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(54) **Title:** PHOSPHOLIPID COMPOSITIONS FOR CONTACT LENS CARE AND PRESERVATION OF PHARMACEUTICAL COMPOSITIONS

(57) **Abstract:** The use of certain synthetic phospholipids to preserve pharmaceutical compositions from microbial contamination is described. The synthetic phospholipids have unique molecular arrangements wherein a phosphate group is linked to a quaternary ammonium functionality via a substituted-propenyl group, and the quaternary ammonium functionality is further linked to at least one long hydrocarbon chain. Such molecular arrangements are what make the phospholipids of formula (I) highly water soluble, e.g., the length of the hydrocarbon chain assists to maintain solubility and efficacy of the molecules for the uses described herein. The synthetic phospholipids described herein have been found to be particularly useful as antimicrobial preservatives for ophthalmic, otic and nasal pharmaceutical compositions, especially ophthalmic compositions. These compounds may also be utilized to disinfect contact lenses. The invention is based in-part upon a finding that the antimicrobial activity of the synthetic phospholipids is affected by the ionic strength of the compositions in which the compounds are contained. The provision of compounds having limited ionic strengths is therefore preferred.

WO 2008/144494 A1

2008254858 03 May 2013

PHOSPHOLIPID COMPOSITIONS FOR CONTACT LENS CARE AND PRESERVATION OF PHARMACEUTICAL COMPOSITIONS

BACKGROUND OF THE INVENTION

The present invention is directed to pharmaceutical compositions having antimicrobial activity, solutions for treating contact lenses having antimicrobial activity, and to the use of phospholipids in such compositions and solutions. More specifically, the invention is directed to use of phospholipid compounds of formula (I) in the preservation of various types of pharmaceutical compositions from microbial contamination, particularly ophthalmic, otic and nasal pharmaceutical compositions. Additionally, the present invention is directed to methods for disinfecting contact lenses.

Many pharmaceutical compositions are required to be sterile, i.e., free of bacteria, fungi and other pathogenic microorganisms. Examples of such compositions include: solutions and suspensions that are injected into the bodies of humans or other mammals; creams, lotions, solutions or other preparations that are topically applied to wounds, abrasions, burns, rashes, surgical incisions, or other conditions where the skin is not intact; and various types of compositions that are applied either directly to the eye (e.g., artificial tears, irrigating solutions, and drug products), or are applied to devices that will come into contact with the eye (e.g., contact lenses).

The foregoing types of compositions can be manufactured under sterile conditions via procedures that have been disclosed. However, once the packaging for a product is opened, such that the composition contained therein is exposed to the atmosphere and other sources of potential microbial contamination (e.g., the hands of a human patient), the sterility of the product may be compromised. Such products are typically utilized multiple times by the patient, and are therefore frequently referred to as being of a "multi-dose" nature,

There is a need for an improved means of preserving pharmaceutical compositions from microbial contamination. This need is particularly prevalent in the fields of ophthalmic, otic and nasal compositions, wherein the antimicrobial agents utilized to preserve the compositions must be effective in preventing microbial contamination of the compositions at concentrations that are non-toxic to ophthalmic, otic and nasal tissues.

Prior multi-dose ophthalmic compositions have generally contained one or more antimicrobial preservatives in order to prevent the proliferation of bacteria, fungi and other microbes. Such compositions may come into contact with the cornea either directly or indirectly. The cornea is particularly sensitive to exogenous chemical agents. Consequently, in order to minimize the potential for harmful effects on the cornea, it is preferable to use anti-microbial preservatives that are relatively non-toxic to the cornea, and to use such preservatives at the lowest possible concentrations, i.e., the minimum amounts required in order to perform their anti-microbial functions.

Balancing the anti-microbial efficacy and potential toxicological effects of anti-microbial preservatives is sometimes difficult to achieve. More specifically, the concentration of an antimicrobial agent necessary for the preservation of ophthalmic formulations from microbial contamination may create the potential for toxicological effects on the cornea and/or other ophthalmic tissues. Using lower concentrations of the anti-microbial agents generally helps to reduce the potential for such toxicological effects, but the lower concentrations may be insufficient to achieve the required level of biocidal efficacy, i.e., antimicrobial preservation.

The use of an inadequate level of antimicrobial preservation may create the potential for microbial contamination of the compositions and ophthalmic infections resulting from such contaminations. This is also a serious problem, since ophthalmic infections involving Pseudomonas aeruginosa or other virulent microorganisms can lead to loss of visual function or even loss of the eye.

Thus, there is a need for a means of enhancing the activity of anti-microbial agents so that very low concentrations of the agents can be utilized without increasing the potential for toxicological effects or subjecting patients to unacceptable risks of microbial contamination and resulting ophthalmic infections.

Phospholipids are phosphorus-containing lipids composed primarily of fatty acid chains, a phosphate group and a nitrogenous base. Of the lipids present in most cellular membranes, it is the phospholipids that provide the structural components for the membrane. Phospholipid molecules are amphiphilic and zwitterionic in nature, wherein the hydrophobic properties of such molecules are ascribed to the presence of long hydrocarbon chains and the hydrophilic properties of the molecule are derived from the charges carried by the phosphate and amino groups. In a typical phospholipid, the solubility properties of the molecule are dependent upon the length of the hydrocarbon chain(s) and the ionic functional groups.

Phospholipids are used extensively in various areas of biological science, such as in the cosmetic industry, pharmaceutical industry and in the preparation of other commercial products. In particular, phospholipids (synthetic or natural) are used in the pharmaceutical industry to prepare liposome-based formulations. Currently, over seven liposome products are available on the market in various disciplines, and several are undergoing development. In all cases, the active drugs are encapsulated in liposome vesicles, are available in a sterile unit dosage form, and no additional preservative ingredients are utilized.

Additional uses for phospholipids in the medical and pharmaceutical arts are described in U.S. Patent No. 5,286,719 (Fost et al.), which discloses a method for protecting substrates subject to contact by infectious viral organisms by treating such substrates with virucidally effective amounts of a composition containing a synthetic phospholipid as defined therein, and U.S. Patent Nos. 5,650,402 (Fost et al.) and 5,648,348 (Fost et al.), which disclose antimicrobial phospholipids that exhibit broad spectrum antibacterial and antifungal activity that are suitable for use as preservative and/or disinfectant agents in personal care and household products. However, these references do not disclose the use of phospholipids alone to preserve a pharmaceutical composition without the need for conventional preservative ingredients, such as benzalkonium chloride.

U.S. Patent No. 6,120,758 (Siddiqui et al.) discloses a preservative system for topically applied cosmetic, skin care, and pharmaceutical products (e.g., dermatologic, otic and ophthalmic preparations), including one or more of benzyl alcohols, disodium EDTA, and a para-hydroxybenzoic acid, in an effective antimicrobial amount, combined with one or more enhancers selected from the group consisting of sorbic acid, salts of sorbic acid, benzoic acid, salts of benzoic acid and certain phospholipids. However, it does not disclose that the phospholipids alone may be utilized to preserve a pharmaceutical drug composition without the need for conventional preservative ingredients, such as, benzalkonium chloride, nor does it disclose the use of the phospholipid compositions for contact lens care.

Contact lenses are exposed to a broad spectrum of microbes during normal wear and become soiled relatively quickly. Routine cleaning and disinfecting of the lenses are therefore required. Although the frequency of cleaning and disinfecting may vary somewhat among different types of lenses and lens care regimens, daily cleaning and disinfecting is

2008254858 03 May 2013

normally required. Failure to clean and disinfect the lens properly can lead to a multitude of problems ranging from mere discomfort when the lenses are being worn to serious ocular infections. Ocular infections caused by particularly virulent microbes, such as *Pseudomonas aeruginosa*, can lead to loss of the infected eye(s) if left untreated or if allowed to reach an advanced stage before treatment is initiated. It is therefore extremely important that patients disinfect their contact lenses in accordance with the regimen prescribed by their optometrist or ophthalmologist.

Unfortunately, patients frequently fail to follow the prescribed regimens. Many patients find regimens to be difficult to understand and/or complicated, and as a result do not comply with one or more aspects of the regimen. Other patients may have a negative experience with the regimen, such as ocular discomfort attributable to the disinfecting agent, and as a result do not routinely disinfect their lenses or otherwise stray from the prescribed regimen. In either case, the risk of ocular infections is exacerbated.

Despite the availability of various types of contact lens disinfecting systems, such as heat, hydrogen peroxide, and other chemical agents, there continues to be a need for improved systems which: 1) are simple to use, 2) have potent antimicrobial activity, and 3) are nontoxic (i.e., do not cause ocular irritation even if the system were to bind to the lens material). There is also a need for chemical disinfecting agents that retain their antimicrobial activity in the presence of salts (e.g., sodium chloride) and other components of compositions utilized to treat contact lenses.

The discussion of documents, acts, materials, devices, articles and the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Where the terms "comprise", "comprises", "comprised" or "comprising" are used in this specification (including the claims) they are to be interpreted as specifying the presence of the stated features, integers, steps or components, but not precluding the presence of one or more other features, integers, steps or components, or group thereof.

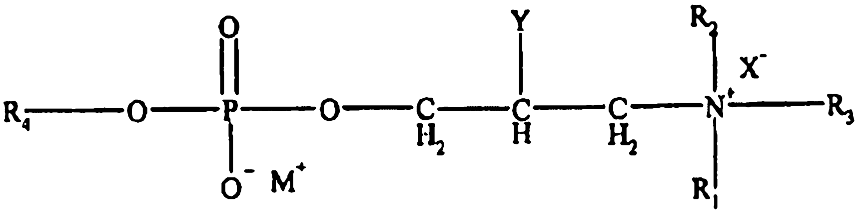
SUMMARY OF THE INVENTION

The present invention is directed to the use of synthetic phospholipid compounds of formula (I) to enhance the antimicrobial activity of pharmaceutical compositions and to

2008254858 03 May 2013

preserve pharmaceutical compositions from contamination by microorganisms, The invention is particularly directed to ophthalmic, otic and nasal compositions of this kind, but is also applicable to various other types of pharmaceutical compositions. The invention is further directed to contact lens care solutions containing one or more synthetic phospholipids of formula (I) and to methods for disinfecting contact lenses with such solutions.

In one aspect the present invention provides a sterile pharmaceutical composition comprising a preservative effective amount of a compound of the following formula,



(I)

wherein:

R_1 and R_3 are $(C_1\text{-}C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1\text{-}C_{16})$-alkyl optionally substituted by $NHC(=O)\text{-}(CH_2)_{10}CH_3$ or $NHC(=O)\text{-}(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$

wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, $O\text{-}(C_1\text{-}C_{10})$-alkyl and $O\text{-}(C_1\text{-}C_{10})$-alkenyl;

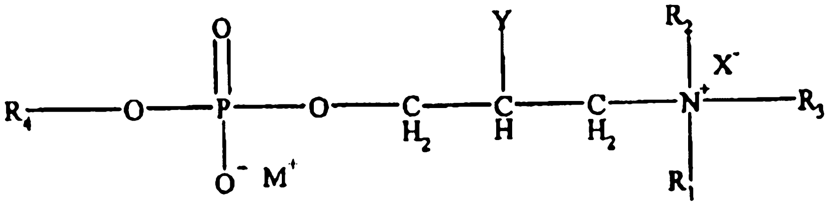
M is selected from the group consisting of sodium and potassium;

and a pharmaceutically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29^{th} revision.

In another aspect the present invention provides a method of preserving a pharmaceutical composition from microbial contamination which comprises adding to the composition a preservative effective amount of a compound of the following formula,

2008254858 03 May 2013



(I)

wherein:

R_1 and R_3 are $(C_1\text{-}C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1\text{-}C_{16})$-alkyl optionally substituted by $NHC(=O)\text{-}(CH_2)_{10}CH_3$ or $NHC(=O)\text{-}(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$;

wherein R_1, R_2, and R_3, are as defined above;

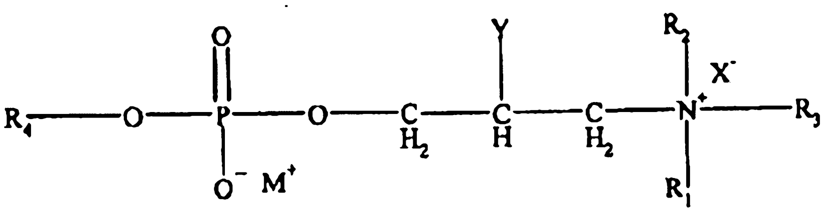
X is halo;

Y is selected from the group consisting of OH, O-$(C_1\text{-}C_{10})$-alkyl and O-$(C_1\text{-}C_{10})$-alkenyl; and

M is selected from the group consisting of sodium and potassium;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29th revision.

In yet another aspect the present invention provides a solution for treating contact lenses, comprising an effective amount of a compound of the following formula:



(I)

wherein:

R_1 and R_3 are $(C_1\text{-}C_6)$-alkyl;

2008254858 03 May 2013

R_2 is selected from the group consisting of hydrogen and $(C_1$-$C_{16})$-alkyl optionally substituted by $NHC(=O)$-$(CH_2)_{10}CH_3$ or $NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$;

wherein R_1, R_2, and R_3, are as defined above;

X is halo;

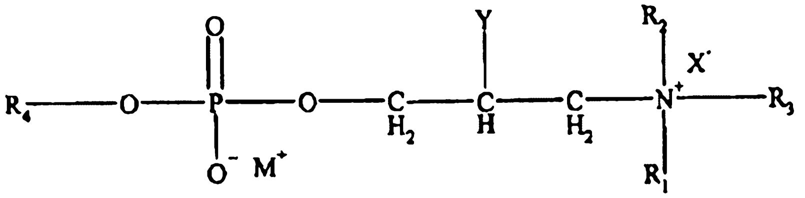
Y is selected from the group consisting of OH, O-$(C_1$-$C_{10})$-alkyl and O-$(C_1$-$C_{10})$-alkenyl;

M is selected from the group consisting of sodium and potassium;

and an ophthalmically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29^{th} revision.

In yet another aspect the present invention also provides a method of disinfecting a contact lens, which comprises contacting the lens with a solution comprising a compound of the following formula in an amount effective to disinfect the lens:



(I)

wherein:

R_1 and R_3 are $(C_1$-$C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1$-$C_{16})$-alkyl optionally substituted by $NHC(=O)$-$(CH_2)_{10}CH_3$ or $NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, O-$(C_1$-$C_{10})$-alkyl and O-$(C_1$-$C_{10})$-alkenyl;

M is selected from the group consisting of sodium and potassium;

and a ophthalmically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29th revision.

The synthetic phospholipids utilized in the present invention have unique molecular arrangements wherein a phosphate group is linked to a quaternary ammonium functionality

2008254858 03 May 2013

via a substituted-propenyl group, and the quaternary ammonium functionality is further linked to at least one long hydrocarbon chain. Such molecular arrangements are what make the phospholipids of formula (I) highly water soluble. In particular, the length of the hydrocarbon chain and the ionic functional groups are important factors to consider for maintaining solubility and efficacy of the molecules for the uses described herein.

The presence of quaternary ammonium functional groups is also a feature of disclosed antimicrobial preservatives, such as benzalkonium chloride, and polyquaternium-1. These functional groups bear a positive charge and as a result tend to interact with negatively charged molecules or ions in solution. Such interactions may adversely affect the ability of the quaternary ammonium compounds to interact with negatively charged sites on the cell walls of microbes, thereby compromising the antimicrobial activity of the compounds.

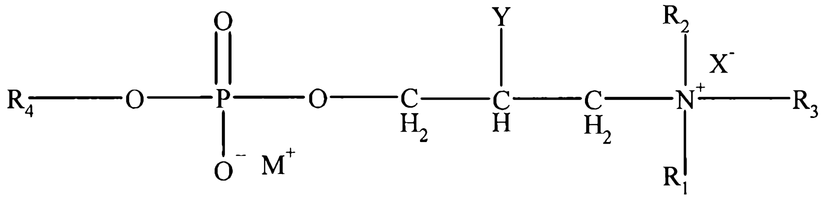
The present invention is based in-part on the finding that the synthetic phospholipids of formula (I) are potent antimicrobial agents and capable of preserving pharmaceutical compositions from microbial contamination without the use of conventional antimicrobial agents, such as benzalkonium chloride or polyquaternium-1, but are particularly susceptible to deactivation in the presence of negatively and positively charged molecules or ions, e.g., sodium and chloride from sodium chloride. The positively charged sodium ions from sodium chloride compete with the positive charge of the preservative to bind on the negative sites of a microorganism, while the presence of additional negatively charged chloride ions increases the probability of interaction with positively charged sites on the preservative.

The present inventors have found that this property of the synthetic phospholipids of formula (I) makes these compounds particularly useful as antimicrobial preservatives for ophthalmic pharmaceutical compositions, because the anions found in the lacrimal fluid of the eye, i.e., tear fluid, interact with the compounds of formula (I) thereby neutralizing the compounds. This neutralization effectively reduces or prevents the ocular irritation that has been frequently associated with the use of conventional quaternary ammonium antimicrobial preservatives, particulary benzalkonium chloride. Thus, the synthetic phospholipids of formula (I) have been found to be very useful to preserve pharmaceutical compositions from microbial contamination during storage, and have the additional advantage of being very gentle when applied to the human eye, due to the above-discussed neutralization effects.

The compounds of formula (I) may be utilized as antimicrobial preservatives for the compositions of the present invention in place of conventional, antimicrobial agents, for example, benzalkonium chloride. More specifically, the pharmaceutical compositions of the present invention may be preserved without the need for conventional antimicrobial preservative agents, such as benzalkonium chloride, benzalkonium bromide, polyquaternium-1, chlorhexidine, chlorobutanol, cetylpyridinium chloride, parabens, thimerosal, chlorine dioxide and N,N-dichlorotaurine. However, the compounds of formula (I) may also be used in combination with conventional preservative ingredients to further increase antimicrobial activity or preservative efficacy of the compositions of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to compositions containing synthetic phospholipids of the formula:



(I)

wherein:

R_1 and R_3 are $(C_1\text{-}C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1\text{-}C_{16})$-alkyl optionally substituted by $NHC(=O)\text{-}(CH_2)_{10}CH_3$ or $NHC(=O)\text{-}(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$, wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, $O\text{-}(C_1\text{-}C_{10})$-alkyl and $O\text{-}(C_1\text{-}C_{10})$-alkenyl; and

M is selected from the group consisting of sodium and potassium.

In the foregoing definitions of R_1, R_2, R_3, R_4, X, Y and M substituents, and throughout, the following terms unless otherwise indicated, shall be understood to have the following meanings:

The term "alkenyl" includes straight or branched chain hydrocarbon groups having 1 to 30 carbon atoms with at least one carbon-carbon double bond, the chain being optionally interrupted by one or more heteroatoms. The chain hydrogens may be substituted with other groups, such as, halo,

$-CF_3$, $-NO_2$, $-NH_2$, $-CN$, $-OCH_3$, $-C_6H_5$, $-O-C_6H_5O$-alkyl, $-O-C_6H_5O$-alkenyl, p–NHC(=O)-C_6H_5-NHC(=O)-CH_3, –CH=NH, –NHC(=O)–Ph and –SH. Preferred straight or branched alkenyl groups include allyl, ethenyl, propenyl, butenyl pentenyl, hexenyl, heptenyl, octenyl, nonenyl, decenyl, undecenyl, dodecenyl, tridecenyl, tetradecenyl, pentadecenyl or hexadecenyl.

The term "alkyl" includes straight or branched chain aliphatic hydrocarbon groups that are saturated and have 1 to 30 carbon atoms. The alkyl groups may be interrupted by one or more heteroatoms, such as oxygen, nitrogen, or sulfur, and may be substituted with other groups, such as, halo, $-CF_3$, $-NO_2$, $-NH_2$, $-CN$, $-OCH_3$, $-C_6H_5$, $-O-C_6H_5O$-alkyl, $-O-C_6H_5O$-alkenyl,

p–NHC(=O)-C_6H_5-NHC(=O)-CH_3, –CH=NH, –NHC(=O)–Ph and –SH. Preferred straight or branched alkyl groups include methyl, ethyl, propyl, isopropyl, butyl, t-butyl, sec-butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl and dodecyl, tridecyl, tetradecyl, pentadecyl or hexadecyl.

The term "halo" means an element of the halogen family. Preferred halo moieties include fluorine, chlorine, bromine or iodine.

The unique molecular arrangement of the synthetic phospholipids (i.e., wherein a phosphate group is linked to a quaternary ammonium functionality via a substituted-propenyl group, and the quaternary ammonium functionality is further linked to at least one long hydrocarbon chain) are what make them highly water soluble. In particular, the length of the hydrocarbon chain and the ionic functional groups are important factors to consider for maintaining solubility and efficacy of the molecules for the uses described herein.

The preferred compounds of formula (I) are those wherein R_1 and R_3 are methyl; R_2 is selected from the group consisting of $(CH_2)_{11}CH_3$, $(CH_2)_3$–NHC(=O)-$(CH_2)_{10}CH_3$ and $(CH_2)_3$–NHC(=O)-$(CH_2)_{12}CH_3$; R_4 is $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$, wherein R_1, R_2, and R_3, are as defined above; X is chloro; Y is OH; and M is sodium. The most preferred compounds are identified in the following table:

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SUBSTITUENT	COMPOUND NO. 1 (PHOSPHOLIPID CDM)	COMPOUND NO. 2 (PHOSPHOLIPID PTC)	COMPOUND NO. 3 (PHOSPHOLIPID PTM)
R_1	$-CH_3$	$-CH_3$	$-CH_3$
R_2	$-(CH_2)_{11}CH_3$	$-(CH_2)_3\text{-}NHC(=O)\text{-}(CH_2)_{10}CH_3$	$-(CH_2)_3\text{-}NHC(=O)\text{-}(CH_2)_{12}CH_3$
R_3	$-CH_3$	$-CH_3$	$-CH_3$
R_4	$-CH_2CH(OH)CH_2N^{+}(CH_3)_2-(CH_2)_{11}CH_3$	$-CH_2CH(OH)CH_2N^{+}(CH_3)_2-(CH_2)_3-NH-C(=O)-(CH_2)_{10}CH_3$	$-CH_2CH(OH)CH_2N^{+}(CH_3)_2-(CH_2)_3-NH-C(=O)-(CH_2)_{12}CH_3$
X^-	Cl^-	Cl^-	Cl^-
Y	$-OH$	$-OH$	$-OH$
M^+	Na^+	Na^+	Na^+

Compound Number 1 is the most preferred compound of formula (I).

The compounds of formula (I) can be synthesized in accordance with known procedures (see for example, U.S. Patent Nos. 5,286,719; 5,648,348 and 5,650,402) and/or purchased from commercial sources, such as Uniquema (Cowick Hall, Snaith, Goole East Yorkshire, DN149AA).

As described above, the synthetic phospholipids of formula (I) have unique molecular arrangements and physical properties relative to other phospholipids that make them highly water soluble and particularly efficacious for the uses described herein. The affinity of the compounds for ionic interactions is one such property.

The ionic strength of the compositions of the present invention has been found to be an important factor for achieving preservation or disinfection with the compound of formula (I). More specifically, the compositions lose antimicrobial activity when the concentration of anionic agents in the compositions is increased. Consequently, it is important to limit the amount of ionic solutes present in the composition of the present invention, so as to avoid a loss of antimicrobial activity that adversely affects the ability of the compound of formula (I) to preserve the compositions from microbial contaimination and/or to disinfect contact lenses. This principle is further illustrated in Example 2 below (see Formulations I through K). The use of solutions having low ionic strengths, i.e., low concentrations of ionic solutes such as sodium chloride, is therefore preferred. Examples of ionic solutes include potassium chloride, magnesium chloride and calcium chloride. As utilized herein, the term "ionic strength" means a measure of the average electrostatic interactions among ions in an electrolyte; it is equal to one-half the sum of the terms obtained by multiplying the molality of each ion by its valence squared.

It has also been found that the relationship between preservative concentration and ionic strength in the formulation is an important factor. For example, in a formulation containing 0.01% w/v phospholipid and no conventional preservative agent, the ionic strength of the formulation should be 0.12 or below to satisfy USP preservative efficacy requirements. However, as phospholipid concentration increases, the ability of the formulations to meet USP preservative efficacy requirements will increase such that the formulation may have an ionic strength of greater than 0.12.

The compounds of formula (I) may also be included in various types of pharmaceutical compositions as preservatives, so as to prevent microbial contamination of the compositions. The types of compositions which may be preserved by the compounds of formula (I) include: (a) ophthalmic pharmaceutical compositions, such as topical compositions used in the treatment of glaucoma, infections, various retinal diseases, allergies or inflammation; (b) otic pharmaceutical compositions, such as topical compositions used in the treatment of bacterial infections or inflammation of the ear; (c) nasal pharmaceutical compositions, such as topical compositions used in the treatment of rhinitis; (d) compositions for treating contact lenses, such as cleaning products and products for enhancing the ocular comfort of patients wearing contact lenses; (e) other types of ophthalmic compositions, such as ocular lubricating products, artificial tears, astringents, and so on; (f) dermatological compositions, such as antiinflammatory compositions, as well as shampoos and other cosmetic compositions; and (f) various other types of pharmaceutical compositions.

The present invention is not limited with respect to the types of pharmaceutical compositions containing compound(s) of formula (I) as preservatives, but the compounds are particularly useful in preserving ophthalmic, otic and nasal compositions from microbial contamination. The compounds are particularly useful in these types of compositions due to the ability of the compounds to exhibit a preservative effect at very low concentrations, without adversely affecting ophthalmic, otic and nasal tissues. In particular, when compound(s) of formula (I) are applied to the eye, they have significantly less effect on ocular tissues due to ionic neutralization and/or dilution effects in the presence of lacrimal fluid, i.e., tears.

The compositions of the present invention may be formulated as aqueous or nonaqueous solutions, but will preferably be aqueous. Additionally, the compositions may be formulated as suspensions, gels, emulsions and other dosage forms known to those skilled in the art.

The ophthalmic, otic and nasal compositions of the present invention will be formulated so as to be compatible with the eye, ear, nose and/or contact lenses to be treated with the compositions. As will be appreciated by those skilled in the art, ophthalmic compositions intended for direct application to the eye will be formulated so as to have a pH and tonicity, i.e., osmolality, that are compatible with the eye. This will normally require a buffer to maintain the pH of the composition at or near physiologic pH (i.e., 7.4) and may require a tonicity-adjusting agent (e.g., NaCl) to bring the osmolality of the composition to a level that ranges from slightly hypotonic to isotonic, relative to human tears.

The ophthalmic compositions of the present invention will contain a preservative effective amount of one or more synthetic phospholipids of formula (I) and an ophthalmically acceptable vehicle. As utilized herein, the term "opthalmically acceptable vehicle" means a pharmaceutical composition having physical properties (e.g., pH and/or osmolality) that are physiologically compatible with ophthalmic tissues.

A preferred range of osmolality for the ophthalmic compositions of the present invention is 150 to 350 milliOsmoles per kilogram (mOsm/kg). A range of 200 to 300 mOsm/kg is particularly preferred and an osmolality of about 275 mOsm/kg is most preferred. The pH for the ophthalmic compositions of the present invention range from about 4.5 to about 9.0.

The pharmaceutical compositions of the present invention may contain one or more active ingredients. As utilized herein, the term "active ingredient" means a compound that causes a physiological effect for a therapeutic purpose, e.g., a compound that lowers or controls intraocular pressure in the treatment of glaucoma, and is therefore functioning as a drug.

The compositions of the present invention will contain one or more synthetic phospholipids of formula (I). The concentrations of the compounds in the compositions will depend on the purpose of the use, e.g., preservation of pharmaceutical compositions, and the absence or inclusion of other antimicrobial agents. The concentrations determined to be necessary for the above-stated purposes can be functionally described as "an amount effective to preserve" or variations thereof as described below. The term "effective to preserve" means an amount of an antimicrobial agent effective in producing the desired effect of preserving the compositions described herein from microbial contamination, preferably an amount which, either singly or in combination with one or more additional antimicrobial agents, is sufficient to satisfy the preservative efficacy requirements of at least the United States Pharmacopoeia ("USP"), 29th Revision, The National Formulary, United States Pharmacopoeial Convention, Inc., Rockville, MD 2256-2259. The concentrations used will generally be in the range of from about 0.001 to about 2 weight/volume percent (w/v %). The concentrations used for preservation of a pharmaceutical composition will generally be in the range of from about 0.001 to about 1 (w/v %), with a range of 0.005 to 0.5 being preferred. When the compound is used to preserve a pharmaceutical composition containing an active ingredient without a conventional ophthalmic, otic or nasal antimicrobial preservative agent, the concentration of the compound will preferably be from about 0.005 to about 1 (w/v%).

While the pharmaceutical compositions of the present invention can be effectively preserved via the inclusion of one or more synthetic phospholipids of formula (I) without using conventional antimicrobial agents such as those described above, the compounds of formula (I) can also be used in combination with conventional disinfectants or preservatives. The compounds of formula (I) may, for example, be used in combination with the polymeric quaternary ammonium compounds described in United States Patent No. 4,407,791 (Stark); the entire contents of that patent are hereby incorporated in the present specification by reference. As described in the '791 patent, those polymeric quaternary ammonium compounds are useful in disinfecting contact lenses and preserving ophthalmic compositions. The preferred polymeric quaternary ammonium compound is polyquaternium-1. Such polymeric quaternary ammonium compounds are typically utilized in an amount of from about 0.00001 to 0.01 w/v %. For the agent polyquaternium-1, a concentration of 0.001 w/v % is preferred.

The active ingredient or ingredients that can be included in the compositions of the present invention include, but are not limited to, ophthalmic, otic or nasal agents that can be topically applied. For example, such ophthalmic agents include (but are not limited to): anti-glaucoma agents, such as beta-blockers (e.g., betaxolol and timolol), muscarinics (e.g., pilocarpine), prostaglandins, carbonic anhydrase inhibitors (e.g., acetazolamide, methazolamide and ethoxzolamide), dopaminergic agonists and antagonists, and alpha adrenergic receptor agonists, such as para-amino clonidine (also known as apraclonidine) and brimonidine; anti-infectives, such as ciprofloxacin; non-steroidal and steroidal anti-inflammatories, such as suprofen, ketorolac, dexamethasone, rimexolone and tetrahydrocortisol; proteins; growth factors, such as EGF; and anti-allergic agents, such as cromolyn sodium, emedastine and olopatadine. Other nonlimiting examples of therapeutic agents that may be used include but not limited to anticholinergic, sympathomimetic agents, antiangiogenic agents, anti vascular permeability agents, anaesthetics, analgesiscs, protease inhibitors, cell transport/mobility impending agents, anti-cytomegalovirus agents, immunological response modifiers, antineoplastics agents. Compositions of the present invention may also include combinations of active ingredients. Most preferred are topically administrable ophthalmic compositions.

As will be appreciated by those skilled in the art, the compositions of the present invention may contain a wide variety of ingredients, such as tonicity agents (e.g., sodium chloride, propylene glycol, mannitol), surfactants (e.g., polysorbate, cremophore, and polyoxyethylene/polyoxypropylene copolymers), viscosity adjusting agents (e.g., hydroxypropyl methyl cellulose, other cellulose derivatives, gums and derivatives of gums), buffering agents (e.g., borates, citrates, phosphates, carbonates) comfort-enhancing agents (e.g., guar gum, xanthan gum and polyvinyl pyrrolidone when appropriate and applicable), solubilizing aids, pH adjusting agents, antioxidants, preservative adjunct ingredients or complexing agents (e.g., (ethylenedinitrilo)-tetraacetic acid disodium salt, also referred to as disodium EDTA, nonnyl ethylenediaminetriacetic acid) and stabilizing agents.. The ability of the compositions of formula (I) to retain their antimicrobial activity in the presence of such agents is a significant advantage of the present invention.

The formulation of compositions for treating contact lenses (e.g., disinfecting and/or cleaning) will involve considerations similar to those described above for other types of ophthalmic compositions, as well as considerations relating to the physical effect of the compositions on contact lens materials and the potential for binding or absorption of the components of the composition by the lens. The contact lens disinfecting compositions of the present invention will preferably be formulated as aqueous solutions, but may also be formulated as nonaqueous solutions, as well as suspensions, gels, emulsions and so on. The compositions may contain a variety of tonicity agents, surfactants, viscosity adjusting agents and buffering agents, as described above.

The above-described compositions may be used to disinfect contact lenses in accordance with processes known to those skilled in the art. More specifically, the lenses will first be removed from the eyes of the patients, and then will be immersed in the compositions for a time sufficient to disinfect the lenses. This immersion will typically be accomplished by means of soaking the lenses in a solution for a period of time ranging from a few hours to overnight, i.e., four to eight hours. The lenses will then be rinsed and placed in the eye. Prior to immersion in the disinfecting compositions, the lenses will preferably also be cleaned and rinsed.

The compositions and methods of the present invention may be used in conjunction with various types of contact lenses, including both lenses generally classified as “hard” and lenses generally classified as “soft”, as well as rigid and soft gas permeable lenses. Such suitable lenses may include silicone and fluorine containing lenses as well as both hydrogel and non-hydrogel lenses. Furthermore, compositions of the present invention are not expected to discolor colored contact lenses. Compositions of the present invention comprise phospholipid compound(s) of formula (I) in an effective amount either alone or in combination with other antimicrobial agents in a physiologically suitable buffer. Illustrative examples of a disinfecting solution, a comfort drop solution for a contact lens user and a lubricant eye drop are provided in Examples 5-9 below.

As described above, the amount of each compound used will depend on the purpose of the use, e.g., disinfection of contact lenses, and the absence or inclusion of other antimicrobial agents. The concentrations determined to be necessary for the above-stated purposes can be functionally described as “an amount effective to disinfect” or variations thereof as described below. The term “effective to disinfect” means an amount of antimicrobial agent effective in producing the desired effect of disinfecting contact lenses by substantially reducing the number of viable microorganisms present on the lenses, preferably an amount which, either singly or in combination with one or more additional antimicrobial agents, is sufficient to satisfy the disinfection requirements according to FDA Premarket Notification (510k) Guidance Document for Contact Lens Care Products (1997) and ISO/FDIS 14729: Ophthalmic optics-Contact lens care products-Microbiological requirements and test methods for products and regimens for hygienic management of contact lenses (2001). The concentrations used will generally be in the range of from about 0.001 to about 2 w/v %.

The following examples are provided to further illustrate the use of the compounds of formula (I) in compositions of the present invention and to demonstrate the antimicrobial activity of the compounds.

EXAMPLE 1

The following formulation represents an example of a preserved ophthalmic formulation of the present invention. In this formulation, the phospholipid compound of formula (I) functions to preserve the formulation from microbial contamination during storage.

Composition of a Preserved Ophthalmic Formulation

Ingredient	Concentration (%, w/v)
Olopatadine Hydrochloride	0.05-0.25
Phospholipid of Formula (I)	0.001-1
Disodium EDTA	0-0.05
Boric acid	0-2
Propylene glycol	0-2
Sodium chloride	0-0.9
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to 6.0 – 8.0

Preparation of 0.1% Preserved Ophthalmic Formulation: Olopatadine hydrochloride (0.111 g) and boric acid (1.0 g) were combined in purified water (~75 mL) and stirred for approximately 30 minutes. To this was added propylene glycol (0.3 g), and then sodium chloride (0.5 g). The mixture was stirred well to dissolve. To the mixture was added phospholipid CDM (1.0 g of 1% stock solution prepared in water). A sufficient amount of purified water was added to bring the formulation to ~95 g. The pH was adjusted to ~7.0, by the addition sodium hydroxide solution (1N) and the final batch amount was then adjusted to 100 g by adding purified water. The formulation was sterilized by filtering through a 0.22 micron membrane filter in a laminar flow hood.

EXAMPLE 2

The antimicrobial activity of the formulations shown in Table 1 below, containing 0.0001-1 (w/v %) of a phospholipid identified above as Compound No. 1 (Phospholipid CDM), Compound No. 2 (Phospholipid PTC) or Compound No. 3 (Phospholipid PTM), were evaluated relative to five microorganisms used in standard antimicrobial preservative efficacy testing. The evaluation was conducted by determining the extent to which the solution reduced an initial population of about 10^6 cfu/mL microorganisms over time. The abbreviation "cfu" means colony forming units. The preservative efficacy results for the formulations are also presented in Table 1. It should be noted that Formulations A through V all have similar osmolalities of about 275 mOsm/kg while differing in relative ionic strength.

TABLE 1

COMPOSITIONS OF PHOSPHOLIPID VEHICLES FOR PET STUDY

FORMULATION	A	B	C	D	C (Repeat)	D (Repeat)	E
INGREDIENT	AMOUNT % (W/V)						
COMPOUND NO. 1	0.0001	0.001	0.01	0.1	0.01	0.1	1.0
COMPOUND NO. 2	0	0	0	0	0	0	0
COMPOUND NO. 3	0	0	0	0	0	0	0
BORIC ACID	1.0	1.0	1.0	1.0	1.0	1.0	1.0
PROPYLENE GLYCOL	0.3	0.3	0.3	0.3	0.3	0.3	0.3
SODIUM CHLORIDE	0.15	0.15	0.15	0.15	0.15	0.15	0.15
DIBASIC SODIUM PHOSPHATE, DODECAHYDRATE	0	0	0	0	0	0	0
GLYCERIN	0	0	0	0	0	0	0
HYDROCHLORIC ACID	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
SODIUM HYDROXIDE	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
PURIFIED WATER	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%
PH	7.0	7.0	7.0	7.0	7.0	7.0	7.0
IONIC STRENGTH	0.0322	0.0322	0.0322	0.0347	0.0322	0.0347	0.0352
PET RESULTS (LOG_{10} UNIT REDUCTION)							
S. aureus (6 hours)	0.0	0.0	4.9	4.9	4.9	4.9	4.9
S. aureus (24 hours)	0.0	0.0	4.9	4.9	4.9	4.9	4.9
S. aureus (7 days)	0.5	1.1	4.9	4.9	4.9	4.9	4.9
S. aureus (14 days)	NT	NT	NT	NT	4.9	4.9	NT
S. aureus (28 days)	NT	NT	NT	NT	4.9	4.9	NT
P. aeruginosa (6 hours)	0.4	0.4	4.9	4.9	4.9	4.9	4.9
P. aeruginosa (24 hours)	0.3	0.3	4.9	4.9	4.9	4.9	4.9
P. aeruginosa (7 days)	0.5	0.5	4.9	4.9	4.9	4.9	4.9
P. aeruginosa (14 days)	NT	NT	NT	NT	4.9	4.9	NT
P. aeruginosa (28 days)	NT	NT	NT	NT	4.9	4.9	NT
E. coli (6 hours)	0.1	0.0	4.9	4.9	4.9	4.9	4.9
E. coli (24 hours)	0.0	0.0	4.9	4.9	4.9	4.9	4.9
E. coli (7 days)	0.0	0.0	4.9	4.9	4.9	4.9	4.9
E. coli (14 days)	NT	NT	NT	NT	4.9	4.9	NT
E. coli (28 days)	NT	NT	NT	NT	4.9	4.9	NT
C. albicans (7 days)	0.0	0.0	4.9	4.9	4.9	4.9	4.9
C. albicans (14 days)	NT	NT	NT	NT	4.9	4.9	NT
C. albicans (28 days)	NT	NT	NT	NT	4.9	4.9	NT
A. niger (7 days)	1.0	1.1	2.1	5.0	5.1	1.1	5.0
A. niger (14 days)	NT	NT	NT	NT	5.1	0.7	NT
A. niger (28 days)	NT	NT	NT	NT	5.1	1.7	NT

NT=Not Tested

TABLE 1 (CONT.)

FORMULATION	F	G	H	I	J	K
INGREDIENT	AMOUNT % (W/V)					
COMPOUND NO. 1	0.005	0.01	0.1	0.01	0.01	0.01
COMPOUND NO. 2	0	0	0	0	0	0
COMPOUND NO. 3	0	0	0	0	0	0
BORIC ACID	0	0	0	0	0	0
PROPYLENE GLYCOL	1.1	1.1	1.1	0.4	0	0
SODIUM CHLORIDE	0.25	0.25	0.25	0.7	0.7	0.85
DIBASIC SODIUM PHOSPHATE, DODECAHYDRATE	0.18	0.18	0.18	0.18	0.18	0.18
GLYCERIN	0	0	0	0	0.4	0
HYDROCHLORIC ACID	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
SODIUM HYDROXIDE	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
PURIFIED WATER	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%
PH	7.0	7.0	7.0	7.0	7.0	7.0
IONIC STRENGTH	0.0567	0.0567	0.0567	0.1297	0.1297	0.1603
PET RESULTS (LOG_{10} UNIT REDUCTION)						
S. aureus (6 hours)	3.9	4.9	4.9	2.4	2.4	1.1
S. aureus (24 hours)	4.9	4.9	4.9	4.3	4.8	4.9
S. aureus (7 days)	4.9	4.9	4.9	4.9	4.9	4.9
S. aureus (14 days)	NT	NT	NT	NT	NT	NT
S. aureus (28 days)	NT	NT	NT	NT	NT	NT
P. aeruginosa (6 hours)	2.4	5.0	5.0	3.7	1.2	1.2
P. aeruginosa (24 hours)	2.6	5.0	5.0	4.9	2.3	2.3
P. aeruginosa (7 days)	2.5	5.0	5.0	<2.5	<1.5	<1.5
P. aeruginosa (14 days)	NT	NT	NT	NT	NT	NT
P. aeruginosa (28 days)	NT	NT	NT	NT	NT	NT
E. coli (6 hours)	0.1	4.9	4.9	0.6	0.3	0.3
E. coli (24 hours)	0.2	4.9	4.9	0.9	0.5	0.5
E. coli (7 days)	4.3	4.9	4.9	4.9	4.9	4.9
E. coli (14 days)	NT	NT	NT	NT	NT	NT
E. coli (28 days)	NT	NT	NT	NT	NT	NT
C. albicans(7 days)	0.4	1.4	4.8	0.2	0.2	0.3
C. albicans (14 days)	NT	NT	NT	NT	NT	NT
C. albicans (28 days)	NT	NT	NT	NT	NT	NT
A. niger (7 days)	+0.1	0.3	3.0	0.6	0.0	0.0
A. niger (14 days)	NT	NT	NT	NT	NT	NT
A. niger (28 days)	NT	NT	NT	NT	NT	NT

NT=Not Tested

TABLE 1 (CONT.)

FORMULATION	L	M	N	O	P
INGREDIENT	AMOUNT % (W/V)				
COMPOUND NO. 1	0	0	0	0	0
COMPOUND NO. 2	0.01	0.1	0	0	0
COMPOUND NO. 3	0	0	0.005	0.01	0.1
BORIC ACID	1.0	1.0	1.0	1.0	1.0
PROPYLENE GLYCOL	1.0	1.0	0.3	0.3	0.3
SODIUM CHLORIDE	0.25	0.25	0.15	0.15	0.15
DIBASIC SODIUM PHOSPHATE, DODECAHYDRATE	0	0	0	0	0
GLYCERIN	0	0	0	0	0
HYDROCHLORIC ACID	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
SODIUM HYDROXIDE	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
PURIFIED WATER	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%
PH	7.0	7.0	7.0	7.0	7.0
IONIC STRENGTH	0.0493	0.0513	0.0322	0.0322	0.0322
PET RESULTS (LOG_{10} UNIT REDUCTION)					
S. aureus (6 hours)	5.0	5.0	1.2	4.9	4.9
S. aureus (24 hours)	5.0	5.0	4.0	4.9	4.9
S. aureus (7 days)	5.0	5.0	4.9	4.9	4.9
S. aureus (14 days)	NT	NT	NT	NT	NT
S. aureus (28 days)	NT	NT	NT	NT	NT
P. aeruginosa (6 hours)	4.9	4.9	4.2	4.8	4.8
P. aeruginosa (24 hours)	4.9	4.9	4.8	4.8	4.8
P. aeruginosa (7 days)	4.9	4.9	4.8	4.8	4.8
P. aeruginosa (14 days)	NT	NT	NT	NT	NT
P. aeruginosa (28 days)	NT	NT	NT	NT	NT
E. coli (6 hours)	5.0	5.0	0.1	4.9	4.9
E. coli (24 hours)	5.0	5.0	0.2	4.9	4.9
E. coli (7 days)	5.0	5.0	0.2	4.9	4.9
E. coli (14 days)	NT	NT	NT	NT	NT
E. coli (28 days)	NT	NT	NT	NT	NT
C. albicans (7 days)	4.9	4.9	1.5	5.1	5.1
C. albicans (14 days)	NT	NT	NT	NT	NT
C. albicans (28 days)	NT	NT	NT	NT	NT
A. niger (7 days)	4.0	4.0	1.9	2.8	4.4
A. niger (14 days)	NT	NT	NT	NT	NT
A. niger (28 days)	NT	NT	NT	NT	NT

NT=Not Tested

TABLE 1 (CONT.)

FORMULATION	Q	R	S	T	U	V
INGREDIENT	AMOUNT (% W/V)					
COMPOUND NO. 1	0	0.01	0.01	0.01	0.01	0.01
COMPOUND NO. 2	0	0	0	0	0	0
COMPOUND NO. 3	0	0	0	0	0	0
BORIC ACID	0	0	0	0	0	0
PROPYLENE GLYCOL	2	2	1.7	1.3	0.6	0
SODIUM CHLORIDE	0	0	0.15	0.3	0.6	0.85
DIBASIC SODIUM PHOSPHATE, DODECAHYDRATE	0.18	0.18	0.18	0.18	0.18	0.18
GLYCERIN	0	0	0	0	0	0
HYDROCHLORIC ACID	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
SODIUM HYDROXIDE	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH	q.s. to pH
PURIFIED WATER	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%	q.s. to 100%
PH	7.0	7.0	7.0	7.0	7.0	7.0
IONIC STRENGTH	0.015	0.015	0.0406	0.0673	0.1175	0.1603
PET RESULTS (LOG_{10} UNIT REDUCTION)						
S. aureus (6 hours)	NT	NT	NT	NT	NT	NT
S. aureus (24 hours)	NT	NT	NT	NT	NT	NT
S. aureus (7 days)	NT	NT	NT	NT	NT	NT
S. aureus (14 days)	NT	NT	NT	NT	NT	NT
S. aureus (28 days)	NT	NT	NT	NT	NT	NT
P. aeruginosa (6 hours)	0.5	5.0	5.0	5.0	4.5	2.5
P. aeruginosa (24 hours)	0.9	5.0	5.0	5.0	5.0	5.0
P. aeruginosa (7 days)	0.4	5.0	5.0	5.0	5.0	0.0
P. aeruginosa (14 days)	NT	NT	NT	NT	NT	NT
P. aeruginosa (28 days)	NT	NT	NT	NT	NT	NT
E. coli (6 hours)	0.0	5.0	5.0	5.0	2.6	0.4
E. coli (24 hours)	0.1	5.0	5.0	5.0	3.4	0.9
E. coli (7 days)	0.0	5.0	5.0	5.0	5.0	5.0
E. coli (14 days)	NT	NT	NT	NT	NT	NT
E. coli (28 days)	NT	NT	NT	NT	NT	NT
C. albicans (7 days)	NT	NT	NT	NT	NT	NT
C. albicans (14 days)	NT	NT	NT	NT	NT	NT
C. albicans (28 days)	NT	NT	NT	NT	NT	NT
A. niger (7 days)	NT	NT	NT	NT	NT	NT
A. niger (14 days)	NT	NT	NT	NT	NT	NT
A. niger (28 days)	NT	NT	NT	NT	NT	NT

NT=Not Tested

The results in Table 1 above demonstrate the potent antimicrobial activity of the synthetic phospholipids of formula (I). The results also demonstrate that the preservative efficacy depends in part upon both the concentration of the phospholipid present and the ionic strength of the composition. Formulations A through E together, Formulations F through H together and Formulations Q through V together each demonstrate that preservative efficacy is concentration dependent, i.e., preservative efficacy improves as phospholipid (Compound No. 1) concentration increases. Formulations I through K together demonstrate that preservative efficacy decreases as the ionic strength increases (relative to Formulations A through E and F through H) due to an increase in the amount of sodium chloride concentration, when the phospholipid (Compound No. 1) concentration is fixed at 0.01.

The following formulations 3 through 9 are aqueous, isotonic solutions. They can be prepared in a similar manner as the solution of Example 1 above.

EXAMPLE 3

Ophthalmic Solution

(preserved by benzalkonium chloride and phospholipid)

Ingredient	Concentration (%, w/v)
Olopatadine hydrochloride	0.111
Benzalkonium chloride	0.005
Phospholipid of Formula (I)	0.001-2
Dibasic sodium phosphate (anhydrous)	0.5
Sodium chloride	0.6
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to pH 7.0

EXAMPLE 4

Otic or Nasal Formulation

Ingredient	Concentration (%, w/v)
Active Ingredient	0.01-5
Phospholipid of Formula (I)	0.005-1
Disodium EDTA	0.001-0.05
Dibasic Sodium Phosphate	0-1
Monobasic Sodium Phosphate	0-1
Sodium chloride	0.5-0.9
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to 4.5 – 8.0

EXAMPLE 5

Disinfecting Solution

Ingredient	Concentration (%, w/v)
Phospholipid of Formula (I)	0.001-2
Disodium EDTA	0.0001-0.05
Boric acid	0-2
Propylene glycol	0-1
Sodium chloride	0.5-0.9
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to 6.0 – 8.0

<u>EXAMPLE 6</u>

Comfort Drop Solution for Contact Lenses

Ingredient	**Concentration (%, w/v)**
Phospholipid of Formula (I)	0.001-2
Disodium EDTA	0.0001-0.05
Dibasic sodium phosphate	0-1
Monobasic sodium phosphate	0-1
Povidone	0-2
Sodium chloride	0.5-0.9
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to 5.0 – 8.0

<u>EXAMPLE 7</u>

Lubricant Eye Drop

Ingredient	**Concentration (%, w/v)**
Phospholipid of Formula (I)	0.001-2
Disodium EDTA	0-0.05
Dextran T 70	0-3
Hydroxypropyl methylcellulose	0-0.5
Sodium bicarbonate	0-2
Sodium chloride	0.5-0.9
Potassium chloride	0.05-0.2
Hydrochloric acid	q.s. to pH
Sodium hydroxide	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to 6.5 – 7.8

EXAMPLE 8

Lubricant Eye Drop

Ingredient	Concentration (%, w/v)
HP-Guar	0.16
Phospholipid CDM	0.01
Boric Acid	0.7
Sorbitol	1.4
Polyethylene Glycol	0.4
Propylene Glycol	0.3
Potassium Chloride	0.12
Sodium Chloride	0.1
Calcium Chloride	0.0053
Magnesium Chloride	0.0064
Zinc Chloride	0.00015
AMP-95	0.6
Sodium Hydroxide	q.s. to pH
Hydrochloric Acid	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to pH 7.9

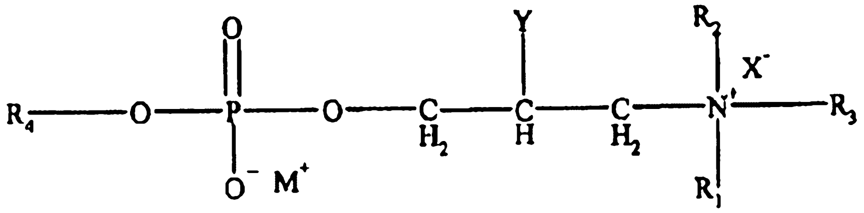
EXAMPLE 9

Lubricant Eye Drop

Ingredient	Concentration (%, w/v)
HP 8A-Guar	0.16-.019
Phospholipid CDM	0.01
Boric Acid	0.63
Sorbitol	1.26
Polyethylene Glycol	0.4
Propylene Glycol	0.3
Potassium Chloride	0.12
Sodium Chloride	0.1
Calcium Chloride	0.0053
Magnesium Chloride	0.0064
Zinc Chloride	0.00135
AMP-95	0.513
Sodium Hydroxide	q.s. to pH
Hydrochloric Acid	q.s. to pH
Purified Water	q.s. to 100
pH	q.s. to pH 7.4-7.9

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A sterile pharmaceutical composition comprising a preservative effective amount of a compound of the following formula,



(I)

wherein:

R_1 and R_3 are $(C_1\text{-}C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1\text{-}C_{16})$-alkyl optionally substituted by $NHC(=O)\text{-}(CH_2)_{10}CH_3$ or $NHC(=O)\text{-}(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$;

wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, O-$(C_1\text{-}C_{10})$-alkyl and O-$(C_1\text{-}C_{10})$-alkenyl;

M is selected from the group consisting of sodium and potassium;

and a pharmaceutically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29th revision.

2. The composition of claim 1, wherein:

R_1 and R_3 are methyl;

R_2 is selected from the group consisting of $(CH_2)_{11}CH_3$, $(CH2)_3\text{-}NHC(=O)\text{-}(CH_2)_{10}CH_3$, and $(CH_2)_3\text{-}NHC(=O)\text{-}(CH_2)_{12}CH_3$;

R_4 is $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are defined as above;

X is chloro;

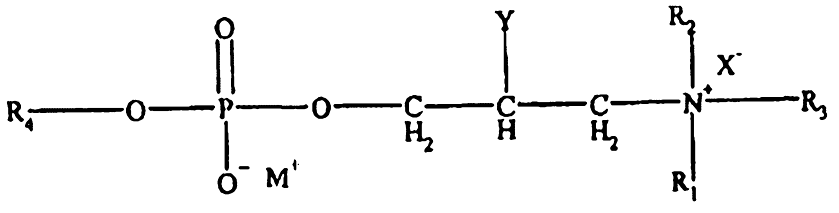
Y is OH; and

M is sodium.

3. The composition of claim 2 wherein the compound of formula (I) is selected from the group consisting of Phospholipid CDM, Phospholipid PTC and Phospholipid PTM.

4. The composition of any one of claims 1 to 3, wherein the composition further comprises a preservative ingredient selected from the group consisting of benzalkonium chloride, benzalkonium bromide, polyquaternium-1, chlorhexidine, chlorobutanol, cetylpyridinium chloride, a paraben, a thimerosal, chlorine dioxide and N,N-dichlorotaurine.

5. A method of preserving a pharmaceutical composition from microbial contamination which comprises adding to the composition a preservative effective amount of a compound of the following formula,



(I)

wherein:

R_1 and R_3 are (C_1-C_6)-alkyl;

R_2 is selected from the group consisting of hydrogen and (C_1-C_{16})-alkyl optionally substituted by $NHC(=O)-(CH_2)_{10}CH_3$ or $NHC(=O)-(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X$;

wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, O-(C_1-C_{10})-alkyl and O-(C_1-C_{10})-alkenyl; and

M is selected from the group consisting of sodium and potassium;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29th revision.

6. The method of claim 5 wherein,

2008254858 23 May 2013

R_1 and R_3 are methyl;

R_2 is selected from the group consisting of $(CH_2)_{11}CH_3$, $(CH2)_3$-$NHC(=O)$-$(CH_2)_{10}CH_3$, and $(CH2)_3$-$NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is $CH2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are as defined above;

X is chloro;

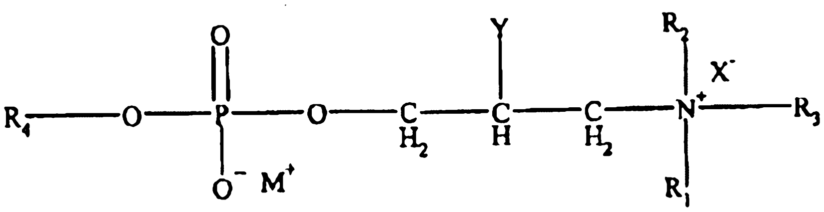
Y is OH; and

M is sodium.

7. The method of claim 6 wherein the compound of formula (I) is selected from the group consisting of Phospholipid CDM, Phospholipid PTC and Phospholipid PTM.

8. The method of any one of claims 5 to 7 wherein the composition further comprises a preservative ingredient selected from the group consisting of benzalkonium chloride, benzalkonium bromide, polyquaternium-1, chlorhexidine, chlorobutanol, cetylpyridinium chloride, a paraben, a thimerosal, chlorine dioxide and N,N-dichlorotaurine.

9. A solution for treating contact lenses, comprising an effective amount of a compound of the following formula:



(I)

wherein:

R_1 and R_3 are $(C_1$-$C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1$-$C_{16})$-alkyl optionally substituted by $NHC(=O)$-$(CH_2)_{10}CH_3$ or $NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$;

wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, O-$(C_1$-$C_{10})$-alkyl and O-$(C_1$-$C_{10})$-alkenyl;

M is selected from the group consisting of sodium and potassium;

2008254858 23 May 2013

and an ophthalmically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29^{th} revision.

10. The solution of claim 9, wherein,

R_1 and R_3 are methyl;

R_2 is selected from the group consisting of $(CH_2)_{11}CH_3$, $(CH2)_3$-$NHC(=O)$-$(CH_2)_{10}CH_3$, and $(CH_2)_3$-$NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are as defined above;

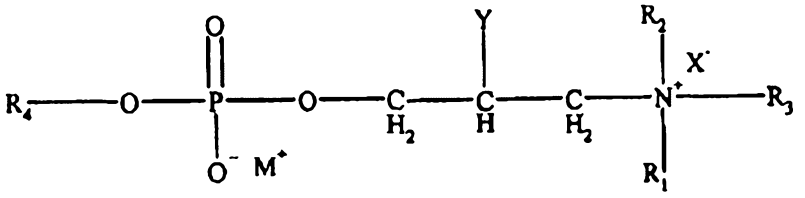
X is chloro;

Y is OH; and

M is sodium.

11. The solution of claim 10 wherein the compound of formula (I) is selected from the group consisting of Phospholipid CDM, Phospholipid PTC and Phospholipid PTM.

12. A method of disinfecting a contact lens, which comprises contacting the lens with a solution comprising a compound of the following formula in an amount effective to disinfect the lens:



(I)

wherein:

R_1 and R_3 are $(C_1$-$C_6)$-alkyl;

R_2 is selected from the group consisting of hydrogen and $(C_1$-$C_{16})$-alkyl optionally substituted by $NHC(=O)$-$(CH_2)_{10}CH_3$ or $NHC(=O)$-$(CH_2)_{12}CH_3$;

R_4 is selected from the group consisting of hydrogen and $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are as defined above;

X is halo;

Y is selected from the group consisting of OH, O-$(C_1$-$C_{10})$-alkyl and O-$(C_1$-$C_{10})$-alkenyl;

M is selected from the group consisting of sodium and potassium;

and a ophthalmically acceptable vehicle therefor;

wherein the concentration of the compound of formula (I) is 0.01 w/v% or below, the composition has an osmolality of 150 to 350 mOsm/kg and a pH of 4.5 to 9.0 such that the composition is suitable for topical application to an eye, the ionic strength of the composition is 0.12 or below and the composition satisfies USP preservative efficacy requirements, 29th revision.

13. The method of claim 12 wherein:

R_1 and R_3 are methyl;

R_2 is selected from the group consisting of $(CH_2)_{11}CH_3$, $(CH_2)_3$-NHC(=O)-$(CH_2)_{10}CH_3$, and $(CH_2)_3$-NHC(=O)-$(CH_2)_{12}CH_3$;

R_4 is $CH_2CH(Y)CH_2N^+R_1R_2R_3X^-$; wherein R_1, R_2, and R_3, are as defined above;

X is chloro;

Y is OH; and

M is sodium.

14. The method of claim 13 wherein the compound of formula (I) is selected from the group consisting of Phospholipid CDM, Phospholipid PTC and Phospholipid PTM.

15. The composition of claim 1, wherein the composition is ophthalmic, otic or nasal.

16. The composition of claim 1, substantially as hereinbefore described with reference to any of the Examples.

17. The method of claim 5, substantially as hereinbefore described with reference to any of the Examples.

18. The solution of claim 9, substantially as hereinbefore described with reference to any of the Examples.

19. The method of claim 12, substantially as hereinbefore described with reference to any of the Examples.