling was repeated 3 times, at which point the solution transitioned from cloudy to clear, indicating formation of HDL. Samples were
5 adjusted to pH 7.4 with NaOH and sterile filtered with either a 0.22 or 0.45 µm syringe filter. sHDL particles containing S1P were characterized by gel permeation chromatography (GPC), as seen in Fig. 1.

Example II.

10 This example describes a S1P-HDL *in vitro* assay.

Human umbilical vein endothelial cells (HUVEC) C2519A Clonetics™ were recovered from cryopreservation and cultured per manufacturer instruction. At passage 5 the cells were trypsinized, counted, re-plated into 12-well plates at 10⁶ cells per well and incubated for 48 hours at 37°C and 5% CO₂. Media was aspirated and replaced with fresh
15 media containing sHDL, S1P-sHDL, free 22A peptide, or PBS. Cells were placed back into incubator for 10 minutes, after which the media was collected and analyzed for nitric oxide (NO) content via ozone chemiluminescence (Figure 2). Remaining cells were stripped with trypsin and collected for qRT-PCR analysis. Fig. 2 demonstrates increased NO release with S1P-HDL.

Example III.

20 This example demonstrates that LXR agonist-sHDL successfully upregulated ABCA1 expression in macrophages.

Incorporation of LXR agonist into sHDL is the first and most important step for all
25 subsequent studies. Phospholipids, apoA-I mimetic peptide (22A) and LXR agonist TO901317 (TO) were hydrated in an aqueous solution and the sHDL nanoparticles were formed after 3 cycles of thermal cycling between 25 and 50°C (see, e.g., Di Bartolo, B. A.; et al., *Atherosclerosis* 2011, 217 (2), 395-400; Dasseux, J.-L. Peptide/lipid complex formation by co-lyophilization. 2001). The homogeneity of the size distribution was confirmed by gel
30 permeation chromatography (GPC) and scanning electron microscopy (SEM) (Fig. 3A-B). The average particle size of sHDL was 6-14 nm (e.g., 8-10 nm) as determined by dynamic light scattering using a Malvern Nanosizer. To assess the therapeutic potential and function of LXR agonist-sHDL, its effect on modulation of ABCA1 and ABCG1 levels *in vitro* was

investigated. Free LXR agonist upregulated ABCA1 and ABCG1 in J774.1 macrophages, but increased upregulation was observed for LXR agonist-sHDL treated macrophages (Fig. 3C-D). In addition, incubation of J774.1 macrophages with LXR agonist-sHDL nanoparticles led to increased cholesterol efflux from macrophages than that of other formulations (Fig. 3E),
5 indicating, for example, sHDL is an efficient carrier for LXR agonist delivery in vitro.

Example IV.

This example shows synthetic HDL (sHDL) nanomedicines can accumulate in atherosclerotic lesions, with less side effects than free LXR agonists.

10 To visualize whether sHDL can deliver its cargo to the plaque efficiently, a lipophilic near-infrared fluorescent dye, DiD, was incorporated into sHDL. DiD was chosen because it exhibits little auto-fluorescence and possesses a low phototoxicity. The DiD-labeled sHDL nanoparticles were administrated by tail vein injection at a dose of 100 µg DiD and 10 mg/Kg sHDL to a murine atherosclerosis model. 24 hours post injection, animals were sacrificed and
15 aortas were removed. DiD fluorescence associated with aortas were analyzed using the Xenogen IVIS optical imaging system. This study clearly showed that the sHDL nanoparticles accumulated in atherosclerotic lesions (Fig. 4). The side effects of different LXR agonist formulations were assessed. It turned out that the LXR agonist-sHDL formulation (sHDL-TO) induced much lower SREBP1c expression (a marker for lipogenesis
20 in the liver) than free LXR agonist, indicating sHDL-TO had less side effects.

Fig. 5 shows regulation of LXR-target gene expression by TO901317-encapsulated sHDL particles in macrophages. In macrophages, LXRs control transcription of several genes involved in the cholesterol efflux pathway, including ABCA1 and ABCG1. To examine the ability of TO901317-encapsulated sHDL particles to activate LXR-target genes, J774.1
25 murine macrophage cells were incubated with sHDL blank particles or TO901317-encapsulated sHDL particles (TO901317 at 10^{-6} M) for 4 hours and the expression of both genes were measured using quantitative real-time PCR (qRT-PCR). RNA from cells was isolated using Qiagen RNA isolation kit. Approximately 2µg of total RNA was reverse transcribed using Superscript-II reverse transcriptase kit to generate cDNA (Invitrogen). The
30 resulting cDNA was amplified with appropriate primers using power SYBR Green PCR Master Mix and analyzed on a CFX real-time PCR system (Bio-Rad). Reactions were run in triplicates and GAPDH was used as an internal control to normalize for the variability in expression levels. Data analysis was performed using the $2^{-\Delta\Delta CT}$ method. The results

indicated that TO901317-encapsulated sHDL particles can upregulate ABCA1 and ABCG1 expression in macrophages at both baseline and lipid loaded conditions.

Fig. 6 shows westernblot analysis for the expression of ABCA1 in TO901317-encapsulated sHDL particles treated macrophages. J774.1 murine macrophage cells were incubated with sHDL blank particles or TO901317-encapsulated sHDL particles for 18 hours. The cells were lysed using RIPA buffer (50 mM Tris-HCl pH 7.4, 150 mM NaCl, 1% (v/v) NP-40, 0.5% (w/v) sodium deoxycholate, 10 mM sodium fluoride, 1 mM sodium orthovanadate, 1 mM PMSF, 10 mM sodium pyrophosphate, 0.1% (w/v), SDS supplemented with protease inhibitor solution (Complete, Roche). After lysis the cells were centrifuged at 14,000 rpm for 20 minutes and the proteins were quantified using Protein Assay Reagent (Thermo Scientific, Rockford, IL). Equal amounts of proteins were separated using SDS-PAGE and then transferred onto a Hybond nitrocellulose membrane (GE Healthcare Life Sciences, Piscataway, NJ). The membranes were blocked using 5% milk and probed over night with appropriate dilutions of the primary antibodies (ABCA1 or GAPDH) for proteins. The blots were then washed three times with TBST and incubated with 1:10000 dilutions of secondary antibodies from LI-COR. The bands were visualized using Odyssey CLx Imager. The results indicated that TO901317-encapsulated sHDL particles can upregulate ABCA1 expression in macrophages.

Fig. 7 shows the effects of TO901317-encapsulated sHDL particles on cholesterol efflux in macrophage. After incubation with ³H-cholesterol for 24h, J774.1 cells were washed and equilibrated in serum-free medium with acyl:coenzyme A cholesterol O-acyltransferase-1 inhibitor overnight in the presence of DMSO, TO901317 at 10 uM, sHDL blank particles, and TO901317-encapsulated sHDL particles with TO901317 at 10 uM for 24 hours. The cells were incubated in DMEM/0.2% fatty acid-free BSA with 20 µg/ml apoA-I (Alfa Aesar, MA) or 100 µg/ml HDL (Sigma) as acceptors for 4h. Efflux capacity was quantified using liquid scintillation to measure radioactive cholesterol effluxed from the cells (medium + intracellular lipids). The results indicated that TO901317-encapsulated sHDL particles can enhance cholesterol efflux in macrophages.

Figs. 8A and 8B show the effects of TO901317-encapsulated sHDL particles on plasma lipids in C57BL/6J Mice. C57BL/6J wild type mice were divided into 8 groups and treated with DMSO, TO901317 at 0.5mg/kg, TO901317 at 1.5mg/kg, TO901317 at 10mg/kg, or sHDL blank particles, TO901317-encapsulated sHDL particles with TO901317 at 0.5mg/kg, TO901317-encapsulated sHDL particles with TO901317 at 1.5mg/kg, TO901317-

encapsulated sHDL particles with TO901317 at 10mg/kg via intraperitoneal injection. Twenty-four hours later, collected plasma and liver tissues were stored at -80°C until processed. Direct LDL-cholesterol (LDL-c), direct HDL-cholesterol (HDL-c), and enzymatic-colorimetric assays used to determine plasma total cholesterol (TC) and triglycerides (TG) were carried out at the Chemistry Laboratory of the Michigan Diabetes Research and Training Center. The plasma TG levels were significantly elevated in free TO901317 treated groups as compared with control (DMSO). TO901317-encapsulated sHDL particles treated groups did not increase plasma TG levels compared to free TO901317 treated groups at equivalent TO901317 dosage.

Fig. 9 shows an RT-PCR analysis for the expression of SREBP1c in the liver. LXR ligands have been implicated in triggering induction of the lipogenic pathway via activation of sterol regulatory element-binding transcription factor 1 (SREBP1c) in the liver, which leads to the adverse effects of steatosis and hypertriglyceridemia. The liver tissues from Fig. 8 were used to detect the expression of SREBP1c using qRT-PCR as described in Fig. 5. The results indicated that TO901317 activated SREBP1c in the liver, but TO901317-encapsulated sHDL particles did not significantly activate the expression of SREBP1c in the liver.

Fig. 10 shows sHDL nanoparticle can deliver compound to atherosclerotic lesions. Six-week-old male apoE^{-/-} mice were placed on atherogenic high fat diet (HFD) for 12 weeks to induce atherosclerotic lesion formation. In order to characterize whether sHDL nanoparticle can deliver compound to atherosclerotic lesions, we employed ex vivo imaging of aorta trees from apoE^{-/-} mice and normal C57BL/6J mice administered with fluorescently labeled HDL particles using a Xenogen IVIS Spectrum Imaging System. Two hours after intravenous injection of DiD-sHDL, we observed the fluorescence signal accumulation in the aortic tree of apoE^{-/-} mice and the fluorescence signal kept for at least for 6 days, but not in the aorta from the normal C57BL/6J mice. This figure shows the representative image at 24 h after injection.

Fig. 11 shows TO901317-encapsulated sHDL nanoparticles can activate ABCA1 and ABCG1 expression in monocytes in vivo. The effect of TO901317-encapsulated sHDL on target gene expression in monocytes from apoE^{-/-} mice was also investigated. Six-week-old male apoE^{-/-} mice were placed on atherogenic high fat diet (HFD) for 12 weeks to induce atherosclerotic lesion formation. Mice were randomly divided into five groups, and each group was treated with intraperitoneal injections of the following regimens with an equivalent dose of 1.5 mg/kg entrapped TO901317: 1) PBS, 2) DMSO, 3) TO901317 dissolved in

dimethyl sulfoxide (DMSO) (free TO901317), 4) sHDL nanoparticles, or 5) TO901317-encapsulated sHDL particles. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). The monocytes from the blood were isolated and the expression of ABCA1 and ABCG1 was detected by qRT-PCR as described in Fig. 5. Both
5 the free TO901317 and TO901317-encapsulated sHDL activated the expression of ABCA1 and ABCG1 in monocytes.

Fig. 12 shows TO901317-encapsulated sHDL nanoparticles induced less triglyceride accumulation in the liver. Six-week-old male apoE^{-/-} mice were placed on atherogenic high fat diet (HFD) for 12 weeks to induce atherosclerotic lesion formation. Mice were randomly
10 divided into five groups, and each group was treated with intraperitoneal injections of the following regimens with an equivalent dose of 1.5 mg/kg entrapped TO901317: 1) PBS, 2) DMSO, 3) TO901317 dissolved in dimethyl sulfoxide (DMSO) (free TO901317), 4) sHDL nanoparticles, or 5) TO901317-encapsulated sHDL particles. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). Liver tissue triglyceride
15 concentrations were measured using a Triglyceride Quantification Kit (Cayman). Fifty mg of liver was homogenized in a 5% NP-40 buffer, and assay was performed according to manufacturer's directions. In the liver, free TO901317 significantly induced the accumulation of triglyceride. TO901317-encapsulated sHDL particles protected against the induction of triglyceride accumulation.

Fig. 13 shows TO901317-encapsulated sHDL nanoparticles induced less SREBP-1c and FAS expression in the liver. LXR ligands have been implicated in triggering induction of the lipogenic pathway via activation of SREBP-1c in the liver, which leads to the adverse effects of steatosis and hypertriglyceridemia. The liver tissues from Fig. 12 were used to detect the expression of SREBP1c and Fatty acid synthase (FAS) using qRT-PCR as
20 described in Fig. 5. The results indicated that TO901317 activated SREBP1c in the liver, but TO901317-encapsulated sHDL particles did not significantly activate the expression of SREBP1c in the liver.

Fig. 14 shows that TO901317-encapsulated sHDL nanoparticles induces atherosclerosis regression *in vivo*. Six-week-old male apoE^{-/-} mice were placed on HFD for 14
30 weeks to induce atherosclerotic lesion formation. Then the atherogenic diet was switched to a regular cholesterol-free chow diet containing 4.3% fat and no added cholesterol, at which point mice were either sacrificed (baseline) or switched to chow diet for 6 weeks. Coincident with the switch to chow diet, mice were randomized into 5 groups and received

intraperitoneal injection with 1) PBS, 2) DMSO, 3) TO901317 dissolved in dimethyl sulfoxide (DMSO) (free TO901317, at 1.5 mg/kg), 4) sHDL nanoparticles, or 5) TO901317-encapsulated sHDL particles with a dose of 1.5 mg/kg of TO901317. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). For the en face analysis of atheromatous plaques, the adventitia of the whole aorta was removed and aortas were opened longitudinally, stained with Oil red O (Sigma) and pinned flat onto a black-wax plate. The percentage of the plaque area stained by oil red O with respect to the total luminal surface area was quantified. TO901317-encapsulated sHDL particles induced atherosclerosis regression.

Example V.

This example describes the materials and methods used in conducting the experiments described in Example 6.

Preparation of drug-loaded sHDL nanoparticles

Drug-loaded sHDL nanoparticles were prepared by a co-lyophilization method. Briefly, lipids, ApoA mimetic peptides and a therapeutic agent (TO901317, Rosiglitazone, or CD3254) were dissolved in glacial acetic acid and lyophilized. The obtained powder was hydrated in PBS (pH 7.4) and thermocycled above and below the phospholipid transition temperature to form drug-loaded sHDL nanoparticles.

Characterization of drug-loaded sHDL nanoparticles

Size and morphology

The drug-loaded sHDL nanoparticles were characterized for purity by gel permeation chromatography (GPC), which can separate sHDL nanoparticles from liposomes and free ApoA-I mimetic peptide. The size distribution and zeta-potential were determined by dynamic light scattering (DLS) using a Malven Nanosizer instrument after proper dilution of samples.

To observe the morphology of drug-loaded sHDL nanoparticles, they were further characterized by transmission electron microscopy (TEM). Briefly, 3 μ L of the sample solution was deposited on carbon film-coated 400 mesh copper grids (Electron Microscopy Sciences) and dried for 1 minute. The samples were then negatively-stained with 5 droplets

of 1% uranyl acetate solution, excessive solutions on the grid were blotted and the grid was dried before TEM observation.

Encapsulation efficiency

5 The encapsulation efficiency of the therapeutic agent was determined by a desalting column method. Briefly, drug-loaded sHDL was passed through a desalting column (MWCO = 7000 Da) to remove any unencapsulated drug, and an equal volume of a sHDL-TA nanoparticle not passed through the desalting column was used as a control to calculate the total amount of unencapsulated and encapsulated drug. All samples were incubated with
10 ethanol to break sHDL and subsequently analyzed by HPLC equipped with a C18 column. The following equation was used to calculate the encapsulation efficiency: Encapsulation efficiency (%) = (the content of drug in sHDL passed through the desalting column)/(the content of therapeutic agent in sHDL not passed through the desalting column) × 100%.

Drug release from sHDL nanoparticles

15 To learn the release profile of therapeutic agent from sHDL, drug-loaded sHDL nanoparticles or free therapeutic agent was placed into a dialysis bag (6-8kda), which was put in 200 ml PBS (pH 7.4) containing 0.1% Tween 80. The release medium was put in a 37°C air bath shaker at 100 rpm. At predetermined time points, 2 ml of the medium was sampled and an
20 equal volume of fresh release medium was added back. The amount of therapeutic agent in the release medium was quantified by reverse-phase HPLC.

Example VI.

25 This example demonstrates the successful encapsulation of six compounds and fatty acids in sHDL nanoparticles. For example, the average particle sizes of sHDL and sHDL-TO (TO901317, Rosiglitazone, or CD3254) nanoparticles 8-12 nm measured by transmission electron microscopy. The sHDL-TO encapsulation efficiency was more than 85%. Four of those compounds were shown to have the ability to upregulate the expression of ABC transporters, which predominately control cholesterol efflux activity in macrophages. sHDL-
30 compound nanoparticle treatment can significantly increase the upregulative effects of those compounds.

Fig. 16 shows compound-encapsulated sHDL nanoparticles can enhance ABCA1 expression compared to sHDL nanoparticle-treated and free compound-treated macrophages.

THP-1-differentiated macrophages were incubated with DMSO, free compound, sHDL blank particles or compound-encapsulated sHDL particles (compound concentration at 10^{-6} M) for 16 hours and the expression of indicated genes were measured using quantitative real-time PCR (qRT-PCR). RNA from cells was isolated using Qiagen RNA isolation kit.

- 5 Approximately 2 μ g of total RNA was reverse transcribed using Superscript-II reverse transcriptase kit to generate cDNA (Invitrogen). The resulting cDNA was amplified with appropriate primers using power SYBR Green PCR Master Mix and analyzed on a CFX real-time PCR system (Bio-Rad). Reactions were run in triplicates and GAPDH was used as an internal control to normalize for the variability in expression levels. Data analysis was
- 10 performed using the $2^{-\Delta\Delta CT}$ method. The results indicated that compound-encapsulated sHDL particles can significantly upregulate ABCA1 expression in human macrophages compared to free compound-treated cells and sHDL-treated cells.

Fig. 17 shows compound-encapsulated sHDL nanoparticles can enhance ABCG1 expression compared to sHDL nanoparticle-treated and free compound-treated macrophages.

- 15 THP-1-differentiated macrophages were incubated with DMSO, free compound, sHDL blank particles or compound-encapsulated sHDL particles (compound concentration at 10^{-6} M) for 16 hours and the expression of indicated genes were measured using quantitative real-time PCR (qRT-PCR). RNA from cells was isolated using Qiagen RNA isolation kit. Approximately 2 μ g of total RNA was reverse transcribed using Superscript-II reverse
- 20 transcriptase kit to generate cDNA (Invitrogen). The resulting cDNA was amplified with appropriate primers using power SYBR Green PCR Master Mix and analyzed on a CFX real-time PCR system (Bio-Rad). Reactions were run in triplicates and GAPDH was used as an internal control to normalize for the variability in expression levels. Data analysis was performed using the $2^{-\Delta\Delta CT}$ method. The results indicated that compound-encapsulated sHDL
- 25 particles can significantly upregulate ABCG1 expression in human macrophages compared to free compound-treated cells and sHDL-treated cells.

Fig. 18 shows compound-encapsulated sHDL nanoparticles can enhance SR-BI expression compared to sHDL nanoparticle-treated and free compound-treated macrophages. THP-1-differentiated macrophages were incubated with DMSO, free compound, sHDL blank

30 particles or compound-encapsulated sHDL particles (compound concentration at 10^{-6} M) for 16 hours and the expression of indicated genes were measured using quantitative real-time PCR (qRT-PCR). RNA from cells was isolated using Qiagen RNA isolation kit. Approximately 2 μ g of total RNA was reverse transcribed using Superscript-II reverse

transcriptase kit to generate cDNA (Invitrogen). The resulting cDNA was amplified with appropriate primers using power SYBR Green PCR Master Mix and analyzed on a CFX real-time PCR system (Bio-Rad). Reactions were run in triplicates and GAPDH was used as an internal control to normalize for the variability in expression levels. Data analysis was performed using the $2^{-\Delta\Delta CT}$ method. The results indicated that compound-encapsulated sHDL particles can significantly upregulate SR-BI expression in human macrophages compared to free compound-treated cells and sHDL-treated cells.

Fig. 19 shows compound-encapsulated sHDL nanoparticles can enhance cholesterol efflux compared to sHDL nanoparticle-treated and free compound-treated macrophages.

THP-1-differentiated macrophages were incubated with 3H-cholesterol for 24h, washed and equilibrated in serum-free medium with acyl:coenzyme A cholesterol O-acyltransferase-1 inhibitor overnight in the presence of DMSO, free compound at 10 μ M, sHDL blank particles, and compound-encapsulated sHDL particles (compound concentration at 10 μ M) for 16 hours. Efflux capacity was quantified using liquid scintillation to measure radioactive cholesterol effluxed from the cells (medium + intracellular lipids). The results indicated that compound-encapsulated sHDL particles can enhance cholesterol efflux in human monocyte-differentiated macrophages compared to free compound- and sHDL particles-treated cells.

Fig. 20 shows TO901317-encapsulated sHDL nanoparticles can attenuate atherosclerotic lesion formation compared to sHDL nanoparticle-treated and TO901317-treated apoE-deficient mice. Six-week-old male apoE^{-/-} mice were placed on HFD for 6 weeks to induce atherosclerotic lesion formation. Mice were randomized into 5 groups and received intraperitoneal injection with 1) PBS, 2) DMSO, 3) TO901317 dissolved in dimethyl sulfoxide (DMSO) (free TO901317, at 1.5 mg/kg), 4) sHDL nanoparticles, or 5) TO901317-encapsulated sHDL particles with a dose of 1.5 mg/kg of TO901317. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). For the en face analysis of atheromatous plaques, the adventitia of the whole aorta was removed and aortas were opened longitudinally, stained with Oil red O (Sigma) and pinned flat onto a black-wax plate. The percentage of the plaque area stained by oil red O with respect to the total luminal surface area was quantified. TO901317-encapsulated sHDL particles inhibit atherosclerosis progression.

Fig. 21 shows CD3254-encapsulated sHDL nanoparticles can attenuate atherosclerotic lesion formation compared to sHDL nanoparticle-treated and CD3254-treated apoE-deficient mice. Six-week-old male apoE^{-/-} mice were placed on HFD for 6 weeks to

induce atherosclerotic lesion formation. Mice were randomized into 5 groups and received intraperitoneal injection with 1) PBS, 2) DMSO, 3) CD3254 dissolved in dimethyl sulfoxide (DMSO) (free CD3254, at 0.1 mg/kg), 4) sHDL nanoparticles, or 5) CD3254-encapsulated sHDL particles with a dose of 0.1 mg/kg of CD3254. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). For the en face analysis of atheromatous plaques, the adventitia of the whole aorta was removed and aortas were opened longitudinally, stained with Oil red O (Sigma) and pinned flat onto a black-wax plate. The percentage of the plaque area stained by oil red O with respect to the total luminal surface area was quantified. CD3254-encapsulated sHDL particles inhibits atherosclerosis progression.

Fig. 22 shows TO901317 treatment induced increased triglyceride levels, whereas TO901317-encapsulated sHDL nanoparticles treatment did not induce triglyceride increase in apoE-deficient mice. Six-week-old male apoE^{-/-} mice were place on HFD for 6 weeks to induce atherosclerotic lesion formation. Mice were randomized into 5 groups and received intraperitoneal injection with 1) PBS, 2) DMSO, 3) CD3254 dissolved in dimethyl sulfoxide (DMSO) (free CD3254, at 0.1 mg/kg), 4) sHDL nanoparticles, or 5) CD3254-encapsulated sHDL particles with a dose of 0.1 mg/kg of CD3254. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). Direct LDL-cholesterol (LDL-c), direct HDL-cholesterol (HDL-c), and enzymatic-colorimetric assays used to determine plasma total cholesterol (TC) and triglycerides (TG) were carried out at the Chemistry Laboratory of the Michigan Diabetes Research and Training Center. The plasma TG levels were significantly elevated in free TO901317 treated groups as compared with control (DMSO). TO901317-encapsulated sHDL particles treated groups did not increase plasma TG levels compared to free TO901317 treated groups at equivalent TO901317 dosage.

Fig. 23 shows RXR agonist treatment did not affect lipid profile in indicated groups of apoE-deficient mice. Six-week-old male apoE^{-/-} mice were place on HFD for 6 weeks to induce atherosclerotic lesion formation. Mice were randomized into 5 groups and received intraperitoneal injection with 1) PBS, 2) DMSO, 3) CD3254 dissolved in dimethyl sulfoxide (DMSO) (free CD3254, at 0.1 mg/kg), 4) sHDL nanoparticles, or 5) CD3254-encapsulated sHDL particles with a dose of 0.1 mg/kg of CD3254. The mice were treated for 6 weeks (three times per week, on Monday, Wednesday and Friday). Direct LDL-cholesterol (LDL-c), direct HDL-cholesterol (HDL-c), and enzymatic-colorimetric assays used to determine

plasma total cholesterol (TC) and triglycerides (TG) were carried out at the Chemistry Laboratory of the Michigan Diabetes Research and Training Center.

Fig. 24: Schematic for the preparation of drug-loaded sHDL. All components were dissolved in acetic acid and lyophilized, followed by hydration with PBS and thermal cycling to form drug-loaded sHDL.

Fig. 25: Transmission electron microscopy of different sHDL nanoparticles. (a) Blank sHDL (DMPC:POPC:22A = 10mg: 10 mg: 10 mg; (b) TO-loaded sHDL (DMPC:POPC:22A: TO901317 = 10mg: 10 mg: 10 mg:0.45 mg); (c) Blank sHDL (DMPC:22A = 20mg : 10 mg; (d) TO-loaded sHDL (DMPC:22A: TO901317 = 20mg: 10 mg:0.45 mg).

Fig. 26: Characterization of drug-loaded sHDL nanoparticles. (a) Sizes of different drug-loaded sHDL nanoparticles; (b) Encapsulation efficiency of different drug-loaded sHDL nanoparticles

Fig. 27: Drug release from sHDL nanoparticles. (a) The percent of drug (TO901317) retained in sHDL nanoparticles over time. (b) The percent of drug (TO901317) released into the release medium over time.

All publications and patents mentioned in the above specification are herein incorporated by reference. Various modifications and variations of the described method and system of the invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. Indeed, various modifications of the described modes for carrying out the invention that are obvious to those skilled in the relevant fields are intended to be within the scope of the present invention.

CLAIMS

We Claim:

- 5 1. A method for preparing a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA) comprising
 - combining at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture;
 - 10 lyophilizing the mixture to produce a dried mixture;
 - hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture;
 - thermocycling the aqueous mixture above and below the phospholipid transition temperature to produce a sHDL-TA;
 - wherein the therapeutic agent is configured to treat a cardiovascular disorder;
 - wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.
- 15 2. The method of Claim 1, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).
- 20 3. The method of Claim 1, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.
4. The method of Claim 3, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.
- 25 5. The method of Claim 1, wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-

maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

6. The method of Claim 1, wherein the therapeutic agent is selected from the group
 5 consisting of a liver X receptor agonist, a retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g.,
 10 candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), antiocoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol,
 15 bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone,
 20 polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amilorone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine,
 25 procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

30 7. The method of Claim 6,
 wherein the liver X receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-

hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid,
 5 SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX),
 10 Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

8. The method of Claim 1,
 wherein the solvent is glacial acetic acid,
 15 wherein the aqueous buffer PBS,
 wherein the thermocycling occurs between 25 and 50°C.

9. The method of Claim 1, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

10. The method of Claim 1, further comprising combining an imaging agent with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture.

11. The method of Claim 10, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

12. A composition comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA),

wherein the sHDL-TA comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein,
 wherein the therapeutic agent is configured to treat a cardiovascular disorder;

wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

13. The composition of Claim 12,

wherein the HDL apolipoprotein is selected from the group consisting of

5 apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4),
apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

wherein the phospholipid is selected from the group consisting of

dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-
(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-
10 phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-
maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-
[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-
phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-
octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-
15 carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine,
phosphatidylethanolamine, and combinations thereof.

14. The composition of Claim 12, wherein the HDL apolipoprotein mimetic is an ApoA-I
mimetic.

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15. The composition of Claim 14, wherein the ApoA-I mimetic is described by any of
SEQ ID NOs: 1-336.

16. The composition of Claim 12, wherein the average particle size of the sHDL-TA
25 nanoparticle is between 6-20 nm.

17. The composition of Claim 12, wherein the therapeutic agent is selected from the
group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-
phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril,
30 Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist
medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin,
guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g.,
candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan,

- valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol,
- 5 bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone,
- 10 polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colessevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine,
- 15 procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).
- 20 18. The composition of Claim 17,
- wherein the Liver X Receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenxoxocinone and (-)bischloroanthrabenxoxocinone ((-)-BABX);
- 25 wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;
- wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-
- 30 3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenxoxocinone, (-)bischloroanthrabenxoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

19. The composition of Claim 1, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein.

5

20. The composition of Claim 19, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

21. A method of treating a subject having a cardiovascular related disorder, comprising administering to the subject a therapeutically effective amount of a composition comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA), wherein the sHDL-TA comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein, wherein the therapeutic agent is configured to treat a cardiovascular disorder, wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

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22. The method of Claim 21, wherein the cardiovascular related disorder is one or more disorders selected from the group consisting of atherosclerosis, coronary artery disease, cardiomyopathy, hypertensive heart disease, heart failure, pulmonary heart disease, cardiac dysrhythmias, inflammatory heart disease (e.g., endocarditis, inflammatory cardiomegaly, myocarditis), valvular heart disease, cerebrovascular disease, peripheral arterial disease, congenital heart disease, and rheumatic heart disease.

23. The method of Claim 21,
wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-

octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(*p*-maleimidomethyl)cyclohexanecarboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

5 24. The method of Claim 21, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

25. The method of Claim 24, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

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26. The method of Claim 21, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

27. The method of Claim 21, wherein the therapeutic agent is selected from the group
 15 consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g.,
 20 candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), antiocoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol,
 25 bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone,
 30 polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g.,

amidarone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

28. The method of Claim 27,

wherein the Liver X Receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

29. The method of Claim 21, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein.

30. The method of Claim 29, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

31. A method of targeting a therapeutic agent to an atheromatous plaque region within a biological sample comprising exposing a therapeutic agent encapsulated within a sHDL nanoparticle to a biological sample such that the therapeutic agent encapsulated within the sHDL nanoparticle accumulates at atheromatous plaque regions within the biological sample.

32. The method of Claim 31, wherein production of the therapeutic agent encapsulated within a synthetic HDL (sHDL) nanoparticle comprises:

combining at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture;
 5 lyophilizing the mixture to produce a dried mixture;
 hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture;
 thermocycling the aqueous mixture above and below the phospholipid transition temperature to produce a therapeutic agent encapsulated within a sHDL nanoparticle;
 wherein the therapeutic agent is configured to treat a cardiovascular disorder;
 10 wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

33. The method of Claim 32, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).

34. The method of Claim 32, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

35. The method of Claim 34, wherein the ApoA-I mimetic is described by any of SEQ ID
 20 NOs: 1-336.

36. The method of Claim 32, wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-
 25 glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-
 30 maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

37. The method of Claim 32, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), kruppel-like factor 14 agonist (e.g., perhexiline), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, 5 alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), antiocoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, 10 tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone 15 blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., 20 atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators 25 (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

38. The method of Claim 37,
 wherein the Liver X Receptor agonist is selected from the group consisting of
 30 TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenxoxocinone and (-)bischloroanthrabenxoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)-anthrabenzoxocinone, (-)-bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

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39. The method of Claim 32,
wherein the solvent is glacial acetic acid,
wherein the aqueous buffer PBS,
wherein the thermocycling occurs between 25 and 50°C.

15

40. The method of Claim 32, wherein the average particle size of the therapeutic agent encapsulated within the sHDL nanoparticle is between 6-20 nm.

41. The method of Claim 32, further comprising combining an imaging agent with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture.

20

42. The method of Claim 41, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

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43. A method of upregulating ABCA1 and ABCG1 expression within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the exposing results in upregulation of ABCA1 and ABCG1 expression within the biological sample,

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wherein the sHDL-TA nanoparticle comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein,

wherein the therapeutic agent is a liver X receptor agonist and/or a retinoid X receptor agonist;

wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

44. The method of Claim 43,

wherein the HDL apolipoprotein is selected from the group consisting of

5 apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4),
apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

wherein the phospholipid is selected from the group consisting of

dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-
(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-
10 phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-
maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-
[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-
phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-
octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-
15 carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine,
phosphatidylethanolamine, and combinations thereof.

45. The method of Claim 43, wherein the HDL apolipoprotein mimetic is an ApoA-I
mimetic.

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46. The method of Claim 44, wherein the ApoA-I mimetic is described by any of SEQ ID
NOs: 1-336.

47. The method of Claim 43, wherein the average particle size of the sHDL-TA
25 nanoparticle is between 6-20 nm.

48. The method of Claim 43,

wherein the liver X receptor agonist is selected from the group consisting of

TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-
30 hydroxy-choleamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)
anthrabenzoquinone and (-)-bischloroanthrabenzoquinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

10

49. The method of Claim 43, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one liver X receptor agonist and/or at least one retinoid X receptor agonist, and at least one HDL apolipoprotein.

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50. The method of Claim 49, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

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51. The method of Claim 43, wherein the upregulation of ABCA1 and ABCG1 expression within the biological sample occurs within macrophages associated with atheromatous plaque regions within the biological sample.

25

52. The method of Claim 51, wherein the upregulation of ABCA1 and ABCG1 expression within the biological sample further induces cholesterol efflux from the macrophages associated with atheromatous plaque regions within the biological sample.

30

53. The method of Claim 43, wherein the biological sample is an *in vitro* biological sample.

54. The method of Claim 43, wherein the biological sample comprises *ex vivo* cells.

55. The method of Claim 43, wherein the biological sample is an *in vivo* biological sample.

56. A method of inducing cholesterol efflux within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the biological sample comprises cells comprising macrophages, wherein the exposing results in cholesterol efflux from the macrophages within the biological sample,

5 wherein the sHDL-TA nanoparticle comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein,

wherein the therapeutic agent is a liver X receptor agonist and/or a retinoid X receptor agonist;

wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

10 57. The method of Claim 56,

wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

15 wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-
20 [4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

25 58. The method of Claim 56, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

59. The method of Claim 58, wherein the ApoA-I mimetic is described by any of SEQ ID
30 NOs: 1-336.

60. The method of Claim 56, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

61. The method of Claim 56,

wherein the liver X receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-
5 hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

10 wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid,
15 SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

62. The method of Claim 56, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor, and at least one HDL apolipoprotein.

20

63. The method of Claim 62, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

64. The method of Claim 56, wherein the cholesterol efflux from the macrophages occurs
25 at macrophages associated with atheromatous plaque regions within the biological sample.

65. The method of Claim 64, wherein the cholesterol efflux within the biological sample further induces upregulation of ABCA1 and ABCG1 expression within the macrophages associated with atheromatous plaque regions within the biological sample.

30

66. The method of Claim 56, wherein the biological sample is an in vitro biological sample or an in vivo biological sample.

67. The method of Claim 56, wherein the biological sample comprises ex vivo cells.

68. A method of treating atherosclerotic lesions within a subject, comprising
administering to the subject a composition comprising a therapeutically effective
5 amount of a composition comprising a synthetic HDL – therapeutic agent nanoparticle
(sHDL-TA), wherein the sHDL-TA comprises a mixture of at least one phospholipid, at least
one liver X receptor agonist, at least one retinoid X receptor, and at least one HDL
apolipoprotein, wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic,
wherein the administering results in accumulation of the sHDL-TA at atherosclerotic
10 lesions within the subject,
wherein accumulation of the sHDL-TA at the atherosclerotic lesions within the
subject results in cholesterol efflux from macrophages at the atherosclerotic lesions.

69. The method of Claim 68, wherein administering the composition comprising a
15 sHDL-TA nanoparticle results in reduced liver related lipogenesis in comparison to
administration of a composition comprising a liver X receptor agonist.

70. The method of Claim 69, wherein the liver related lipogenesis is measured by
SREBP1c expression.

71. The method of Claim 68, wherein the cholesterol efflux from macrophages at the
atherosclerotic lesions further involves upregulation of ABCA1 and ABCG1 expression
within the macrophages.

72. The method of Claim 68,
wherein the HDL apolipoprotein is selected from the group consisting of
apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4),
apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),
wherein the phospholipid is selected from the group consisting of
30 dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-
(2-pyridylidithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-
phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-
maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-

[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine,
 5 phosphatidylethanolamine, and combinations thereof.

73. The method of Claim 68, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

10 74. The method of Claim 73, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

75. The method of Claim 68, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

15

76. The method of Claim 68,
 wherein the Liver X Receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)
 20)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

25 wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

30

77. The method of Claim 68, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor, and at least one HDL apolipoprotein.

78. The method of Claim 77, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

5 79. A method of inducing nitric oxide efflux within a biological sample, comprising exposing a composition comprising a synthetic HDL-TA nanoparticle to the biological sample, wherein the biological sample comprises cells comprising endothelial cells, wherein the exposing results in nitric oxide efflux from the endothelial cells within the biological sample,

10 wherein the sHDL-TA nanoparticle comprises a mixture of at least one phospholipid, at least one therapeutic agent, and at least one HDL apolipoprotein, wherein the therapeutic agent is sphingosine-1-phosphate; wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

15 80. The method of Claim 79, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

20 wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-sn-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

30 81. The method of Claim 79, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

82. The method of Claim 81, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

83. The method of Claim 79, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

84. The method of Claim 79, further comprising an imaging agent within the sHDL-TA mixture of at least one phospholipid, at least one liver X receptor agonist, at least one retinoid X receptor and at least one HDL apolipoprotein.

85. The method of Claim 84, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

86. The method of Claim 79, wherein the biological sample is an *in vitro* biological sample.

87. The method of Claim 79, wherein the biological sample comprises *ex vivo* cells.

88. The method of Claim 79, wherein the biological sample is an *in vivo* biological sample.

89. A method of detecting the presence of atherosclerotic lesions in a subject, comprising administering to the subject compositions comprising synthetic HDL – imaging agent (sHDL-IA) nanoparticles, wherein the synthetic HDL-IA nanoparticles accumulate at atherosclerotic lesions, wherein the sHDL-IA nanoparticles comprise a mixture of at least one phospholipid, at least one imaging agent, and at least one HDL apolipoprotein, imaging the amount and location of the sHDL-IA within the subject, wherein determination of imaging at vascular regions indicates the presence of atherosclerotic lesions within the subject,

wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E),

wherein the phospholipid is selected from the group consisting of
 dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-
 (2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-
 phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-
 5 maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-
 [4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-
 phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-
 octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-
 carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine,
 10 phosphatidylethanolamine, and combinations thereof.

90. The method of Claim 89, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

15 91. The method of Claim 90, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

92. The method of Claim 89, wherein the average particle size of the sHDL-IA nanoparticle is between 6-20 nm.

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93. The method of Claim 89, further comprising combining a therapeutic agent with the mixture of at least one phospholipid, at least one imaging agent, and at least one HDL apolipoprotein.

25 94. The method of Claim 93, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin,
 30 guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel,

eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers
 (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol,
 bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine,
 felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine),
 5 diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid,
 torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide,
 chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone,
 polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g.,
 cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate),
 10 statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective
 cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g.,
 amilorone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine,
 procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g.,
 alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors,
 15 vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide
 mononitrate, nitroglycerin).

95. The method of Claim 94,

wherein the Liver X Receptor agonist is selected from the group consisting of
 20 TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-
 hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)
 anthrabenxoxocinone and (-)bischloroanthrabenxoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of
 Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid,
 25 SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected
 from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-
 3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-
 hydroxycholesterol, (-)anthrabenxoxocinone, (-)bischloroanthrabenxoxocinone ((-)-BABX),
 30 Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid,
 SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

96. The method of Claim 89, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

97. The method of Claim 96, wherein the lipophilic near infrared fluorescent dye is DiD.

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98. A kit comprising,
at least one phospholipid,
at least one therapeutic agent, and
at least one HDL apolipoprotein.

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99. The kit of Claim 98, further comprising at least one imaging agent.

100. The kit of Claim 98, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), antiocoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesvelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amilorone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine,

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procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dintrate, isorbide mononitrate, nitroglycerin).

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101. The kit of Claim 100,

wherein the Liver X Receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

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wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

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102. The kit of Claim 98, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).

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103. The kit of Claim Claim 102, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

104. The kit of Claim 103, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

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105. The kit of Claim 98, wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-sn-glycero-3-

phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

106. A method for preparing a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA) comprising

combining at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture; lyophilizing the mixture to produce a dried mixture; hydrating the dried mixture in an aqueous buffer to produce an aqueous mixture; incubating the aqueous mixture above and below the phospholipid transition temperature to produce a sHDL-TA;

wherein the therapeutic agent is configured to treat a cardiovascular disorder;

wherein the HDL apolipoprotein is an HDL apolipoprotein mimetic.

107. The method of Claim 106, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II), apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).

108. The method of Claim 106, wherein the HDL apolipoprotein mimetic is an ApoA-I mimetic.

109. The method of Claim 108, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

110. The method of Claim 106, wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-

N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9*Z*-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

111. The method of Claim 106, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colesevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

112. The method of Claim 111,

wherein the liver X receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

113. The method of Claim 106,

wherein the solvent is organic solvent,

wherein the aqueous buffer PBS,

wherein the incubating occurs between 35 and 55°C.

114. The method of Claim 106, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

115. The method of Claim 106, further comprising combining an imaging agent with the combining of at least one phospholipid having a transition temperature, at least one therapeutic agent, and at least one HDL apolipoprotein in a solvent to produce a mixture.

116. The method of Claim 115, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

117. A composition comprising a synthetic HDL – therapeutic agent nanoparticle (sHDL-TA),

wherein the sHDL comprises at least one HDL apolipoprotein and at least one phospholipid,

wherein the therapeutic agent is between 0.01 – 20% by weight of the sHDL-TA,

wherein the sHDL is between 80-99.99% by weight of the sHDL-TA.

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118. The composition of Claim 117, wherein the therapeutic agent is between 1-10% by weight of the sHDL-TA.

119. The composition of Claim 117, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II),
10 apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).

120. The composition of Claim 119, wherein the HDL apolipoprotein is an ApoA-I mimetic.

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121. The composition of Claim 120, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

122. The composition of Claim 117, wherein the phospholipid is selected from the group
20 consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-
25 glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol, phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

123. The composition of Claim 117, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril, Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist

medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin, reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfapyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine), diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colestesvelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate), statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amiloride, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors, vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

124. The composition of Claim 123,

wherein the liver X receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoquinone and (-)bischloroanthrabenzoquinone ((-)-BABX);

wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-

hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

5 125. The composition of Claim 117, wherein the average particle size of the sHDL-TA nanoparticle is between 6-20 nm.

126. A composition comprising a synthetic HDL – therapeutic agent-imaging agent nanoparticle (sHDL-TA/IA),

10 wherein the sHDL comprises at least one HDL apolipoprotein and at least one phospholipid,

wherein the therapeutic agent-imaging agent is between 0.01 – 20% by weight of the sHDL-TA/IA,

wherein the sHDL is between 80-99.99% by weight of the sHDL-TA/IA.

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127. The composition of Claim 126, wherein the therapeutic agent-imaging agent is between 1-10% by weight of the sHDL-TA/IA.

128. The composition of Claim 126, wherein the HDL apolipoprotein is selected from the group consisting of apolipoprotein A-I (apo A-I), apolipoprotein A-II (apo A-II),
20 apolipoprotein A4 (apo A4), apolipoprotein Cs (apo Cs), and apolipoprotein E (apo E).

129. The composition of Claim 128, wherein the HDL apolipoprotein is an ApoA-I mimetic.

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130. The composition of Claim 129, wherein the ApoA-I mimetic is described by any of SEQ ID NOs: 1-336.

131. The composition of Claim 126, wherein the phospholipid is selected from the group consisting of dipalmitoylphosphatidylcholine (DPPC), dioleoyl-*sn*-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio) propionate] (DOPE-PDP), 1,2-dipalmitoyl-*sn*-glycero-3-phosphothioethanol, 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-

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phosphoethanolamine-N-[4-(p-maleimidophenyl)butyramide], 1,2-dihexadecanoyl-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], 1,2-di-(9Z-octadecenoyl)-*sn*-glycero-3-phosphoethanolamine-N-[4-(p-maleimidomethyl)cyclohexane-carboxamide], phosphatidylcholine, phosphatidylinositol,
 5 phosphatidylserine, phosphatidylethanolamine, and combinations thereof.

132. The composition of Claim 126, wherein the therapeutic agent is selected from the group consisting of a liver X receptor agonist, retinoid X receptor agonist, sphingosine-1-phosphate (S1P), angiotensin-converting enzyme (ACE) inhibitors (e.g., benazepril, enalapril,
 10 Lisinopril, perindopril, Ramipril), adenosine, alpha blockers (alpha adrenergic antagonist medications) (e.g., clonidine, guanabenz, labetalol, phenoxybenzamine, terazosin, doxazosin, guanfacine, methyl dopa, prazosin), angiotensin II receptor blockers (ARBs) (e.g., candesartan, irbesartan, olmesartan medoxomil, telmisartan, eprosartan, losartan, tasosartan, valsartan), anticoagulants (e.g., heparin fondaparinux, warfarin, ardeparin, enoxaparin,
 15 reviparin, dalteparin, nadroparin, tinzaparin), antiplatelet agents (e.g., abciximab, clopidogrel, eptifibatide, ticlopidine, cilostazol, dipyridamole, sulfinpyrazone, tirofiban), beta blockers (e.g., acebutolol, betaxolol, carteolol, metoprolol, penbutolol, propranolol, atenolol, bisoprolol, esmolol, nadolol, pindolol, timolol), calcium channel blockers (e.g., amlodipine, felodipine, isradipine, nifedipine, verapamil, diltiazem, nicardipine, nimodipine, nisoldipine),
 20 diuretics, aldosterone blockers, loop diuretics (e.g., bumetanide, furosemide, ethacrynic acid, torsemide), potassium-sparing diuretics, thiazide diuretics (e.g., chlorothiazide, chlorthalidone, hydrochlorothiazide, hydroflumethiazide, methyclothiazide, metolazone, polythiazide, quinethazone, trichlormethiazide), inotropics, bile acid sequestrants (e.g., cholestyramine, colestipol, colessevelam), fibrates (e.g., clofibrate, gemfibrozil, fenofibrate),
 25 statins (e.g., atorvastatin, lovastatin, simvastatin, fluvastatin, pravastatin), selective cholesterol absorption inhibitors (e.g., ezetimibe), potassium channel blockers (e.g., amilorone, ibutilide, dofetilide), sodium channel blockers (e.g., disopyramide, mexiletine, procainamide, quinidine, flecainide, moricizine, propafenone), thrombolytic agents (e.g., alteplase, reteplase, tenecteplase, anistreplase, streptokinase, urokinase), vasoconstrictors,
 30 vasodilators (e.g., hydralazine, minoxidil, mecamlamine, isorbide dinitrate, isorbide mononitrate, nitroglycerin).

133. The composition of Claim 132,

wherein the liver X receptor agonist is selected from the group consisting of TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone and (-)bischloroanthrabenzoxocinone ((-)-BABX);

5 wherein the retinoid X receptor agonist is selected from the group consisting of Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506;

10 wherein the combined compounds including LXR and RXR agonists are selected from TO901317, ATI-111, LXR-623, XL-652, hypocholamide, GW3965, N,N-dimethyl-3beta-hydroxy-cholenamide (DMHCA), 22(R)-hydroxycholesterol, 24(S)-hydroxycholesterol, (-)anthrabenzoxocinone, (-)bischloroanthrabenzoxocinone ((-)-BABX), Bexarotene, CD3254, Docosahexaenoic acid, fluorobexarotene, isotretinoin, retinoic acid, SR11237, fenretinide, HX630, liarozole dihydrochloride, LG100754 and LG101506.

15 134. The composition of Claim 126, wherein the average particle size of the sHDL-TA/IA nanoparticle is between 6-20 nm.

135. The composition of Claim 126, wherein the imaging agent is a lipophilic near infrared fluorescent dye or a nuclear imaging agent.

20

REPLACEMENT SHEET

FIG. 1

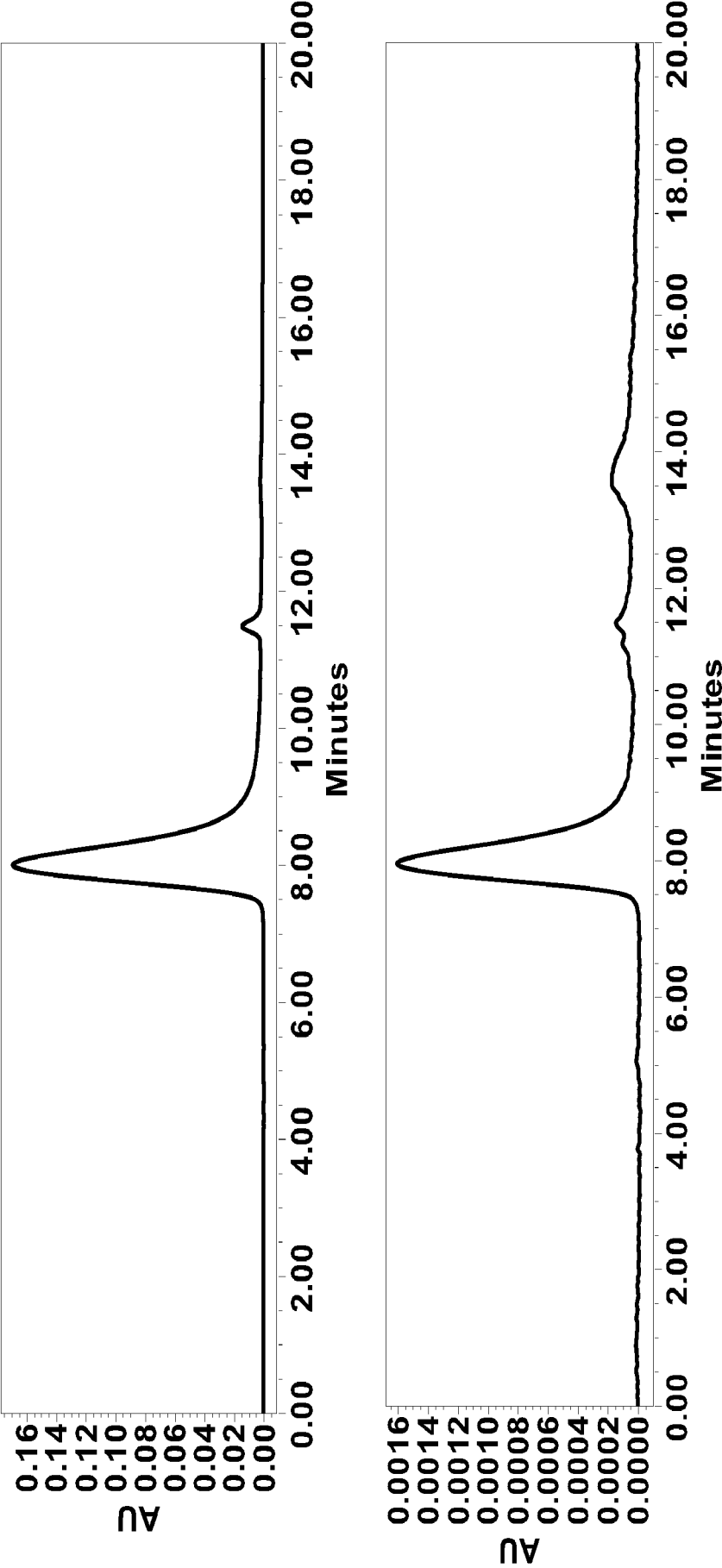
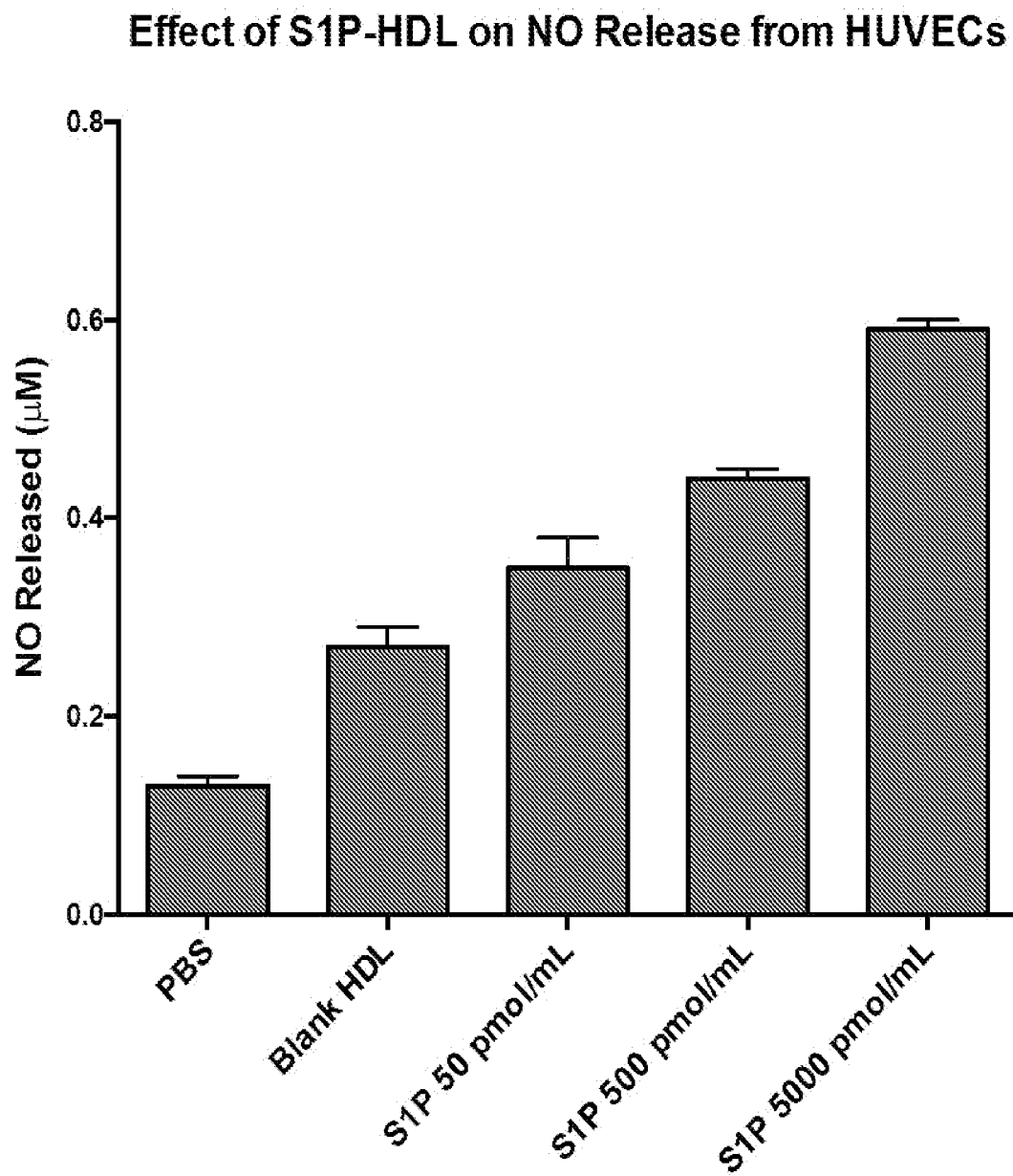


FIG. 2



HUVECs were treated with 1.0 mg/mL HDL (22A:DPPC, 1:2 w/w) containing different concentrations of S1P and released Nitric Oxide was measured in supernatants by ozone chemiluminescence. Blank 22A:DPPC HDL (1.0 mg/mL) and PBS were used as controls.

REPLACEMENT SHEET

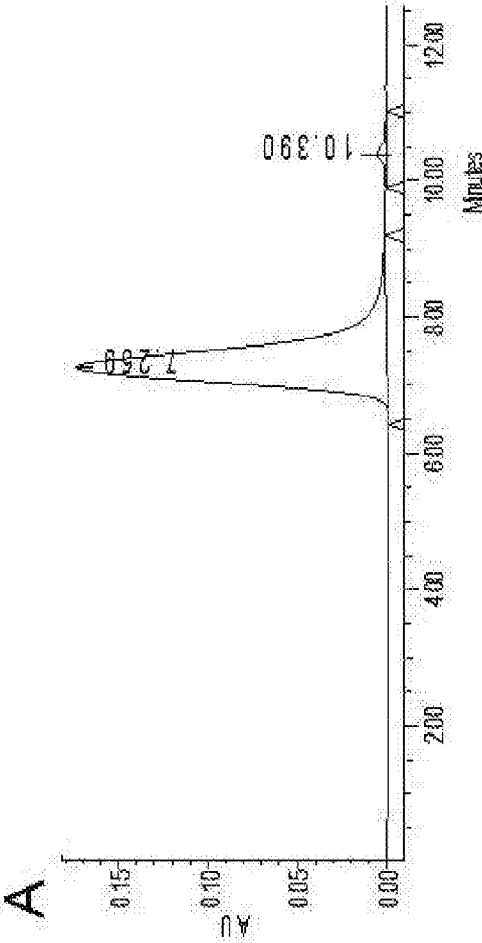


FIG. 3

B

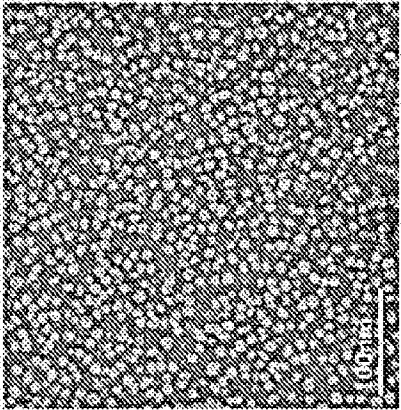


FIG. 3 Cont'd.

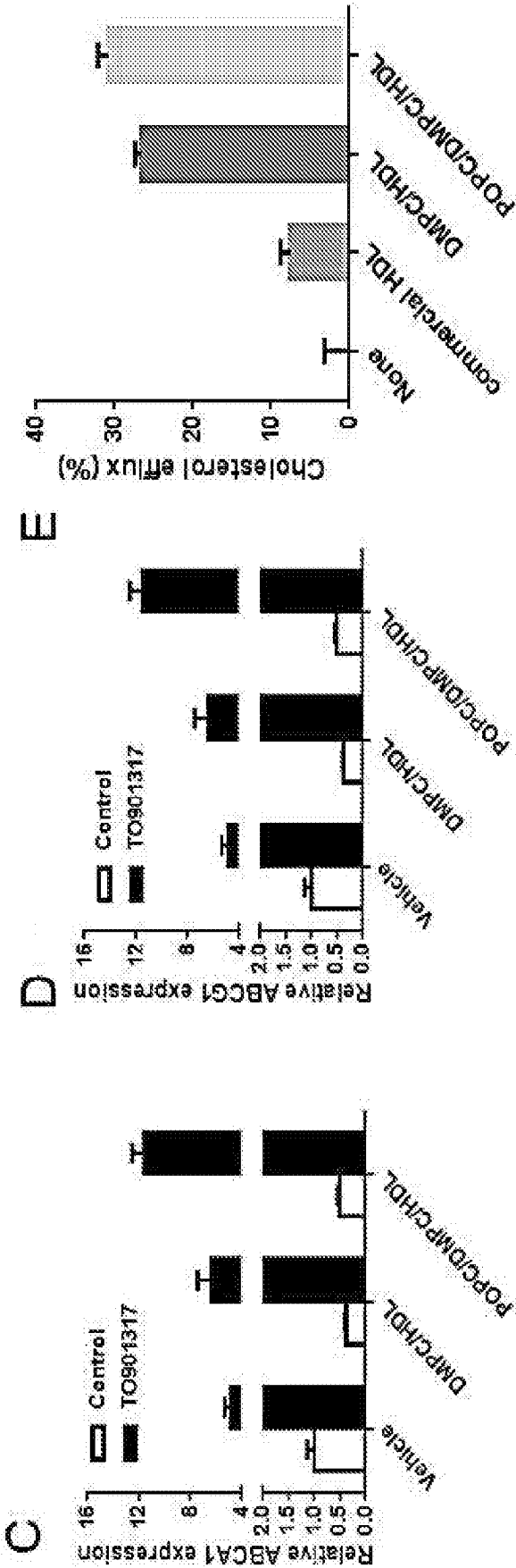


FIG. 4A

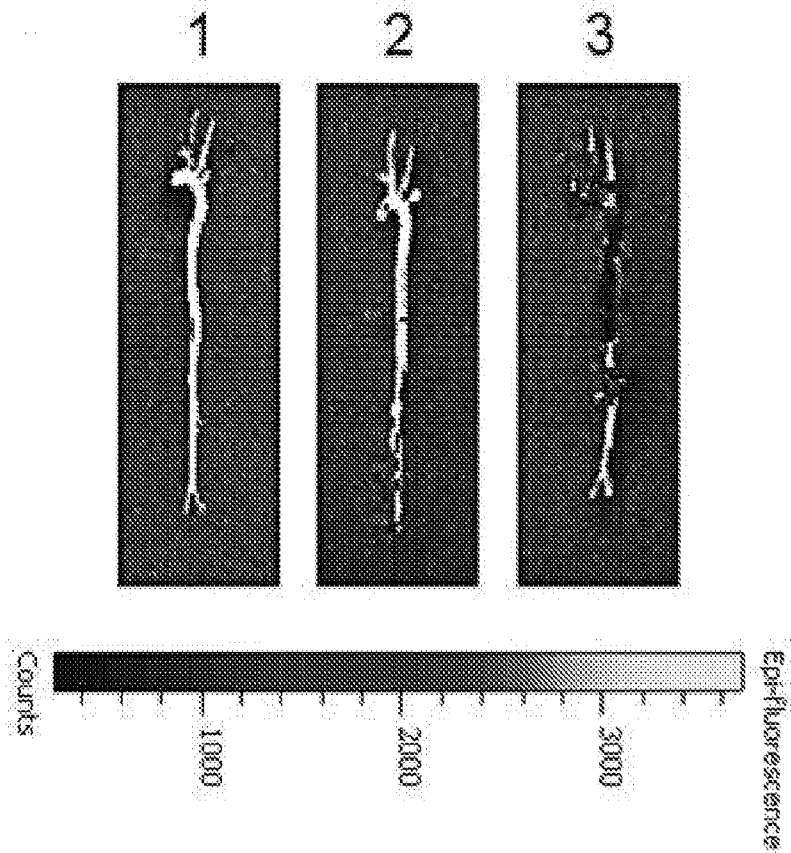


FIG. 4B

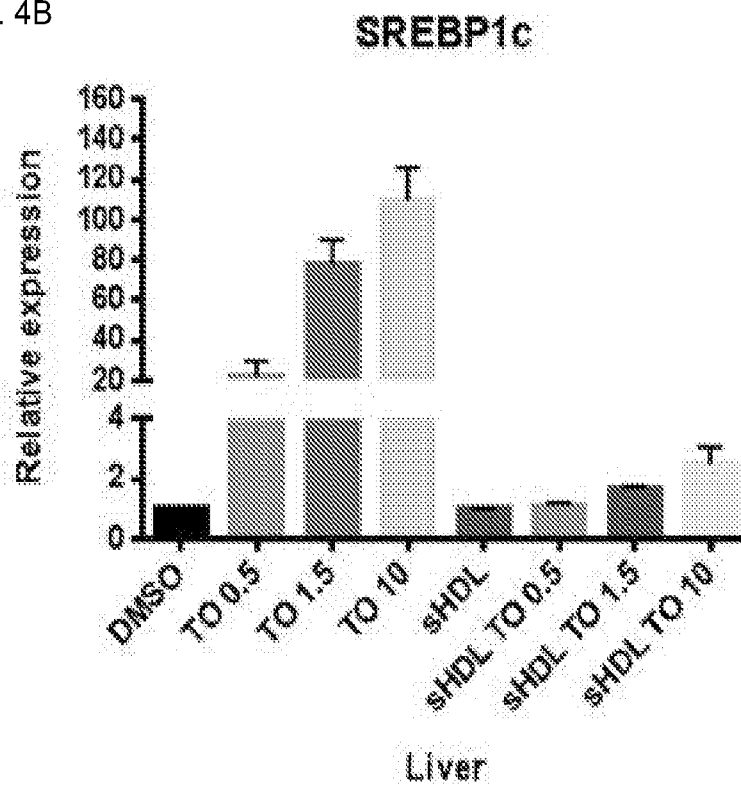


FIG. 5

TO901317-encapsulated sHDL particles upregulates ABCA1 and ABCG1
in macrophages

TO901317: 1 μ M

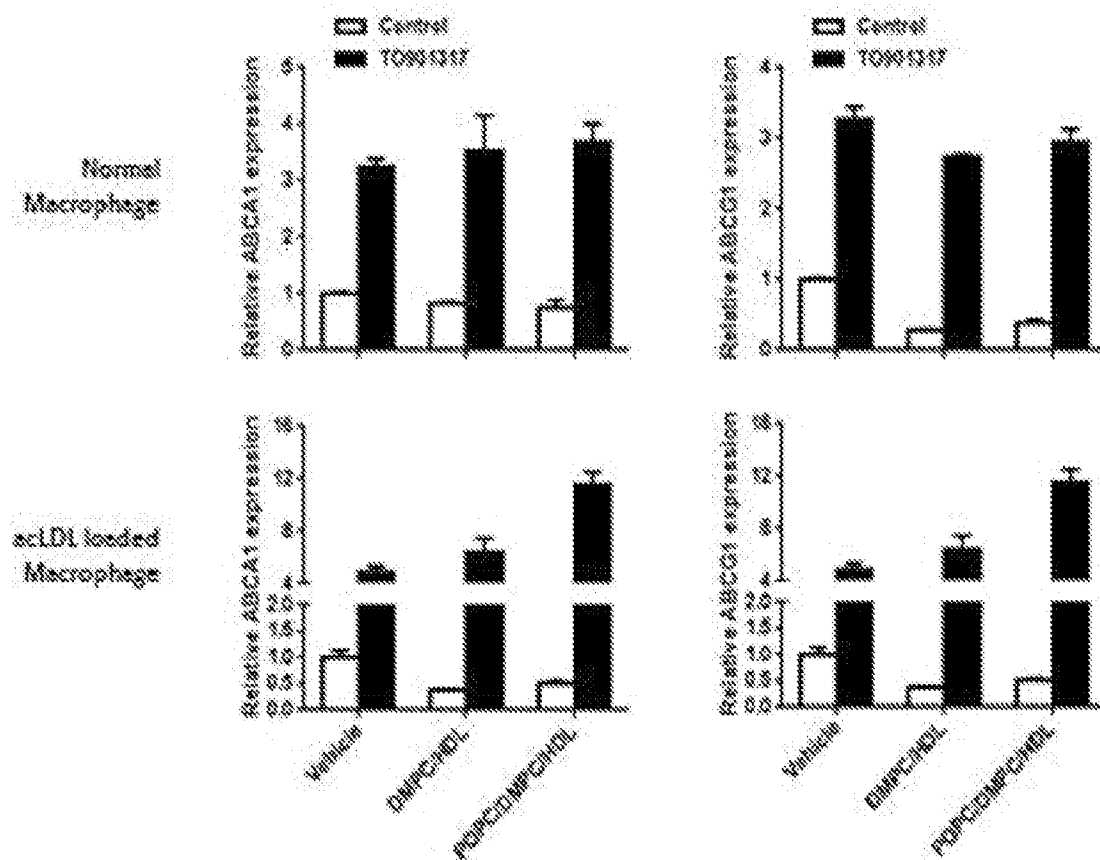


FIG. 6

TO901317-encapsulated sHDL particles upregulated ABCA1 expression in macrophages

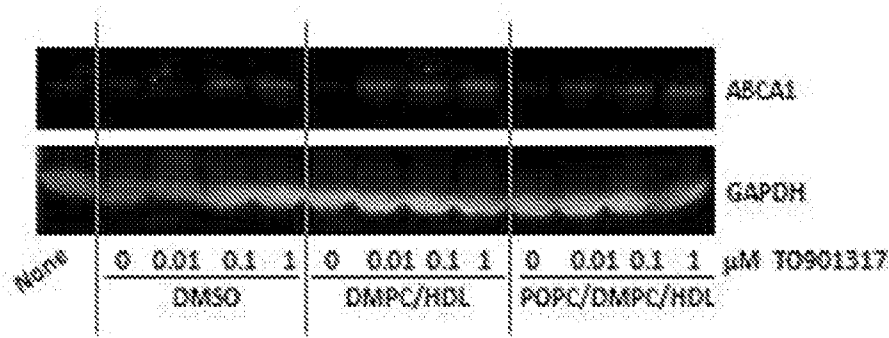


FIG. 7

TO901317-encapsulated sHDL particles enhance cholesterol efflux in macrophages

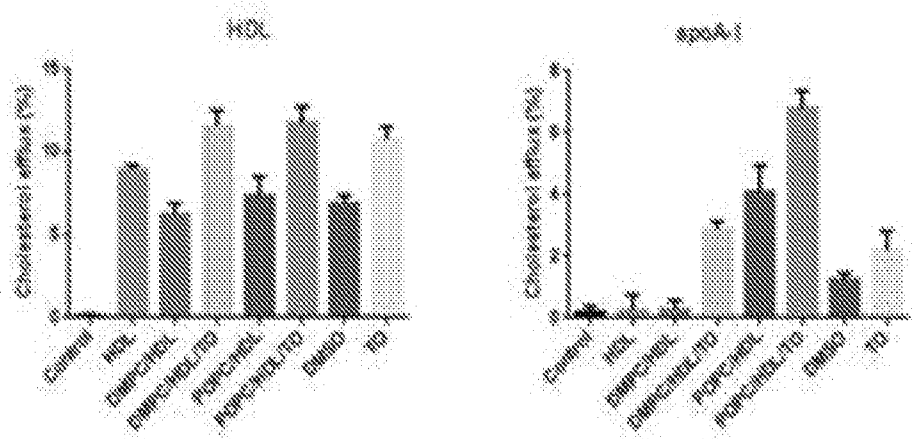


FIG. 8A

C57BL/6 mice once IP injection (24 h)		
DMSO n=3		
TO901317 n=3	0.5mg/kg	
TO901317 n=3	1.5mg/kg	
TO901317 n=3	10mg/kg	
sHDL n=3	50mg/kg 22A	
sHDL/TO n=3	50mg/kg 22A 0.5mg/kg	
sHDL/TO n=3	50mg/kg 22A 1.5mg/kg	
sHDL/TO n=3	50mg/kg 22A 3mg/kg	

Serum: HDL, LDL, TG

Liver: expression of lipogenesis related genes (SREBP1c, FAS, SCD1)

FIG. 8B

C57bl/6 mice treated with sHDL and/or LXR agonist
IP injection lipid profile 24 hours after injection

Group	Tot.Chol	HDL	Tg/y	LDL
DMSO	77	45	76	13
TO 0.5	110	46	94	7
TO 1.5	83	35	103	12
TO 10	116	34	110	7
sHDL	90	51	73	13
sHDL TO 0.5	80	44	76	12
sHDL TO 1.5	90	42	72	14
sHDL TO 3	89	43	72	10

FIG. 9

Effects of sHDL and/or TO901317 on the expression of lipogenesis related genes in vivo

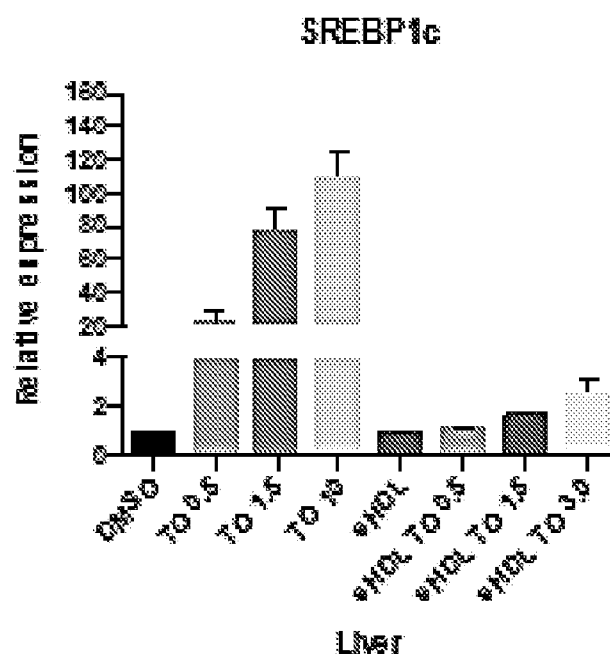
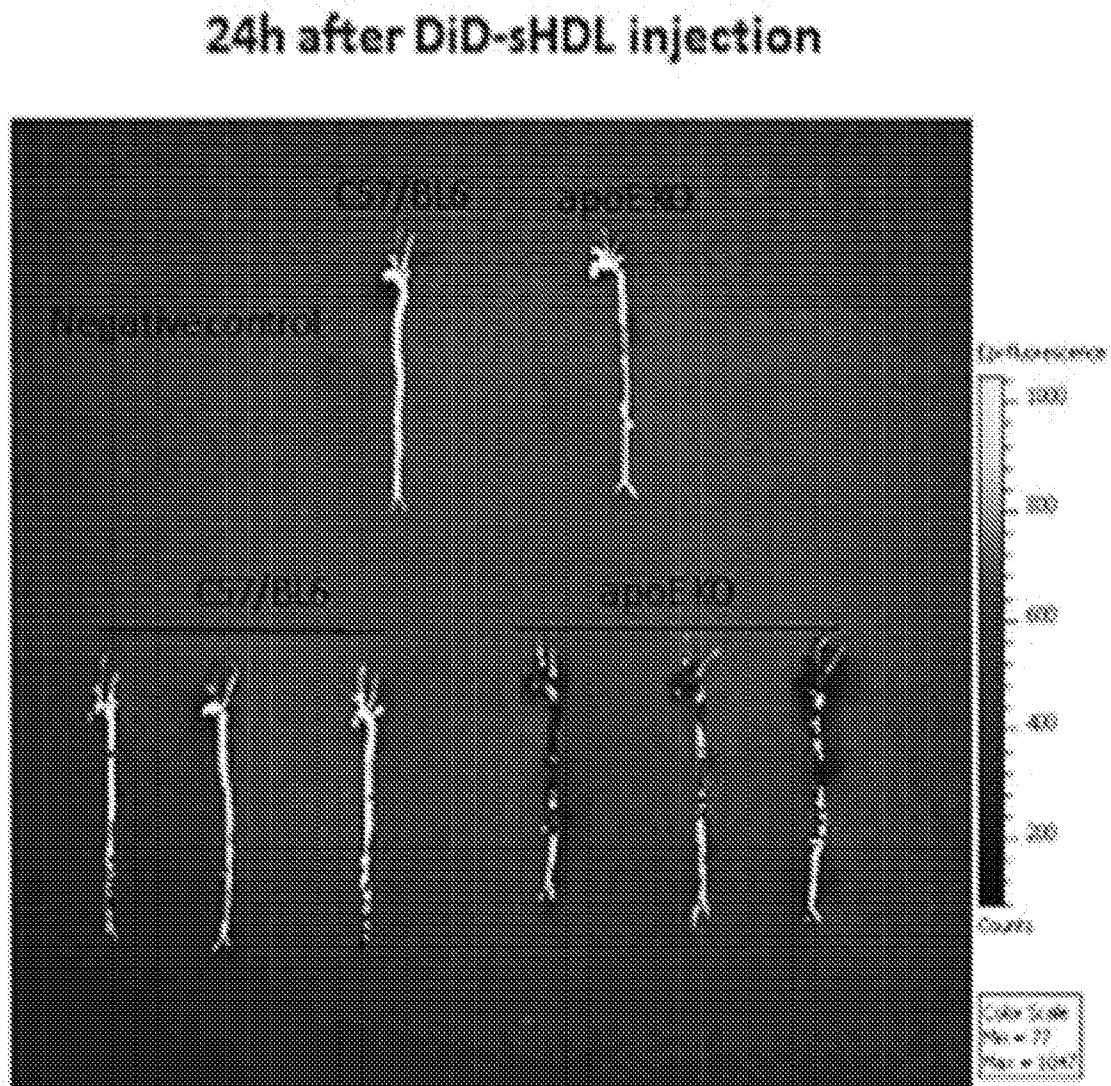


FIG. 10



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FIG. 11

Effects on the expression of LXR target genes in monocytes isolated from blood

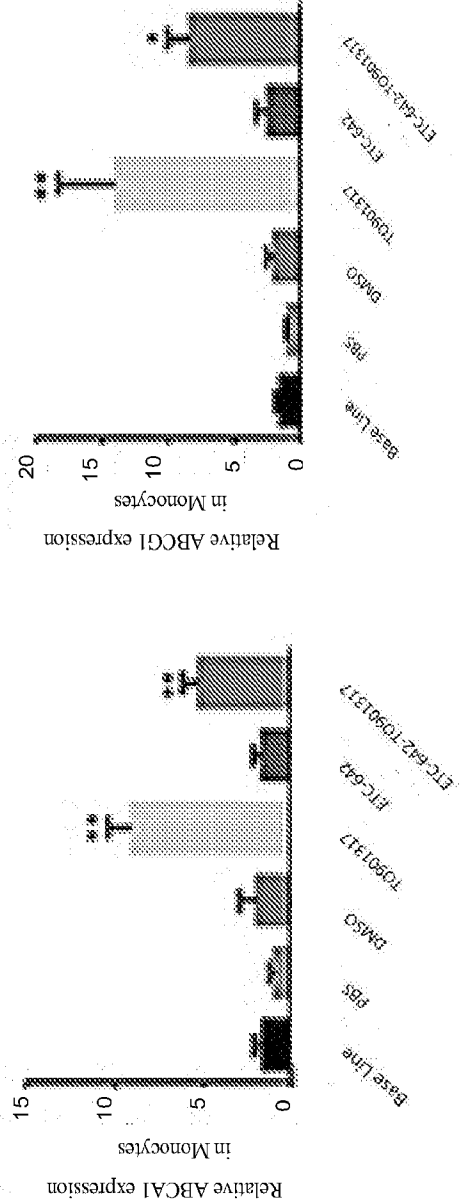


FIG. 12

Free TO1317 increased liver TG accumulation

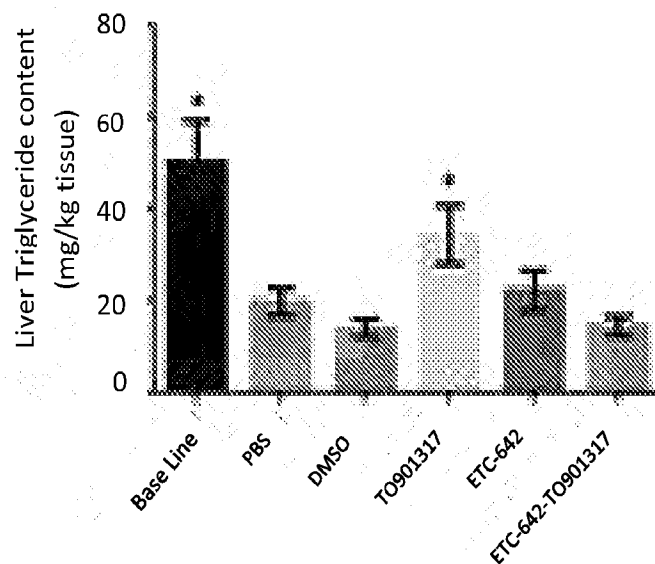


FIG. 13

sHDL-TO less potent than free TO in lipogenic gene
induction in the liver

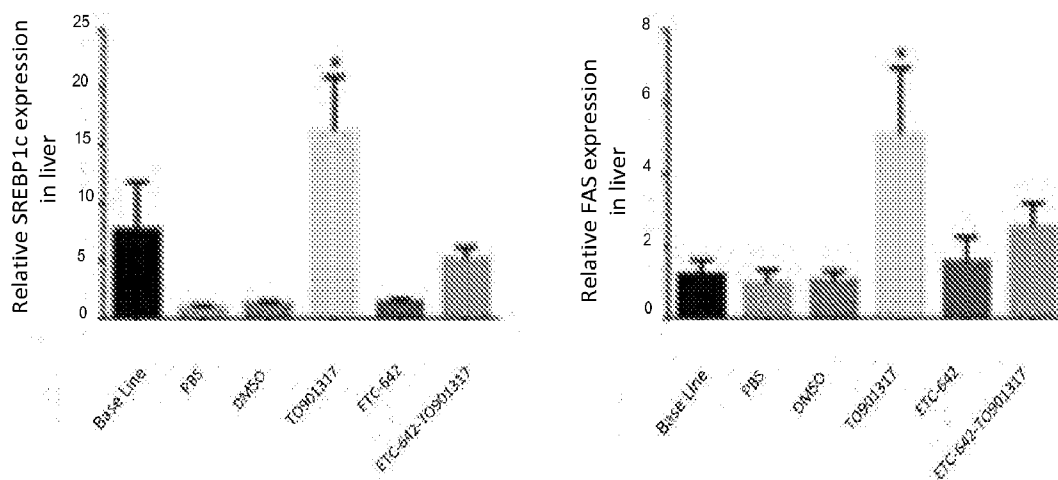


FIG. 14

TO901317-encapsulated sHDL nanoparticles induces
atherosclerosis regression *in vivo*

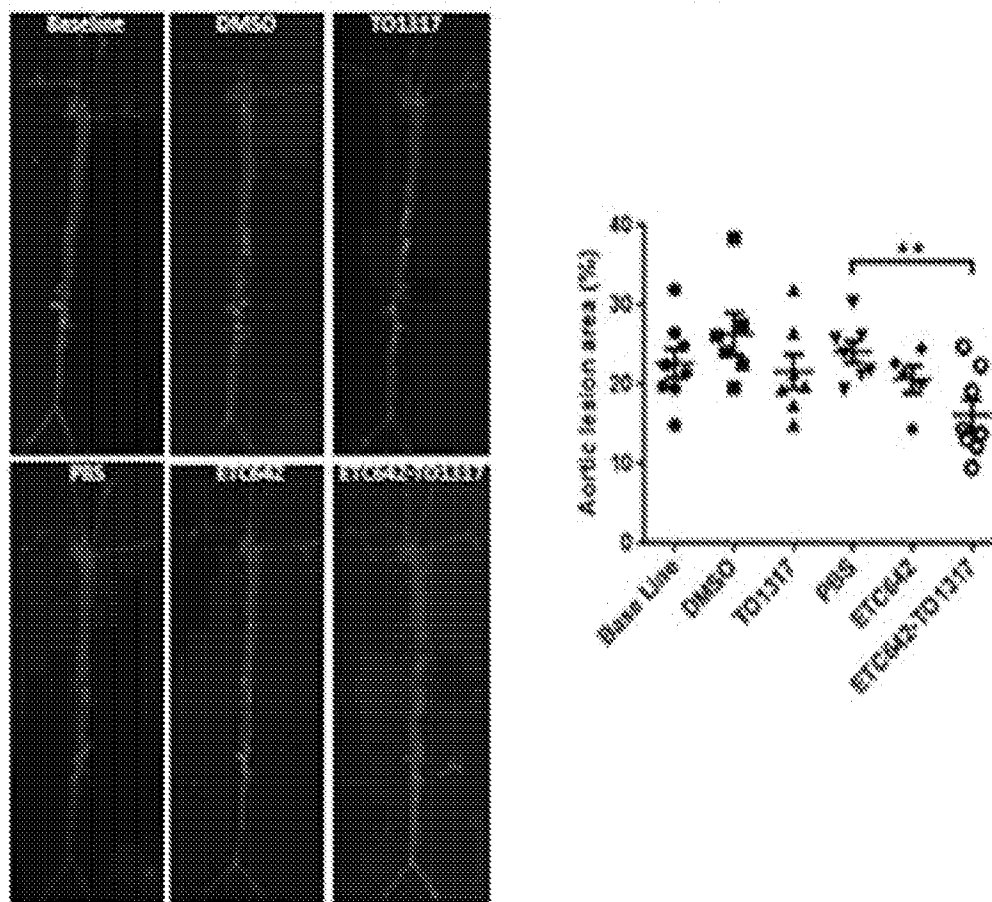


FIG. 15

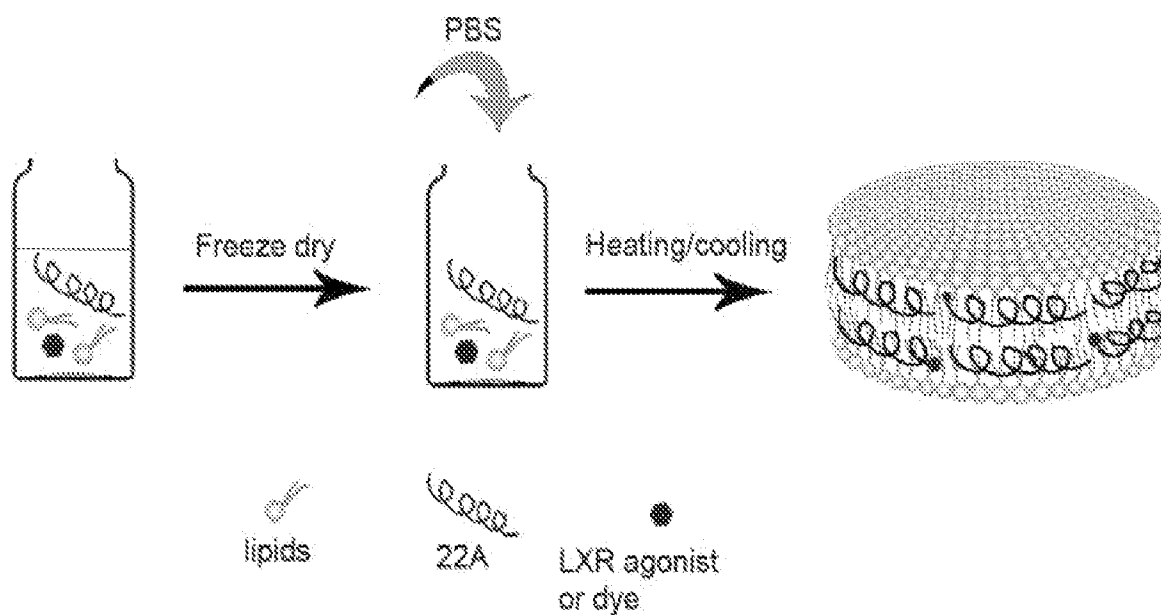


FIG. 16

Effects on ABCA1 expression in human macrophages (fold change)

	DMSO	Free compound	sHDL	sHDL-compound
TO901317	1	3.2	1	8.1
Rosiglitazone	1	2	1	2.9
CD3254	1	3.9	1	34.7

FIG. 17

Effects on ABCG1 expression in human macrophages (fold change)

	DMSO	Free compound	sHDL	sHDL-compound
TO901317	1	54.4	1	441
Rosiglitazone	1	3.4	1	2.6
CD3254	1	20.9	1	141.5

FIG. 18

Effects on SR-BI expression in human macrophages (fold change)

	DMSO	Free compound	sHDL	sHDL-compound
TO901317	1	1.3	1	4.5
Rosiglitazone	1	2.2	1	3.5
CD3254	1	1.9	1	4.6

FIG. 19

Effects on cholesterol efflux in macrophages

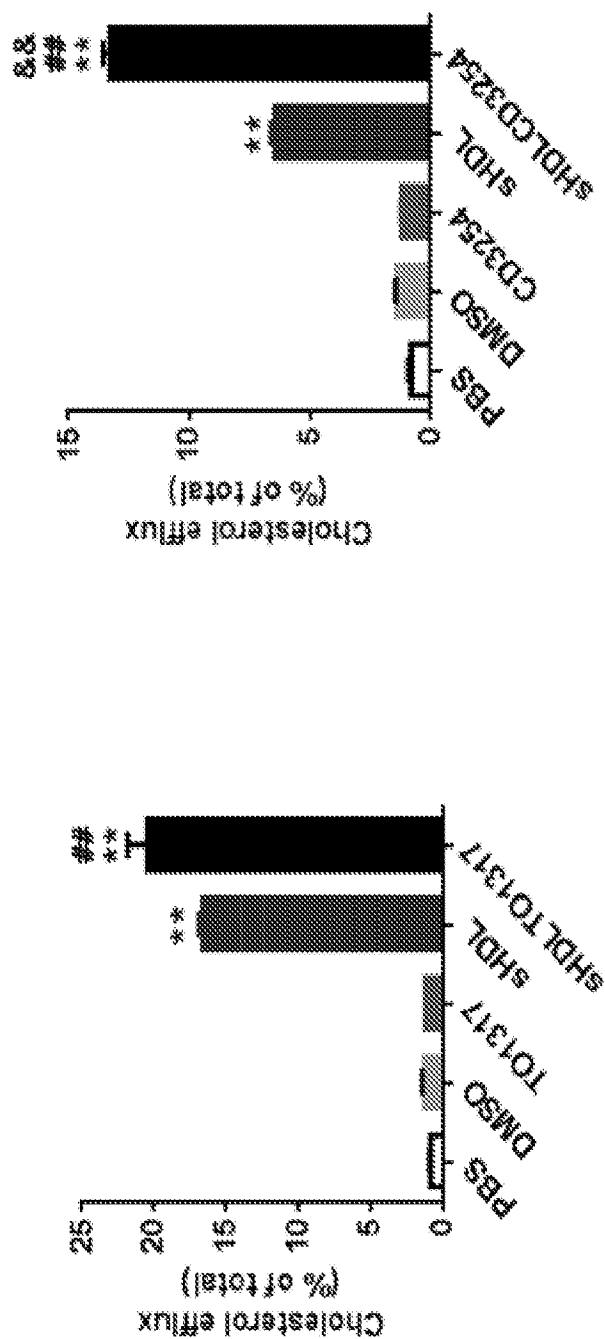


FIG. 20

Effects of LXR agonists on atherosclerosis progression

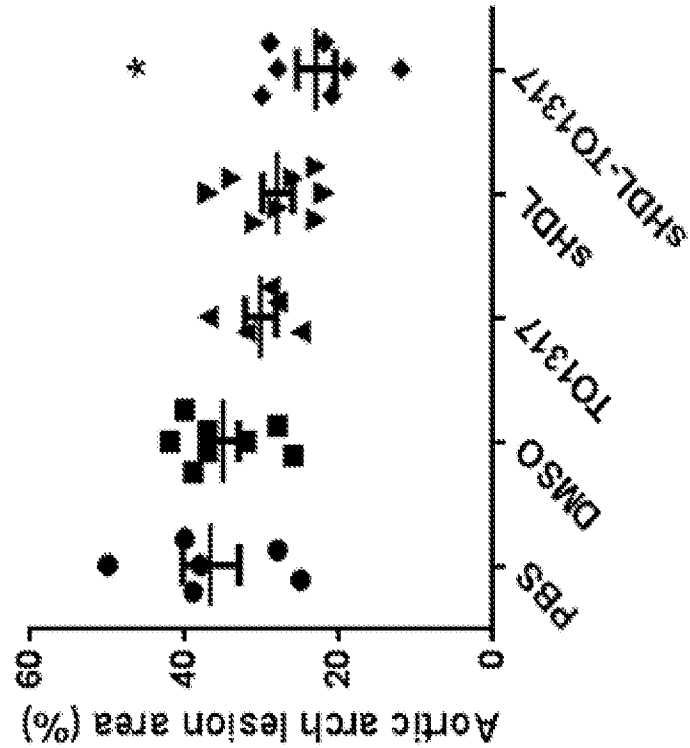


FIG. 21

Effects of RXR agonists on atherosclerosis progression

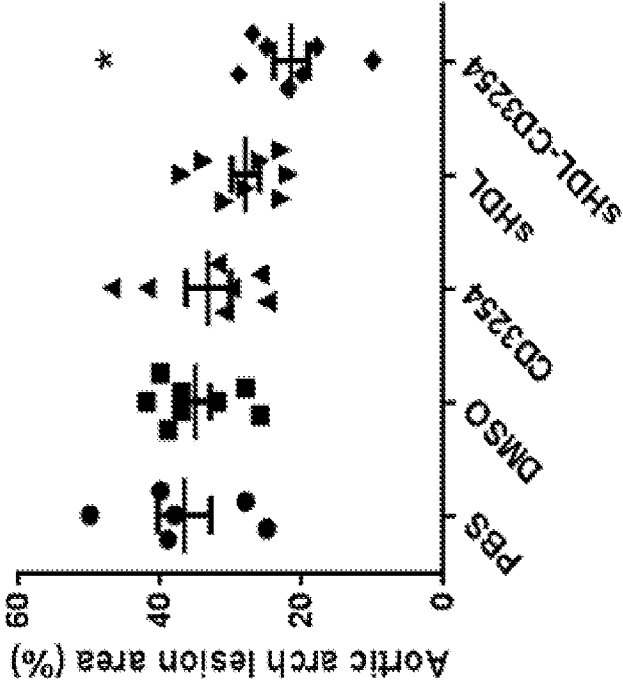


FIG. 22

Effects of LXR agonists on lipid profile in apoE-deficient mice

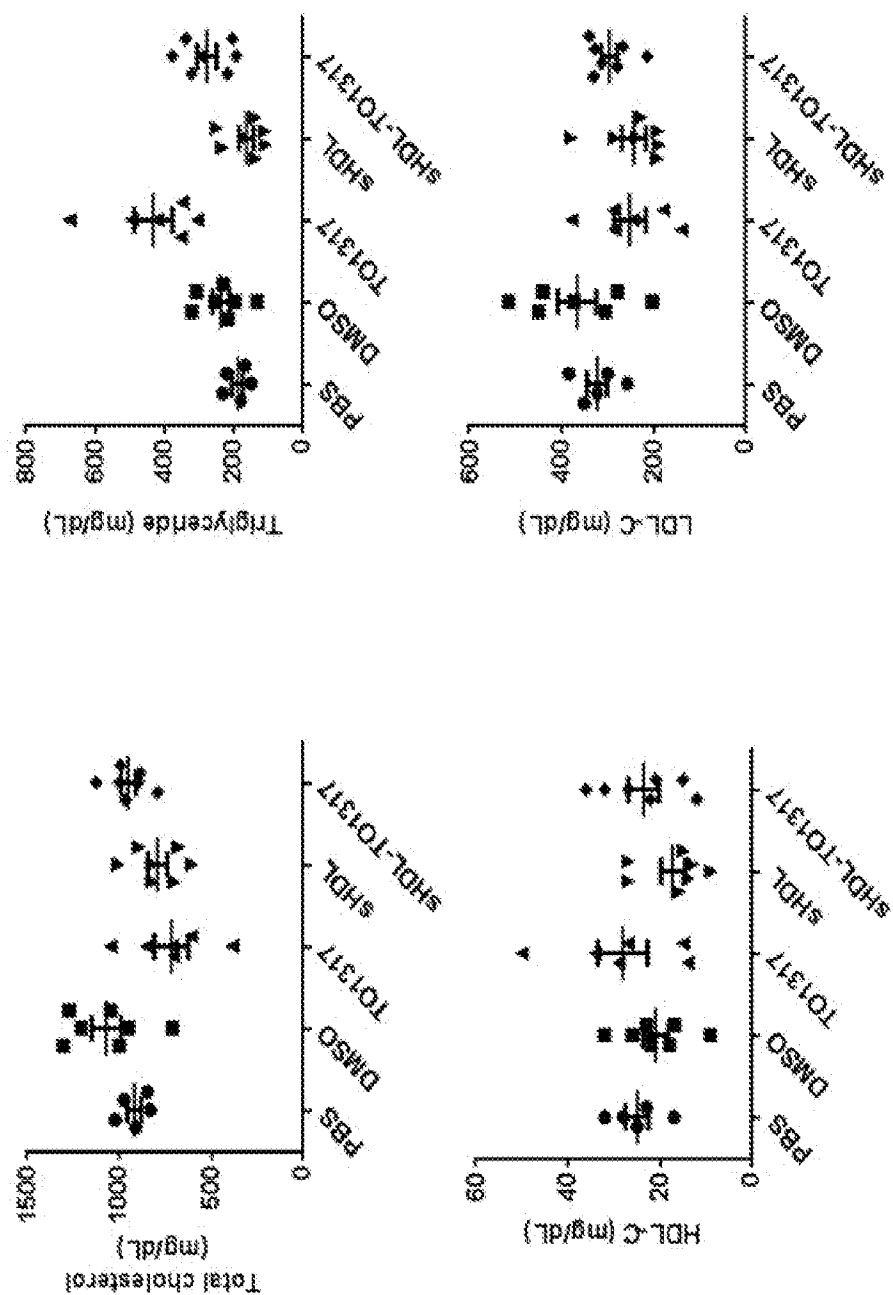


FIG. 23

Effects of RXR agonist on lipid profile in apoE-deficient mice

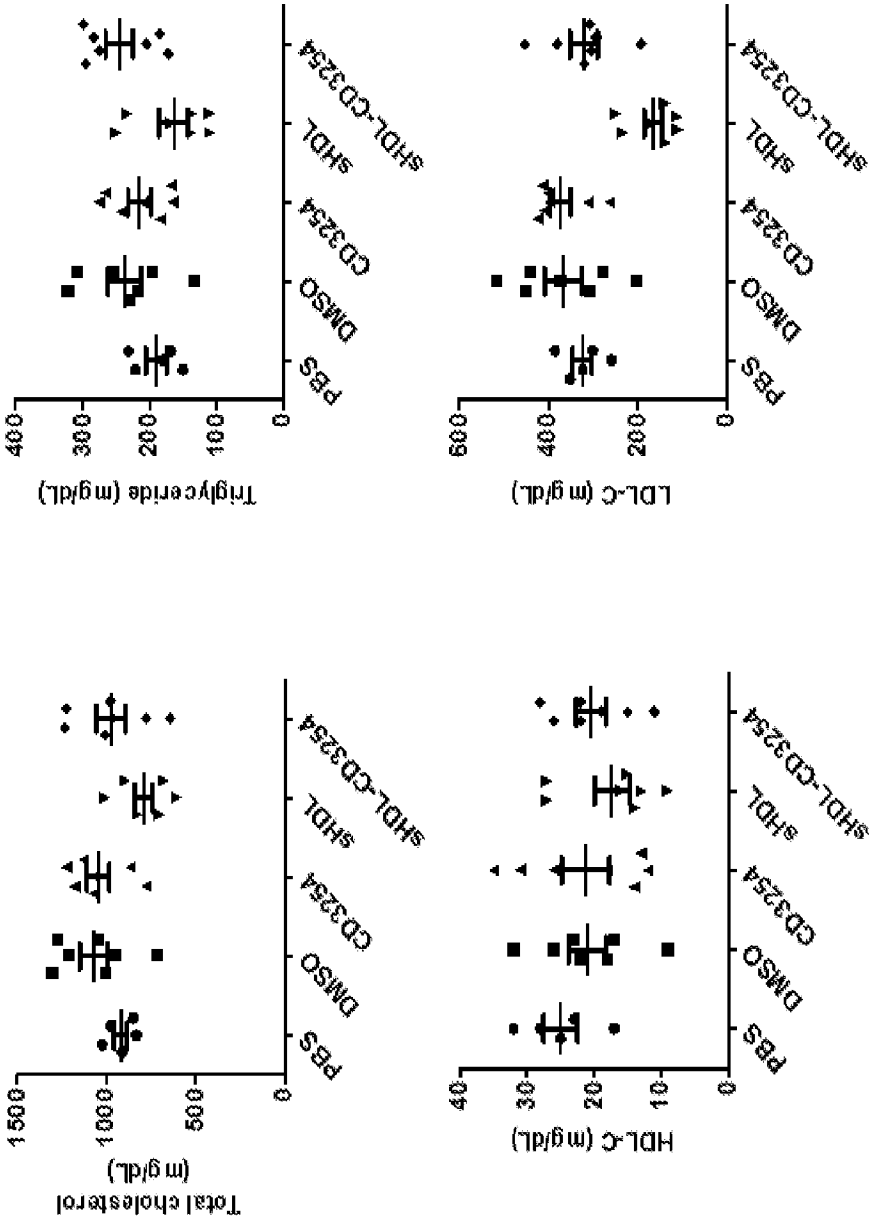


FIG. 24

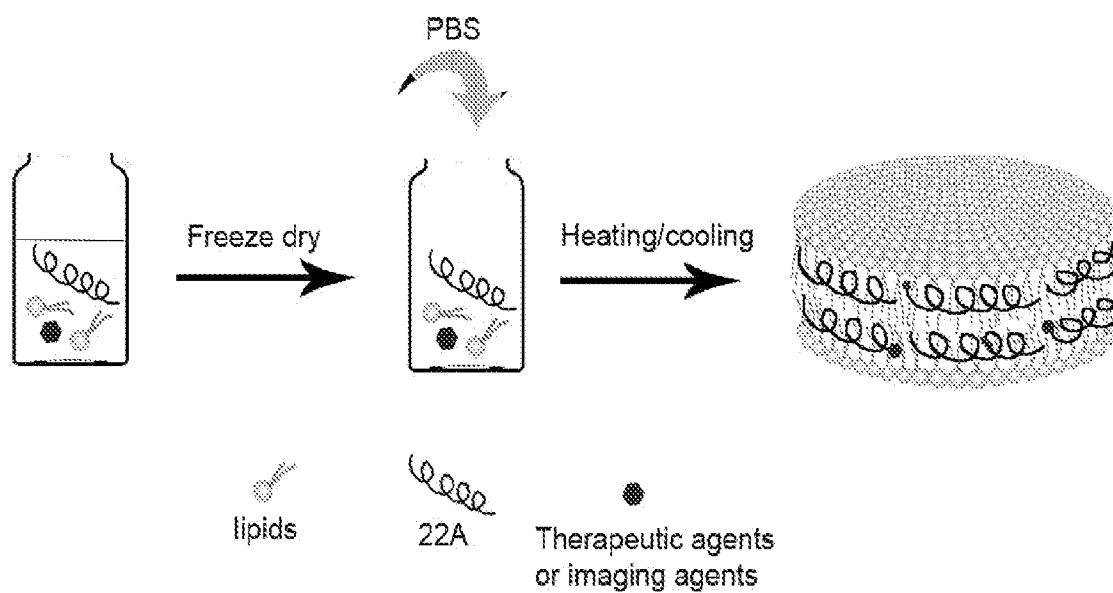
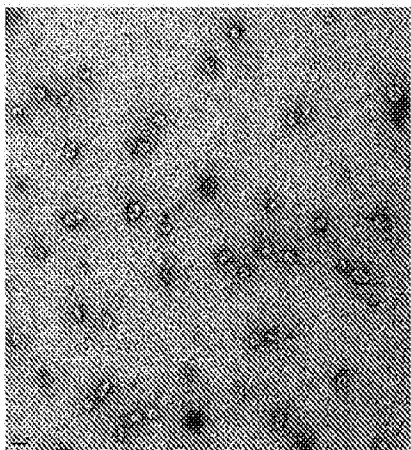
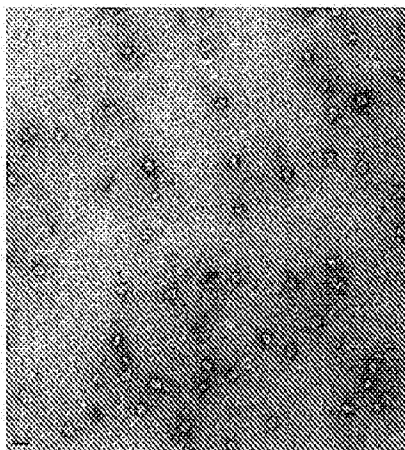


FIG. 25

a



b



c



d

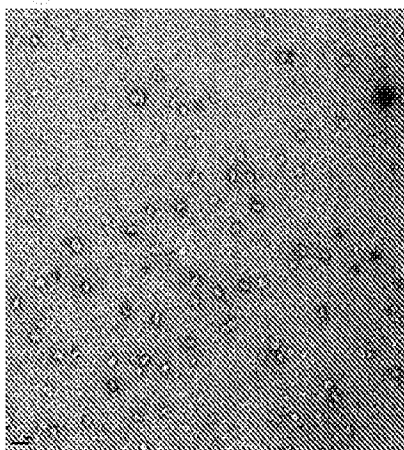


FIG. 26

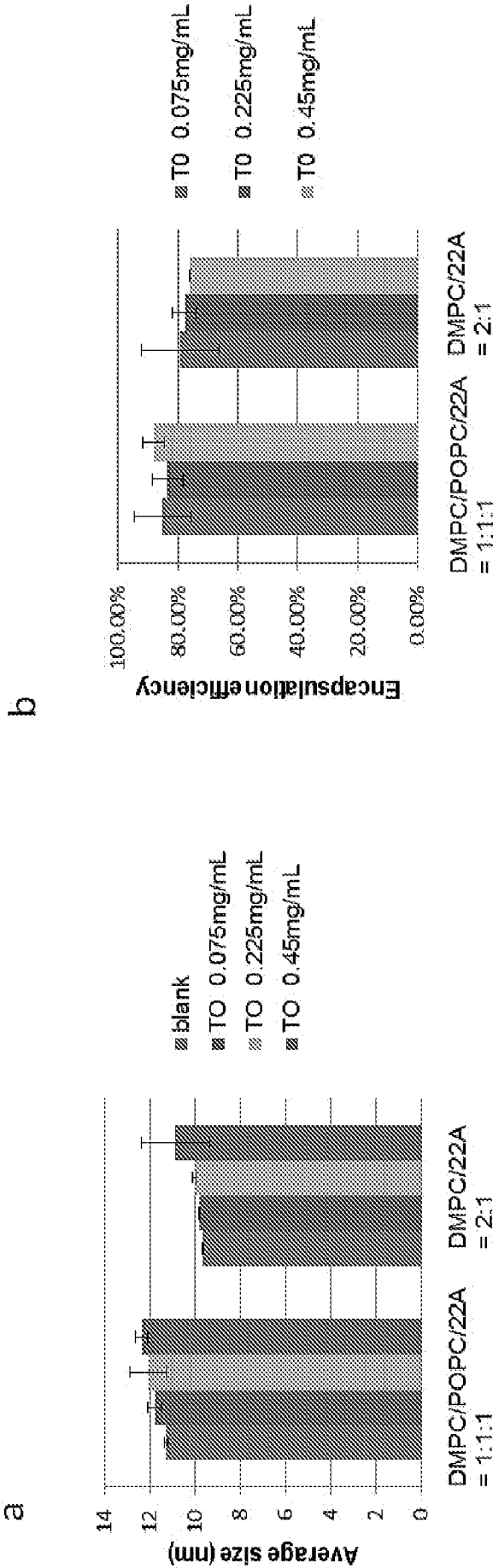


FIG. 27

