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(54) Title: TOPICAL FORMULATIONS AND USES THEREOF

(57) Abstract: Provided herein include formulations of defined active agents for topical administration, such as ophthalmic formulations, and methods of using such formulations. In some aspects and embodiments the formulations may include a polyoxyl lipid or fatty acid, and or a polyalkoxylated alcohol and may include nanomicelles. Also included are methods of treating or preventing diseases or conditions, such as ocular diseases or conditions.

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TOPICAL FORMULATIONS AND USES THEREOF

FIELD OF THE INVENTION

[0001] The present disclosure relates to the field of formulations for topical administration, such as ophthalmic formulations, and methods of using such formulations.

BACKGROUND OF THE INVENTION

[0002] The information provided herein and references cited are provided solely to assist the understanding of the reader, and does not constitute an admission that any of the references or information is prior art to the present invention.

[0003] United States Patent Application Nos US2010/0310462 and US2009/0092665 disclose drug delivery systems for ophthalmic use that have nanomicelles that include vitamin E TPGS.

[0004] Travoprost involves a formulation for glaucoma or ocular hypertension that includes HCO-40 and a prostaglandin analog as the active ingredient. See dailymed.nlm.nih.gov/dailymed/lookup.cfm?setid=338e7ff4-0d91-4208-a45d-bfa2be52334d on the world-wide web. The active ingredient is present at 0.004%. The formulation includes propylene glycol and does not include nanomicelles. HCO-40 is present in Travoprost at 0.5%. See ema.europa.eu/docs/en_GB/document_library/EPAR_-_Product_Information/human/000665/WC500038389.pdf on the world-wide web.

SUMMARY OF THE INVENTION

[0005] The present disclosure relates to topical formulations such as formulations suitable for ophthalmic administration of an active ingredient. In certain aspects and embodiments, the formulations of the present disclosure may include a polyoxyl lipid or fatty acid, and or a polyalkoxylated alcohol and may include nanomicelles.

[0006] In certain aspects and embodiments as described herein, the formulations as described herein may have certain surprising features and advantages that could not have been predicted prior to the present disclosure. For example, formulations of the present disclosure may be able to support a dose of an active ingredient such as a hydrophobic active ingredient that is surprisingly higher than many prior art formulations. The dose of an active ingredient or agent used in the formulations described herein may be selected based on various criteria, including the amount that the formulation can support, the desired dose for various therapeutic applications, etc. In this regard, in some embodiments the active ingredient (such as for ophthalmic administration) the active agent may be at least about 0.05%, or at least about 0.08%, or at least about 0.09%, or at least about 0.1%, or at least about 0.15%; or at least about 0.2%: or at least about 0.3%: or at least about 0.4%; or at least about 0.5%; or at least about 0.6%; or at least about 0.7%; or at least about 0.8%; or at least about 0.9%; or at least about 1.0%; or at least about 1.5%; or at least about 2%; or at least about 3%; or at least about 4%; or at least about 5%; or between 0.05 and 5%; or between 0.05 and 0.5%; or between 0.05 and 0.2%, or between 0.08 and 0.12%; or between 0.1 and 0.5%, or between 0.5 and 1%, or between 0.5 and 1.5%; or between 1 and 5%; or between 2 and 4%; or between 4 and 6% of the formulation.

[0007] In some embodiments the formulation has nanomicelles with a relatively increased entrapment efficiency; in such embodiments the active agent (such as hydrophobic active agents for ophthalmic administration) may be at least about 0.05%, or at least about 0.08%, or at least about 0.09%, or at least about 0.1%, or at least about 0.15%; or at least about 0.2%: or at least about 0.3%: or at least about 0.4%; or at least about 0.5%; or at least about 0.6%; or at least about 0.7%; or at least about 0.8%; or at least about 0.9%; or at least about 1.0%; or at least about 1.5%; or at least about 2%; or at least about 3%; or at least about 4%; or at least about 5%; or between 0.05 and 5%; or between 0.05 and 0.5%; or between 0.05 and 0.2%, or between 0.08 and 0.12%; or between 0.1 and 0.5%, or between 0.5 and 1%, or between 0.5 and 1.5%; or between 1 and 5%; or between 2 and 4%; or between 4 and 6% of the formulation and is present in nanomicelles of the formulation.

[0008] In certain aspects and embodiments, the formulations of the disclosure are surprisingly effective in dissolving and/or delivering active ingredients (such as hydrophobic active ingredients) without a need for organic solvents (such as propylene glycol) that can be an irritant when included in ophthalmic formulations. In some embodiments, the formulations of the present disclosure are surprisingly stable at high temperatures, for example, temperatures above about 40°C. In some aspects and embodiments the nanomicellular nature of some formulations described herein allow for improved ocular tissue distribution. In certain aspects and embodiments, formulations as described herein are particularly suitable for anterior eye delivery, or posterior eye delivery, or anterior and posterior eye delivery. Moreover, the formulations of certain aspects and embodiments of the disclosure may have the surprising advantage of being adaptable to facilitate delivery of active agents having various sizes or properties; for example, in certain embodiments in formulations that include a polyoxyl castor oil, HCO-60 could be used for active agents having relatively small molecule sizes and HCO-80 and/or HCO-100 could be used for relatively larger sized active agents.

[0009] Accordingly, in a first aspect provided is an ophthalmic formulation that includes an active agent, a polyoxyl lipid or fatty acid and a polyalkoxylated alcohol. In some embodiments the formulation includes nanomicelles. In some embodiments the polyoxyl lipid or fatty acid is a polyoxyl castor oil. In some embodiments, the polyoxyl lipid or fatty acid is one or more selected from HCO-40, HCO-60, HCO-80 or HCO-100. In some embodiments the polyoxyl lipid or fatty acid (such as a polyoxyl castor oil such as HCO-40, HCO-60, HCO-80 or HCO-100) is present between 1 and 6%; or 2 and 6%; or 2 and 6%; or 3 and 6%; or 4 and 6%; or 2 and 5%; or 3 and 5%; or 3 and 5%; or 2 and 6%; or about 4%; or greater than 0.7%; or greater than 1%, or greater than 1.5%; or greater than 2%; or greater than 3%; or greater than 4% by weight of the formulation. In some embodiments the polyoxyl lipid is HCO-60. In some embodiments the polyoxyl lipid is HCO-80. In some embodiments the polyoxyl lipid is HCO-100. In some embodiments, the formulation includes a polyalkoxylated alcohol that is octoxynol-40. In some embodiments, the formulation includes a polyalkoxylated alcohol (such as octoxynol-40) present between 0.002 and 4%; or between 0.005 and 3%; or 0.005 and 2%; or 0.005 and 1%; or 0.005 and 0.5%; or 0.005 and 0.1%; or 0.005 and 0.05%; or 0.008 and 0.02%; or about 0.01% by weight of the formulation.

[0010] As used herein, the term “polyoxyl lipid or fatty acid” refers to mono- and diesters of lipids or fatty acids and polyoxyethylene diols. Polyoxyl lipids or fatty acids may be numbered (“n”) according to the average polymer length of the oxyethylene units (e.g., 40, 60, 80, 100) as is well understood in the art. The term “n ≥ 40 polyoxyl lipid” means that the ployoxyl lipid or fatty acid has an average oxyethylene polymer length equal to or greater than 40 units. Stearate hydrogenated castor oil and castor oil are common lipids/fatty acids commercially available as polyoxyl lipids or fatty acid, however, it is understood that any lipid or fatty acid could polyoxylated to become a polyoxyl lipid or fatty acid as contemplated herein. Examples of polyoxyl lipid or fatty acids include without limitation HCO-40, HCO-60, HCO-80, HCO-100, polyoxyl 40 stearate, polyoxyl 35 castor oil.

[0011] In some embodiments of any of the compositions and methods described herein, the average polymer length of the oxyethylene units of a polyoxyl lipid or fatty acid is longer for a relatively larger active ingredient and is shorter for a relatively smaller active ingredient; for example in some embodiments in which the active ingredient is a relatively smaller active ingredient, the polyoxyl lipid is HCO-60, and in some embodiments where the active ingredient is a relatively larger active ingredient, the polyoxyl lipid is HCO-80 or HCO-100.

[0012] As used herein, the term "micelle" or “nanomicelle” refers to an aggregate (or cluster) of surfactant molecules. Micelles only form when the concentration of surfactant is greater than the critical micelle concentration (CMC). Surfactants are chemicals that are amphipathic, which means that they contain both hydrophobic and hydrophilic groups. Micelles can exist in different shapes, including spherical, cylindrical, and discoidal. A micelle comprising at least two different molecular species is a mixed micelle. The in some embodiments, ophthalmic compositions of the present disclosure include an aqueous, clear, mixed micellar solution.

[0013] In a second aspect, provided is an ophthalmic formulation, comprising an active agent, and a n≥ 40 polyoxyl lipid or fatty acid. In some embodiments the formulation includes nanomicelles. In some embodiments the polyoxyl lipid or fatty acid is a polyoxyl castor oil. In some embodiments, the polyoxyl lipid or fatty acid is one or more selected from HCO-40, HCO-60, HCO-80 or HCO-100. In some embodiments the polyoxyl lipid or fatty acid (such as a polyoxyl castor oil such as HCO-40, HCO-60, HCO-80 or HCO-100) is present between 0.5 and 2%, or 0.7 and 2%, or 1 and 6%; or 2 and 6%; or 2 and 6%; or 3 and 6%; or 4 and 6%; or 2 and 5%; or 3 and 5%; or 3 and 5%; or 2 and 6%; or about 4%; or greater than 0.7%; or greater than 1%, or greater than 1.5%; or greater than 2%; or greater than 3%; or greater than 4% by weight of the formulation. In some embodiments the polyoxyl lipid is HCO-60. In some embodiments the polyoxyl lipid is HCO-80. In some embodiments the polyoxyl lipid is HCO-100. In some embodiments, the formulation further includes polyalkoxylated alcohol. In some embodiments, the formulation further includes polyalkoxylated alcohol that is octoxynol-40. In some embodiments, the formulation includes a polyalkoxylated alcohol (such as octoxynol-40) present between 0.002 and 4%; or between 0.005 and 3%; or between 0.005 and 2%; or between 0.005 and 1%; or between 0.005 and 0.5%; or between 0.005 and 0.1%; or between 0.005 and 0.05%; or between 0.008 and 0.02%; or between 0.01 and 0.1%; or between 0.02 and 0.08%; or between 0.005 and 0.08%; or about 0.05%, or about 0.01% by weight of the formulation.

[0014] In a third aspect, provided is an ophthalmic formulation, that includes an active ingredient (such as a hydrophobic active ingredient) and a polyoxyl lipid or fatty acid;

wherein said polyoxyl lipid or fatty acid is present in an amount equal to or greater than 1% of said formulation. In a similar aspect, provided is an ophthalmic formulation, that includes an active ingredient (such as a hydrophobic active ingredient) and a polyoxyl lipid or fatty acid; wherein said polyoxyl lipid or fatty acid is present in an amount equal to or greater than 0.05% of said formulation. In some embodiments the formulation includes nanomicelles. In some embodiments the polyoxyl lipid or fatty acid is a polyoxyl castor oil. In some embodiments, the polyoxyl lipid or fatty acid is one or more selected from HCO-40, HCO-60, HCO-80 or HCO-100. In some embodiments the polyoxyl lipid or fatty acid (such as a polyoxyl castor oil such as HCO-60, HCO-80 or HCO-100) is present between 0.5 and 2%, or 0.7 and 2%, or between 1 and 6%; or 2 and 6%; or 2 and 6%; or 3 and 6%; or 4 and 6%; or 2 and 5%; or 3 and 5%; or 3 and 5%; or 2 and 6%; or about 4%; or greater than 1.5%; or greater than 2%; or greater than 3%; or greater than 4% by weight of the formulation. In some embodiments the polyoxyl lipid is HCO-40. In some embodiments the polyoxyl lipid is HCO-60. In some embodiments the polyoxyl lipid is HCO-80. In some embodiments the polyoxyl lipid is HCO-100. In some embodiments, the formulation further includes polyalkoxylated alcohol. In some embodiments, the formulation further includes polyalkoxylated alcohol that is octoxynol-40. In some embodiments, the formulation includes a polyalkoxylated alcohol (such as octoxynol-40) present between 0.002 and 4%; or between 0.005 and 3%; or between 0.005 and 2%; or between 0.005 and 1%; or between 0.005 and 0.5%; or between 0.005 and 0.1%; or between 0.005 and 0.05%; or between 0.008 and 0.02%; or between 0.01 and 0.1%; or between 0.02 and 0.08%; or between 0.005 and 0.08%; or about 0.05%, or about 0.01% by weight of the formulation.

[0015] In a fourth aspect, provided is an ophthalmic formulation, that includes an active agent and a polyoxyl lipid or fatty acid; wherein said formulation comprises nanomicelles. In some embodiments the polyoxyl lipid or fatty acid is a polyoxyl castor oil. In some embodiments, the polyoxyl lipid or fatty acid is one or more selected from HCO-40, HCO-60, HCO-80 or HCO-100. In some embodiments the polyoxyl lipid or fatty acid (such as a polyoxyl castor oil such as HCO-40, HCO-60, HCO-80 or HCO-100) is present between 0.5 and 2%, or 0.7 and 2%, or between 1 and 6%; or 2 and 6%; or 2 and 6%; or 3 and 6%; or 4 and 6%; or 2 and 5%; or 3 and 5%; or 3 and 5%; or 2 and 6%; or about 4%; or greater than 0.7%; or greater than 1%, or greater than 1.5%; or greater than 2%; or greater than 3%; or greater than 4% by weight of the formulation. In some embodiments the polyoxyl lipid is HCO-40. In some embodiments the polyoxyl lipid is HCO-60. In some embodiments the polyoxyl lipid is HCO-80. In some embodiments the polyoxyl lipid is HCO-100. In some embodiments, the formulation further includes polyalkoxylated alcohol. In some embodiments, the formulation further includes polyalkoxylated alcohol that is octoxynol-40. In some embodiments, the formulation includes a polyalkoxylated alcohol (such as octoxynol-40) present between 0.002 and 4%; or between 0.005 and 3%; or between 0.005 and 2%; or between 0.005 and 1%; or between 0.005 and 0.5%; or between 0.005 and 0.1%; or between 0.005 and 0.05%; or between 0.008 and 0.02%; or between 0.01 and 0.1%; or between 0.02 and 0.08%; or between 0.005 and 0.08%; or about 0.05%, or about 0.01% by weight of the formulation.

[0016] In a further aspect provided is an ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40.

[0017] In another aspect, provided is ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40.

[0018] In yet another aspect, provided is an ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40.

[0019] In one aspect, provided is an ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40.

[0020] In a further aspect provided is an ophthalmic formulation, comprising an active agent, about 4% of HCO-60 and about 0.01% octoxynol-40.

[0021] In another aspect provided is an ophthalmic formulation, comprising an active agent, 0.7-1.5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.05% octoxynol-40.

[0022] In another aspect, provided is ophthalmic formulation, comprising an active agent, 0.7-1.5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.05% octoxynol-40.

[0023] In yet another aspect, provided is an ophthalmic formulation, comprising an active agent, 0.7-1.5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.05% octoxynol-40.

[0024] In one aspect, provided is an ophthalmic formulation, comprising an active agent, 0.7-1.5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.05% octoxynol-40.

[0025] In a further aspect provided is an ophthalmic formulation, comprising an active agent, about 1% of HCO-60 and about 0.05% octoxynol-40.

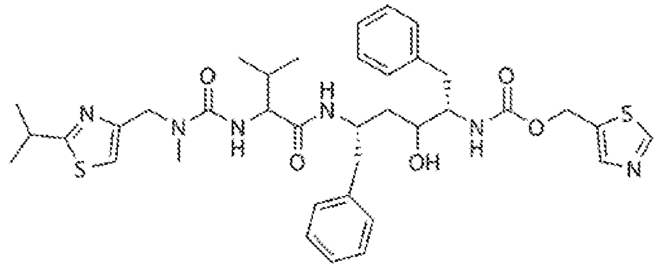
[0026] In various embodiments of any of the aspects and embodiments described herein, the formulation includes nanomicelles.

[0027] In some embodiments of the aspects and embodiments described herein, the formulation includes a polyoxyl lipid or fatty acid. In some embodiments the polyoxyl lipid or fatty acid is a polyoxyl castor oil. In some embodiments, the polyoxyl lipid or fatty acid is one or more selected from HCO-40, HCO-60, HCO-80 or HCO-100. In some embodiments the polyoxyl lipid or fatty acid (such as a polyoxyl castor oil such as HCO-60, HCO-80 or HCO-100) is present between 0.5 and 2%, or 0.7 and 2%, or 1 and 6%; or 2 and 6%; or 2 and 6%; or 3 and 6%; or 4 and 6%; or 2 and 5%; or 3 and 5%; or 3 and 5%; or 2 and 6%; or about 4%; or greater than 0.7%; or greater than 1%, or greater than 1.5%; or greater than 2%; or greater than 3%; or greater than 4% by weight of the formulation. In some embodiments the polyoxyl lipid is HCO-40. In some embodiments the polyoxyl lipid is HCO-60. In some embodiments the polyoxyl lipid is HCO-80. In some embodiments the polyoxyl lipid is HCO-100.

[0028] In some embodiments of the aspects and embodiments disclosed herein, the formulation includes a polyalkoxylated alcohol. In some embodiments, the formulation includes a polyalkoxylated alcohol that is octoxynol-40. In some embodiments, the formulation includes a polyalkoxylated alcohol (such as octoxynol-40) present between 0.002 and 4%; or between 0.005 and 3%; or between 0.005 and 2%; or between 0.005 and 1%; or between 0.005 and 0.5%; or between 0.005 and 0.1%; or between 0.005 and 0.05%; or between 0.008 and 0.02%; or between 0.01 and 0.1%; or between 0.02 and 0.08%; or between 0.005 and 0.08%; or about 0.05%, or about 0.01% by weight of the formulation.

[0029] In certain aspects and embodiments disclosed herein, the active agent is one or more selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations (e.g., micellar corticosteroid such as loteprednol, prednisolone, difluprednate, triamcinolone, rimexolone, or the like, in an aqueous solution of a quinolone antibiotic such as moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, or the like, in an aqueous solution of an aminoglycoside antibiotic, such as gentamicin, tobramycin or the like), polyene antifungals (e.g., amphotericin B, nystatin, natamycin, or the like), imidazole antifungals (e.g., miconazole, ketoconazole, or the like), and the like.

[0030] In one embodiment, the active agent is HIF ritonivir (also referred to as ritonavir), an HIV protease inhibitor that is commonly used as a component of highly active anti-retroviral therapy (HAART) in the treatment of HIV infection. Ritonavir exhibits antiviral, anti-angiogenic, neuroprotective, and hyperlipidemic activities. Ritonavir inhibits expression of VEGF and HIF-1α, decreasing proliferation in retinal epithelial cells and indicating potential use as a treatment for ocular diseases. Ritonavir also inhibits translocation of apoptosis-inducing factor (AIF), activates caspase 9, and inhibits permeability alterations in the mitochondrial membrane potential, preventing apoptosis in retinal photoreceptor cells and macrophages. This compound decreases levels of sarco/endoplasmic reticulum Ca^{2+}-ATPase (SERCA) and intracellular Ca^{2+}, increasing endoplasmic reticular stress and injury. Additionally, ritonavir increases levels of IL-6 and decreases levels of adiponectin, GLUT4, and fatty acid synthase, inhibiting lipogenesis and increasing lipodystrophy; this compound also increases levels of VLDL, and has the structure: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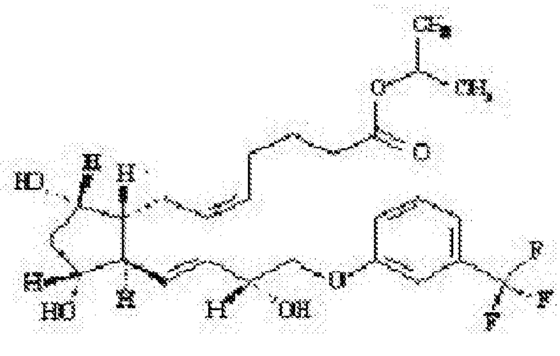
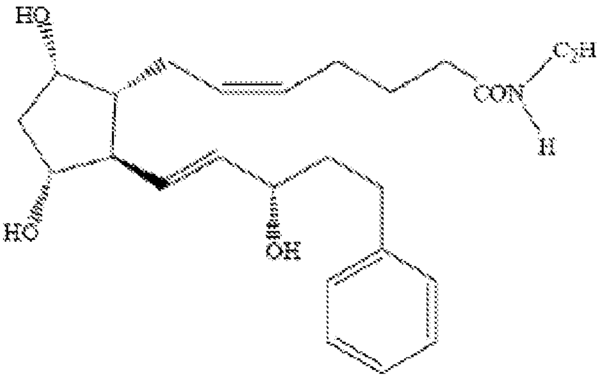
[0031] In one embodiment, the active agent is travoprost, a synthetic prostaglandin F analogue having the systematic chemical name: is [1*R*-[1α(Z),2β(1*E*,3*R**),3α,5α]]-7-[3,5-Dihydroxy-2-[3-hydroxy-4-[3-(trifluoromethyl)phenoxy]-1 -butenyl]cyclopentyl]-5-

heptenoic acid, 1–methylethylester, a molecular formula of $C_{26}H_{35}F_3O_6$ and a molecular weight of 500.55. The chemical structure of travoprost is:



[0032] Travoprost is a clear, colorless to slightly yellow oil that is very soluble in acetonitrile, methanol, octanol, and chloroform. It is practically insoluble in water, hence the delivery thereof presents challenges.

[0033] In some embodiments, the active ingredient is bimatoprost (e.g., LUMIGAN® ophthalmic solution 0.03%), a synthetic prostamide analog with ocular hypotensive activity. Its systematic chemical name is (Z)-7-[(1R,2R,3R,5S)-3,5-Dihydroxy-2[(1E,3S)-3-hydroxy-5-phenyl-1-pentenyl]cyclopentyl]-5-N-ethylheptenamide; its molecular weight is 415.58, and its molecular formula is $C_{25}H_{37}NO_4$. Bimatoprost has the chemical structure:

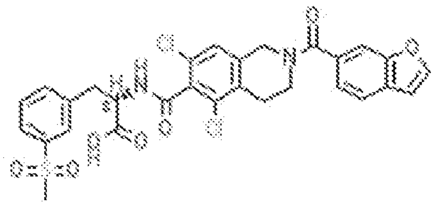


[0034] Bimatoprost is a powder, which is very soluble in ethyl alcohol and methyl alcohol but only slightly soluble in water. LUMIGAN® 0.03% is a clear, isotonic, colorless, sterile ophthalmic solution with an osmolality of approximately 290 mOsmol/kg. LUMIGAN® 0.03% contains bimatoprost 0.3 mg/mL; and the following inactives: benzalkonium chloride 0.05 mg/mL; sodium chloride; sodium phosphate, dibasic; citric acid; and purified water. Sodium hydroxide and/or hydrochloric acid may be added to adjust pH. The pH during its shelf life ranges from 6.8-7.8.

[0035] Tafluprost (i.e., Zioptan ophthalmic solution) is a fluorinated analog of prostaglandin F2α indicated for reducing elevated intraocular pressure in patients with open-angle glaucoma or ocular hypertension. Common side effects of Zioptan include eye redness, eye stinging or irritation, eye itching, cataracts, dry eyes, eye pain, blurred vision, headache, cold symptoms, cough, and urinary tract infections. Other side effects of Zioptan include gradual changes in eyelashes and vellus hair ("peach fuzz" hairs) in the treated eye including darkening, increased length, changes in color, thickness, shape, and number of lashes. Eyelash changes are usually reversible upon discontinuation of treatment.

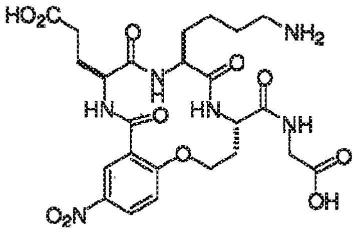
[0036] Tafluprost (e.g., Zioptan ophthalmic solution) is available at a strength of 0.015 mg/mL in a solution. The recommended dose of Zioptan is one drop in the conjunctival sac of the affected eye(s) once daily in the evening. The dose should not exceed once daily. Serious side effects include cataracts. Zioptan should not be used during pregnancy unless the potential benefit justifies the potential risk to the fetus. It is not known whether Zioptan or its metabolites are excreted in human milk. Because many drugs are excreted in human milk, caution should be exercised when Zioptan is administered to a nursing woman. Use in pediatric patients is not recommended with Zioptan because of potential safety problems related to increased pigmentation.

[0037] In one embodiment, the active agent is Lifitegrast, which has the structure :



and binds to the integrin lymphocyte function-associated antigen-1 (LFA-1), a cell surface protein found on leukocytes and blocks the interaction of LFA-1 with its cognate ligand intercellular adhesion molecule-1 (ICAM-1). ICAM-1 is over-expressed in corneal and conjunctival tissues in dry eye disease. LFA-1/ICAM-1 interaction contributes to formation of an immunological synapse resulting in T-cell activation and migration to target tissues. *In* *vitro* studies have demonstrated that lifitegrast inhibits T-cell adhesion to ICAM-1 expressing cells and inhibits secretion of key inflammatory cytokines (IFNγ, TNFα, IL-2) as well as inhibiting other proinflammatory cytokines: IL-1α, IL-1β, IL-2, IL-4, IL-5, and IL-13, all of which are known to be associated with dry eye disease.

[0038] In one embodiment, the active agent is MIM-D3, which has the structure:



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and is a proteolytically stable, cyclic peptidomimetic partial TrkA receptor agonist, which demonstrates similar activities to NGF (i.e., NGF activates the tropomyosin-related kinase (TrkA) receptor and the p75NTR receptor, a member of the tumor necrosis factor superfamily).

[0039] A3 adenosine receptor agonists: Adenosine A_3 receptors are G protein-coupled receptors that couple to Gi/Gq and are involved in a variety of intracellular signaling pathways and physiological functions. Such receptors mediate a sustained cardioprotective function during cardiac ischemia; such receptors are also involved in the inhibition of neutrophil degranulation in neutrophil-mediated tissue injury, and have been implicated in both neuroprotective and neurodegenerative effects. Furthermore, Adenosine A_3 receptors may also mediate both cell proliferation and cell death. Recent publications demonstrate that adenosine A3 receptor antagonists (e.g., SSR161421) could have therapeutic potential in the treatment of bronchial asthma.

[0040] Exemplary Adenosine A_3 receptor Agonists/Positive Allosteric Modulators include 2-(1-Hexynyl)-N-methyladenosine, CF-101 (IB-MECA), CF-102, 2-Cl-IB-MECA, CP-532,903, Inosine, LUF-6000, MRS-3558, and the like.

[0041] A1-selective AR agonists: The adenosine A_1 receptor is one member of the adenosine receptor group of G protein-coupled receptors with adenosine as endogenous ligand. A_1 receptors are implicated in sleep promotion by inhibiting wake-promoting cholinergic neurons in the basal forebrain. https://en.wikipedia.org/wiki/Adenosine_A1_receptor - cite_note-pmid17329439-2. A_1

receptors are also present in smooth muscle throughout the vascular system. The adenosine A_1 receptor has been found to be ubiquitous throughout the entire body.

[0042] Activation of the adenosine A_1 receptor by an agonist causes binding of $G_{i1/2/3}$ or G_o protein. Binding of $G_{i1/2/3}$ causes an inhibition of adenylate cyclase and, therefore, a decrease in the cAMP concentration. An increase of the inositol triphosphate/diacylglycerol concentration is caused by an activation of phospholipase C, whereas the elevated levels of arachidonic acid are mediated by DAG lipase, which cleaves DAG to form arachidonic acid. Several types of potassium channels are activated but N-, P-, and Q-type calcium channels are inhibited.

[0043] Exemplary Adenosine A_1 receptors include 2-Chloro-N(6)-cyclopentyladenosine (CCPA), N6-Cyclopentyladenosine, N(6)-cyclohexyladenosine, and the like.

[0044] Steroid/antibiotic combinations contemplated herein include micellar corticosteroids (such as loteprednol, prednisolone, difluprednate, triamcinolone, rimexolone, or the like), in an aqueous solution of a quinolone antibiotic (such as moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, or the like), in an aqueous solution of an aminoglycoside antibiotic (such as gentamicin, tobramycin or the like), polyene antifungals (e.g., amphotericin B, nystatin, natamycin, or the like), imidazole antifungals (e.g., miconazole, ketoconazole, or the like).

[0045] In certain aspects and embodiments disclosed herein, the active agent includes loteprednol and one or more of moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, gentamicin, tobramycin, amphotericin B, nystatin, natamycin, miconazole, and/or ketoconazole.

[0046] In certain aspects and embodiments disclosed herein, the active agent includes prednisolone and one or more of moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, gentamicin, tobramycin, amphotericin B, nystatin, natamycin, miconazole, and/or ketoconazole.

[0047] In certain aspects and embodiments disclosed herein, the active agent includes difluprednate and one or more of moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, gentamicin, tobramycin, amphotericin B, nystatin, natamycin, miconazole, and/or ketoconazole.

[0048] In certain aspects and embodiments disclosed herein, the active agent includes triamcinolone and one or more of moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, gentamicin, tobramycin, amphotericin B, nystatin, natamycin, miconazole, and/or ketoconazole.

[0049] In certain aspects and embodiments disclosed herein, the active agent includes rimexolone and one or more of moxifloxacin, levofloxacin, ciprofloxacin, besoflaxacin, gentamicin, tobramycin, amphotericin B, nystatin, natamycin, miconazole, and/or ketoconazole.

[0050] In certain aspects and embodiments disclosed herein, the active agent includes a prodrug of any of the foregoing, or a pharmaceutically acceptable salt of any of the foregoing.

[0051] As used herein, “prodrug” refers to agents which are converted in vivo to active forms (see, e.g., R.B. Silverman, 1992, "The Organic Chemistry of Drug Design and Drug Action," Academic Press, Chp. 8).

[0052] For example, prodrugs can be used to alter the biodistribution (e.g., to allow agents which would not typically enter the reactive site) or the pharmacokinetics for a particular agent. For example, a carboxylic acid group can be esterified, e.g., with a methyl group or an ethyl group to yield an ester. When the ester is administered to a subject, the ester is cleaved, enzymatically or non-enzymatically, reductively, oxidatively, or hydrolytically, to reveal the anionic group. An anionic group can be esterified with moieties (e.g., acyloxymethyl esters) which are cleaved to reveal an intermediate agent which subsequently decomposes to yield the active agent. The prodrug moieties may be metabolized in vivo by esterases or by other mechanisms to carboxylic acids.

[0053] Examples of prodrugs and their uses are well known in the art (see, e.g., Berge, et al., "Pharmaceutical Salts", J Pharm. Sci. 66, 1-19 (1977)). Prodrugs can be prepared in situ during the final isolation and purification of the active agents, or by separately reacting the purified agent in its free acid form with a suitable derivatizing agent. Carboxylic acids can be converted into esters via treatment with an alcohol in the presence of a catalyst.

[0054] Examples of cleavable carboxylic acid prodrug moieties include substituted and unsubstituted, branched or unbranched lower alkyl ester moieties, (e.g., ethyl esters, propyl esters, butyl esters, pentyl esters, cyclopentyl esters, hexyl esters, cyclohexyl esters), lower alkenyl esters, dilower alkyl-amino lower-alkyl esters (e.g., dimethylaminoethyl ester), acylamino lower alkyl esters, acyloxy lower alkyl esters (e.g., pivaloyloxymethyl ester), aryl esters (phenyl ester), aryl-lower alkyl esters (e.g., benzyl ester), substituted (e.g., with methyl, halo, or methoxy substituents) aryl and aryl-lower alkyl esters, amides, lower-alkyl amides, dilower alkyl amides, and hydroxy amides.

[0055] As used hererin, "pharmaceutically acceptable salts" refer to derivatives of agents modified by making base salts thereof, as described further below and elsewhere in the present application. Examples of pharmaceutically acceptable salts include alkali or organic salts of acidic residues such as sulfonates. Pharmaceutically acceptable salts include the conventional non-toxic salts or the quaternary ammonium salts of the parent agent formed, for example, from non-toxic inorganic or organic acids. Such conventional non-toxic salts include those derived from inorganic acids such as hydrochloric, hydrobromic, sulfuric, sulfamic, phosphoric, and nitric acid; and the salts prepared from organic acids such as acetic, propionic, succinic, glycolic, stearic, lactic, malic, tartaric, citric, ascorbic, palmoic, maleic, hydroxymaleic, phenylacetic, glutamic, mesylate, benzoic, salicylic, sulfanilic, 2-acetoxybenzoic, fumaric, toluenesulfonic, methanesulfonic, ethane disulfonic, oxalic, and isethionic acid. Pharmaceutically acceptable salts may be synthesized from the parent agent which contains a basic or acidic moiety by conventional chemical methods. Generally, such salts may be prepared by reacting the free acid or base forms of these agents with a stoichiometric amount of the appropriate base or acid in water or in an organic solvent, or in a mixture of the two.

[0056] All acid, salt, base, and other ionic and non-ionic forms of the compounds described are included as compounds of the disclosure. For example, if a compound is shown as an acid herein, the salt forms of the compound are also included. Likewise, if a compound is shown as a salt, the acid and/or basic forms are also included.

[0057] "Protecting group" refers to a group of atoms that, when attached to a reactive functional group in a molecule, mask, reduce or prevent the reactivity of the functional group. Typically, a protecting group may be selectively removed as desired during the course of a synthesis. Examples of protecting groups can be found in Greene and Wuts, *Protective Groups in Organic Chemistry,* 3rd Ed., 1999, John Wiley & Sons, NY and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8, 1971-1996, John Wiley & Sons, NY. Representative nitrogen protecting groups include, but are not limited to, formyl, acetyl, trifluoroacetyl, benzyl, benzyloxycarbonyl (“CBZ”), tert-butoxycarbonyl (“Boc”), trimethylsilyl (“TMS”), 2-trimethylsilyl-ethanesulfonyl (“TES”), trityl and substituted trityl groups, allyloxycarbonyl, 9-fluorenylmethyloxycarbonyl (“FMOC”), nitro-veratryloxycarbonyl (“NVOC”) and the like. Representative hydroxylprotecting groups include, but are not limited to, those where the hydroxyl group is either acylated (esterified) or alkylated such as benzyl and trityl ethers, as well as alkyl ethers, tetrahydropyranyl ethers, trialkylsilyl ethers (e.g., TMS or TIPS groups), glycol ethers, such as ethylene glycol and propylene glycol derivatives and allyl ethers.

[0058] The present disclosure further relates to treating or preventing ocular diseases or disorders, for example by local administration of the formulations as described herein.

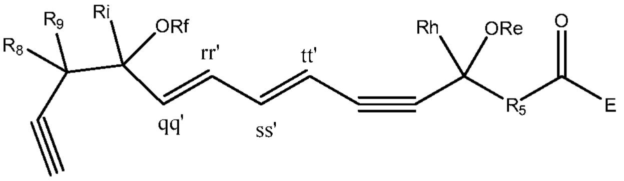
[0059] A patient or subject to be treated by any of the compositions or methods of the present disclosure can mean either a human or a non-human animal. In an embodiment, the present disclosure provides methods for the treatment of an ocular disease in a human patient in need thereof. In an embodiment, the present disclosure provides methods for the treatment of an inflammatory ocular disease in a human patient in need thereof. In another embodiment, the present disclosure provides methods for the treatment of an ocular disease in a veterinary patient in need thereof, including, but not limited to dogs, horses, cats, rabbits, gerbils, hamsters, rodents, birds, aquatic mammals, cattle, pigs, camelids, and other zoological animals.

[0060] In some embodiments of the compositions and methods disclosed herein, the active agent includes a combination of two or more different active ingredients. In some embodiments of the compositions and methods disclosed herein, one active ingredient of the combination may be hydrophobic and another active ingredient of the combination may be hydrophilic. Without wishing to be bound by any theory, it is thought that the active components of such a combination would partition so that the hydrophobic component would reside substantially in the nano micelles and the hydrophilic component would reside primarily in the aqueous phase.

[0061] Exemplary hydrophobic components contemplated for use in the combinations contemplated herein include cyclosporine A, voclosporin, ascomycin, tacrolimus, pimecrolimus, and the like, as well as analogs thereof, and/or pharmaceutically acceptable salts thereof.

[0062] Additional exemplary hydrophobic components contemplated for use in the combinations contemplated herein include resolvins or resolvin-like compounds. As used herein a resolvin-like compound includes resolvins and compounds with similar structures and/or features. Resolvins and resolvin-like compounds include a compound of formula A, a compound of any one of formulae 1-49, a compound of any one of formulae I-III, a prodrug of any of the foregoing, or a pharmaceutically acceptable salt of any of the foregoing.

[0063] In some embodiments of any of the aspects and embodiments disclosed herein, the resolvins or resolvin-like compounds contemplated for use in the combinations contemplated herein include a compound of formula I,



(I),

and pharmaceutically acceptable salts thereof, wherein:

the stereochemistry of the carbon qq' to carbon rr' double bond is cis or trans;

the stereochemistry of the carbon ss' to carbon tt' double bond is cis or trans;

Re and Rf are independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, acyl (e.g., alkoxyacyl, aminoacyl), aminocarbonyl, alkoxycarbonyl, or silyl;

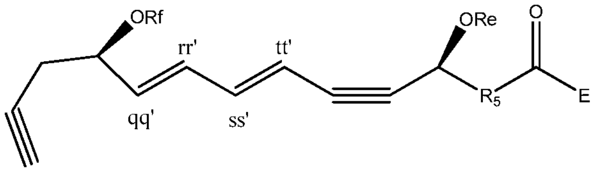
E is a branched alkoxy such as isopropoxy, isobutoxy, sec-butoxy, tert-butoxy, 3-methylbutoxy, 2,2-dimethylpropoxy, or 1,1,2-trimethylpropoxy;

Rh and Ri are independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl or heteroaryl;

R_5 is selected from i-iv as follows: i) $CH_2CH(R_6)CH_2$, where R_6 is hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl, heteroaryl, fluoro, hydroxyl or alkoxy; ii) $CH_2C(R_6R_7)CH_2$, where R_6 and R_7 are each independently alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl, or fluoro, or R_6 and R_7 are connected together to form a carbocyclic or heterocyclic ring; iii) CH_2OCH_2, $CH_2C(O)CH_2$, or CH_2CH_2; or iv) R_5 is a carbocyclic, heterocyclic, aryl or heteroaryl ring; and

R_8 and R_9 are independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, alkoxy, aryl or heteroaryl, or R_8 and R_9 are connected together to form a carbocyclic or heterocyclic ring.

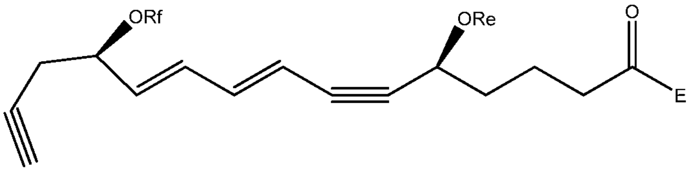
[0064] In certain embodiments, a compound of formula I contemplated for use in the combinations contemplated herein is represented by formula II,



(II),

and pharmaceutically acceptable salts thereof, wherein:
the stereochemistry of the carbon qq' to carbon rr' double bond is cis or trans;
the stereochemistry of the carbon ss' to carbon tt' double bond is cis or trans; and
Re, Rf, R_5, and E are as defined above.

[0065] In certain embodiments, a compound of formula I or II is which is contemplated for use in the combinations contemplated herein is represented by formula III,



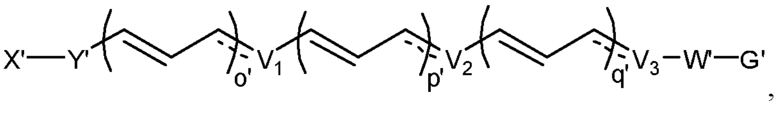
(III),

and pharmaceutically acceptable salts thereof, wherein:
Re, Rf, and E are as defined above.

[0066] In some embodiments of any of the aspects disclosed herein, resolvins or resolvin-like compounds contemplated for use in the combinations contemplated herein include a compound of formula I, wherein: Re, Rf, Rh, Ri, R_8 and R_9 are hydrogen; E is branched alkoxy (such as isopropyl); and R_5 is $CH_2CH_2CH_2$.

[0067] In some embodiments of any of the aspects disclosed herein, the resolvins and resolvin-like compounds contemplated for use in the combinations contemplated herein include a compound 1001 or a pharmaceutically acceptable salt thereof.

[0068] Compounds contemplated for use in the combinations contemplated herein include those of Formula A,



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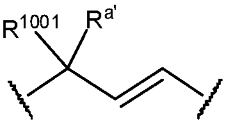
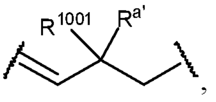
wherein:

each of W' and Y' is a bond or a linker independently selected from a ring containing up to 20 atoms or a chain of up to 20 atoms, provided that W' and Y' can independently include one or more nitrogen, oxygen, sulfur or phosphorous atoms, further provided that W' and Y' can independently include one or more substituents independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, chloro, iodo, bromo, fluoro, hydroxy, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, carboxamido, cyano, oxo, thio, alkylthio, arylthio, acylthio, alkylsulfonate, arylsulfonate, phosphoryl, or sulfonyl, further provided that W' and Y' can independently contain one or more fused carbocyclic, heterocyclic, aryl or heteroaryl rings, and further provided that when o' is 0, and V_1 is



,Y' is connected to V_1 via a carbon atom;

V_1 is selected from



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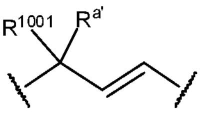

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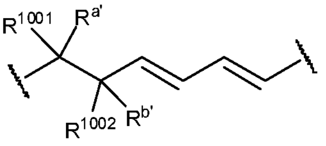

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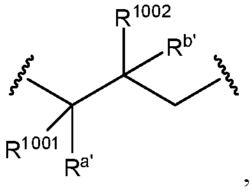

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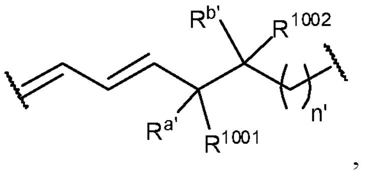
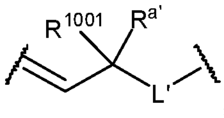


, wherein when q' is 0 and V_3 is a bond, n' is 0 or 1; otherwise n' is 1;

V_2 is selected from a bond,



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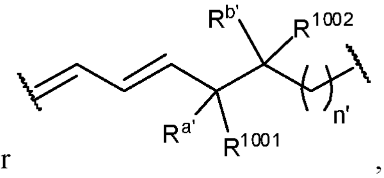

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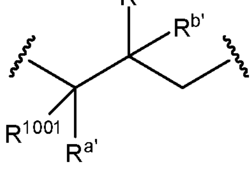
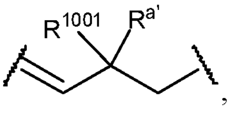
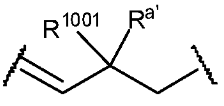


wherein:

L' is selected from -C(R^{1003})(R^{1004})-, wherein each of R^{1003} and R^{1004} is independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, alkoxy, aryl or heteroaryl, or R^{1003} and R^{1004} are connected together to form a carbocyclic or heterocyclic ring; when V_3 is 

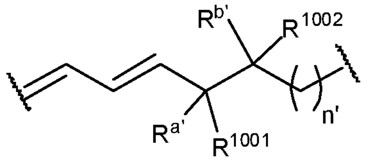
, L' is additionally selected from W'; and n' is 0 or 1;

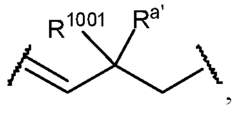
V_3 is selected from a bond or 

wherein:

each $R^{1001}$and R^{1002} is independently for each occurrence selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, alkylaryl, alkoxy, or halo, wherein said alkyl- or aryl-containing moiety is optionally substituted with up to 3 independently selected substituents;

each of $R^{a'}$ and $R^{b'}$ is independently for each occurrence selected from –OR' or –N(R')$_2$, or adjacent $R^{a'}$ and $R^{b'}$ are taken together to form an epoxide ring having a cis or trans configuration, wherein each R' is independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, acyl, silyl, alkoxyacyl, aminoacyl, aminocarbonyl, alkoxycarbonyl, or a protecting group;

or when V_1 is 

and V_2 is 

, R^{1002} and $R^{b'}$ are both hydrogen;

X' is selected from -CN, -C(NH)N(R")(R"), -C(S)-A', -C(S)R", -C(O)-A', -C(O)-R", -C(O)-SR", -C(O)-NH-S(O)$_2$-R", -S(O)$_2$-A', -S(O)$_2$-R", S(O)$_2$N(R")(R"), -P(O)$_2$-A', -PO(OR")-A', -tetrazole, alkyltetrazole, or -CH$_2$OH, wherein

A' is selected from -OR", -N(R")(R") or –OM';

each R" is independently selected from hydrogen, alkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl or a detectable label molecule, wherein any alkyl-, aryl- or heteroaryl-containing moiety is optionally substituted with up to 3 independently selected substituents; and

M' is a cation;

G' is selected from hydrogen, halo, hydroxy, alkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, carboxamido or a detectable label molecule, wherein any alkyl-, aryl- or heteroaryl-containing moiety is optionally substituted with up to 3 independently selected substituents;

o' is 0, 1, 2, 3, 4, or 5;

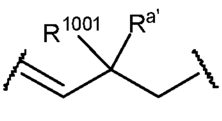
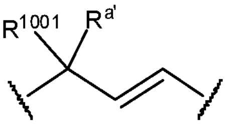
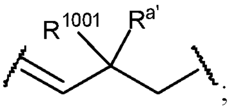
p' is 0, 1, 2, 3, 4, or 5;

q' is 0, 1, or 2; and

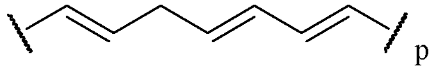
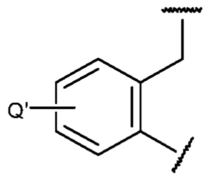
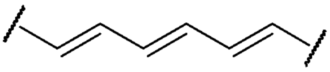
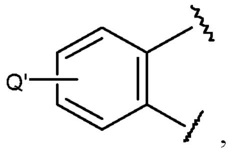
o' + p' + q' is 1, 2, 3, 4, 5 or 6;

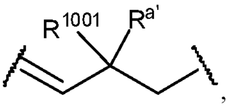
wherein:

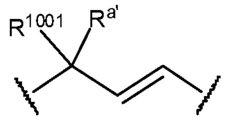
if V_2 is a bond, then q' is 0, and V_3 is a bond;

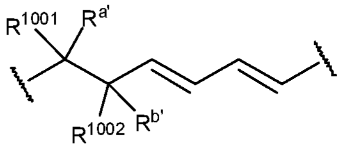
if V_3 is  , then o' is 0, V_1 is  , p' is 1 and V_2 is  ;

any acyclic double bond may be in a cis or a trans configuration or is optionally replaced by a triple bond; and

either one  portion of the compound, if present, is optionally replaced by  or one  portion of the compound, if present, is optionally replaced by  , wherein Q' represents one or more substituents and each Q' is independently selected from halo, alkyl, alkenyl, alkynyl, cycloalkyl, aryl, heteroaryl, alkoxy, aryloxy, alkylcarbonyl, arylcarbonyl, alkoxycarbonyl, aryloxycarbonyl, amino, hydroxy, cyano, carboxyl, alkoxycarbonyloxy, aryloxycarbonyloxy or aminocarbonyl.

[0069] In certain embodiments, V_1 is selected from 

, 

, or 

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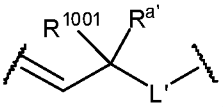
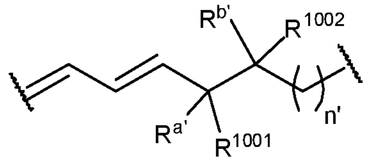
[0070] In certain embodiments, V_2 is selected from a bond, 

, or 

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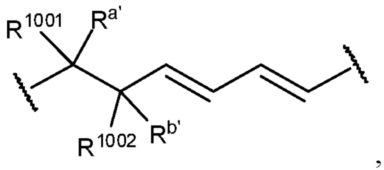
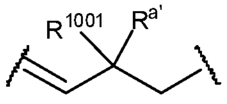
[0071] In certain embodiments, when q' is 0 and V_3 is a bond, n' is 0 or 1; otherwise n' is 1.

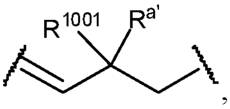
[0072] In certain embodiments, p' is 0, 1, 2, 3, or 5.

[0073] In certain embodiments, q' is 0 or 1.

[0074] In certain embodiments, if V_1 is 

, then o' is 0 or 1, p' is 1 or 2, o' + p' is 1 or 2, V_2 is 

and V_3 is a bond.

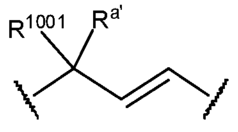
[0075] In certain embodiments, if V_1 is 

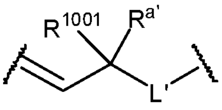
, then o' is 3, 4 or 5, p' is 0, 1 or 2, o' + p' is 4 or 5, and V_2 is a bond.

[0076] In certain embodiments, if V_2 is a bond, then o' is 0, 3, 4 or 5; p' is 0, 1, 2 or 5, o' + p' is 4 or 5, q' is 0, and V_3 is a bond.

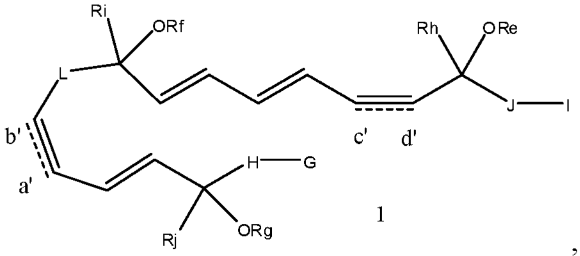
[0077] In certain embodiments, each of W' and Y' is independently selected from a bond or lower alkyl or heteroalkyl optionally substituted with one or more substituents independently selected from alkenyl, alkynyl, aryl, chloro, iodo, bromo, fluoro, hydroxy, amino, or oxo.

[0078] In certain embodiments, the compound of formula A is other than a compound of formulae 48, 48a, 48b, 48c, or 48d.

[0079] In certain embodiments of Formula A, when o' is 2, V_1 is  ,

p' is 1, V_2 is  , q' is 1, and V_3 is a bond, at least one occurrence of R^{1001} is other than hydrogen.

[0080] Compounds contemplated for use in the combinations contemplated herein include those of Formula 1,



1

,

wherein:

Carbons a' and b' are connected by a double bond or a triple bond;

Carbons c' and d' are connected by a double bond or a triple bond;

Re, Rf, and Rg are independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, acyl (e.g., alkoxyacyl, aminoacyl), aminocarbonyl, alkoxycarbonyl, or silyl;

Rh, Ri and Rj are independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl or heteroaryl;

I is selected from -C(O)-E, -SO_2-E, -PO(OR)-E, where E is hydroxy, alkoxy, aryloxy, amino, alkylamino, dialkylamino, or arylamino; and R is hydrogen or alkyl;

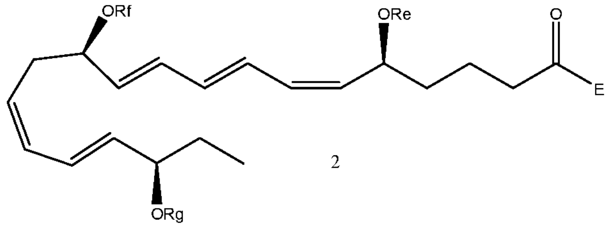
J, L and H are linkers independently selected from a ring containing up to 20 atoms or a chain of up to 20 atoms, provided that J, L and H can independently include one or more nitrogen, oxygen, sulfur or phosphorous atoms, and further provided that J, L and H can independently include one or more substituents selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, chloro, iodo, bromo, fluoro, hydroxy, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, carboxamido, cyano, oxo, thio, alkylthio, arylthio, acylthio, alkylsulfonate, arylsulfonate, phosphoryl, and sulfonyl, and further provided that J, L and H can also contain one or more fused carbocyclic, heterocyclic, aryl or heteroaryl rings, and provided that linker J is connected to the adjacent C(R)OR group via a carbon atom;

G is selected from hydrogen, alkyl, perfluoroalkyl, alkenyl, alkynyl, aryl, heteroaryl, chloro, iodo, bromo, fluoro, hydroxy, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, or carboxamido;

or pharmaceutically acceptable salts thereof.

[0081] In certain embodiments, a pharmaceutically acceptable salt of the compound is formed by derivatizing E, wherein E is -OM, where M is a cation selected from ammonium, tetra-alkyl ammonium, Na, K, Mg, and Zn.

[0082] In certain embodiments, compound contemplated for use in the combinations contemplated herein include compounds of formula 2:



2

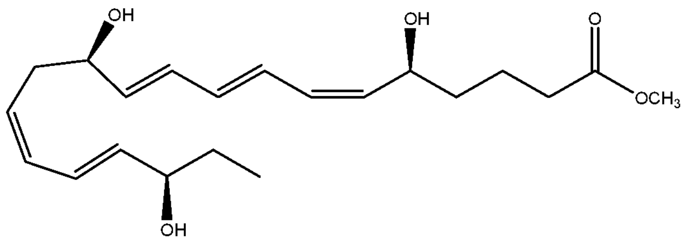
,

wherein:

E, Re, Rf, and Rg are as defined above.

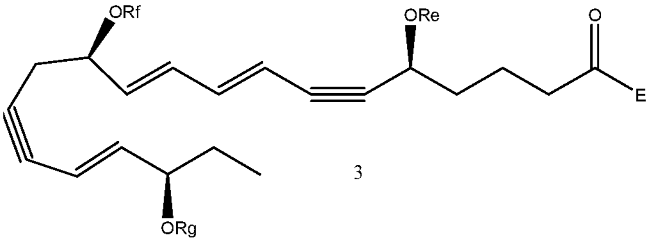
[0083] In certain embodiments, compounds contemplated for use in the combinations contemplated herein include pharmaceutically acceptable salts of the compound formed by derivatizing E, wherein E is -OM, where M is a cation selected from ammonium, tetra-alkyl ammonium, Na, K, Mg, and Zn.

[0084] Exemplary compounds of formula 2 contemplated for use in the combinations contemplated herein include compound 2a,



(2a).

[0085] In certain embodiments, compound contemplated for use in the combinations contemplated herein include compouns of formula 3:



3

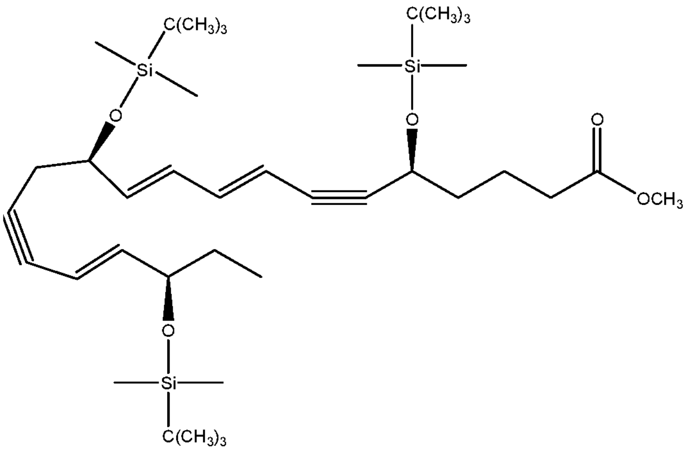
,

wherein:

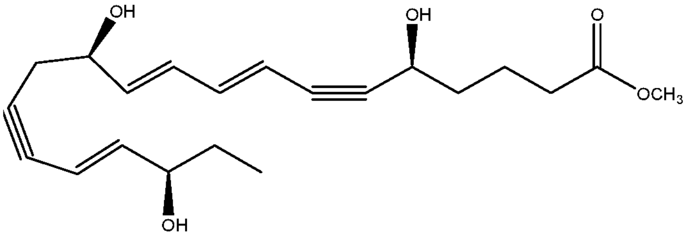
E, Re, Rf, and Rg are as defined above.

[0086] In certain embodiments, compounds contemplated for use in the combinations contemplated herein include compounds formed by derivatizing E, wherein E is -OM, where M is a cation selected from ammonium, tetra-alkyl ammonium, Na, K, Mg, and Zn.

[0087] Exemplary compounds of formula 3 contemplated for use in the combinations contemplated herein include compound 3a:

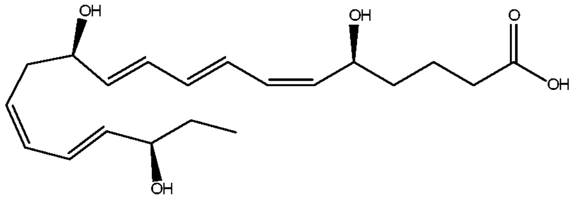


(3a) and compound 3b,



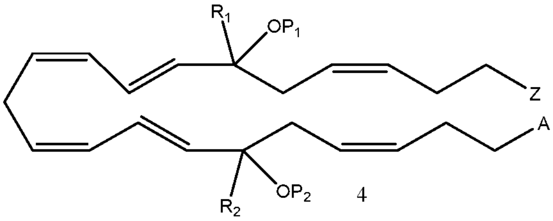
(3b).

[0088] Further exemplary compounds of formula 1 contemplated for use in the combinations contemplated herein include Compound X,



(X), and pharmaceutically acceptable salts and esters thereof.

[0089] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 4,



4

,

wherein:

A is H or -OP_4;

P_1, P_2 and P_4 each individually is a protecting group or hydrogen atom;

R_1 and R_2 each individually is a substituted or unsubstituted, branched or unbranched alkyl, alkenyl, or alkynyl group, substituted or unsubstituted aryl group, substituted or unsubstituted, branched or unbranched alkylaryl group, halogen atom, hydrogen atom;

Z is -C(O)OR^d, -C(O)NR^cR^c, -C(O)H, -C(NH)NR^cR^c, -C(S)H, -C(S)OR^d, -C(S)NR^cR^c, -CN, preferably a carboxylic acid, ester, amide, thioester, thiocarboxamide or a nitrile;

each R^a, if present, is independently selected from hydrogen, (C1-C6) alkyl, (C2-C6) alkenyl, (C2-C6) alkynyl, (C3-C8) cycloalkyl, cyclohexyl, (C4-C11) cycloalkylalkyl, (C5-

C10) aryl, phenyl, (C6-C16) arylalkyl, benzyl, 2-6 membered heteroalkyl, 3-8 membered heterocyclyl, morpholinyl, piperazinyl, homopiperazinyl, piperidinyl, 4-11 membered heterocyclylalkyl, 5-10 membered heteroaryl and 6-16 membered heteroarylalkyl;

each R^b, if present, is a suitable group independently selected from =O, $-OR^d$, (C1-C3) haloalkyloxy, $-OCF_3$, =S, $-SR^d$, $=NR^d$, $=NOR^d$, $-NR^cR^c$, halogen, $-CF_3$, -CN, -NC, -OCN, -SCN, -NO, $-NO_2$, $=N_2$, $-N_3$, $-S(O)R^d$, $-S(O)_2R^d$, $-S(O)_2OR^d$, $-S(O)NR^cR^c$, $-S(O)_2NR^cR^c$, $-OS(O)R^d$, $-OS(O)_2R^d$, $-OS(O)_2OR^d$, $-OS(O)_2NR^cR^c$, $-C(O)R^d$, $-C(O)OR^d$, $-C(O)NR^cR^c$, $-C(NH)NR^cR^c$, $-C(NR^a)NR^cR^c$, $-C(NOH)R^a$, $-C(NOH)NR^cR^c$, $-OC(O)R^d$, $-OC(O)OR^d$, $-OC(O)NR^cR^c$, $-OC(NH)NR^cR^c$, $-OC(NR^a)NR^cR^c$, $-[NHC(O)]_nR^d$, $-[NR^aC(O)]_nR^d$, $-[NHC(O)]_nOR^d$, $-[NR^aC(O)]_nOR^d$, $[NHC(O)]_nNR^cR^c$, $-[NR^aC(O)]_nNR^cR^c$, $-[NHC(NH)]_nNR^cR^c$ and $-[NR^aC(NR^a)]_nNR^cR^c$;

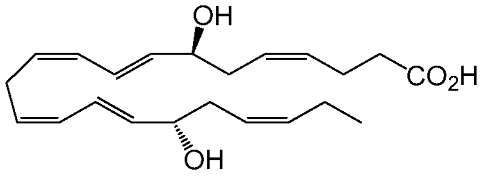
each R^c, if present, is independently a protecting group or R^a, or, alternatively, two R^c taken together with the nitrogen atom to they are bonded form a 5 to 8-membered heterocyclyl or heteroaryl which optionally including one or more additional heteroatoms and optionally substituted with one or more of the same or different R^a or suitable R^b groups;

each n independently is an integer from 0 to 3;

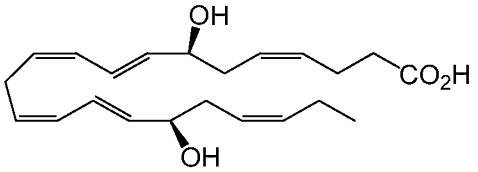
each R^d independently is a protecting group or R^a;

or pharmaceutically acceptable salts thereof.

[0090] Exemplary compounds of formula 4 contemplated for use in the combinations contemplated herein include include compound 4a,

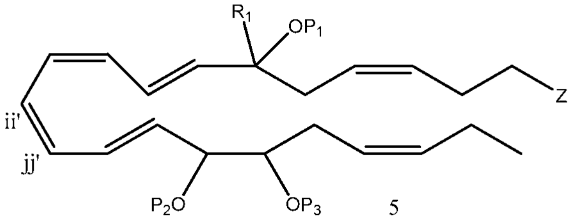


(4a), compound 4b,



(4b), and pharmaceutically acceptable salts and esters thereof.

[0091] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 5,



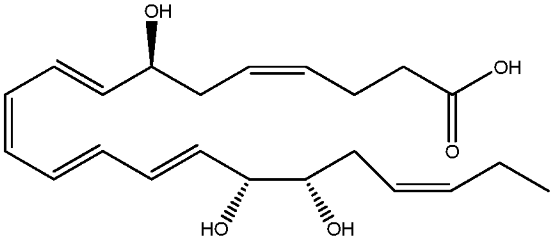
5

,

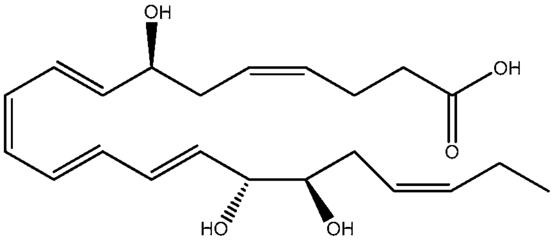
or pharmaceutically acceptable salts thereof, wherein:
the stereochemistry of the carbon ii' to carbon jj' bond is cis or trans;
P_3 is a protecting group or hydrogen atom; and
P_1, P_2, R_1 and Z are as defined above in formula 4.

[0092] In certain embodiments, the stereochemistry of the carbon ii' to carbon jj' bond is trans.

[0093] Exemplary compounds of formula 5 contemplated for use in the combinations contemplated herein include compound 5a,

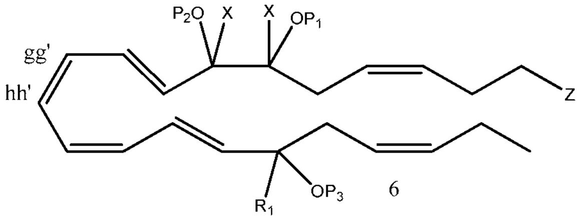


(5a), compound 5b,



(5b), and pharmaceutically acceptable salts and esters thereof.

[0094] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 6,



6

,

or pharmaceutically acceptable salts thereof, wherein:

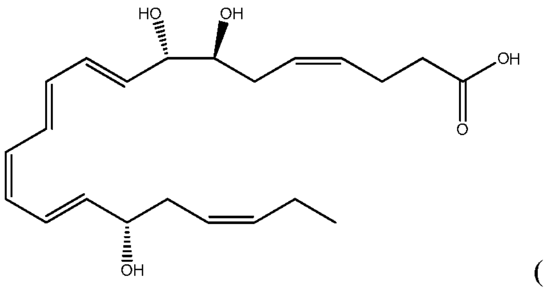
the stereochemistry of the carbon gg' to carbon hh' bond is cis or trans;

each X represents hydrogen or taken together both X groups represent one substituted or unsubstituted methylene, an oxygen atom, a substituted or unsubstituted N atom, or a sulfur atom such that a three-membered ring is formed; and

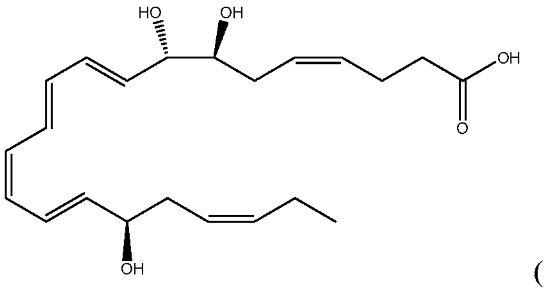
P_1, P_2, P_3, R_1 and Z are as defined above.

[0095] In certain embodiments, the stereochemistry of the carbon gg' to carbon hh' bond is trans.

[0096] Exemplary compounds of formula 6 contemplated for use in the combinations contemplated herein include compound 6a,

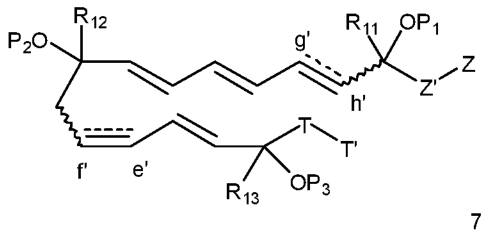


(6a), compound 6b,



(6b), and pharmaceutically acceptable salts and esters thereof.

[0097] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 7,



7,

or pharmaceutically acceptable salts thereof, wherein:

Carbons e' and f' are connected by a double bond or a triple bond, and when carbon e' is connected to carbon f' through a double bond the stereochemistry is cis or trans;

Carbons g' and h' are connected by a double bond or a triple bond and when carbon g' is connected to carbon h' through a double bond the stereochemistry is cis or trans;

m is 0 or 1;

T' is hydrogen, (C1-C6) alkyl, (C2-C6) alkenyl, (C2-C6) alkynyl, (C5-C14) aryl, (C6-C16) arylalkyl, 5-14 membered heteroaryl, 6-16 membered heteroarylalkyl, or $-CH=CHCH_2CH_3$;

T is $-(CH_2)_q-$ or $-(CH_2)_q-O-$, where q is an integer from 0 to 6;

Z' is (C1-C6) alkylene optionally substituted with 1, 2, 3, 4, 5 or 6 of the same or different halogen atoms, $-(CH_2)_p-O-CH_2-$ or $-(CH_2)_m-S-CH_2-$, where p is an integer from 0 to 4;

R_{11}, R_{12} and R_{13} each individually is substituted or unsubstituted, branched or unbranched alkyl, alkenyl, or alkynyl group, substituted or unsubstituted aryl group, substituted or unsubstituted, branched or unbranched alkylaryl group, $C_{1\text{-}4}$alkoxy, halogen atom, -CH_2R_{14}, -$CHR_{14}R_{14}$, -$CR_{14}R_{14}R_{14}$, or a hydrogen atom;

R_{14} is independently for each occurrence selected from -CN, -NO_2 or halogen; and

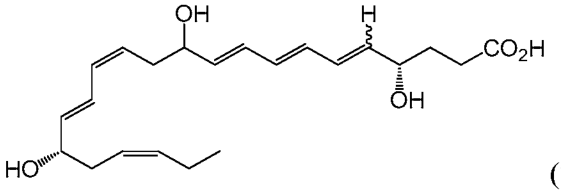
P_1, P_2, P_3, and Z are as defined above.

[0098] In certain embodiments, carbons e' and f' are connected by a cis double bond.

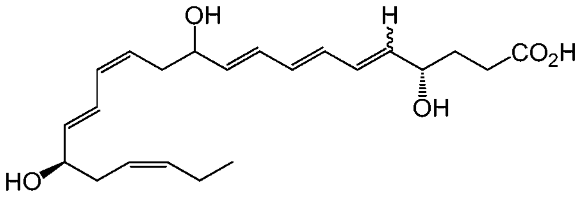
[0099] In certain embodiments, carbons g' and h' are connected by a double bond.

[00100] In certain embodiments, carbons e' and f' are connected by a cis double bond and carbons g' and h' are connected by a double bond.

[00101] Exemplary compounds of formula 7 contemplated for use in the combinations contemplated herein include compound 7a,

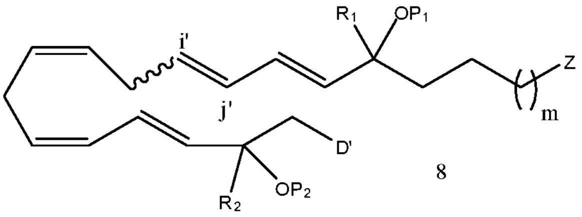


(7a), compound 7b,



(7b), and pharmaceutically acceptable salts and esters thereof.

[00102] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 8,



8

,

or pharmaceutically acceptable salts thereof, wherein:

the stereochemistry of the carbon i' to carbon j' bond is cis or trans;

m is 0 or 1;

D' is CH_3, -$CH{=}CHCH_2U$ or -$CH{=}CHCH_2CH_2A$;

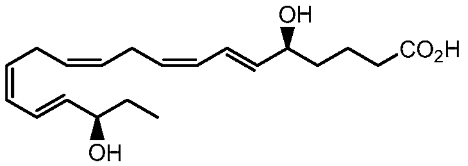
U is a branched or unbranched, substituted or unsubstituted alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkoxy, aryloxy, alkylcarbonyl, arylcarbonyl, alkoxycarbonyl, aryloxycarbonyl, alkoxycarbonyloxy, and aryloxycarbonyloxy group;

A is H or -OP_4;

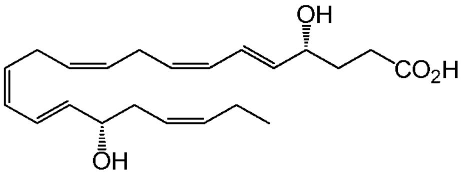
P_1, P_2, P_4, R_1, R_2 and Z are as defined above.

[00103] In certain embodiments, the stereochemistry of the carbon i' to carbon j' bond is cis.

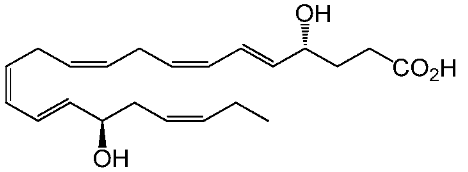
[00104] Exemplary compounds of formula 8 contemplated for use in the combinations contemplated herein include compound 8a,



(8a), compound 8b,

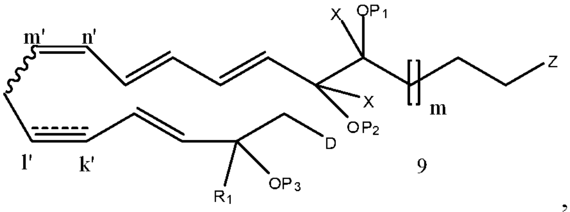


(8b), compound 8c,



(8c), and pharmaceutically acceptable salts and esters thereof.

[00105] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 9,



9

,

or pharmaceutically acceptable salts thereof, wherein:

Carbons k' and l' are connected by a double bond or a triple bond, and when carbon k' is connected to carbon l' through a double bond the stereochemistry is cis or trans;

the stereochemistry of the carbon m' to carbon n' double bond is cis or trans;

m is 0 or 1;

D is $-CH_3$ or $-CH=CHCH_2CH_3$;

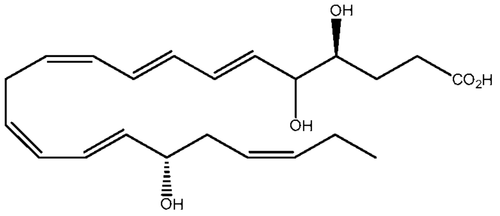
P_1, P_2, P_3, R_1, X, and Z are as defined above.

[00106] In certain embodiments, the stereochemistry of the carbon m' to carbon n' double bond is cis.

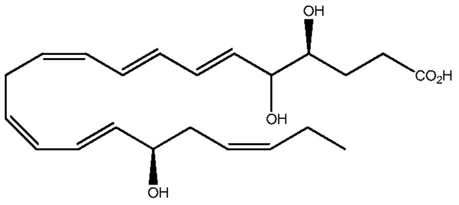
[00107] In certain embodiments, carbons k' and l' are connected by a cis double bond.

[00108] In certain embodiments, the stereochemistry of the carbon m' to carbon n' double bond is cis and carbons k' and l' are connected by a cis double bond.

[00109] Exemplary compounds of formula 9 contemplated for use in the combinations contemplated herein include compound 9a,

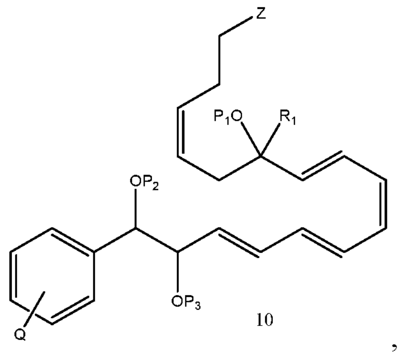


(9a), compound 9b,



(9b), and pharmaceutically acceptable salts and esters thereof.

[00110] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 10,



10

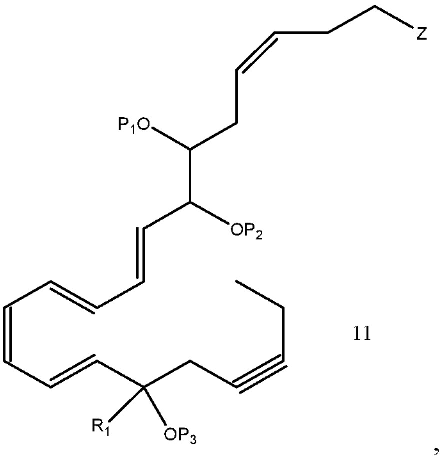
,

or pharmaceutically acceptable salts thereof, wherein:

P_1, P_2, P_3, R_1 and Z are as defined above; and

Q represents one or more substituents and each Q individually, if present, is a halogen atom or a branched or unbranched, substituted or unsubstituted alkyl, alkenyl, alkynyl, cycloalkyl, aryl, alkoxy, aryloxy, alkylcarbonyl, arylcarbonyl, alkoxycarbonyl, aryloxycarbonyl, amino, hydroxy, cyano, carboxyl, alkoxycarbonyloxy, aryloxycarbonyloxy or aminocarbonyl group.

[00111] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 11,



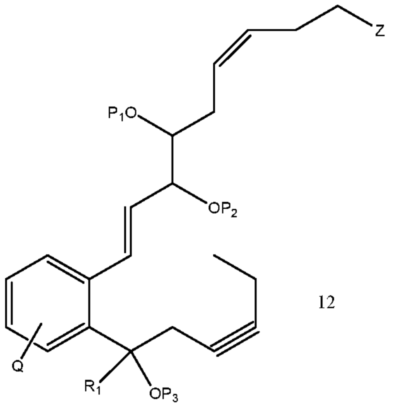
11

,

or pharmaceutically acceptable salts thereof, wherein:

P_1, P_2, P_3, R_1, and Z are as defined above.

[00112] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 12,



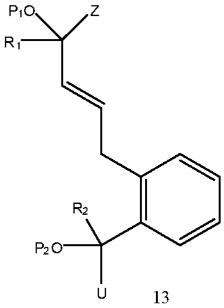
12

,

or pharmaceutically acceptable salts thereof, wherein

P_1, P_2, P_3, Q, R_1, and Z are as defined above.

[00113] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 13,

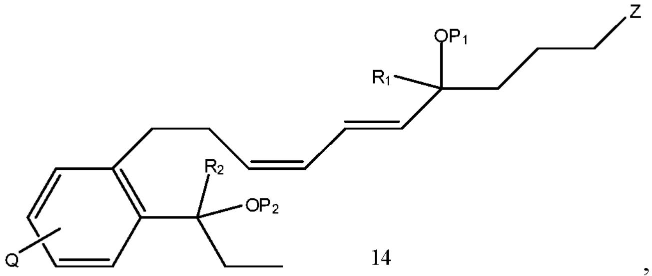


13 ,

or pharmaceutically acceptable salts thereof, wherein:

P_1, P_2, R_1, R_2, U, and Z are as defined above.

[00114] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 14,

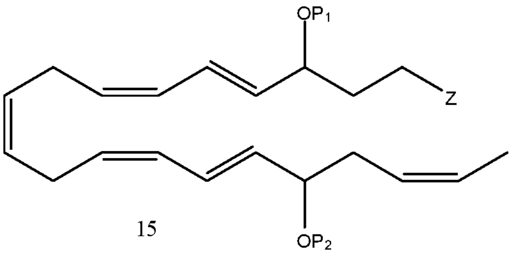


14 ,

or pharmaceutically acceptable salts thereof, wherein:

P_1, P_2, R_1, R_2, Q, and Z are as defined above.

[00115] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 15,

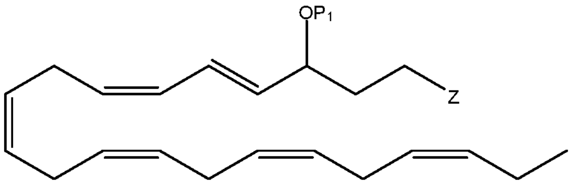


15 ,

or pharmaceutically acceptable salts thereof, wherein:

P_1, P_2, and Z are as defined above.

[00116] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 16,



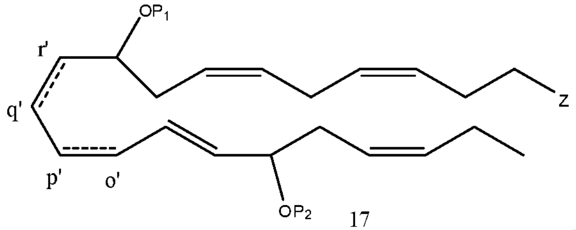
16

,

or pharmaceutically acceptable salts thereof, wherein:

P_1 and Z are as defined above.

[00117] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 17,



17

,

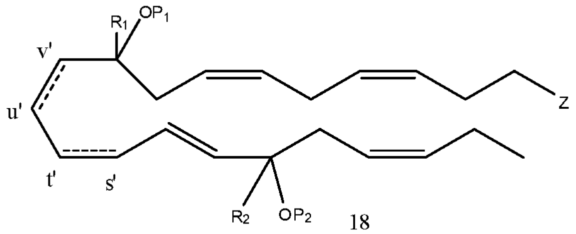
or pharmaceutically acceptable salts thereof, wherein:

Carbons o' and p' are connected by a single or a double bond (e.g., a cis or trans double bond);

Carbons q' and r' are connected by a single or a double bond (e.g., a cis or trans double bond); and

P_1, P_2, and Z are as defined above.

[00118] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 18,



18

,

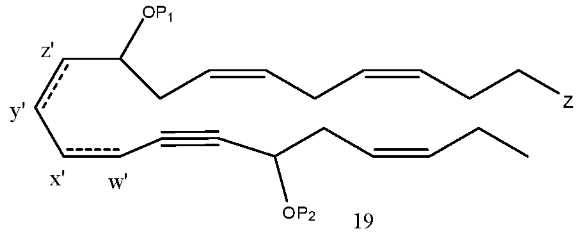
or pharmaceutically acceptable salts thereof, wherein:

the stereochemistry of the carbon s' to carbon t' double bond is cis or trans;

the stereochemistry of the carbon u' to carbon v' double bond is cis or trans; and

P_1, P_2, R_1, R_2, and Z are as defined above.

[00119] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 19,



19

,

or pharmaceutically acceptable salts thereof, wherein:

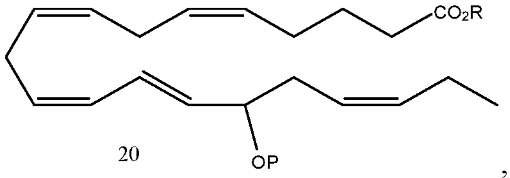
Carbons w' and x' are connected by a single or a double bond;

Carbons y' and z' are connected by a single or a double bond; and

P_1, P_2, and Z are as defined above.

[00120] In certain embodiments of formulae 4 to 19, each R^b, if present, is a suitable group independently selected from =O, -OR^d, (C1-C3) haloalkyloxy, -OCF_3, =S, -SR^d, =NR^d, =NOR^d, -NR^cR^c, halogen, -CF_3, -CN, -NC, -OCN, -SCN, -NO, -NO_2, =N_2, -N_3, -$S(O)R^d$, -$S(O)_2R^d$, -$S(O)_2OR^d$, -$S(O)NR^cR^c$, -$S(O)_2NR^cR^c$, -$OS(O)R^d$, -$OS(O)_2R^d$, -$OS(O)_2OR^d$, -$OS(O)_2NR^cR^c$, -$C(O)R^d$, -$C(O)OR^d$, -$C(O)NR^cR^c$, -$C(NH)NR^cR^c$, -$C(NR^a)NR^cR^c$, -$C(NOH)R^a$, -$C(NOH)NR^cR^c$, -$OC(O)R^d$, -$OC(O)OR^d$, -$OC(O)NR^cR^c$, -$OC(NH)NR^cR^c$, -$OC(NR^a)NR^cR^c$, -$[NHC(O)]_nR^d$, -$[NR^aC(O)]_nR^d$, -$[NHC(O)]_nOR^d$, $[NHC(O)]_nNR^cR^c$, -$[NR^aC(O)]_nNR^cR^c$, -$[NHC(NH)]_nNR^cR^c$ and -$[NR^aC(NR^a)]_nNR^cR^c$.

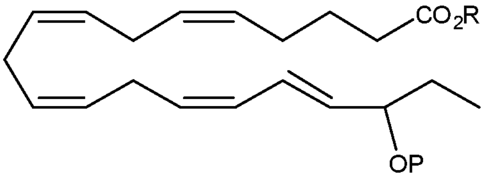
[00121] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 20,



20

,

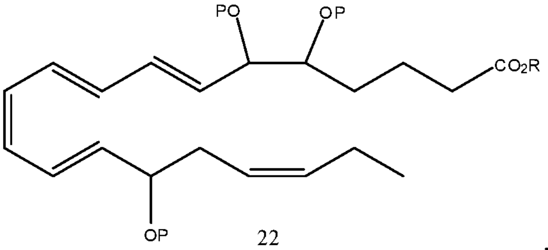
Formula 21,



21

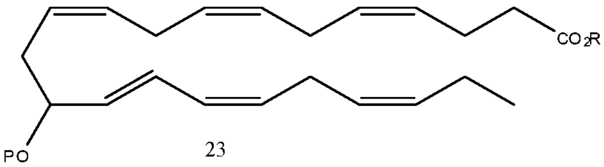
,

Formula 22,



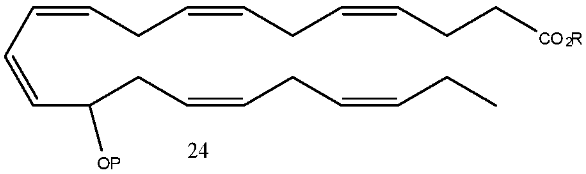
22 ,

Formula 23,



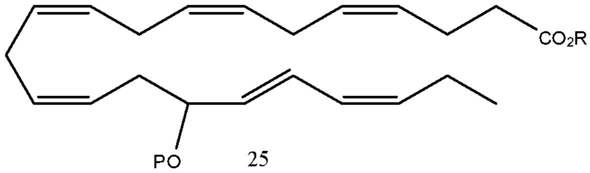
23 ,

Formula 24,



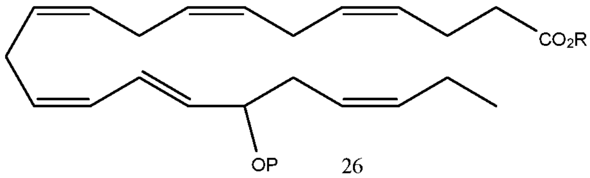
24 ,

Formula 25,



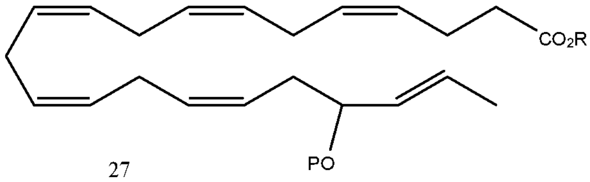
25 ,

Formula 26,



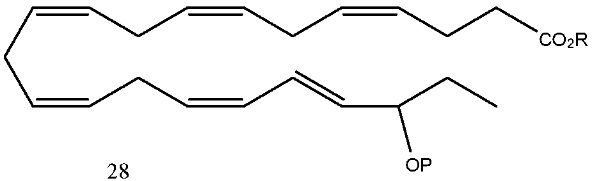
26 ,

Formula 27,



27 ,

or Formula 28,



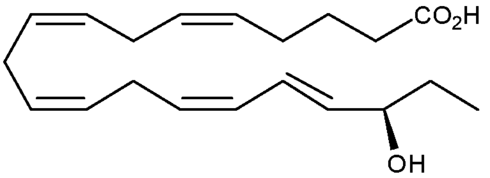
28

, or pharmaceutically acceptable salts of any of the above, wherein

each P is individually selected from H or a protecting group; and

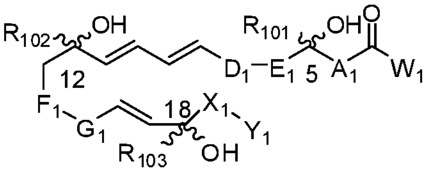
R is H, C_{1-6}alkyl (e.g., methyl, ethyl, glycerol), C_{2-6}alkenyl or C_{2-6}alkynyl.

[00122] Exemplary compounds of formula 21 contemplated for use in the combinations contemplated herein include compound 21a,



(21a), and pharmaceutically acceptable salts and esters thereof.

[00123] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 29,



29

and pharmaceutically acceptable salts, hydrates and solvates thereof, wherein:

D_1-E_1 and F_1-G_1 are independently are *cis* or *trans* -C=C-or -C≡C-;

R_{101}, R_{102} and R_{103} are independently selected from hydrogen, (C1-C4) straight-chained or branched alkyl, (C2-C4) alkenyl, (C2-C4) alkynyl, (C1-C4) alkoxy, $-CH_2R_{104}$, $-CHR_{104}R_{104}$ and $-CR_{104}R_{104}R_{104}$;

each R_{104} is independently selected from CN, $-NO_2$ and halogen;

W_1 is selected from-R_{105}, $-OR_{105}$, $-SR_{105}$ and $-NR_{105}R_{105}$;

each R_{105} is independently selected from hydrogen, (C1-C6) alkyl, (C2-C6) alkenyl or (C2-C6) alkynyl optionally substituted with one or more of the same or different R groups, (C5-C14) aryl optionally substituted with one or more of the same or different R groups, phenyl optionally substituted with one or more of the same or different R groups, (C6-C16) arylalkyl optionally substituted with one or more of the same or different R groups, 5-14 membered heteroaryl optionally substituted with one or more of the same or different R groups, 6-16 membered heteroarylalkyl optionally substituted with one or more of the same or different R groups and a detectable label molecule;

A_1 is selected from (C1-C6) alkylene optionally substituted with 1, 2, 3, 4, 5 or 6 of the same or different halogen atoms, $-(CH_2)_m-O-CH_2-$ and $-(CH_2)_m-S-CH_2-$, where m is an integer from 0 to 4;

X_1 is selected from $-(CH_2)_n-$ and $-(CH_2)_n-O-$, where n is an integer from 0 to 6;

Y_1 is selected from hydrogen, (C1-C6) alkyl, (C2-C6) alkenyl, or (C2-C6) alkynyl, optionally substituted with one or more of the same or different R_{100} groups, (C5-C14) aryl optionally substituted with one or more of the same or different R_{100} groups, phenyl, optionally substituted with one or more of the same or different R_{100} groups, (C6-C16) arylalkyl optionally substituted with one or more of the same or different R_{100} groups, 5-14 membered heteroaryl optionally substituted with one or more of the same or different R_{100} groups, 6-16 membered heteroarylalkyl optionally substituted with one or more of the same or different R_{100} groups and a detectable label molecule;

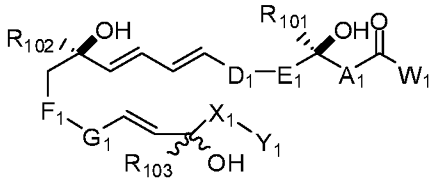
each R_{100} is independently selected from an electronegative group, =O, $-OR^{a1}$, (C1-C3) haloalkyloxy, =S, $-SR^{a1}$, $=NR^{a1}$, $=NONR^{a1}$, $-NR^{c1}R^{c1}$, halogen, $-CF_3$, -CN, -NC, -OCN, -SCN, -NO, $-NO_2$, $=N_2$, $-N_3$, $-S(O)R^{a1}$, $-S(O)_2R^{a1}$, $-S(O)_2OR^{a1}$, $-S(O)_2NR^{c1}R^{c1}$, $-OS(O)R^{a1}$, $-OS(O)_2R^{a1}$, $-OS(O)_2OR^{a1}$, $-OS(O)_2NR^{c1}R^{c1}$, $-C(O)R^{a1}$, $-C(O)OR^{a1}$, $-C(O)NR^{c1}R^{c1}$, $-C(NH)NR^{c1}R^{c1}$, $-OC(O)R^{a1}$, $-OC(O)OR^{a1}$, $-OC(O)NR^{c1}R^{c1}$, $-OC(NH)NR^{c1}R^{c1}$, $-NHC(O)R^{a1}$, $-NHC(O)OR^{a1}$, $-NHC(O)NR^{c1}R^{c1}$ and $-NHC(NH)NR^{c1}R^{c1}$;

each R^{a1} is independently selected from hydrogen, (C1-C4) alkyl, (C2-C4) alkenyl or (C2-C4) alkynyl; and

each R^{c1} is independently an R^{a1} or, alternatively, $R^{c1}R^{c1}$ taken together with the nitrogen atom to which it is bonded forms a 5 or 6 membered ring.

[00124] In certain embodiments of Formula 29, when X_1-Y_1 is $-CH_2CH_3$, then at least one of R_{101}, R_{102} or R_{103} is other than hydrogen.

[00125] In certain embodiments, a compound of Formula 29, as represented by Formula 30, is contemplated for use in the combinations contemplated herein,



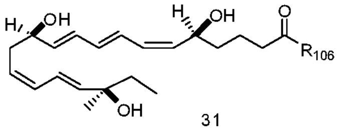
30

and pharmaceutically acceptable salts, hydrates and solvates thereof, wherein:

D_1-E_1 and F_1-G_1 are independently are *cis* or *trans* -C=C-or -C≡C-; and

R_{101}, R_{102}, R_{103}, R_{104}, W_1, R_{105}, A_1, X_1, n, Y_1, R_{100}, R^{a1}, and R^{c1} are as defined above.

[00126] Other compounds contemplated for use in the combinations contemplated herein include those of Formulae 31 to 37



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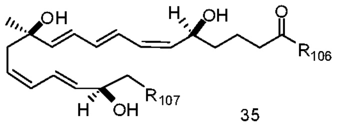
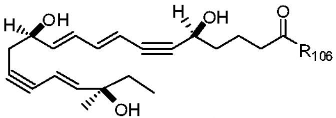


35



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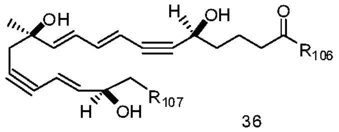

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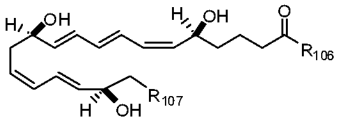

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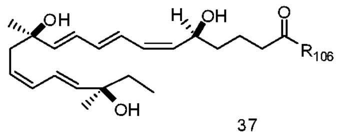

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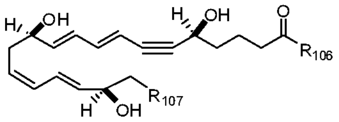
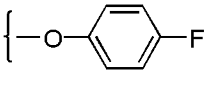


34

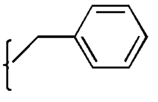
and pharmaceutically acceptable salts, hydrates and solvates thereof, wherein:

R_{106} is -OH, -OCH$_3$, -OCH(CH$_3$)$_2$ or -NHCH$_2$CH$_3$; and

R_{107} is

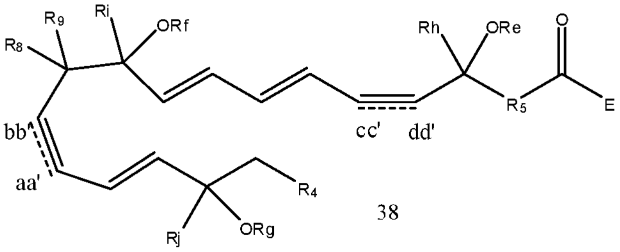


or



.

[00127] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 38,



38

,

wherein:

Carbons aa' and bb' are connected by a double bond or a triple bond;

Carbons cc' and dd' are connected by a double bond or a triple bond;

Re, Rf, and Rg are independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, acyl (e.g., alkoxyacyl, aminoacyl), aminocarbonyl, alkoxycarbonyl, or silyl;

E is hydroxyl, alkoxy, aryloxy, amino, alkylamino, dialkylamino, or arylamino;

Rh, Ri and Rj are independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl or heteroaryl;

R_4 is selected from hydrogen, alkyl, perfluoroalkyl, alkenyl, alkynyl, aryl, heteroaryl, fluoro, hydroxyl, alkoxy, aryloxy;

R_5 is selected from i-iv as follows: i) $CH_2CH(R_6)CH_2$, where R_6 is hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl, heteroaryl, fluoro, hydroxyl or alkoxy; ii) $CH_2C(R_6R_7)CH_2$, where R_6 and R_7 are each independently alkyl, alkenyl, alkynyl, perfluoroalkyl, aryl, or fluoro, or R_6 and R_7 are connected together to form a carbocyclic or heterocyclic ring; iii) CH_2OCH_2, $CH_2C(O)CH_2$, or CH_2CH_2; or iv) R_5 is a carbocyclic, heterocyclic, aryl or heteroaryl ring; and

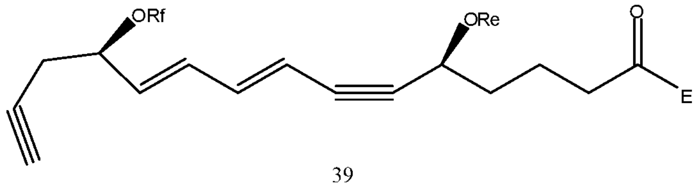
R_8 and R_9 are independently selected from hydrogen, alkyl, alkenyl, alkynyl, perfluoroalkyl, alkoxy, aryl or heteroaryl, or R_8 and R_9 are connected together to form a carbocyclic or heterocyclic ring;

or pharmaceutically acceptable salts thereof.

[00128] In certain embodiments R_8 and R_9 are hydrogen.

[00129] In certain embodiments, a pharmaceutically acceptable salt of the compound formed by derivatizing E, wherein E is -OM, where M is a cation selected from ammonium, tetra-alkyl ammonium, Na, K, Mg, and Zn is contemplated for use in the combinations contemplated herein.

[00130] Other compounds contemplated for use in the combinations contemplated herein include those of Formulae 39-44,



39

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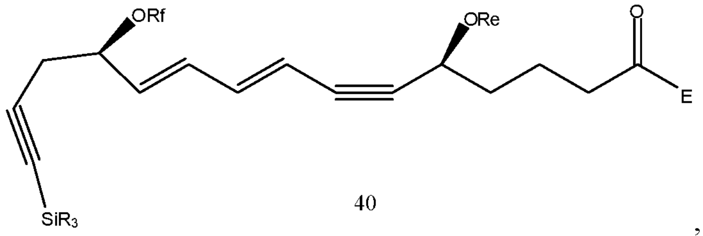

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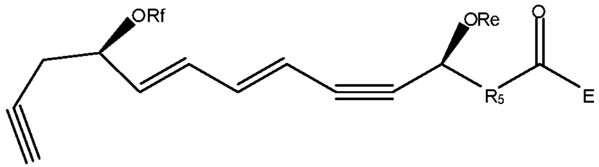

41

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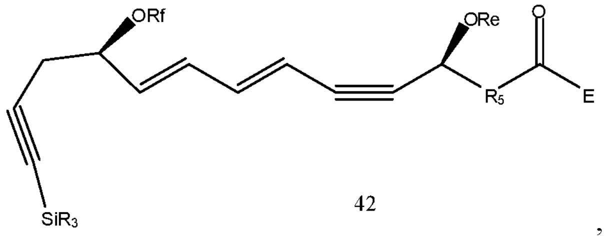

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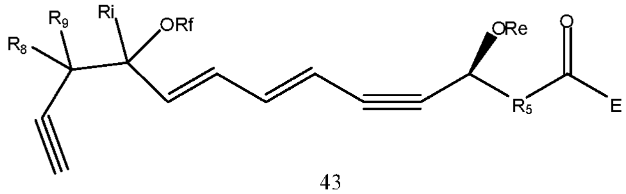

43

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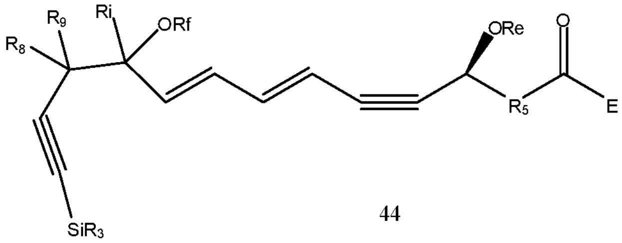
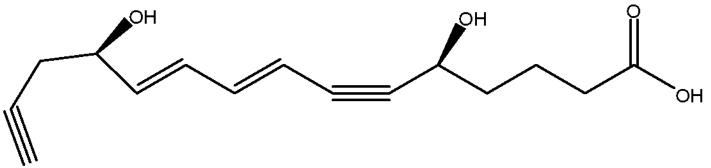


44

and pharmaceutically acceptable salts thereof, wherein:

Re, Rf, E, Ri, R_5, R_8 and R_9 are as defined above.

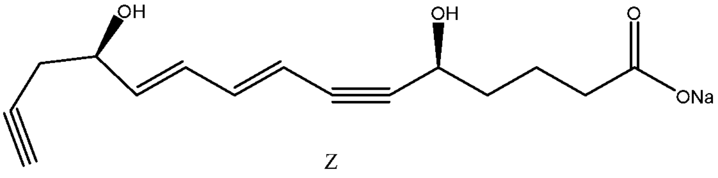
[00131] Exemplary compounds of formulae 39, 41, and 43 include:



45

, and pharmaceutically acceptable salts and esters thereof.

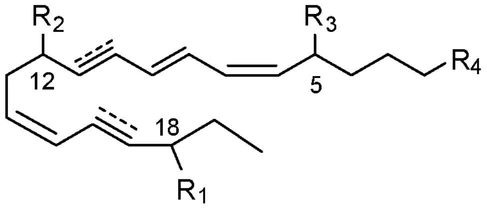
[00132] In certain embodiments, compositions of the present disclosure may include a compound formed by derivatizing E, wherein E is -OM, where M is a cation selected from ammonium, tetra-alkyl ammonium, Na, K, Mg, and Zn. Examples of such compounds include compound Z,



Z

.

[00133] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 46,



46

or a pharmaceutically acceptable salt or prodrug thereof, wherein:

each $\overset{\text{-----}}{=}$ independently designates a double or triple bond;

R^1, R^2, and R^3 are each independently OR, OX^1, SR, SX^2, $N(R)_2$, NHX^3, NRC(O)R, NRC(O)$N(R)_2$, C(O)OR, C(O)$N(R)_2$, SO_2R, $NRSO_2R$, C(O)R, or $SO_2N(R)_2$;

each R is independently selected from hydrogen or an optionally substituted group selected from C_{1-6} aliphatic, a 3-8 membered saturated, partially unsaturated, or aryl ring having 0-4 heteroatoms independently selected from nitrogen, oxygen, or sulfur, or;

two R on the same nitrogen are taken together with the nitrogen to form a 5-8 membered heterocyclyl or heteroaryl ring having 1-3 heteroatoms independently selected from nitrogen, oxygen, or sulfur;

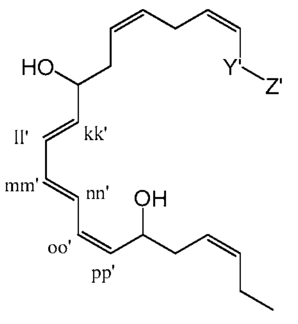
each X^1 is independently a suitable hydroxyl protecting group;

each X^2 is independently a suitable thiol protecting group;

each X^3 is independently a suitable amino protecting group; and

R^4 is NRC(O)R, NRC(O)N(R)$_2$, C(O)OR, C(O)N(R)$_2$, SO$_2$R, NRSO$_2$R, C(O)R, or SO$_2$N(R)$_2$.

[00134] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 47,



(47)

or a pharmaceutically acceptable salt or prodrug thereof, wherein:

the stereochemistry of the carbon kk' to carbon ll' double bond is cis or trans;

the stereochemistry of the carbon mm' to carbon nn' double bond is cis or trans;

the stereochemistry of the carbon oo' to carbon pp' double bond is cis or trans;

Y' is a bond or a linker selected from a ring containing up to 20 atoms or a chain of up to 20 atoms, provided that Y' can include one or more nitrogen, oxygen, sulfur or phosphorous atoms, further provided that Y' can include one or more substituents independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, chloro, iodo, bromo, fluoro, hydroxy, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, carboxamido, cyano, oxo, thio, alkylthio, arylthio, acylthio, alkylsulfonate, arylsulfonate, phosphoryl, or sulfonyl, further provided that Y' can contain one or more fused carbocyclic, heterocyclic, aryl or heteroaryl rings;

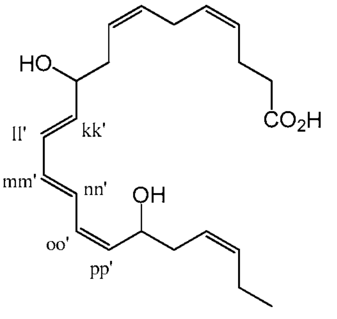
Z' is selected from -CN, -C(NH)N(R")(R"), -C(S)-A', -C(S)R", -C(O)-A', -C(O)-R", -C(O)-SR", -C(O)-NH-S(O)$_2$-R", -S(O)$_2$-A', -S(O)$_2$-R", S(O)$_2$N(R")(R"), -P(O)$_2$-A', -PO(OR")-A', -tetrazole, alkyltetrazole, or -CH$_2$OH, wherein

A' is selected from -OR", -N(R")(R") or –OM';

each R" is independently selected from hydrogen, alkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl or a detectable label molecule, wherein any alkyl-, aryl- or heteroaryl-containing moiety is optionally substituted with up to 3 independently selected substituents; and

M' is a cation.

[00135] In certain embodiments, a compound of formula 47 is represented by formula 48,



(48),

or pharmaceutically acceptable salts and esters thereof, wherein:
the stereochemistry of the carbon kk' to carbon ll' double bond is cis or trans;
the stereochemistry of the carbon mm' to carbon nn' double bond is cis or trans;
the stereochemistry of the carbon oo' to carbon pp' double bond is cis or trans.

[00136] In certain embodiments, the stereochemistry of the carbon kk' to carbon ll' double bond is trans.

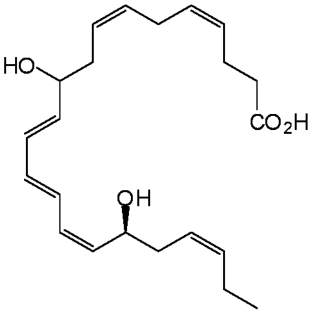
[00137] In certain embodiments, the stereochemistry of the carbon mm' to carbon nn' double bond is trans.

[00138] In certain embodiments, the stereochemistry of the carbon oo' to carbon pp' double bond is cis.

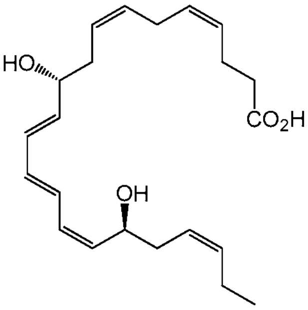
[00139] In certain embodiments, the stereochemistry of the carbon kk' to carbon ll' double bond is trans, the stereochemistry of the carbon mm' to carbon nn' double bond trans, and the stereochemistry of the carbon oo' to carbon pp' double bond is cis.

[00140] In certain embodiments, a compound of formula 47 is represented by

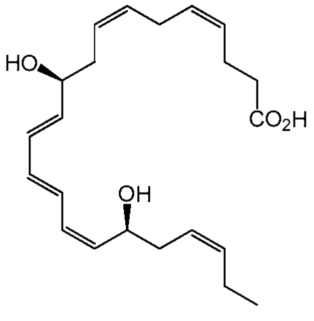
compound 48a,



(48a), compound 48b,

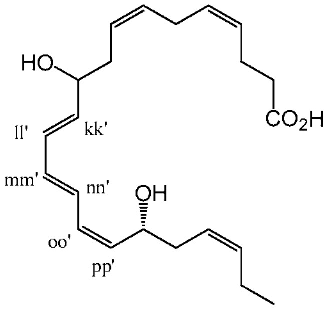


(48b), compound 48c,



(48c), or pharmaceutically acceptable salts and esters thereof.

[00141] In certain embodiments, a compound of formula 47 is represented by formula 48d,

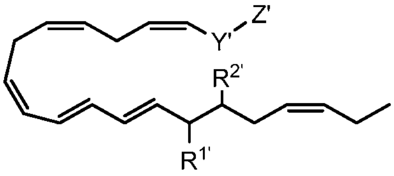


(48d), or pharmaceutically acceptable salts and esters thereof, wherein:

the stereochemistry of the carbon kk' to carbon ll' double bond is cis or trans;
the stereochemistry of the carbon mm' to carbon nn' double bond is cis or trans;
the stereochemistry of the carbon oo' to carbon pp' double bond is cis or trans.

[00142] In certain embodiments, the compound of formula 47 is other than a compound of formula 48, 48a, 48b, 48c, or 48d.

[00143] Other compounds contemplated for use in the combinations contemplated herein include those of Formula 49,



(49),

or a pharmaceutically acceptable salt or prodrug thereof, wherein:

Y' is a bond or a linker selected from a ring containing up to 20 atoms or a chain of up to 20 atoms, provided that Y' can include one or more nitrogen, oxygen, sulfur or phosphorous atoms, further provided that Y' can include one or more substituents independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, chloro, iodo, bromo, fluoro, hydroxy, alkoxy, aryloxy, carboxy, amino, alkylamino, dialkylamino, acylamino, carboxamido, cyano, oxo, thio, alkylthio, arylthio, acylthio, alkylsulfonate, arylsulfonate, phosphoryl, or sulfonyl, further provided that Y' can contain one or more fused carbocyclic, heterocyclic, aryl or heteroaryl rings;

Z' is selected from -CN, -C(NH)N(R'')(R''), -C(S)-A', -C(S)R'', -C(O)-A', -C(O)-R'', -C(O)-SR'', -C(O)-NH-S(O)$_2$-R'', -S(O)$_2$-A', -S(O)$_2$-R'', S(O)$_2$N(R'')(R''), -P(O)$_2$-A', -PO(OR'')-A', -tetrazole, alkyltetrazole, or -CH$_2$OH, wherein

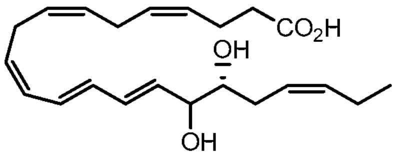
A' is selected from -OR'', -N(R'')(R'') or –OM';

each R'' is independently selected from hydrogen, alkyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl or a detectable label molecule, wherein any alkyl-, aryl- or heteroaryl-containing moiety is optionally substituted with up to 3 independently selected substituents; and

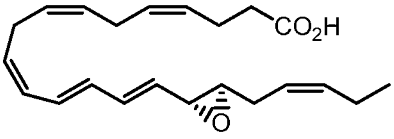
M' is a cation; and

each of R$^{a'}$ and R$^{b'}$ is independently for each occurrence selected from –OR', or adjacent R$^{a'}$ and R$^{b'}$ are taken together to form an epoxide ring having a cis or trans configuration, wherein each R' is independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, heteroaryl, acyl, silyl, alkoxyacyl, aminoacyl, aminocarbonyl, alkoxycarbonyl, or a protecting group.

[00144] Exemplary compounds of formula 49 include compound 49a,



(49a), compound 49b,



(49b), or pharmaceutically acceptable salts and esters thereof.

[00145] The compounds above (e.g., compounds of formula A or formulae 1 to 49) are known to be useful in the treatment or prevention of inflammation or inflammatory disease. Examples of such compounds are disclosed in the following patents and applications: US 2003/0191184, WO 2004/014835, WO 2004/078143, US 6670396, US 2003/0236423, US 2005/0228047, US 2005/0238589 and US2005/0261255. These compounds are also contemplated for use in the combinations contemplated herein.

[00146] The term "acyl" is art-recognized and refers to a group represented by the general formula hydrocarbylC(O)-, preferably alkylC(O)-.

[00147] The term “acylamino” is art-recognized and refers to an amino group substituted with an acyl group and may be represented, for example, by the formula hydrocarbylC(O)NH-.

[00148] The term “acyloxy” is art-recognized and refers to a group represented by the general formula hydrocarbylC(O)O-, preferably alkylC(O)O-.

[00149] The term “alkoxy” refers to an alkyl group, preferably a lower alkyl group, having an oxygen attached thereto. Representative alkoxy groups include methoxy, ethoxy, propoxy, tert-butoxy and the like.

[00150] The term “alkoxyalkyl” refers to an alkyl group substituted with an alkoxy group and may be represented by the general formula alkyl-O-alkyl.

[00151] The term “alkenyl”, as used herein, refers to an aliphatic group containing at least one double bond and is intended to include both "unsubstituted alkenyls" and "substituted alkenyls", the latter of which refers to alkenyl moieties having substituents replacing a hydrogen on one or more carbons of the alkenyl group. Such substituents may occur on one or more carbons that are included or not included in one or more double bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed below, except where stability is prohibitive. For example, substitution of alkenyl groups by one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated.

[00152] The term "alkyl" refers to the radical of saturated aliphatic groups, including straight-chain alkyl groups, branched-chain alkyl groups, cycloalkyl (alicyclic) groups, alkyl-substituted cycloalkyl groups, and cycloalkyl-substituted alkyl groups. In preferred embodiments, a straight chain or branched chain alkyl has 30 or fewer carbon atoms in its backbone (e.g., C_1-C_{30} for straight chains, C_3-C_{30} for branched chains), and more preferably 20 or fewer. Likewise, preferred cycloalkyls have from 3-10 carbon atoms in their ring structure, and more preferably have 5, 6 or 7 carbons in the ring structure.

[00153] Moreover, the term "alkyl" (or "lower alkyl") as used throughout the specification, examples, and claims is intended to include both "unsubstituted alkyls" and "substituted alkyls", the latter of which refers to alkyl moieties having substituents replacing a hydrogen on one or more carbons of the hydrocarbon backbone. Such substituents, if not otherwise specified, can include, for example, a halogen, a hydroxyl, a carbonyl (such as a carboxyl, an alkoxycarbonyl, a formyl, or an acyl), a thiocarbonyl (such as a thioester, a thioacetate, or a thioformate), an alkoxyl, a phosphoryl, a phosphate, a phosphonate, a phosphinate, an amino, an amido, an amidine, an imine, a cyano, a nitro, an azido, a sulfhydryl, an alkylthio, a sulfate, a sulfonate, a sulfamoyl, a sulfonamido, a sulfonyl, a heterocyclyl, an aralkyl, or an aromatic or heteroaromatic moiety. It will be understood by those skilled in the art that the moieties substituted on the hydrocarbon chain can themselves be substituted, if appropriate. For instance, the substituents of a substituted alkyl may include substituted and unsubstituted forms of amino, azido, imino, amido, phosphoryl (including phosphonate and phosphinate), sulfonyl (including sulfate, sulfonamido, sulfamoyl and sulfonate), and silyl groups, as well as ethers, alkylthios, carbonyls (including ketones, aldehydes, carboxylates, and esters), $-CF_3$, -CN and the like. Exemplary substituted alkyls are described below. Cycloalkyls can be further substituted with alkyls, alkenyls, alkoxys, alkylthios, aminoalkyls, carbonyl-substituted alkyls, $-CF_3$, -CN, and the like.

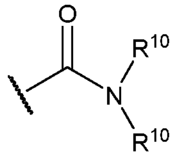
[00154] The term "C_{x-y}" when used in conjunction with a chemical moiety, such as, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy is meant to include groups that contain from x to y carbons in the chain. For example, the term "C_{x-y}alkyl" refers to substituted or unsubstituted saturated hydrocarbon groups, including straight-chain alkyl and branched-chain alkyl groups that contain from x to y carbons in the chain, including haloalkyl groups such as trifluoromethyl and 2,2,2-tirfluoroethyl, etc. C_0 alkyl indicates a hydrogen where the group is in a terminal position, a bond if internal. The terms "C_{2-y}alkenyl" and "C_{2-y}alkynyl" refer to substituted or unsubstituted unsaturated aliphatic groups analogous in length and possible substitution to the alkyls described above, but that contain at least one double or triple bond respectively.

[00155] The term "alkylamino", as used herein, refers to an amino group substituted with at least one alkyl group.

[00156] The term "alkylthio", as used herein, refers to a thiol group substituted with an alkyl group and may be represented by the general formula alkylS-.

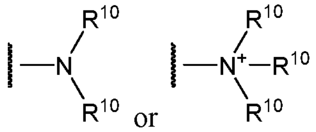
[00157] The term "alkynyl", as used herein, refers to an aliphatic group containing at least one triple bond and is intended to include both "unsubstituted alkynyls" and "substituted alkynyls", the latter of which refers to alkynyl moieties having substituents replacing a hydrogen on one or more carbons of the alkynyl group. Such substituents may occur on one or more carbons that are included or not included in one or more triple bonds. Moreover, such substituents include all those contemplated for alkyl groups, as discussed above, except where stability is prohibitive. For example, substitution of alkynyl groups by one or more alkyl, carbocyclyl, aryl, heterocyclyl, or heteroaryl groups is contemplated.

[00158] The term “amide”, as used herein, refers to a group



wherein each R^{10} independently represent a hydrogen or hydrocarbyl group, or two R^{10} are taken together with the N atom to which they are attached complete a heterocycle having from 4 to 8 atoms in the ring structure.

[00159] The terms “amine” and “amino” are art-recognized and refer to both unsubstituted and substituted amines and salts thereof, e.g., a moiety that can be represented by



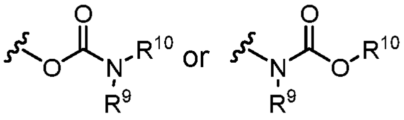
wherein each R^{10} independently represents a hydrogen or a hydrocarbyl group, or two R^{10} are taken together with the N atom to which they are attached complete a heterocycle having from 4 to 8 atoms in the ring structure.

[00160] The term “aminoalkyl”, as used herein, refers to an alkyl group substituted with an amino group.

[00161] The term “aralkyl”, as used herein, refers to an alkyl group substituted with an aryl group.

[00162] The term “aryl” as used herein include substituted or unsubstituted single-ring aromatic groups in which each atom of the ring is carbon. Preferably the ring is a 5- to 7-membered ring, more preferably a 6-membered ring. The term “aryl” also includes polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is aromatic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls. Aryl groups include benzene, naphthalene, phenanthrene, phenol, aniline, and the like.

[00163] The term "carbamate" is art-recognized and refers to a group



wherein R^9 and R^{10} independently represent hydrogen or a hydrocarbyl group, such as an alkyl group, or R^9 and R^{10} taken together with the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

[00164] The terms "carbocycle", "carbocyclyl", and "carbocyclic", as used herein, refers to a non-aromatic saturated or unsaturated ring in which each atom of the ring is carbon. Preferably a carbocycle ring contains from 3 to 10 atoms, more preferably from 5 to 7 atoms.

[00165] The term "carbocyclylalkyl", as used herein, refers to an alkyl group substituted with a carbocycle group.

[00166] The term "carbonate" is art-recognized and refers to a group $-OCO_2-R^{10}$, wherein R^{10} represents a hydrocarbyl group.

[00167] The term "carboxy", as used herein, refers to a group represented by the formula $-CO_2H$.

[00168] The term "ester", as used herein, refers to a group $-C(O)OR^{10}$ wherein R^{10} represents a hydrocarbyl group.

[00169] The term "ether", as used herein, refers to a hydrocarbyl group linked through an oxygen to another hydrocarbyl group. Accordingly, an ether substituent of a hydrocarbyl group may be hydrocarbyl-O-. Ethers may be either symmetrical or unsymmetrical. Examples of ethers include, but are not limited to, heterocycle-O-heterocycle and aryl-O-heterocycle. Ethers include "alkoxyalkyl" groups, which may be represented by the general formula alkyl-O-alkyl.

[00170] The terms "halo" and "halogen" as used herein means halogen and includes chloro, fluoro, bromo, and iodo.

[00171] The terms “hetaralkyl” and “heteroaralkyl”, as used herein, refers to an alkyl group substituted with a hetaryl group.

[00172] The term "heteroalkyl", as used herein, refers to a saturated or unsaturated chain of carbon atoms and at least one heteroatom, wherein no two heteroatoms are adjacent.

[00173] The terms “heteroaryl” and “hetaryl” include substituted or unsubstituted aromatic single ring structures, preferably 5- to 7-membered rings, more preferably 5- to 6-membered rings, whose ring structures include at least one heteroatom, preferably one to four heteroatoms, more preferably one or two heteroatoms. The terms “heteroaryl” and “hetaryl” also include polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is heteroaromatic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls. Heteroaryl groups include, for example, pyrrole, furan, thiophene, imidazole, oxazole, thiazole, pyrazole, pyridine, pyrazine, pyridazine, and pyrimidine, and the like.

[00174] The term “heteroatom” as used herein means an atom of any element other than carbon or hydrogen. Preferred heteroatoms are nitrogen, oxygen, and sulfur.

[00175] The terms “heterocyclyl”, “heterocycle”, and “heterocyclic” refer to substituted or unsubstituted non-aromatic ring structures, preferably 3- to 10-membered rings, more preferably 3- to 7-membered rings, whose ring structures include at least one heteroatom, preferably one to four heteroatoms, more preferably one or two heteroatoms. The terms “heterocyclyl” and “heterocyclic” also include polycyclic ring systems having two or more cyclic rings in which two or more carbons are common to two adjoining rings wherein at least one of the rings is heterocyclic, e.g., the other cyclic rings can be cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls. Heterocyclyl groups include, for example, piperidine, piperazine, pyrrolidine, morpholine, lactones, lactams, and the like.

[00176] The term “heterocyclylalkyl”, as used herein, refers to an alkyl group substituted with a heterocycle group.

[00177] The term “hydrocarbyl”, as used herein, refers to a group that is bonded through a carbon atom that does not have a =O or =S substituent, and typically has at least one carbon-hydrogen bond and a primarily carbon backbone, but may optionally include heteroatoms. Thus, groups like methyl, ethoxyethyl, 2-pyridyl, and trifluoromethyl are considered to be hydrocarbyl for the purposes of this application, but substituents such as acetyl (which has a =O substituent on the linking carbon) and ethoxy (which is linked through oxygen, not carbon) are not. Hydrocarbyl groups include, but are not limited to aryl, heteroaryl, carbocycle, heterocycle, alkyl, alkenyl, alkynyl, and combinations thereof.

[00178] The term "hydroxyalkyl", as used herein, refers to an alkyl group substituted with a hydroxy group.

[00179] The term "lower" when used in conjunction with a chemical moiety, such as, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy is meant to include groups where there are ten or fewer non-hydrogen atoms in the substituent, preferably six or fewer. A "lower alkyl", for example, refers to an alkyl group that contains ten or fewer carbon atoms, preferably six or fewer. In certain embodiments, acyl, acyloxy, alkyl, alkenyl, alkynyl, or alkoxy substituents defined herein are respectively lower acyl, lower acyloxy, lower alkyl, lower alkenyl, lower alkynyl, or lower alkoxy, whether they appear alone or in combination with other substituents, such as in the recitations hydroxyalkyl and aralkyl (in which case, for example, the atoms within the aryl group are not counted when counting the carbon atoms in the alkyl substituent).

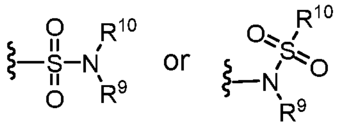
[00180] The terms "polycyclyl", "polycycle", and "polycyclic" refer to two or more rings (e.g., cycloalkyls, cycloalkenyls, cycloalkynyls, aryls, heteroaryls, and/or heterocyclyls) in which two or more atoms are common to two adjoining rings, e.g., the rings are "fused rings". Each of the rings of the polycycle can be substituted or unsubstituted. In certain embodiments, each ring of the polycycle contains from 3 to 10 atoms in the ring, preferably from 5 to 7.

[00181] The term "silyl" refers to a silicon moiety with three hydrocarbyl moieties attached thereto.

[00182] The term "substituted" refers to moieties having substituents replacing a hydrogen on one or more carbons of the backbone. It will be understood that "substitution" or "substituted with" includes the implicit proviso that such substitution is in accordance with permitted valence of the substituted atom and the substituent, and that the substitution results in a stable compound, e.g., which does not spontaneously undergo transformation such as by rearrangement, cyclization, elimination, etc. As used herein, the term "substituted" is contemplated to include all permissible substituents of organic compounds. In a broad aspect, the permissible substituents include acyclic and cyclic, branched and unbranched, carbocyclic and heterocyclic, aromatic and non-aromatic substituents of organic compounds. The permissible substituents can be one or more and the same or different for appropriate organic compounds. For purposes of the present disclosure, the heteroatoms such as nitrogen may have hydrogen substituents and/or any permissible substituents of organic compounds described herein which satisfy the valences of the heteroatoms. Substituents can include any substituents described herein, for example, a halogen, a hydroxyl, a carbonyl (such as a carboxyl, an alkoxycarbonyl, a formyl, or an acyl), a thiocarbonyl (such as a thioester, a thioacetate, or a thioformate), an alkoxyl, a phosphoryl, a phosphate, a phosphonate, a phosphinate, an amino, an amido, an amidine, an imine, a cyano, a nitro, an azido, a sulfhydryl, an alkylthio, a sulfate, a sulfonate, a sulfamoyl, a sulfonamido, a sulfonyl, a heterocyclyl, an aralkyl, or an aromatic or heteroaromatic moiety. It will be understood by those skilled in the art that the moieties substituted on the hydrocarbon chain can themselves be substituted, if appropriate. Unless specifically stated as "unsubstituted," references to chemical moieties herein are understood to include substituted variants. For example, reference to an "aryl" group or moiety implicitly includes both substituted and unsubstituted variants.

[00183] The term "sulfate" is art-recognized and refers to the group -OSO_3H, or a pharmaceutically acceptable salt thereof.

[00184] The term "sulfonamide" is art-recognized and refers to the group represented by the general formulae



wherein R^9 and R^{10} independently represents hydrogen or hydrocarbyl, such as alkyl, or R^9 and R^{10} taken together with the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

[00185] The term "sulfoxide" is art-recognized and refers to the group -S(O)-R^{10}, wherein R^{10} represents a hydrocarbyl.

[00186] The term "sulfonate" is art-recognized and refers to the group SO_3H, or a pharmaceutically acceptable salt thereof.

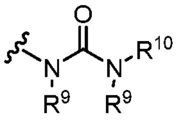
[00187] The term “sulfone” is art-recognized and refers to the group -$S(O)_2$-R^{10}, wherein R^{10} represents a hydrocarbyl.

[00188] The term “thioalkyl”, as used herein, refers to an alkyl group substituted with a thiol group.

[00189] The term “thioester”, as used herein, refers to a group -$C(O)SR^{10}$ or -$SC(O)R^{10}$ wherein R^{10} represents a hydrocarbyl.

[00190] The term “thioether”, as used herein, is equivalent to an ether, wherein the oxygen is replaced with a sulfur.

[00191] The term “urea” is art-recognized and may be represented by the general formula



wherein R^9 and R^{10} independently represent hydrogen or a hydrocarbyl, such as alkyl, or either occurrence of R^9 taken together with R^{10} and the intervening atom(s) complete a heterocycle having from 4 to 8 atoms in the ring structure.

[00192] “Protecting group” refers to a group of atoms that, when attached to a reactive functional group in a molecule, mask, reduce or prevent the reactivity of the functional group. Typically, a protecting group may be selectively removed as desired during the course of a synthesis. Examples of protecting groups can be found in Greene and Wuts, *Protective Groups in Organic Chemistry,* 3rd Ed., 1999, John Wiley & Sons, NY and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8, 1971-1996, John Wiley & Sons, NY. Representative nitrogen protecting groups include, but are not limited to, formyl, acetyl, trifluoroacetyl, benzyl, benzyloxycarbonyl (“CBZ”), tert-butoxycarbonyl (“Boc”), trimethylsilyl (“TMS”), 2-trimethylsilyl-ethanesulfonyl (“TES”), trityl and substituted trityl groups, allyloxycarbonyl, 9-fluorenylmethyloxycarbonyl (“FMOC”), nitro-veratryloxycarbonyl (“NVOC”) and the like. Representative hydroxylprotecting groups include, but are not limited to, those where the hydroxyl group is either acylated (esterified) or alkylated such as benzyl and trityl ethers, as well as alkyl ethers, tetrahydropyranyl ethers, trialkylsilyl ethers (e.g., TMS or TIPS groups), glycol ethers, such as ethylene glycol and propylene glycol derivatives and allyl ethers.

[00193] In some embodiments of the compositions and methods disclosed herein, the hydrophobic component is cyclosporine and the hydrophilic component is Lifitegrast. In some embodiments of the compositions and methods disclosed herein, the hydrophobic component is cyclosporine and the hydrophilic component is MIM-D3. In some embodiments of the compositions and methods disclosed herein, the hydrophobic component is a resolvin and the hydrophilic component is Lifitegrast. In some embodiments of the compositions and methods disclosed herein, the hydrophobic component is a resolvin and the hydrophilic component is MIM-D3.

[00194] The term "treating" refers to: preventing a disease, disorder or condition from occurring in a cell, a tissue, a system, animal or human which may be predisposed to the disease, disorder and/or condition but has not yet been diagnosed as having it; stabilizing a disease, disorder or condition, i.e., arresting its development; and/or relieving one or more symptoms of the disease, disorder or condition, i.e., causing regression of the disease, disorder and/or condition.

[00195] As used herein, a therapeutic that “prevents” a disorder or condition refers to a compound that, in a statistical sample, reduces the occurrence of the disorder or condition in the treated sample relative to an untreated control sample, or delays the onset or reduces the severity of one or more symptoms of the disorder or condition relative to the untreated control sample.

[00196] As used herein, the terms "ocular disease," "ocular condition," "eye disease," and "eye condition" refer to diseases/conditions of the eye(s) that can be sight threatening, lead to eye discomfort, and may signal systemic health problems.

[00197] As used herein, the term "anterior segment disease" refers to all disorders that affect the eye surface, anterior chamber, iris and ciliary body and lens of the eye. The eye surface is composed of the cornea, conjunctiva, eyelids, lacrimal and meibomian glands, and the interconnecting nerves.

[00198] As used herein, the terms "posterior segment eye disease" and "back-of-the-eye disease" refer to all disorders that affect the posterior segment of the eye. A posterior eye disease is a disease which primarily affects a posterior ocular site such as choroid or sclera, vitreous, vitreous chamber, retina, optic nerve, and blood vessels and nerves which vascularize or innervate a posterior ocular site.

[00199] Accordingly, in one aspect, provided is a method treating or preventing an ocular disease or condition, that includes locally administering a formulation of any of the aspects or embodiments as disclosed herein. In some embodiments, the ocular disease is an anterior segment disease. In some embodiments, the ocular disease is a posterior segment disease. In some embodiments, the ocular disease is one or more selected from the group consisting of dry eye syndrome, Sjogren's syndrome, uveitis, anterior uveitis (iritis), chorioretinitis, posterior uveitis, conjunctivitis, allergic conjunctivitis, keratitis, keratoconjunctivitis, vernal keratoconjunctivitis (VKC), atopic keratoconjunctivitis, systemic immune mediated diseases such as cicatrizing conjunctivitis and other autoimmune disorders of the ocular surface, blepharitis, scleritis, age-related macular degeneration (AMD), diabetic retinopathy (DR), diabetic macular edema (DME), ocular neovascularization, age-related macular degeneration (ARMD), proliferative vitreoretinopathy (PVR), cytomegalovirus (CMV) retinitis, optic neuritis, retrobulbar neuritis, and macular pucker. In one embodiment, the ocular disease is dry eye. In one embodiment, the ocular disease is allergic conjunctivitis. In one embodiment the ocular disease is age-related macular degeneration (AMD). In one embodiment the ocular disease is diabetic retinopathy.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Active Agents

[00200] In accordance with various aspects and embodiments of the methods and compositions provided herein, an active agent can be any agent capable of affecting a biological process. Active agents (the term active ingredient is used herein interchangably with the term active agent) include HIF ritonivir, travoprost, bimatoprost, tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like. In some embodiments an active agent in accordance with the aspects and embodiments disclosed herein is an agent capable of, or approved for, treating or preventing an disease or condition, for example in some embodiments an active agent is capable of, or approved for, treating or preventing an ocular disease or condition.

[00201] The compositions of the present disclosure can be used as a topically applied or locally injected drug delivery platform for delivery of a variety of active agents including hydrophobic, water-insoluble drugs. Active agents may include HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

Ocular Diseases

[00202] In various aspects and embodiments the formulations as disclosed herein may be used to treat or prevent an ocular disease or disorder. Ocular diseases and disorders contemplated herein include anterior segment diseases and posterior segment diseases. Exemplary ocular diseases that may in certain embodiments be treated with formulations as disclosed herein include the following.

[00203] Dry eye syndrome (DES, Chronic dry eye, Keratitis sicca; Xerophthalmia; Keratoconjunctivitis sicca) can be defined as a condition that includes a variety of disorders that result in a loss of, or altered composition of, the natural tear film, which maintains the surface of the eye. Without this tear film, vision is impaired and patients may suffer severe ocular discomfort. DES can be caused by excessive tear evaporation or by a reduction of tear production in the lacrimal gland, which is the site of tear production. Though the exact causes of this condition are unknown, there is evidence supporting the link between reduced tear production and inflammation of one or more components of the lacrimal apparatus. Currently available medications for DES are leaving substantial room for more effective and better tolerated products.

[00204] DES may also be a manifestation of Sjogren's syndrome which is an autoimmune disorder in which the glands that produce tears and saliva are destroyed. This leads to dry mouth, decreased tearing, and other dry mucous membranes.

[00205] Noninfectious uveitis is a chronic inflammatory, putative Th1/Th17-mediated autoimmune disease associated with substantial visual morbidity and is potentially blinding. Blindness from uveitis usually does not occur from a single inflammatory episode; rather, cumulative damage results from recurrent episodes of inflammation. The inflammatory sequelae resulting in vision loss may include one or more of cystoid macular edema, cataracts, vitreous debris, glaucoma, macular pathology (scarring and atrophy), optic neuropathy, and retinal detachment.

[00206] Anterior uveitis (iritis) occurs in the front of the eye and is the most common form of uveitis. Par planitis is an inflammation of the pars plana, a narrow area between the iris and the choroid. This condition occurs more frequently in young men, but is usually not associated with another disease. Posterior uveitis (chondroitis) affects primarily the choroid; the back portion of the uveal tract. If the retina is also involved, it is called chorioretinitis. Posterior uveitis may occur in association with an autoimmune disease, or follow a systemic infection. In posterior uveitis, inflammation can last from months to years and may cause permanent vision damage, even with treatment.

[00207] Uveitis can cause vision impairment, ocular pain, and loss of vision. It is estimated that about 10% of new cases of blindness in the U.S. are caused by uveitis. Approximately 300,000 people suffer from uveitis in the U.S. alone, the majority of whom are affected by anterior uveitis. The only therapeutic class approved by the FDA for treatment of uveitis is corticosteroids, which are noted for multiple side effects, such as hypertension, hyperglycemia, and hypercholesterolemia, and in the eye, glaucoma and cataract formation.

[00208] Conjunctivitis (pink eye) describes a group of diseases that cause swelling, itching, burning, and redness of the conjunctiva, the protective membrane that lines the eyelids and covers exposed areas of the sclera, or white of the eye.

[00209] Keratitis is an inflammation of the cornea (clear portion in the front of the eye). Keratitis can be caused by an infection (bacterial, fungal, viral, parasite, etc.) or a non-infectious agent (e.g., certain types of auto-immune diseases are associated with a variety of non-infectious keratitises).

[00210] Keratoconjunctivitis refers to an inflammation of the cornea and conjunctiva.

[00211] Vernal keratoconjunctivitis (VKC) is a recurrent ocular inflammatory disease characterized by hard, elevated, cobblestone like bumps on the upper eyelid. There may also be swellings and thickening of the conjunctiva. The conjunctiva is the outermost membrane which lines the eyelids as well as the exposed parts of the eye, except for the cornea.

[00212] Atopic keratoconjunctivitis is the result of a condition called atopy. Atopy is a genetic condition whereby the immune system produces higher than normal antibodies in response to a given allergen.

[00213] Systemic immune mediated diseases such as cicatrizing conjunctivitis and other autoimmune disorders of the ocular surface represent a clinically heterogeneous group of conditions where acute and chronic autoreactive mechanisms can cause significant damage to the eye. When severe and affecting the epithelium and substantia propria of the conjunctiva, cicatrization can ensue, leading to significant mechanical alterations as a result of the fibrosis. These conditions, though generally infrequent, can be the cause of profound pathology and visual disability.

[00214] Blepharitis is a common condition that causes inflammation of the eyelids.

[00215] Scleritis is a serious inflammatory disease that affects the white outer coating of the eye, known as the sclera.

[00216] Age-related macular degeneration (AMD) is a disease associated with aging that gradually destroys sharp, central vision. AMD affects the macula, which is located at the center of the retina. AMD occurs in two forms: wet and dry. Wet AMD occurs when abnormal blood vessels behind the retina start to grow under the macula. These new blood vessels tend to be very fragile and often leak blood and fluid. The blood and fluid raise the macula from its normal place at the back of the eye. Damage to the macula occurs rapidly. Dry AMD occurs when the light-sensitive cells in the macula slowly break down, gradually blurring central vision in the affected eye.

[00217] Diabetes can affect the eye in a number of ways. Diabetic retinopathy (DR) is a complication of diabetes that results from damage to the blood vessels of the light-sensitive tissue at the back of the eye (the retina). At first, diabetic retinopathy may cause no symptoms or only mild vision problems. Eventually, however, diabetic retinopathy can result in blindness. Diabetic macular edema (DME) is the swelling of the retina in diabetes mellitus due to leaking of fluid from blood vessels within the macula.

[00218] Ocular neovascularization is the abnormal or excessive formation of blood vessels in the eye. Ocular neovascularization has been shown in diabetic retinopathy and age-related macular degeneration (AMD).

[00219] Proliferative vitreoretinopathy (PVR) is scar tissue formation within the eye. "Proliferative" because cells proliferate and "vitreoretinopathy" because the problems involve the vitreous and retina. In PVR scar tissue forms in sheets on the retina which contract. This marked contraction pulls the retina toward the center of the eye and detaches and distorts the retina severely. PVR can occur both posteriorly and anteriorly with folding of the retina both anteriorly and circumferentially.

[00220] The cytomegalovirus (CMV) is related to the herpes virus and is present in almost everyone. When a person's immune system is suppressed because of disease (HIV), organ or bone marrow transplant, or chemotherapy, the CMV virus can cause damage and disease to the eye and the rest of the body. CMV affects the eye in about 30% of the cases by causing damage to the retina. This is called CMV retinitis.

[00221] Optic neuritis occurs when the optic nerve becomes inflamed and the myelin sheath becomes damaged or is destroyed. Nerve damage that occurs in the section of the optic nerve located behind the eye, is called retrobulbar neuritis, which is another term sometimes used for optic neuritis.

[00222] Also known as macular pucker, epiretinal membrane is a scar-tissue like membrane that forms over the macula. It typically progresses slowly and affects central vision by causing blurring and distortion. As it progresses, the pulling of the membrane on the macula may cause swelling.

[00223] In an embodiment, the compositions can be used for preventing transplant rejection of, for example, corneal allografts following transplantation. It is well known that in inflammation T-lymphocytes play a critical role in mediating rejection of foreign tissues. Prevention of rejection is of paramount importance in maintaining the health of transplanted corneas. Rejection may occur in any of the layers comprising the cornea, for example, the corneal epithelium, the corneal stroma or the corneal endothelium. The functioning of the cornea can be compromised following endothelial rejection. The endothelial layer serves to maintain the cornea in a compact state, acting as a pump by removing water from the corneal stroma. If the function of the endothelial layer is compromised, disorientation of collagen fibers can ensue, and transparency of the cornea can be lost. Human endothelial cells are non-replicative, and as a consequence, donor cell loss in the setting of rejection is irreversible and may lead to diminished graft function and survival. Thus, the goal of either prevention or treatment of rejection in corneal transplant recipients is to minimize endothelial cell loss. The compositions of the present disclosure can be used for the prevention of rejection following corneal allograft transplantation.

Additional Formulation Ingredients

[00224] The compositions of the present disclosure may also contain other components such as, but not limited to, additives, adjuvants, buffers, tonicity agents, bioadhesive polymers, and preservatives. In any of the compositions of this disclosure for topical to the eye, the mixtures are preferably formulated at about pH 5 to about pH 8. This pH range may be achieved by the addition of buffers to the composition as described in the examples. In an embodiment, the pH range in the composition in a formulation is about pH 6.6 to about pH 7.0. It should be appreciated that the compositions of the present disclosure may be buffered by any common buffer system such as phosphate, borate, acetate, citrate, carbonate and borate-polyol complexes, with the pH and osmolality adjusted in accordance with well-known techniques to proper physiological values. The mixed micellar compositions of the present disclosure are stable in buffered aqueous solution. That is, there is no adverse interaction between the buffer and any other component that would cause the compositions to be unstable.

[00225] Tonicity agents include, for example, mannitol, sodium chloride, xylitol, etc. These tonicity agents may be used to adjust the osmolality of the compositions. In one aspect, the osmolality of the formulation is adjusted to be in the range of about 250 to about 350 mOsmol/kg. In a preferred aspect, the osmolality of the formulation is adjusted to between about 280 to about 300 mOsmol/kg.

[00226] An additive such as a sugar, a glycerol, and other sugar alcohols, can be included in the compositions of the present disclosure. Pharmaceutical additives can be added to increase the efficacy or potency of other ingredients in the composition. For example, a pharmaceutical additive can be added to a composition of the present disclosure to improve the stability of the calcineurin inhibitor or mTOR inhibitor, to adjust the osmolality of the composition, to adjust the viscosity of the composition, or for another reason, such as effecting drug delivery. Non-limiting examples of pharmaceutical additives of the present disclosure include sugars, such as, trehalose, mannose, D-galactose, and lactose. In an embodiment, the sugars can be incorporated into a composition prior to hydrating the thin film (i.e., internally). In another embodiment, the sugars can be incorporated into a composition during the hydration step (i.e., externally) (see Example 17). In an embodiment, an aqueous, clear, mixed micellar solution of the present disclosure includes additives such as sugars.

[00227] In an embodiment, compositions of the present disclosure further comprise one or more bioadhesive polymers. Bioadhesion refers to the ability of certain synthetic and biological macromolecules and hydrocolloids to adhere to biological tissues. Bioadhesion is a complex phenomenon, depending in part upon the properties of polymers, biological tissue, and the surrounding environment. Several factors have been found to contribute to a polymer's bioadhesive capacity: the presence of functional groups able to form hydrogen bridges (--OH, COOH), the presence and strength of anionic charges, sufficient elasticity for the polymeric chains to interpenetrate the mucous layer, and high molecular weight. Bioadhesion systems have been used in dentistry, orthopedics, ophthalmology, and in surgical applications. However, there has recently emerged significant interest in the use of bioadhesive materials in other areas such as soft tissue-based artificial replacements, and controlled release systems for local release of bioactive agents. Such applications include systems for release of drugs in the buccal or nasal cavity, and for intestinal or rectal administration.

[00228] In an embodiment, a composition of the present disclosure includes at least one bioadhesive polymer. The bioadhesive polymer can enhance the viscosity of the composition and thereby increase residence time in the eye. Bioadhesive polymers of the present disclosure include, for example, carboxylic polymers like Carbopol® (carbomers), Noveon® (polycarbophils), cellulose derivatives including alkyl and hydroxyalkyl cellulose like methylcellulose, hydroxypropylcellulose, carboxymethylcellulose, gums like locust beam, xanthan, agarose, karaya, guar, and other polymers including but not limited to polyvinyl alcohol, polyvinyl pyrollidone, polyethylene glycol, Pluronic® (Poloxamers), tragacanth, and hyaluronic acid; phase-transition polymers for providing sustained and controlled delivery of enclosed medicaments to the eye (e.g., alginic acid, carrageenans (e.g., Eucheuma), xanthan and locust bean gum mixtures, pectins, cellulose acetate phthalate, alkylhydroxyalkyl cellulose and derivatives thereof, hydroxyalkylated polyacrylic acids and derivatives thereof, poloxamers and their derivatives, etc. Physical characteristics in these polymers can be mediated by changes in environmental factors such as ionic strength, pH, or temperature alone or in combination with other factors. In an embodiment, the optional one or more bioadhesive polymers is present in the composition from about 0.01 wt % to about 10 wt %/volume, preferably from about 0.1 to about 5 wt %/volume. In an embodiment, the compositions of the present disclosure further comprise at least one hydrophilic polymer excipient selected from, for example, PVP-K-30, PVP-K-90, HPMC, HEC, and polycarbophil. In an embodiment, the polymer excipient is selected from PVP-K-90, PVP-K-30 or HPMC. In an embodiment, the polymer excipient is selected from PVP-K-90 or PVP-K-30.

[00229] In an embodiment, if a preservative is desired, the compositions may optionally be preserved with any of many well-known preservatives, including benzyl alcohol with/without EDTA, benzalkonium chloride, chlorhexidine, Cosmocil® CQ, or Dowicil® 200. In certain embodiments, it may be desireable for a formulation as described herein to not include any preservatives. In this regard, preservatives may in some embodiments not be necessary or desirable in formulations included in single use containers. In other embodiments it may be advantageous to include preservatives, such as in certain embodiments in which the formulations are included in a multiuse container.

[00230] The ophthalmic compositions can be administered topically to the eye as biocompatible, aqueous, clear mixed micellar solutions. The compositions have the drugs incorporated and/or encapsulated in micelles which are dispersed in an aqueous medium.

Non-Limiting List of Exemplary Embodiments

[00231] In addition to the aspects and embodiments described and provided elsewhere in this disclosure, the following non-limiting list of particular embodiments are specifically contemplated.

1. An ophthalmic formulation, comprising an active agent, a polyoxyl lipid or fatty acid and a polyalkoxylated alcohol, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.
2. An ophthalmic formulation, comprising an active agent, and a $n \geq 40$ polyoxyl lipid or fatty acid, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.
3. An ophthalmic formulation, comprising an active ingredient and a polyoxyl lipid or fatty acid; wherein said polyoxyl lipid or fatty acid is present in an amount equal to or greater than 1% of said formulation, and wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.
4. An ophthalmic formulation, comprising an active agent and a polyoxyl lipid or fatty acid; wherein said formulation comprises nanomicelles, and wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost,

Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

5. An ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

6. An ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

7. An ophthalmic formulation, comprising greater than 0.2% of an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

8. An ophthalmic formulation, comprising an active agent, 1.5-4% of one or more polyoxl lipids selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

9. An ophthalmic formulation, comprising an active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

10. An ophthalmic formulation, comprising an active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01-0.1% octoxynol-40; wherein the formulation comprises nanomicelles, wherein said active agent is selected from the group consisting of HIF ritonivir,

Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

11. An ophthalmic formulation, comprising a hydrophobic active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01-0.1% octoxynol-40; wherein the formulation comprises nanomicelles, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

12. An ophthalmic formulation, comprising an active agent, about 4% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

13. An ophthalmic formulation, comprising an active agent, about 4% of HCO-60 and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

14. An ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

15. An ophthalmic formulation, comprising an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

16. An ophthalmic formulation, comprising greater than 0.2% of an active agent, 1-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3,

A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

17. An ophthalmic formulation, comprising an active agent, 1.5-4% of one or more polyoxl lipids selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

18. An ophthalmic formulation, comprising an active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

19. An ophthalmic formulation, comprising an active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01% octoxynol-40; wherein the formulation comprises nanomicelles, and wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

20. An ophthalmic formulation, comprising a hydrophobic active agent, 1.5-4% of polyoxl lipids or fatty acids; and about 0.01% octoxynol-40; wherein the formulation comprises nanomicelles, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

21. An ophthalmic formulation, comprising an active agent, about 4% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80 and HCO-100; and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

22. An ophthalmic formulation, comprising an active agent, about 4% of HCO-60 and about 0.01% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3

adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

23. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 0.5 and 6% by weight of said formulation.

24. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 0.5 and 2% by weight of said formulation.

25. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 0.5 and 3% by weight of said formulation.

26. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 0.5 and 4% by weight of said formulation.

27. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 0.5 and 5% by weight of said formulation.

28. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 6% by weight of said formulation.

29. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 2% by weight of said formulation.

30. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 3% by weight of said formulation.

31. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 4% by weight of said formulation.

32. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 5% by weight of said formulation.

33. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 1 and 6% by weight of said formulation.

34. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 2 and 6% by weight of said formulation.

35. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 3 and 6% by weight of said formulation.

36. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 4 and 6% by weight of said formulation.

37. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 2 and 5% by weight of said formulation.

38. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is between 3 and 5% by weight of said formulation.

39. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is about 4% by weight of said formulation.

40. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is greater than about 0.7% by weight of said formulation.

41. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is greater than about 1% by weight of said formulation.

42. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is greater than about 1.5% by weight of said formulation.

43. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is greater than about 2% by weight of said formulation.

44. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is greater than about 3% by weight of said formulation.

45. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.002 and 4% by weight of said formulation.

46. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 3% by weight of said formulation.

47. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 2% by weight of said formulation.

48. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 1% by weight of said formulation.

49. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 0.5% by weight of said formulation.

50. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 0.1% by weight of said formulation.

51. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.005 and 0.05% by weight of said formulation.

52. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is between 0.008 and 0.02% by weight of said formulation.

53. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol if present is about 0.01% by weight of said formulation.

54. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, or the like.

55. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, or the like.

56. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.2%.

57. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.3%.

58. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.4%.

59. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.5%.

60. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.6%.

61. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.7%.

62. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.8%.

63. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 0.9%.

64. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 1%.

65. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 1.5%.

66. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 2%.

67. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 3%.

68. The formulation of any of the preceding embodiments, wherein said active ingredient is present in said formulation in an amount greater than 4%.

69. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is a polyoxyl castor oil.

70. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is one or more selected from HCO-60, HCO-80 or HCO-100.

71. The formulation of any of the preceding embodiments, wherein said polyoxyl lipid or fatty acid is HCO-60.

72. The formulation of any of the preceding embodiments, wherein said polyalkoxylated alcohol, if present is octoxynol-40.

73. The formulation of any of the preceding embodiments, wherein said active agent is one or more selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

74. The formulation of any of the preceding embodiments, wherein said active agent is one or more selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like, an analog thereof, or a pharmaceutically acceptable salt thereof.

75. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, or the like.

76. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, or the like.

77. The formulation of any of the preceding embodiments, wherein said active agent is one or more selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like, an analog thereof, or a pharmaceutically acceptable salt thereof.

78. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like, a prodrug of any of the foregoing, or a pharmaceutically acceptable salt of any of the foregoing.

79. The formulation of any of the preceding embodiments, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations,

or the like, a prodrug of any of the foregoing, or a pharmaceutically acceptable salt of any of the foregoing.

80. The formulation of any of the preceding embodiments, wherein said active agent comprises a combination of two different agents.

81. The formulation of any of the preceding embodiments, wherein the active agent comprises two or more active agents selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, steroid/antibiotic combinations, and the like.

82. The formulation of any of the preceding embodiments, wherein said formulation comprises a preservative.

83. The formulation of any of the preceding embodiments, wherein said formulation comprises one or more preservatives selected from the group consisting of benzyl alcohol with/without EDTA, benzalkonium chloride, chlorhexidine, Cosmocil® CQ, and Dowicil® 200.

84. The formulation of any of the preceding embodiments, wherein said formulation does not include preservatives.

85. The formulation of any of the preceding embodiments, wherein said formulation does not include benzyl alcohol with/without EDTA, benzalkonium chloride, chlorhexidine, Cosmocil® CQ, or Dowicil® 200.

86. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments.

87. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is an anterior segment disease.

88. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is an posterior segment disease.

89. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is one or more selected from the group consisting of dry eye syndrome, Sjogren's syndrome, uveitis, anterior uveitis (iritis), chorioretinitis, posterior uveitis, conjunctivitis, allergic conjunctivitis, keratitis, keratoconjunctivitis, vernal keratoconjunctivitis (VKC), atopic keratoconjunctivitis, systemic immune mediated diseases such as cicatrizing conjunctivitis and other autoimmune disorders of the ocular surface,

blepharitis, scleritis, age-related macular degeneration (AMD), diabetic retinopathy (DR), diabetic macular edema (DME), ocular neovascularization, age-related macular degeneration (ARMD), proliferative vitreoretinopathy (PVR), cytomegalovirus (CMV) retinitis, optic neuritis, retrobulbar neuritis, and macular pucker.

90. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is dry eye syndrome.

91. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is allergic conjunctivitis.

92. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding embodiments; wherein said disease is age-related macular degeneration (AMD).

[00232] The following examples are provided to further illustrate aspects of the invention. These examples are non-limiting and should not be construed as limiting any aspect of the invention.

EXAMPLE 1

Preparation of Mixed Nanomicellar Formulation Using Dialysis Method

[00233] Mixed nanomicellar formulation of one or more of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and/or steroid/antibiotic combinations is prepared by dialysis method with varying ratio of polymers and the drug. Experimental design software, JMP 9.0 is used to design the experiments and analyze the results. Accurately weighted quantities of two polymers (namely polyoxyl hydrogenated castor-60 (HCO-60) and octoxynol-40 (Oc-40)) are dissolved in 300 microliter volume of propylene glycol. Eighty microliter (or 80 mg of an exemplary compound in PG) of propylene glycol containing compound of interest is added to this polymer mixture and vortex mixed to get a clear homogenous solution. The volume of the mixture is made up (500 microliters) with propylene glycol. The solution is vortex mixed to get a homogenous solution. A volume of 500 microliter distilled deionized water is added to this mixture to obtain a total volume of 1000 microliter (1 milliliter). Addition of water to the active agent-polymer mixture in organic solvent should spontaneously generate micelles thereby entrapping the pharmaceutical active agent in the hydrophobic core of mixed nanomicelles. The mixture is transferred to a dialysis bag (molecular weight cut off 1000) and transferred to a beaker containing one liter of distilled deionized water. Beaker and the contents thereof are protected from sunlight by covering with aluminum foil and are kept under slow constant stirring at room temperature. Dialysis of the mixture is carried out over a period of 24 h to remove the water soluble organic solvent, propylene glycol, from the mixture. Water in the dialysis chamber is changed at predetermined time points : 1h, 2h, 4h, 6h, 12h and 24h. At the end of dialysis(24h), the contents of the dialysis bag are carefully transferred to a 15-mL centrifuge tube and formulations are subjected to sonication in water bath (time range from 0 min to 5 min). The final volume is made up with 2X phosphate buffer saline and the pH of the formulation adjusted to 6.5±0.1. The resultant formulation is filtered with 0.22 micrometer nylon filter to remove any foreign particulate matter.

[00234] The prepared formulations are subjected to various tests such as entrapment efficiency, loading efficiency, mixed nanomicellar size and polydispersity index.

[00235] **Mixed nanomicellar Size and polydispersity index:** The formulation size and polydispersity index are determined with Zetasizer, Malvern Instruments, NJ. In brief, approximately 1mL of each formulation is transferred to a cuvette and placed in the instrument. A laser beam of light is used to determine the mixed nanomicellar size. The results of the size are summarized in Table 1.

[00236] **Entrapment efficiency:** To determine the entrapment efficiency of the formulation, all the prepared formulations are subjected to entrapment efficiency test. Briefly, formulations are vortex mixed for homogeneity and 1mL is transferred to a fresh (1.5 mL) eppendorf tube. Each formulation is lyophilized to obtain a solid at the bottom of eppendorf tube. The obtained solid is suspended in 1mL of organic solvent (diethyl ether) to generate reverse micelles and release the drug into the external organic solvent. The organic solvent is evaporated overnight in speed vacuum. The resultant reversed micelles are resuspended in 1mL of 2-propanol (dilution factor was taken into account) and further diluted to determine the concentration of compound 1001 entrapped in each micellar preparation with HPLC. The entrapment efficiency of the formulation is calculated with the following formula (wherein MNF= Mixed Nanomicellar Formulation):

$$\text{Entrapment efficiency} = \frac{\text{(amount of drug quantified in MNF)}}{\text{Amount of drug added in the MNF}} \times 100$$

[00237] **Drug Quantification by an HPLC method:** *In vitro* analysis of one or more of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and/or steroid/antibiotic combinations is performed by a reverse phase high performance liquid chromatography (RP-HPLC) method with a Shimadzu HPLC pump (Shimadzu, Shimadzu Scientific instruments, Columbia, MD), Alcott autosampler (model 718 AL), Shimadzu UV/Visible detector (Shimadzu, SPD-20A/20AV, USA), ODS column (5 µm, 150 x 4.6 mm) thermostated at 40° ± 1 C and Hewlett Packard HPLC integrator (Hewlett Packard, Palo Alto, CA). The mobile phase is comprised of methanol (MeOH), water and trifluoroacetic acid (TFA) (70:30:0.05% v/v) which is set at a flow rate of 0.5 mL/min. Detection wavelength is set at 272 nm. The sample tray temperature is maintained at 4° C. Calibration curve (0.5 to 5 µg/mL) for one or more of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and/or steroid/antibiotic combinations is prepared by making appropriate dilutions from the stock solution in 2-propanol. An injection volume of 10 µl is injected into the HPLC column for analysis. All the standards and samples prepared are stored at 4°C before and during the analysis.

EXAMPLE 2

Preparation of Mixed Nanomicellar Formulation Using Ethyl Acetate Solvent Evaporation Method

[00238] Mixed nanomicellar formulation encapsulating one or more of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and/or steroid/antibiotic combinations is prepared by solvent evaporation method in two steps: 1) Preparation of basic formulation and 2) rehydration. In step one, active agent, HCO-60 and octoxynol-40 are dissolved separately in 0.3mL of ethyl acetate. These three solutions are mixed together in 15-mL centrifuge tube. The resultant mixture is vortexed to obtain a homogenous solution. Ethyl acetate solvent is removed with speed vacuum to obtain a solid thin film. The residue is kept overnight under high vacuum at room temperature to remove residual organic solvent. In step two, the resultant thin film is hydrated with 1mL of double distilled deionized water by vortexing the solution. The rehydrated formulation is suspended in 2X phosphate buffer solution, (pH 6.5). It is filtered through 0.2 µm nylon filter membrane to remove the unentrapped drug aggregates and other foreign particulates. The entrapment of active agent is determined by RP-HPLC following disruption of the micelles and solubilization of the active agent in the diluent (2-propanol) as described below

[00239] The prepared formulations are subjected to various tests such as entrapment efficiency, loading efficiency, mixed nanomicellar size and polydispersity index according to the methods described in Example 1.

[00240] Weight percent of drug loaded into MNF is determined following the method for entrapment efficiency. Size and polydispersity index of the formulations is determined with Malvern zetasizer as described above. The results obtained are summarized in Table 1 below. The formulations appear clear and have small size and narrow size distribution.

Table 1

Characterization of the mixed nanomicellar formulation encapsulating active agent with solvent evaporation method

HCO-60 (wt%)	Octoxynol-40 (wt%)	Active agent (initially added) wt%	Active agent (loaded in mixed micelles) wt%	Mixed nanomicellar size (nm)	Polydispersity Index	Result
4	0.01	0.035	0.033	24.90	0.442	Clear/transparent solution before and after filtration
4	0.01	0.070	0.065	25.01	0.414	Clear/transparent solution before and after filtration
4	0.01	0.095	0.084	24.79	0.415	Clear/transparent solution before and after filtration
4	0.01	0.120	0.11	18.28	0.320	Pale yellow color transparent solution before and after filtration
4	0.01	0.250	0.26	18.37	0.331	Yellow color solution before and after filtration
4	0.01	0.300	0.32	18.29	0.345	Yellow color solution before and after filtration
4	0.01	0.400	0.45	18.2	0.333	

EXAMPLE 3

Preparation of Mixed Nanomicellar Formulations Using Melt Method

[00241] Two hundred milligrams of hydrogenated castor oil-60 (HCO-60) (4 wt%) is weighed and transferred to a 10mL round bottom flask (RBF). The neck of the round bottom flask is closed with aluminum foil, sealed with parafilm and transferred to a water bath set at 40°C. The round bottom flask is left overnight in the water bath to liquefy/melt the HCO-60. On the next day, ten micro liters of octoxynol-40 is diluted 100 fold and allowed to equilibrate at 40°C for 1h in water bath. Similarly, active agent is allowed to equilibrate at 40°C in the water bath for 1 h. To the HCO-60 melt, 50 µL of 100 fold diluted octoxynol-40 (0.01 wt%) is added at 40°C. To the above mixture, ~20 µL of active agent at 40°C is added and stirred. To this mixture distilled deionized water, approx. 2 mL, equilibrated at 40°C is slowly added and stirred. The neck of the round bottom flask is closed with aluminum foil and sealed with parafilm. The solution is stirred in a water bath set at 40°C overnight protected from light (covering with aluminum foil). On the next day, the above obtained solution at 40°C is removed from the water bath and allowed to cool to room temperature and observed for clarity. Two milliliters phosphate buffer (2X) is added to the above prepared solution (phosphate buffer is previously prepared and the pH is adjusted to 5.5). The volume of the formulation is made up to 5 mL with the 2X phosphate buffer saline. The prepared formulation is filtered with 0.2 µm nylon filter and stored at 4°C.

[00242] The prepared formulations are subjected to various tests such as entrapment efficiency, loading efficiency, mixed nanomicellar size and polydispersity index according to the methods described in Example 1.

EXAMPLE 4

Preparation of Mixed Nanomicellar Formulations Using Second Melt Method

[00243] The preparation of MNF encapsulating one or more of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and/or steroid/antibiotic combinations can be divided into two steps. As an example for the development of 3.0 wt% HCO-40 or HCO-60 MNF encapsulating 0.4% of an active agent as contemplated herein is described below. In step 1, HCO-40 or HCO-60, 150 mg, is thermostated at 40ºC in a water bath to melt and result in a clear thick viscous liquid. To this melt polymer active agent (~20 mg), thermostated at 40ºC, is added and mixed for homogenous distribution. The mixture is allowed to reach room temperature, which results in a pale yellow color viscous liquid with HCO-40 and waxy solid with HCO-60. Further, to solidify the viscous liquid of HCO-40, the mixture is stored at 4°C (in refrigerator).

[00244] In step 2, the pellet and/or viscous liquid is allowed to reach room temperature under natural conditions. The pellet and/or viscous liquid is thermostated in a water bath at 40°C and resuspended in 2.0 mL of distilled water (thermostated at 40° C) under constant stirring. This results in spontaneous development of a clear aqueous solution of 0.4% active agent MNF. This aqueous solution is allowed to reach room temperature, under natural conditions. The pH of the solution is adjusted to 5.5 and the volume is made up with 2X phosphate buffer saline (pH 5.5) containing octoxynol-40 (0.01 wt%) and PVP-K-90 (1.2 wt%). The formulation is filtered through 0.2 μm nylon filter to remove any foreign material and obtain a clear homogenous aqueous formulation of active agent.

[00245] **^{1}H NMR qualitative studies:** To determine the absence of free drug in the outer aqueous environment, qualitative studies are conducted. Qualitative proton nuclear magnetic resonance (NMR) studies are conducted with Varian 400 MHz NMR. Deuterated chloroform and water are used as solvent systems to resuspend the formulation for NMR studies.

[00246] **Results:** Compound added to HCO-40 or HCO-60 at 40°C can be used to entrap active agent. At higher temperatures the polymer and the drug mixture remain in viscous liquid state. When allowed to reach room temperature, under natural conditions, HCO-60 mixture solidifies and develops a waxy solid. This waxy solid when thermostated at 40°C, helps in resuspending the formulation in distilled water to spontaneously develop containing active agent. Similar observations and results are obtained with HCO-40 viscous liquid. The viscosity of the mixture appears to be improved at lower temperatures (4°C). Therefore, it appears to stick to the walls of the container as thick viscous liquid. Upon allowing to return to room temperature the viscosity appears to be reduced and the mixture retains its flow back.

[00247] The waxy solid developed with the mixture of HCO-60 and active agent may be helpful to protect the drug and prevent the drug degradation with a surface blanket of an inert gas. The other polymer (HCO-40) does not result in development of waxy solid at room temperature or at low refrigerated conditions (4°C) when used up to approx. 3.0 wt%.

[00248] Qualitative proton NMR studies show that resuspending the formulation in the aqueous phase (D_2O) spontaneously generates mixed nanomicelles; no free drug peaks are evident in the aqueous solution. If the active agent is not entrapped in the core of mixed nanomicelles then the oil would be floating at the surface as a separate oil phase. While on the otherhand, resuspending the same formulation in organic solvent such as deuterated chloroform ($CDCl_3$) shows distinct peaks corresponding to drug along with polymer peaks. This indicates that the drug is not encapsulated in the micelle core, and is freely available when present in organic solvent.

[00249] The results obtained for physical appearance of the mixture, different phases, at different temperatures and appearance of final formulation are summarized in Tables 2a – 2c.

Table 2a

Physical appearance of melt mixture of HCO-60 and active agent at 25° C, resuspending in water at 40°C and final formulation of mixed nanomicellar formulation encapsulating active agent (HCO-60 was melted and active agent is added to the melt, then allowed to cool to room temperature and the physical appearance is noted)

HCO-60 (wt %)	Active agent (wt%)	Physical appearance at room temperature (25° C)	Resuspend in water	Final formulation (make up with 2X buffer containing 0.01% Oc-40)
1.0	4	Pale yellow half solid and half viscous liquid	Emulsion	Emulsion
2.0	4	Pale yellow viscous solid (with waxy and viscous liquid)	Forms pale emulsion	Pale yellow clear solution
2.25	4	Pale yellow waxy solid	Forms pale emulsion	Pale yellow clear solution
2.5	4	Pale yellow waxy solid	Forms very pale emulsion	Pale yellow clear solution
2.75	4	Pale yellow waxy solid	Forms very pale emulsion	Clear solution
3.0	4	Pale yellow waxy solid	Clear solution	Clear solution
3.5	4	Pale yellow waxy solid	Clear solution	Clear solution

4.0	4	Pale yellow waxy solid	Clear solution	Clear solution

Table 2b

Physical appearance for HCO-40 and active agent melt mixture at 25°C, resuspending in water and final formulation of mixed nanomicellar formulation encapsulating active agent (HCO-40 is melted and active agent is added to the melt at 40°C, then allowed to cool to room temperature and the physical appearance was noted

HCO-40 (wt %)	Active Agent (wt%)	Mixture physical appearance at room temperature (25°C)	Resuspend in water	Final formulation
0.5	4	Viscous yellow liquid	Emulsion	Emulsion
0.75	4	Viscous yellow liquid	Emulsion	Emulsion
1.0	4	Viscous yellow liquid	Emulsion	Emulsion
1.25	4	Viscous yellow liquid	Emulsion	Emulsion
1.5	4	Viscous yellow liquid	Emulsion	Emulsion
1.75	4	Viscous yellow liquid	Emulsion	Emulsion
2.0	4	Viscous yellow liquid	Emulsion	Emulsion
2.25	4	Viscous yellow liquid	Emulsion	Emulsion
2.5	4	Viscous yellow liquid	Yellow solution	Yellow color solution
2.75	4	Viscous yellow liquid	Pale yellow solution	Pale yellow color solution
3.0	4	Viscous yellow liquid	Clear solution	Clear solution
4.0	4	Viscous yellow liquid	Clear solution	Clear solution

Table 2c

Physical appearance of HCO-40 and active agent melt mixture at 25°C and 4°C, mixture resuspended in water at 40° C and final formulation. (HCO-40 is melted and active agent is added to melt at 40°C, then allowed to cool to room temperature, placed at 4°C and brought back to room temperature. Physical appearance of mixture was noted at all temperatures)

HCO-40 (wt %)	Active Agent (wt%)	Mixture physical appearance at room temperature (25° C)	Mixture physical appearance at room temperature (4° C)	Allow to reach room temperature (25° C)	Resuspend in water	Final formulation
0.5	4	Viscous yellow liquid	Viscous liquid	Viscous liquid	Emulsion	Emulsion
0.75	4	Viscous yellow liquid	Viscous liquid	Viscous liquid	Emulsion	Emulsion
1.0	4	Viscous yellow liquid	Viscous liquid	Viscous liquid	Emulsion	Emulsion
1.25	4	Viscous yellow liquid	Viscous liquid	Viscous liquid	Emulsion	Emulsion
1.5	4	Viscous yellow liquid	Yellow waxy solid	Viscous liquid	Emulsion	Emulsion
1.75	4	Viscous yellow liquid	Yellow waxy solid	Viscous liquid	Emulsion	Emulsion
2.0	4	Viscous yellow liquid	Yellow waxy solid	Viscous liquid	Emulsion	Emulsion
2.25	4	Viscous yellow liquid	Yellow waxy solid	Viscous liquid	Emulsion	Emulsion
2.5	4	Viscous yellow liquid	Yellow waxy solid	Viscous liquid	Yellow solution	Yellow color solution
2.75	4	Viscous yellow liquid	Pale yellow waxy solid	Viscous liquid	Pale yellow solution	Very pale yellow color solution
3.0	4	Viscous yellow liquid	Pale yellow solid	Viscous liquid (half solid half viscous liquid)	Clear solution	Clear solution
4.0	4	Viscous yellow liquid	Pale yellow waxy solid	Pale yellow waxy solid	Clear solution	Clear solution

[00250] Conclusions. These studies show that the polymer HCO-60 can be used to entrap an active agent by way of the Hot Melt method. HCO-40 does not develop waxy solid at higher weight percent (3.0%) under the conditions of this study. On the other hand, HCO-60 developed waxy solid at 2.0 wt%. This method has unique advantages of being an easy and fast method that avoids the use of organic solvent in the preparation of MNF. Also, the method of preparation is easy and fast. The waxy solid developed in stage 1 may be helpful in preventing degradation of the active agent, and help the active agent to stay in a waxy solid state at room temperature with a blanket of inert gas. Qualitative proton NMR studies show that active agent is not freely available when resuspended in aqueous solution. On the other hand, when the same formulation is resuspended in an organic solvent ($CDCl_3$), drug peaks are clearly evident, indicating the presence of active agent in the outer organic solvent environment due to the formation.

EXAMPLE 5

Preparation of Mixed Nanomicellar Formulations

[00251] MNF formulations of active agent are prepared by solvent evaporation method in two steps: 1. Preparation of basic formulation and 2. rehydration. In step one, active agent, HCO-40 and octoxynol-40 are dissolved separately in 0.5 mL of ethanol aliquots. These three solutions are mixed together in a round bottom flask. The resultant mixture is stirred to obtain a homogenous solution. Ethanol solvent is removed by high speed vacuum evaporation overnight to obtain a solid thin film.

[00252] In step two, the resultant thin film is hydrated with 2.0 mL of double distilled deionized water and resuspended with stirring overnight. The rehydrated formulation is pH adjusted and the volume thereof is made up with 2X phosphate buffer solution, (pH 6.8). Further the formulation is filtered through 0.2 μm nylon filter membrane to remove the unentrapped drug aggregates and other foreign particulates.

[00253] Different polymer weight percent combinations than are used for the preceding examples are used to develop aqueous MNF entrapping 0.2 wt% active agent. Formulations are characterized for their appearance, size and polydispersity indices. The formulations are found to be clear and have very small size with narrow polydispersity index. The results are summarized in tables 3a and 3b.

Table 3a

Mixed nanomicellar formulations at lower polymer concentrations.

HCO-40 wt%	Octoxynol-40 wt%	Visual appearance	Size (nm)	Polydispersity index
0.5	0.1	Emulsion	N.D	N.D
0.75	0.1	Emulsion	N.D	N.D
1	0.1	Emulsion	N.D	N.D
1.25	0.1	Emulsion	N.D	N.D
1.5	0.1	Emulsion	N.D	N.D
1.75	0.1	Clear solution	14.86	0.062
2.00	0.1	Clear solution	36.14	0.884
0.5	0.5	Emulsion	N.D	N.D
0.75	0.5	Emulsion	N.D	N.D
1	0.5	Emulsion	N.D	N.D
1.25	0.5	Emulsion	N.D	N.D
1.5	0.5	Emulsion	N.D	N.D
1.75	0.5	Clear solution	14.81	0.075
2.00	0.5	Clear solution	21.27	0.295

N.D – Not Determined.

Table 3b

Mixed nanomicellar formulations at higher polymer concentrations.

HCO-40 wt%	Octoxynol-40 wt%	Visual appearance	Size (nm)	Polydispersity index
0.5	1.0025	Clear solution	12.9	0.069
0.5	2	Clear solution	18.1	0.069
2.5	0.005	Clear solution	15.65	0.064
2.5	1.0025	Clear solution	14.56	0.096
2.5	1.0025	Clear solution	14.81	0.078
2.5	1.0025	Clear solution	14.80	0.098
2.5	1.0025	Clear solution	14.45	0.102
2.5	2	Clear solution	13.92	0.108
4.5	0.005	Clear solution	20.59	0.271
4.5	1.0025	Clear solution	15.08	0.087
4.5	2	Clear solution	15.37	0.079

[00254] *Water Method.* MNF formulations of active agent are prepared by the water method. One mL of double distilled deionized water is heated to 60°C in a round bottom flask. This heated water is kept under stirring and HCO-40 is added to the heated water and allowed to dissolve under constant stirring. Octoxynol-40 is then added to this mixture and allowed to dissolve. In a separate container, phosphates, sodium chloride and active agent are blended by hand shaking for a few minutes. Under stirring conditions, the phosphates / active agent / sodium chloride blend is added to the solution of HCO-40 and octoxynol-40 to disperse the active agent. This mixture is allowed to cool to room temperature while stirring and checked for complete dissolution of the active agent. PVP K 90 solution is separately prepared using the remaining 1 mL double distilled deionized water. This PVP K 90 solution is added to the solution of polymer/surfactant/active agent/phosphate/sodium chloride. Water is added to make up the final volume. Then the formulation is filtered through 0.2μm nylon membrane to remove the active agent aggregates and other foreign particulates.

EXAMPLE 6

Local Tolerability in Rabbits of Formulations

[00255] Healthy young adult New Zealand albino rabbits (3-4 Kg) are used for the study of the local tolerability of the formulations described herein, for example a formulation of Examples 1-5. One drop (approximately 30 .mu.L) of saline is placed in one eye and a drop of formulation is placed in the other eye of the rabbit. Both eyes of each animal are examined by a veterinary ophthalmologist using a hand-held slit lamp and indirect ophthalmoscope. Both control and test eyes are graded according to conjunctival congestion, swelling, and discharge, aqueous flare, iris light reflex and involvement, corneal cloudiness severity and area, pannus, fluorescein examination and lens opacity using the Hackett/McDonald scoring system (see, for example, Hackett, R. B. and McDonald, T. O. Ophthalmic Toxicology and Assessing Ocular Irritation. Dermatoxicology, 5.sup.th Edition. Ed. F. N. Marzulli and H. I. Maibach. Washington, D.C.: Hemisphere Publishing Corporation. 1996; 299-305 and 557-566.). In the fluorescein examination, approximately one drop of 0.9% sodium chloride, USP, is applied to the end of a fluorescein impregnated strip and then applied to the superior sclera of the left and right eyes (one fluorescein impregnated strip is used for each animal). After an approximate 15 second exposure, the fluorescein dye is gently rinsed from each eye with 0.9% sodium chloride, USP. The eyes are then examined using a slit lamp with a cobalt blue filtered light source. For the lenticular examination approximately one drop of a short-acting mydriatic solution is instilled onto each eye in order to dilate the pupil. After acceptable dilation has occurred, the lens of each eye is examined using a slit-lamp biomicroscope.

[00256] The crystalline lens is observed with the aid of the slit-lamp biomicroscope, and the location of lenticular opacity is discerned by direct and retro illumination. The location of lenticular opacities are arbitrarily divided into the following lenticular regions beginning with the anterior capsule: Anterior subcapsular, Anterior cortical Nuclear Posterior cortical, Posterior subcapsular, Posterior capsular. The lens is evaluated routinely during ocular evaluations and graded as either 0 (normal) or 1 (abnormal). The presence of lenticular opacities are described and the location noted.

EXAMPLE 7

Ocular Tissue Distribution of Formulations of 0.05 wt%, 0.2 wt % and 0.5 wt% in Mixed Micellar Formulations of the Present Disclosure

[00257] The temporal distribution and potential accumulation with repeat dosing, gender difference, and potential melanin binding of (ophthalmic solution) of the present disclosure (for example the formulations of Examples 1-5) after ocular application is assessed by determining concentration of active ingredients in ocular tissues, tears, and blood in New Zealand White (NZW) and Dutch Belted (DB) rabbits.

[00258] NZW rabbits are used in a single dose (SD) and 7-day repeat dose (RD) studies. DB rabbits will be used in a single dose study. Animals are either untreated (controls) or given a single or a daily topical ocular dose for 7 days (0.05 wt%, 0.2 wt% or 0.5 wt% in a mixed micellar formulation to one or both eyes). Blood and ocular tissue concentrations are assessed.

[00259] The concentration of active agent is in tissues in the front of the eye (cornea, conjunctiva, sclera) and at the back of the eye (retina, optic nerve) but minimal in the middle of the eye (aqueous and vitreous humor), suggesting transport of the drug by a mechanism other than passive transport through the eye. The high drug levels achieved at the back of the eye make topical administration of the compositions of the present disclosure feasible for the treatment of diseases of the back-of-the-eye (e.g., retinal, diseases involving optic nerve such as glaucoma). Very high levels, especially in target tissues such as lachrymal gland, are expected to be achieved with the compositions of the present disclosure.

EXAMPLE 8

Use of Mixed Nanomicellar Formulations for Treating Dry Eye

[00260] Mixed nanomicellar formulations according to Examples 1-5 are administered to a patient having dry eye at a concentration of between 0.05% and 0.2% b.i.d. over a period of 1 month to 1 year or more.

EXAMPLE 9

Use of Mixed Nanomicellar Formulations for Treating Diabetic Retinopathy

[00261] Mixed nanomicellar formulations according to Examples 1-5 are administered to a patient having proliferative diabetic retinopathy at a concentration of between 0.2 wt% to 0.5 wt% b.i.d. over a period of 1 month to 1 year or more.

EXAMPLE 10

Tollerance and Ocular Tissue Distribution of Mixed Nanomicellar Formulations

[00262] A study is conducted in rabbits to test the tolerance and ocular tissue distribution of a nanomicellar formulation of active agent against its placebo and balanced saline solution (BSS). Healthy New Zealand female white rabbits (2-3 kg) are used for this study. study drug was prepared having 0.1% active agent essentially as described in the examples herein. The below table shows the formulation composition of the active agent-containing formulation and the Placebo.

Table 4. Formulation Composition:

	Active agent **0.1% formulation**	**Placebo**
Components		
Active agent	0.1%	0
Hydrogenated castor oil-40	1.0%	1.0%
Octoxynol-40	0.05%	0.05%
Sodium chloride	0.10%	0.10%
PVP-K90	0.60%	0.60%
Disodium EDTA	0.05%	0.05%
Benzalkonium chloride	0.003%	0.003%
Sodium Phosphate buffer	~0.4%	~0.4%
pH	7	7

[00263] One drop (approximately 35μL) of study drug is applied o.d. 4x / day at two hour intervals for 5 days. One drop of BSS is applied to the contralateral eye.

[00264] The tolerance parameters evaluated are: physical examination (acclimation study release); viability (daily); clinical observations (daily); Hackett-McDonald Ocular Irritation scores (pre-dose baseline data for each rabbit and then a pre-dose [prior to first daily dose] each day and then 30 min after last dose daily, intraocular pressure (IOP) pre-dose baseline data for each rabbit and then 30 minutes after the evening examinations each day, electroretinography (ERG) pre-dose-(pre-study) baseline data for each rabbit and then one hour after the last treatment, and ocular histopathology at euthanasia.

[00265] Mean cumulative Hackett-McDonald ocular irritation scores demonstrate very minimal scores for both BSS-treated left eyes and active agent-treated right eyes throughout the study, both for pre-treatment and post-treatment examination times. Mean cumulative inflammatory scores of less than 2 are observed in eyes treated with the TA, placebo, and BSS. These clinical scores represented mild conjunctival hyperemia (redness) and swelling. However, there are no significant differences in mean cumulative Hackett-McDonald ocular irritation scores between the groups, suggesting no difference in irritation from topical application of 0.1% active agent in HCO-40, the HCO-40 placebo, and BSS.

[00266] No changes in IOP are noted in eyes treated with BSS, HCO-40, or active agent. No toxicologic changes in retinal function are noted on ERG after 5 days of treatment with the test articles. No toxicologic or inflammatory changes are observed histologically in the anterior (conjunctiva / cornea / iris) or posterior segments (vitreous / retina) of the eye of any groups.

[00267] Samples of selected ocular tissues (aqueous humor, vitreous humor, conjunctiva, cornea, iris-ciliary body, lens, retina/choroid, and sclera) are collected 1 hour following the last dose on Day 5 from all two rabbits that received 0.1% active agent with HCO-40 (OD), and BSS (OS), and from one rabbit (No. 21) that received placebo HCO-40 formulation (OD) and BSS (OS). The samples are assayed for active agent by liquid chromatography-tandem mass spectrometry (LC-MS/MS). The internal standard was d_4-active agent. The established analytical ranges for active agent are 0.100 – 100 ng/mL for whole blood, and 2.00 – 2000 ng/mL for aqueous humor and vitreous humor. The analytical ranges for the solid tissues are 0.125 – 30 ng (low range) and 1.00 – 2500 ng (high range). The results of the solid tissue analyses are converted to ng/g by correcting for the amount of tissue analyzed.

[00268] Concentrations of active agent in ocular tissues collected 1 hour following the last dose on Day-5 are summarized in Table 5. Following repeated administration of the 0.1% Active agent, HCO-40 formulation, the highest average CsA concentrations in the treated eye are observed in the cornea (7805 ng/g), followed by conjunctiva (2125 ng/g), sclera (720 ng/g), iris-ciliary body (204 ng/g), and aqueous humor (134 ng/mL). The lowest active agent concentrations are observed in the lens (68.6 ng/g), retina/choroid (54 ng/g), and vitreous humor (~8 ng/mL). Active agent concentrations in the collateral eye treated with BSS are quite low, suggesting minimal systemic transfer of active agent.

[00269] The ocular tissue concentrations for the 0.1% active agent formulation observed in this study are generally higher than the C_{max} values following repeat dose administration (bid for 7 days) of an Allergan 0.2% 3H cyclosporine A formulation to rabbits (see Acheampong AA, Shackleton M, Tang-Liu D, Ding S, Stern ME, Decker R Distribution of cyclosporin A in ocular tissues after topical administration to albino rabbits and beagle dogs; Current Eye Research 18(2); 1999; pp91-103).

Table 5:

Matrix	Nanomicellar 0.1% Active Agent	Allergan 0.2% Active Agent (CsA)
Aqueous Humor	134. 5 ng/mL	19.3 ng-eq/mL
Vitreous Humor	8.37 ng/mL	0.810 ng-eq/mL
Sclera	720.5 ng/g	35.2 ng-eq/g
Conjunctiva	2125 ng/g	ND ng-eq/g
Cornea	7805 ng/g	6011 ng-eq/g
Iris-Ciliary Body	204ng/g	109 ng-eq/g
Lens	68.6 ng/g	39.6 ng-eq/g
Retina/Choroid	53.7 ng/g	4.62 ng-eq/g

EXAMPLE 11

Tolerance and Ocular Tissue Distribution of Mixed Nanomicellar Formulations containing active agent

[00270] A study is conducted in rabbits to test the tolerance and ocular tissue distribution of two nanomicellar formulations of active agent against matching placebos (Table 6a and 6b) and balanced saline solution (BSS). Healthy New Zealand female white rabbits (2-3 kg) are used for this study. One drop (approximately 35µL) of study drug is applied o.d. 4x / day at two hour intervals for 5 days. One drop of BSS es applied to the contralateral eye.

[00271] The tolerance parameters evaluated are: physical examination (acclimation study release); viability (daily); clinical observations (daily); Hackett-McDonald Ocular Irritation scores (pre-dose baseline data for each rabbit and then a pre-dose [prior to first daily dose] each day and then 30 min after last dose daily, intraocular pressure (IOP) pre-dose baseline data for each rabbit and then 30 minutes after the evening examinations each day, electroretinography (ERG) pre-dose-(pre-study) baseline data for each rabbit and then one hour after the last treatment, and ocular histopathology at euthanasia.

Table 6a. Formulation Composition: 0.1% Active Agent

	RX-10045 (0.1%) in HCO-40	Placebo
Components	percentage	percentage
RX-10045	0.1%	0
Hydrogenated Castor Oil-40	1.0%	1.0%
Octoxynol-40	0.05%	0.05%
Sodium chloride	0.10%	0.10%
PVP-K90	0.60%	0.60%
Disodium EDTA	0.05%	0.05%
Benzalkonium chloride	0.003%	0.003%
Sodium Phosphate buffer	~0.4%	~0.4%
pH	5.5	5.5

Table 6b. Formulation Composition 0.15% Active Agent

	RX-10045 (0.15%) in HCO-60	Placebo
Components	**percentage**	**Percentage**
RX-10045	0.15%	0
Hydrogenated Castor Oil-60	1.0%	1.0%
Octoxynol-40	0.05%	0.05%
Sodium chloride	0.10%	0.10%
PVP-K90	0.60%	0.60%
Disodium EDTA	0.05%	0.05%
Benzalkonium chloride	0.003%	0.003%
Sodium Phosphate buffer	~0.4%	~0.4%
pH	5.5	5.5

[00272] Cumulative Hackett-McDonald ocular irritation scores demonstrate very minimal mean values for both BSS-treated left eyes and test-article treated right eyes throughout the study, both for pre-treatment and post-treatment examination times. There are no significant differences in mean cumulative Hackett-McDonald ocular irritation scores between the groups (Table 7). The observed ocular irritation is interpreted as minimal and transient in all groups.

Table 7. Hackett-McDonald Composite Scores (mean ± s.d.)

	HCO-40 Placebo[a]	RX-10045 0.1%[b]	HCO-60 Placebo[a]	RX-10045 0.15%[b]
Day 1 Predose	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Day 1 Postdose	1.7 ± 1.5	0.5 ± 0.1	0.0 ± 0.0	0.5 ± 0.1
Day 2 Predose	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	1.0 ± 1.2
Day 2 Postdose	2.0 ± 0.0	0.0 ± 0.0	0.7 ± 1.1	0.5 ± 1.0
Day 3 Predose	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.5 ± 1.0
Day 3 Postdose	1.3 ± 1.2	0.0 ± 0.0	0.0 ± 0.0	1.0 ± 1.2
Day 4 Predose	1.3 ± 1.2	0.0 ± 0.0	0.3 ± 0.6	0.5 ± 1.0
Day 4 Postdose	1.3 ± 1.2	0.0 ± 0.0	0.7 ± 1.2	0.8 ± 1.0
Day 5 Predose	0.0 ± 0.0	0.5 ± 1.0	1.0 ± 1.0	0.0 ± 0.0
Day 5 Postdose	1.3 ± 2.3	0.0 ± 0.0	0.3 ± 0.6	0.8 ± 1.1

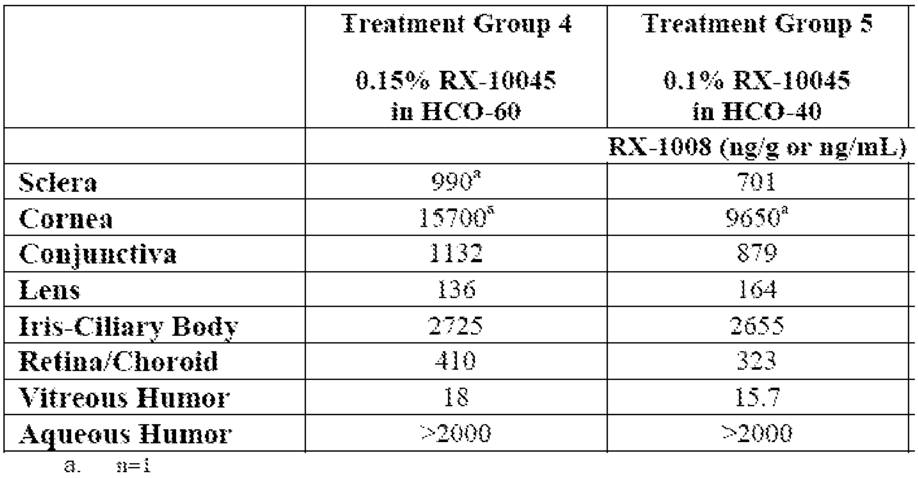
[00273] No changes in IOP are noted in eyes treated with BSS or test articles. No toxicologic changes in retinal function are noted on ERG after 5 days of treatment with the test articles. No toxicologic or inflammatory changes are observed histologically in the anterior (conjunctiva / cornea / iris) or posterior segments (vitreous / retina) of the eye of any groups.

[00274] Selected ocular fluids/tissues (aqueous humor, vitreous humor, conjunctiva, cornea, iris-ciliary body, lens, retina/choroid, and sclera) collected from two rabbits each in the RX-10045 (0.15% in HCO-60, 0.1% in HCO-40) treatment groups, and from one rabbit in each of the matching placebo groups, are assayed for active agent by liquid chromatography-tandem mass spectrometry (LC-MS/MS). Warfarin-d_5 and 5-HDA are used as internal standards for the analysis of active agent in aqueous humor and vitreous humor. For the other ocular tissues (solid tissues), warfarin-d5 and phenyl acetic acid-d5 (PAA-d_5) are used as the internal standards for active agent. The analytical range for the solid tissues is 0.125 – 100 ng. The results of the solid tissue analyses are converted to ng/g by correcting for the amount of tissue analyzed.

[00275] Only sporadic, relatively low, concentrations of active agent is observed in the sclera and conjunctiva. Active agent is either not detected or is below the quantitation limit of the assay in the majority of ocular tissues.

[00276] A summary of the active agent tissue concentrations is presented in Table 8. The highest concentrations of active agent are found in the cornea, followed by the iris-ciliary body, conjunctiva, and sclera. There are also relatively high concentrations of active agent in the aqueous humor. Lower amounts are found in the retina/choroid and lens. The lowest levels of active agent are found in the vitreous humor.

Table 8: Comparison of mean (n=2) ocular tissue concentrations of active agent following topical ocular administration of thereof (0.15% in HCO-60, 0.1% in HCO-40) formulations to the eye four times a day at 2 hour intervals for five days to New Zealand White Rabbits



	Treatment Group 4 0.15% RX-10045 in HCO-60	Treatment Group 5 0.1% RX-10045 in HCO-40
		RX-1008 (ng/g or ng/mL)
Sclera	990[a]	701
Cornea	15700[a]	9650[a]
Conjunctiva	1132	879
Lens	136	164
Iris-Ciliary Body	2725	2655
Retina/Choroid	410	323
Vitreous Humor	18	15.7
Aqueous Humor	>2000	>2000

a. n=1

[00277] The invention illustratively described herein may be practiced in the absence of any element or elements, limitation or limitations which is not specifically disclosed herein. The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention that in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the concepts herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention as defined by the appended claims.

[00278] The contents of the articles, patents, and patent applications, and all other documents and electronically available information mentioned or cited herein, are hereby incorporated by reference in their entirety to the same extent as if each individual publication was specifically and individually indicated to be incorporated by reference. Applicants reserve the right to physically incorporate into this application any and all materials and information from any such articles, patents, patent applications, or other documents.

[00279] The inventions illustratively described herein may suitably be practiced in the absence of any element or elements, limitation or limitations, not specifically disclosed herein. Thus, for example, the terms "comprising", "including," containing", etc. shall be read expansively and without limitation. Additionally, the terms and expressions employed

herein have been used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed. Thus, it should be understood that although the present invention has been specifically disclosed by preferred embodiments and optional features, modification and variation of the inventions embodied therein herein disclosed may be resorted to by those skilled in the art, and that such modifications and variations are considered to be within the scope of this invention.

[00280] The invention has been described broadly and generically herein. Each of the narrower species and subgeneric groupings falling within the generic disclosure also form part of the invention. This includes the generic description of the invention with a proviso or negative limitation removing any subject matter from the genus, regardless of whether or not the excised material is specifically recited herein.

[00281] In addition, where features or aspects of the invention are described in terms of Markush groups, those skilled in the art will recognize that the invention is also thereby described in terms of any individual member or subgroup of members of the Markush group.

[00282] Other embodiments are set forth within the following claims.

WHAT IS CLAIMED IS:

1. An ophthalmic formulation, comprising an active agent, a polyoxyl lipid or fatty acid and a polyalkoxylated alcohol, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

2. An ophthalmic formulation, comprising an active agent, and an ≥ 40 polyoxyl lipid or fatty acid, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

3. An ophthalmic formulation, comprising an active ingredient and a polyoxyl lipid or fatty acid; wherein said polyoxyl lipid or fatty acid is present in an amount equal to greater than 1% of said formulation, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

4. An ophthalmic formulation, comprising an active agent and a polyoxyl lipid or fatty acid; wherein said formulation comprises nanomicelles, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

5. An ophthalmic formulation, comprising an active agent, .05-5% of one or more selected from the group consisting of HCO-40, HCO-60, HCO-80, HCO-100, polyoxyl 40 stearate and polyoxyl 35 castor oil; and about 0.01-0.1% octoxynol-40, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

6. The ophthalmic formulation of any of the preceding claims, wherein said active agent is one or more selected from the group consisiting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

7. The ophthalmic formulation of any of the preceding claims, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

8. The ophthalmic formulation of any of the preceding claims, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

9. The ophthalmic formulation of any of the preceding claims, wherein said active agent is one or more selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

10. The ophthalmic formulation of any of the preceding claims, wherein said active agent is HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, or steroid/antibiotic combinations.

11. A method of treating or preventing an ocular disease or condition, said method comprising topically administering a formulation of any of the preceding claims.

12. A method of manufacturing an ophthalmic formulation comprising liquefying/melting and mixing (a) a polyoxyl lipid or fatty acid, (b) a polyalkoxylated alcohol and (c) an active agent and subsequently adding a buffer and a saline, wherein said active agent is selected from the group consisting of HIF ritonivir, Travoprost, Bimatoprost, Tafluprost, Lifitegrast, MIM-D3, A3 adenosine receptor agonists, A1 adenosine receptor agonists, and steroid/antibiotic combinations.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US16/61167

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - A61K 31/202, 47/10, 47/44 (2016.01)
CPC - A61K 9/0048, 9/1075, 47/44
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): A61K 31/202, 47/10, 47/44 (2016.01)
CPC: A61K 9/0048, 9/1075, 47/44 USPC: 514/560

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PATSEER (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, Other Countries (INPADOC), RU, AT, CH, TH, BR, PH); EBSCO; Google Scholar; IP.com; KEYWORDS: ophthalmic composition*, polyoxyl lipid*, fatty acid*, polyalkoxylat* alcohol*, treat* ocular disease*, dry eye, glaucoma, HCO 40, octoxynol 40, nanomicelle*, therapeut* agent*, prostaglandin*, travoprost, bimatoprost, ritonavir

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2015/0165048 A1 (OCULAR TECHNOLOGIES SARL) 18 June 2015; paragraphs [0008]-[0009], [0013]-[0014], [0102], [0567]-[0571], [0707]; claim 12	1-5, 6/1-5, 12
Y	US 2013/0267591 A1 (KHOPADE, AJ et al.) 10 October 2013; paragraphs [0001], [0014]-[0015], [0029]	1-5, 6/1-5, 12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
09 December 2016 (09.12.2016)

Date of mailing of the international search report
27 DEC 2016

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US16/61167

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 7-11
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report coves only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.