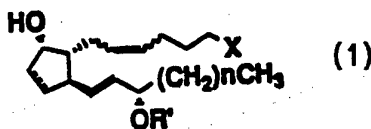




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<p>(21) International Application Number: PCT/US93/10061 (22) International Filing Date: 20 October 1993 (20.10.93) (30) Priority data: 07/964,223 21 October 1992 (21.10.92) US (71) Applicant: ALLERGAN, INC. [US/US]; 2525 Dupont Drive, P.O. Box 19534, Irvine, CA 92713-9534 (US). (72) Inventors: GARST, Michael, E. ; 2433 Vista Hogar, Newport Beach, CA 92660 (US). BURK, Robert ; 3901 Parkview, 17D, Irvine, CA 92715 (US). (74) Agents: BARAN, Robert, J. et al.; Allergan, Inc., 2525 Dupont Drive, P.O. Box 19534, Irvine, CA 92713-9534 (US).</p>		<p>(81) Designated States: AU, CA, CZ, HU, JP, NO, NZ, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: NOVEL 7-(5-SUBSTITUTED CYCLOPENTYL) AND (5-SUBSTITUTED CYCLOPENTENYL) HEPTYL ALCOHOLS, HEPTYLAMINES AND HEPTANOIC ACID AMINES, AND METHOD OF LOWERING INTRAOCULAR PRESSURE IN THE EYE OF A MAMMAL BY ADMINISTRATION OF THESE NOVEL COMPOUNDS



(57) Abstract

Compounds of formula (1) where the dotted line represents a bond or the absence of a bond, the wavy lines represent bonds which are either in cis or trans configuration; R_1 represents H, or $CO-R_2$ where R_2 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group; X represents $CO-NR_3R_4$, CH_2OH , CH_2OR_5 , CH_2O-COR_6 , and $CH_2-NR_3R_4$, where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group, and n is an integer between 0 and 8 are capable of lowering intraocular pressure in the eye of a mammal.

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NOVEL 7-(5-SUBSTITUTED CYCLOPENTYL) AND (5-SUBSTITUTED
CYCLOPENTENYL) HEPTYL ALCOHOLS, HEPTYLAMINES AND
HEPTANOIC ACID AMIDES, AND METHOD OF LOWERING
INTRAOCULAR PRESSURE IN THE EYE OF A MAMMAL BY
5 ADMINISTRATION OF THESE NOVEL COMPOUNDS

1. Field of the Invention

The present invention relates to 7-(5-substituted cyclopentyl) and (5-substituted cyclopentenyl) heptyl alcohols, heptyl amines and heptanoic acid amides,
10 which are structurally related to certain prostaglandins. The present invention also relates to methods of administering said novel compounds to mammals for the purpose of lowering intraocular pressure in the mammalian eye.

152. Background of the Invention

Ocular hypotensive agents are useful in the treatment of a number of various ocular hypertensive conditions, such as post-surgical and post-laser trabeculectomy ocular hypertensive episodes, glaucoma,
20 and as presurgical adjuncts.

Glaucoma is a disease of the eye characterized by increased intraocular pressure. On the basis of its etiology, glaucoma has been classified as primary or secondary. For example, primary glaucoma in adults
25 (congenital glaucoma) may be either open-angle or acute or chronic angle-closure. Secondary glaucoma results from pre-existing ocular diseases such as uveitis, intraocular tumor or an enlarged cataract.

The underlying causes of primary glaucoma are not
30 yet known. The increased intraocular tension is due to the obstruction of aqueous humor outflow. In chronic open-angle glaucoma, the anterior chamber and its anatomic structures appear normal, but drainage of the

aqueous humor is impeded. In acute or chronic angle-closure glaucoma, the anterior chamber is shallow, the filtration angle is narrowed, and the iris may obstruct the trabecular meshwork at the entrance of the canal of Schlemm. Dilatation of the pupil may push the root of the iris forward against the angle, and may produce pupillary block and thus precipitate an acute attack. Eyes with narrow anterior chamber angles are predisposed to acute angle-closure glaucoma attacks of various degrees of severity.

Secondary glaucoma is caused by any interference with the flow of aqueous humor from the posterior chamber into the anterior chamber and subsequently, into the canal of Schlemm. Inflammatory disease of the anterior segment may prevent aqueous escape by causing complete posterior synechia in iris bombe and may plug the drainage channel with exudates. Other common causes are intraocular tumors, enlarged cataracts, central retinal vein occlusion, trauma to the eye, operative procedures and intraocular hemorrhage.

Considering all types together, glaucoma occurs in about 2% of all persons over the age of 40 and may be asymptotic for years before progressing to rapid loss of vision. In cases where surgery is not indicated, topical B-adrenoreceptor antagonists have traditionally been the drugs of choice for treating glaucoma.

Prostaglandins were earlier regarded as potent ocular hypertensives; however, evidence accumulated in the last two decades shows that some prostaglandins are highly effective ocular hypotensive agents and are ideally suited for the long-term medical management of glaucoma. (See, for example, M. S. Starr, Exp. Eye

Res. 11, 170-177, (1971); Bito, L. Z. Biological Protection with Prostaglandins Cohen, M. M., ed., Boca Raton, Fla. CRC Press Inc., 1985, pp. 231-252; and Bito, L. Z., Applied Pharmacology in the Medical Treatment of Glaucomas Drance, S. M. and Neufeld, A. H. eds., New York, Grune & Stratton, 1984, pp. 477-505). Such prostaglandins include PGF_{2α}, PGF_{1α}, PGE₂, and certain lipid-soluble esters, such as C₁ to C₅ alkyl esters, e.g. 1-isopropyl ester, of such compounds.

10 In the United States Patent No. 4,599,353 certain prostaglandins, in particular PGE₂ and PGF_{2α} and the C₁ to C₅ alkyl esters of the latter compound, were reported to possess ocular hypotensive activity and were recommended for use in glaucoma management.

15 Although the precise mechanism is not yet known, recent experimental results indicate that the prostaglandin-induced reduction in intraocular pressure results from increased uveoscleral outflow [Nilsson et al., Invest. Ophthalmol. Vis. Sci. 28 (suppl), 284 (1987)].

20 The isopropyl ester of PGF_{2α} has been shown to have significantly greater hypotensive potency than the parent compounds, which was attributed to its more effective penetration through the cornea. In 1987 this compound was described as "the most potent ocular hypotensive agent ever reported." [See, for example, Bito, L. Z., Arch. Ophthalmol. 105, 1036 (1987), and Siebold et al., Prodrug 5, 3 (1989)].

30 Whereas prostaglandins appear to be devoid of significant intraocular side effects, ocular surface (conjunctival) hyperemia and foreign-body sensation have been consistently associated with the topical ocular use of such compounds, in particular PGF_{2α} and

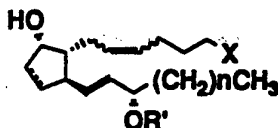
its prodrugs, e.g. its 1-isopropyl ester, in humans. The clinical potential of prostaglandins in the management of conditions associated with increased ocular pressure, e.g. glaucoma, is greatly limited by
5 these side effects.

Certain phenyl and phenoxy mono, tri and tetra nor prostaglandins and their 1-esters are disclosed in European Patent Application 0,364,417 as useful in the treatment of glaucoma or ocular hypertension.

10 In a series of co-pending United States patent applications assigned to Allergan, Inc. prostaglandin esters with increased ocular hypotensive activity accompanied with no or substantially reduced side-effects are disclosed. The co-pending USSN 386,835
15 (filed 27 July 1989), relates to certain 11-acyl-prostaglandins, such as 11-pivaloyl, 11-acetyl, 11-isobutyryl, 11-valeryl, and 11-isovaleryl $\text{PGF}_{2\alpha}$. Intraocular pressure reducing 15-acyl prostaglandins are disclosed in the co-pending application USSN
20 357,394 (filed 25 May 1989). Similarly, 11,15- 9,15- and 9,11-diesters of prostaglandins, for example 11,15-dipivaloyl $\text{PGF}_{2\alpha}$ are known to have ocular hypotensive activity. See the co-pending patent applications USSN No. 385, 645 filed 27 July 1990, now U.S. Patent No.
25 4,494,274; 584,370 which is a continuation of USSN No. 386,312, and 585,284, now U.S. Patent No. 5,034,413 which is a continuation of USSN 386,834, where the parent applications were filed on 27 July 1989. The disclosures of these patent applications are hereby
30 expressly incorporated by reference.

SUMMARY OF THE INVENTION

Novel compounds of the present invention are shown in **Formula 1**



5

Formula 1

10 where the dotted line represents a bond or the absence of a bond, the wavy lines represent bonds which are either in cis or trans configuration;

R_1 represents H, or CO- R_2 where R_2 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic
15 aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group;

X represents CO-N R_3R_4 , CH₂OH, CH₂OR₅, CH₂O-COR₆, and CH₂-N R_3R_4 , where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and
20 R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group, and

n is an integer between 0 and 8.

In another aspect the present invention relates to
25 pharmaceutical compositions containing as active ingredient one or more compounds of the present invention (or their pharmaceutically acceptable salts).

In still another aspect the present invention relates to methods of administering to a mammal a
30 pharmaceutical composition having as its active ingredient one or more compounds of **Formula 1** (or their pharmaceutically acceptable salts) for the purpose of lowering intraocular pressure in the eye of the mammal.

DETAILED DESCRIPTION OF THE INVENTIONGENERAL EMBODIMENTS

The present invention relates to novel compounds of **Formula 1**, and to their use in pharmaceutical compositions and methods for the purpose of lowering intraocular pressure in the eye of a mammal.

Definitions

In **Formula 1** as well as in all other chemical formulas in the present application for United States letters patent, bonds shown with hashed lines indicate a bond below the plane of the paper, thus signifying α configuration; bonds shown as a solid triangle indicate a bond above the plane of the paper, thus signifying β configuration; a dashed or dotted line represents a single bond or absence of a bond, and wavy lines attached to a double bond indicate that the configuration of substituents about the double bond can be cis or trans. Trans (E) configuration of substituents about a double bond is indicated by bonds pointing in opposite directions about a double bond, whereas cis (Z) configuration of substituents about a double bond is indicated by bonds pointing in the same direction about a double bond.

The term alkyl refers to and covers any and all groups which are known as normal alkyl, branch-chain alkyl and cycloalkyl. Lower alkyl means the above-defined broad definition of alkyl groups having 1 to 6 carbons, and as applicable, 3 to 6 carbons for branch chained and cyclo-alkyl groups.

The term "ester" as used here refers to and covers any compound falling within the definition of that term classically used in organic chemistry. Where the ester is derived from a carboxylic acid corresponding to

Formula 1, the term covers the products derived from the treatment of this function with alcohols, preferably with aliphatic alcohols having 1 - 6 carbons. Where the ester is derived from alcohols corresponding to Formula 1, the term covers compounds of the formula $-CH-OOCR_2$ where R_2 is lower alkyl, carbocyclic aryl, heteroaryl, or carbocyclic aryl or heteroaryl substituted lower alkyl group.

Amide has the meaning classically accorded that term in organic chemistry. In this instance it includes but is not limited to unsubstituted amides and aliphatic mono-and di-substituted amides.

A pharmaceutically acceptable salt may be prepared for any compound used in the method of treatment of this invention, if the compound has a functionality capable of forming such salt, for example an acid functionality. A pharmaceutically acceptable salt may be any salt which retains the activity of the parent compound and does not impart any deleterious or untoward effect on the subject to which it is administered and in the context in which it is administered.

Such a salt may be derived from any organic or inorganic acid or base. The salt may be a mono or polyvalent ion. Of particular interest where the acid function is concerned are the inorganic ions, sodium, potassium, calcium, and magnesium. Organic amine salts may be made with amines, particularly ammonium salts such as mono-, di- and trialkyl amines or ethanol amines. Salts may also be formed with caffeine, tromethamine and similar molecules. Where there is a nitrogen sufficiently basic as to be capable of forming acid addition salts, such may be formed with any inorganic or organic acids or alkylating agent such as

methyl iodide. Preferred salts are those formed with inorganic acids such as hydrochloric acid, sulfuric acid or phosphoric acid. Any of a number of simple organic acids such as mono-, di- or tri-acid may also
5 be used.

The compounds of the present invention contain at least one double bond and therefore have trans and cis (E and Z) isomers. In addition, the compounds of the present invention contain one or more chiral centers
10 and therefore exist in enantiomeric and diastereomeric forms. Unless the structural formula or the language of this application specifically designate a particular cis or trans isomer or a particular configuration of a chiral center, the scope of the present invention is
15 intended to cover all such isomers per se, as well as mixtures of cis and trans isomers, mixtures of diastereomers and racemic mixtures of enantiomers (optical isomers) as well.

For the sake of ease of description, the side
20 chain in **Formula 1** which contains the 7-carbon side chain is sometimes referred to in the application as the " α side chain", and the other side chain attached to the cyclopentane or cyclopentene ring in accordance with **Formula 1** is sometimes called as the " Ω side
25 chain". This nomenclature is similar to the nomenclature used in naming the side chains of related prostaglandin compounds.

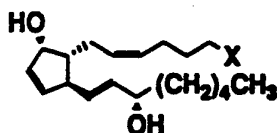
General Description of the Preferred Compounds of the Invention

30 Referring now to the structure shown in **Formula 1**, and regarding the olefinic bond in the α side chain, in the preferred compounds this olefinic bond is in the cis (Z) configuration.

With respect to the group R_1 on the Ω side chain of the compounds of the invention, R_1 is preferably H or $CO-R_2$, where R_2 is lower alkyl, still more preferably lower alkyl of 1 to 3 carbons. With respect to the group X , compounds are preferred where X is CH_2OH , CH_2OCH_3 , $CH_2OCO-t\text{-butyl}$, and where X is $CO-NH_2$, or $CO-NR_3R_4$ where one of R_3 and R_4 is isopropyl, or where both R_3 and R_4 are methyl.

The most preferred compounds of the invention are 10 identified below with reference to Formula 2.

15



20

		Formula 2	
COMPOUND #	"dashed line"	represents	X
	1	absence of a bond	CH_2OH
	2	absence of a bond	$CONH_2$
25	3	absence of a bond	$CONH-CH(CH_3)_2$
	4	absence of a bond	$CON(CH_3)_2$
	5	a bond	CH_2OH
	6	a bond	CH_2OCH_3
	7	a bond	$CH_2OCO-C(CH_3)_3$
30	8	a bond	$CONH_2$
	9	a bond	$CONH-CH(CH_3)_2$
	10	a bond	$CON(CH_3)_2$
	11	a bond	$CH_2N(CH_3)_2$

Methods of Administration, Formulations

Pharmaceutical compositions may be prepared by combining a therapeutically effective amount of at least one compound according to the present invention, 5 or a pharmaceutically acceptable salt thereof, as an active ingredient, with conventional ophthalmically acceptable pharmaceutical excipients, and by preparation of unit dosage forms suitable for topical ocular use. The therapeutically efficient amount 10 typically is between about 0.0001 and about 5% (w/v), preferably about 0.001 to about 1.0% (w/v) in liquid formulations.

For ophthalmic application, preferably solutions are prepared using a physiological saline solution as a 15 major vehicle. The pH of such ophthalmic solutions should preferably be maintained between 4.5 and 8.0 with an appropriate buffer system, a neutral pH being preferred but not essential. The formulations may also contain conventional, pharmaceutically acceptable 20 preservatives, stabilizers and surfactants.

Preferred preservatives that may be used in the pharmaceutical compositions of the present invention include, but are not limited to, benzalkonium chloride, chlorobutanol, thimerosal, phenylmercuric acetate and 25 phenylmercuric nitrate. A preferred surfactant is, for example, Tween 80. Likewise, various preferred vehicles may be used in the ophthalmic preparations of the present invention. These vehicles include, but are not limited to, polyvinyl alcohol, povidone, 30 hydroxypropyl methyl cellulose, poloxamers, carboxymethyl cellulose, hydroxyethyl cellulose, cyclodextrin and purified water.

Tonicity adjustors may be added as needed or

convenient. They include, but are not limited to, salts, particularly sodium chloride, potassium chloride, mannitol and glycerin, or any other suitable ophthalmically acceptable tonicity adjustor.

5 Various buffers and means for adjusting pH may be used so long as the resulting preparation is ophthalmically acceptable. Accordingly, buffers include acetate buffers, citrate buffers, phosphate buffers and borate buffers. Acids or bases may be used
10 to adjust the pH of these formulations as needed.

In a similar vein, an ophthalmically acceptable antioxidant for use in the present invention includes, but is not limited to, sodium metabisulfite, sodium thiosulfate, acetylcysteine, butylated hydroxyanisol
15 and butylated hydroxytoluene.

Other excipient components which may be included in the ophthalmic preparations are chelating agents. The preferred chelating agent is edentate disodium, although other chelating agents may also be used in
20 place or in conjunction with it.

The ingredients are usually used in the following amounts:

	<u>Ingredient</u>	<u>Amount (% w/v)</u>
	active ingredient	about 0.001-5
25	preservative	0-0.10
	vehicle	0-40
	tonicity adjustor	0-10
	buffer	0.01-10
	pH adjustor	q.s. pH 4.5-7.5
30	antioxidant	as needed
	surfactant	as needed
	purified water	as needed to make 100%

The actual dose of the active compounds of the

present invention depends on the specific compound, and on the condition to be treated; the selection of the appropriate dose is well within the knowledge of the skilled artisan.

5 The ophthalmic formulations of the present invention are conveniently packaged in forms suitable for metered application, such as in containers equipped with a dropper, to facilitate application to the eye. Containers suitable for dropwise application are
10 usually made of suitable inert, non-toxic plastic material, and generally contain between about 0.5 and about 15 ml solution. One package may contain one or more unit doses.

Especially preservative-free solutions are often
15 formulated in non-resealable containers containing up to about ten, preferably up to about five units doses, where a typical unit dose is from one to about 8 drops, preferably one to about 3 drops. The volume of one drop is about 20-35 μ l.

20 Biological Activity

The ability of a pharmaceutical composition which contains a compound of **Formula 1** to lower intraocular pressure in the eye of a mammal, can be demonstrated by an assay performed on the eyes of dogs. The assay is
25 descibed as follows: male and female beagle dogs weighing 10 - 15 kg had been trained for a minimum of 2 months so that intraocular pressure could be measured without the use of restraining devices. Intraocular pressure was measured by pneumatonometry using
30 applanation tonometers (Alcon). One minute prior to tonometry, 25 μ l of proparacaine (Allergan, Irvine California) was applied to minimize ocular discomfort during the procedure. Determination of the effects of

the compounds of the invention on intraocular pressure involved administration of 1 to 25 μ l of solution of the compound to one eye and an equal volume of vehicle to the contralateral eye as a control.

5 The effect of the compounds of the invention to lower intraocular pressure in dog eyes, in accordance with the above-described assay is shown in Table 1 with respect to the following compounds:

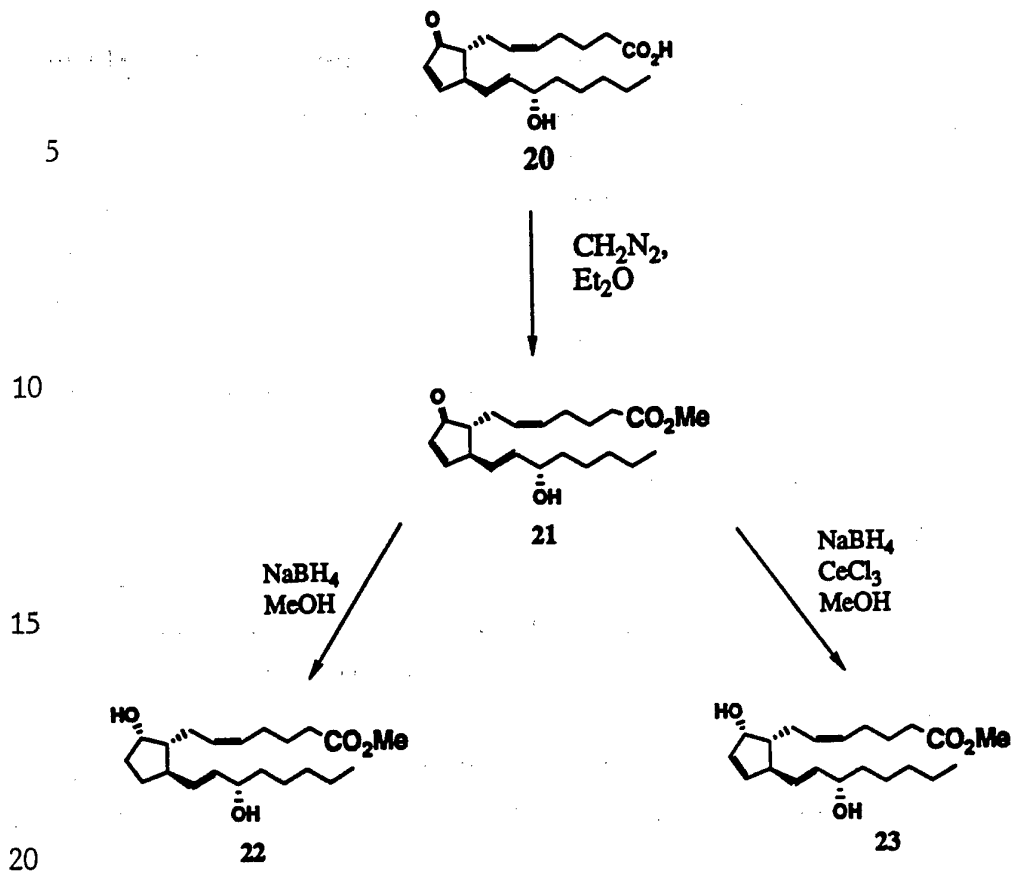
Table 1

10	Compound #	Concentration %	Change in IOP 6 hours after administr.
	1	0.1	-6.0
	2	0.1	-4.4
	3	0.1	-3.5
15	4	0.1	-4.3
	5	0.1	-4.8
	7	0.1	-2.4
	8	0.1	-6.2
	11	0.1	-2.5

20 General Description of Synthetic Procedures

The compounds of the invention can be made by a number of different synthetic chemical pathways. To illustrate the invention, the following detailed description is provided. The synthetic chemist will readily appreciate that the conditions set out here are specific embodiments which can be generalized to obtain any and all compounds described in the present specification.

Reaction Scheme 1



Referring now to Reaction Scheme 1, the compound 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoic acid (Compound 20) serves as a starting material. Compound 20 is also known as prostaglandin A₂, and is available commercially (Cayman Chemical Co., Ann Arbor, Michigan). Compound 20 is methylated by reaction with diazomethane in diethyl ether (or by some other known esterification procedure) to provide methyl 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-

Referring now to **Reaction Scheme 2**, the heptenoate ester function of **Compound 22** is reduced with lithium borohydride, or by other suitable reducing agent, to provide the primary alcohol, **Compound 1**. **Compound 1** is a biologically active compound in accordance with the present invention.

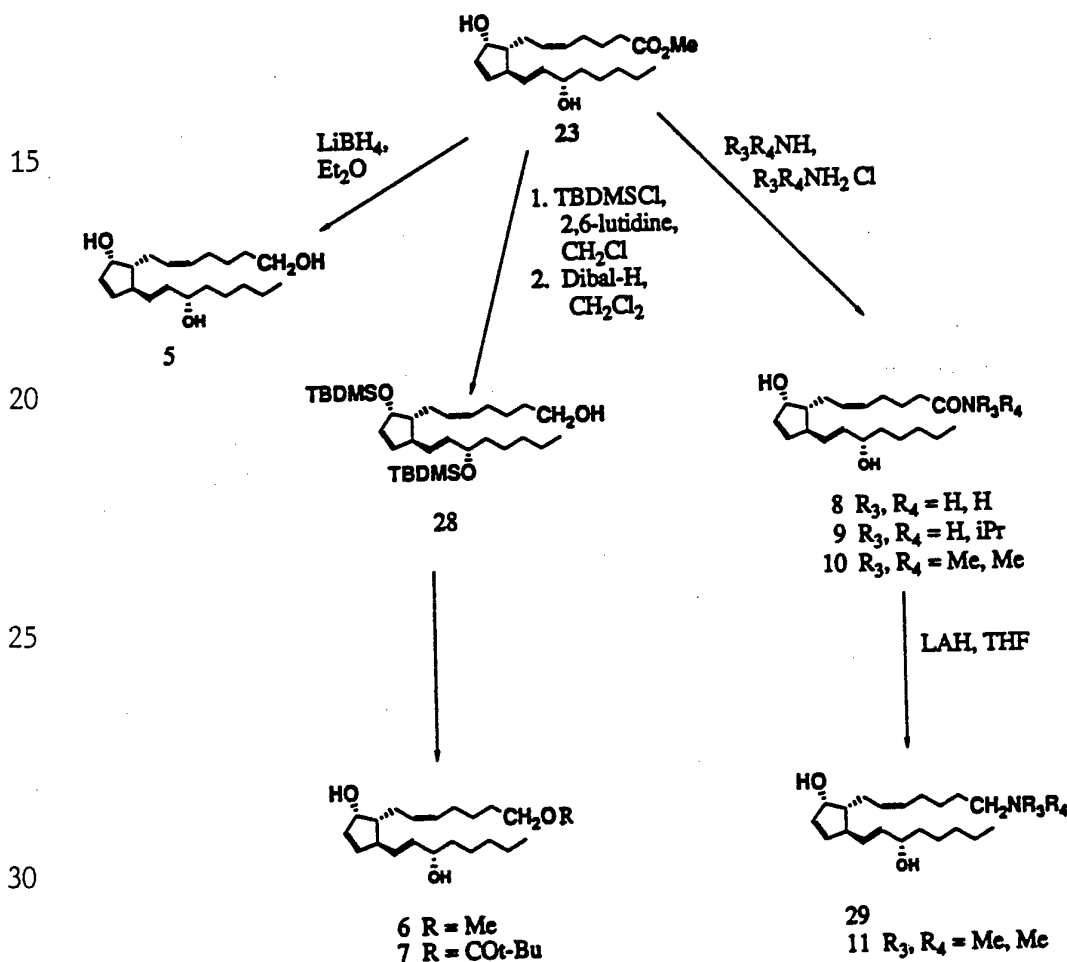
In order to obtain ester or ether derivatives of **Compound 1**, that is to obtain compounds where with reference to **Formula 1 X** is CH_2OR_5 or $\text{CH}_2\text{O-COR}_6$, the reduction of the heptenoate ester function is performed on the derivative (**Compound 24**) where the hydroxyl functions are protected by *t*-butyldimethylsilyl or other suitable protecting groups. **Compound 24** can be obtained, for example, by reaction of **Compound 22** with *t*-butyldimethylsilyl chloride in 2,6-lutidine. After reduction of **Compound 24** the primary alcohol function can be esterified by reagents normally used for this purpose (such as an acyl chloride R_6COCl) or converted into an ether, (for example into an alkyl ether by reaction with an alkyl iodide $\text{R}_5\text{-I}$) whereafter the *t*-butyldimethylsilyl groups (or other suitable protecting groups) are removed from the secondary hydroxyl groups of the molecule to yield the ester (**Compound 25**) or ether (**Compound 26**).

To obtain compounds of the invention where the α side chain terminates with a carboxamide function (that is to obtain compounds where with reference to **Formula 1 X** is $\text{CO-NR}_3\text{R}_4$) **Compound 22** is reacted with an amine and ammonium salt of the formula $\text{R}_3\text{R}_4\text{NH}$, $\text{R}_3\text{R}_4\text{NH HCl}$. When the reagent is ammonia and ammonium chloride then the resulting compound is the unsubstituted amide (**Compound 2**); when the reagent is *N*-isopropylamine, *N*-isopropylamine hydrochloride, then the resulting

compound is the isopropylamide (Compound 3), and when the reagent is *N,N*-dimethylamine and *N,N*-dimethylamine hydrochloride, then the resulting compound is the dimethylamide (Compound 4). The carboxamides obtained in the just described manner (such as Compounds 2, 3 and 4) are reduced with lithium aluminum hydride (or other suitable reducing agent) to provide the amine compounds of Formula 27.

10

Reaction Scheme 3



Referring now to **Reaction Scheme 3**, methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (**Compound 23**) which is obtained in accordance with **Reaction Scheme 1**, serves as the starting material. The heptenoate ester function of **Compound 23** is reduced with lithium borohydride to provide the corresponding primary alcohol (**Compound 5**). Ether and ester derivatives of the primary alcohol (heptanol) function are obtained in analogy to the similar reaction steps described in connection with **Reaction Scheme 2**. Thus the two secondary hydroxyl functions of **Compounds 23** are first protected by reaction with *t*-butyldimethylsilylchloride or with *t*-butyldimethylsilyl trifluoromethane sulfonate, and thereafter the heptenoate ester function is reduced with diisobutylaluminum hydride (or other suitable reducing agent) to provide **Compound 28**. **Compound 28** has a free primary alcohol group while the secondary alcohol groups are protected. Therefore **Compound 28** can be acylated or converted into an ether with reactions well known in the art for this purpose. (See **Reaction Scheme 2** for analogous reactions). The *t*-butyldimethylsilyl groups are removed by treatment with aqueous acid, to yield ether or ester derivatives of the primary alcohol function. **Compound 6** is an example of the foregoing, where the primary alcohol has been converted into a methyl ether, and **Compound 7** is an example where the primary alcohol is esterified by a *t*-butanoic (pivalic) acid residue.

Reaction of **Compound 23** with ammonia and ammonium chloride, or with an amine of the formula R_3R_4NH and the corresponding hydrochloride salt, yields the carboxamide compounds of the invention, that is

compounds where with reference to **Formula 1** **X** is $\text{CO-NR}_3\text{R}_4$. Thus, when the reagent is ammonia and ammonium chloride then the resulting compound is the unsubstituted amide (**Compound 8**); when the reagent is **N**-isopropylamine, **N**-isopropylamine hydrochloride, then
5 **N**-isopropylamine, **N**-isopropylamine hydrochloride, then the resulting compound is the isopropylamide (**Compound 9**), and when the reagent is **N,N**-dimethylamine and **N,N**-dimethylamine hydrochloride, then the resulting compound is the dimethylamide (**Compound 10**). Reduction
10 of the carboxamides, such as **Compounds 8, 9, and 10**, with lithium aluminum hydride (or other suitable reducing agents) results in compounds of the invention where the α side chain is a heptenylamine, of the general structure of **Formula 29**.

15 Compounds of the invention where the 3α -hydroxyl group of the Ω side chain is esterified (that is compounds where with reference to **Formula 1** R_1 is CO-R_2) are obtained by esterification of the "free" 3α -hydroxyl compounds by reactions with an acid chloride
20 (R_2COCl), dimethylaminopyridine catalyzed reaction with a carboxylic acid anhydride ($(\text{R}_2\text{-CO})_2\text{O}$), or reaction with an acid ($\text{R}_2\text{-COOH}$) in dimethylaminopyridine, or other esterification reactions known in the art. These reagents or reactions preferentially esterify the 3α -
25 hydroxyl group over the hydroxyl group attached to the cyclopentane or cyclopentene ring. In the event a mixture of esters is obtained, the desired 3α -hydroxyl ester can be isolated, for example, by chromatography. Compounds of the invention where the 3α -hydroxyl group
30 is esterified, and the α side chain includes a free heptenol moiety (that is compounds where with reference to **Formula 1** R_1 is CO-R_2 , and **X** is CH_2OH) are obtained from the corresponding heptenols (such as **Compound 28**)

by first protecting the primary alcohol (heptenol) function with a suitable protecting group, such as the acid labile tetrahydropyranyl group. The t-butyldimethylsilyl groups are then removed from the secondary hydroxyl group by treatment with tetrabutylammonium fluoride, the 3 α -hydroxyl group is preferentially acylated (as described above), and the tetrahydropyranyl protecting group is removed by mild acid treatment.

Compounds of the invention where the olefinic bond of the α side chain is in the trans configuration are obtained by isomerisation of the compounds of the invention through irradiation with U. V. light (for approximately 4 hours) in toluene as a solvent, in the presence of phenyldisulfide and 2,2'-azobisisobutyronitrile (AIBN). Preferably, intermediates such as **Compound 24**, are isomerized where the heptenoic acid or heptinol function and the secondary hydroxyl groups are protected.

Specific Examples

Methyl 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 21)

A solution of diazomethane in Et₂O was added dropwise to a solution of 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-octenyl)- α -3-cyclopentenyl]-5-cis-heptenoic acid (**Compound 20**, 2.0 g, 6.22 mmol) in Et₂O (100 mL) at 0°C until the solution remained bright yellow. The reaction was allowed to warm to room temperature and was quenched with a few drops of acetic acid. The solvent was removed in vacuo to yield 2.0g (93%) of the title compound as a clear, colorless oil: ¹H NMR (250 MHz, CDCl₃) δ 7.48 (dd, J=2.1, 4.8 Hz, 1H), 6.16 (dd, J=2.1, 4.8 Hz, 1H), 5.59-5.29 (m, 4H), 4.12-4.04 (m,

1H), 3.64 (s, 3H), 3.22-3.20 (m, 1H), 2.52-2.04 (m, 8H), 1.70-1.26 (m, 10H), 0.87 (t, J=5.5 Hz, 3H).

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 22)

5 Sodium tetrahydridoborate (154 mg, 4.07 mmol) was added to a solution of methyl 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 21, 1.77 g, 4.07 mmol) in methanol (16 mL) at 0°C. The reaction was allowed to warm to
10 23°C and after 2 hours was quenched with saturated aqueous ammonium chloride. The solvent was removed in vacuo and the residue was diluted with CH₂Cl₂ (50 mL). The organic portion was separated, dried (Na₂SO₄), and concentrated in vacuo after filtration. Purification of
15 the residue by flash column chromatography (silica gel, 3:1 hexane/EtOAc) afforded 1.70 g (98%) of a 1:1 mixture of α and β -cyclopentanol, which were separated by high pressure liquid chromatography (HPLC). ¹H NMR (250 MHz, CDCl₃) for the title compound (α -alcohol): δ
20 5.48-5.30 (m, 4H), 4.21-4.17 (m, 1H), 4.07-4.00 (m, 1H), 3.64 (s, 3H), 2.38-1.86 (m, 9H), 1.71-1.26 (m, 15H), 0.87 (t, J=5.8 Hz, 3H).

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound

25 **23)**

A solution of the methyl 7 α -[2-oxo-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 21, 1.36 mg, 3.23 mmol) in methanolic cerium trichloride heptahydrate (8.1 mL of a 0.4 M solution in
30 MeOH, 3.23 mmol) was treated with sodium tetrahydridoborate (122 mg, 3.23 mmol) at 0°C. The reaction was allowed to warm to 23°C, stirred for 2 hours, and was then quenched with saturated aqueous

ammonium chloride (2.0 mL). The resultant mixture was extracted with CH_2Cl_2 (2 X) and the combined organics were dried (Na_2SO_4), filtered and the filtrate concentrated in vacuo. Purification of the residue by
5 flash column chromatography (silica gel, 3:1 hexane/EtOAc) afforded 1.22 g (89%) of a 1:1.5 mixture of α and β cyclopentanol which were separated by HPLC. ^1H NMR (250 MHz, CDCl_3) for the title compound (α -
10 alcohol): δ 5.95-5.85 (m, 2H), 5.55-5.32 (m, 4H), 4.65-4.61 (m, 1H), 4.06-4.01 (m, 1H), 3.64 (s, 3H), 3.05-2.99 (m, 1H), 2.32-2.06 (m, 7H), 1.77-1.23 (m, 12H), 0.87 (t, $J=5.8$ Hz, 3H).

7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenol (Compound 1)

15 Lithium tetrahydridoborate (0.177 mmol) was added to a solution of methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoate (Compound 22, 0.089 mmol) in Et_2O (0.5 mL) at 23°C. After stirring for 1 hour the reaction was quenched
20 with 2 N NaOH and stirred for 0.5 h. The organic portion was separated and the aqueous layer was extracted with EtOAc. The combined organics were dried (MgSO_4), filtered and concentrated in vacuo.

Purification of the residue by flash column
25 chromatography (silica gel, 2:1 EtOAc/hex) afforded (82%) of title compound as a clear, colorless oil. ^1H NMR (250 MHz, CDCl_3): δ 5.49-5.40 (m, 4H), 4.25-4.21 (m, 1H), 4.07-4.03 (m, 1H), 3.65 (t, $J=5.3$ Hz, 2H), 2.41-1.89 (m, 7H), 1.68-1.27 (m, 18H), 0.88 (t, $J=5.5$
30 Hz, 3H).

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoic acid amide (Compound 2)

Ammonia gas (≈ 4 mL) was condensed into a tube

containing methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoate (**Compound 22**, 57.8 mg, 0.130 mmol) and ammonium chloride (70 mg, 1.30 mmol). The tube was sealed and heated to 75°C for
5 48 hours. The tube was then cooled to -70°C, vented and allowed to slowly warm to room temperature. The residue was diluted with saturated ammonium chloride and extracted with EtOAc. The organic portion was dried (MgSO₄), filtered and concentrated in vacuo.

10 Purification of the residue by flash column chromatography (silica gel, 9:1 CH₂Cl₂/MeOH) afforded 45 mg (99%) of the title compound as an amorphous solid. ¹H NMR (250 MHz, CDCl₃): δ 6.10 (br s, 2H), 5.47-5.29 (m, 4H), 4.20-4.16 (m, 1H), 4.07-4.00 (m,
15 1H), 2.58 (br s, 2H), 2.35-1.87 (m, 9H), 1.72-1.22 (m, 13H), 0.85 (t, J=5.8 Hz, 3H).

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoic acid N-isopropylamide
(**Compound 3**)

20 Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoate (**Compound 22**, 70 mg, 0.16 mmol) was converted to the title compound in 72% yield using N-isopropylamine and N-isopropylamine hydrochloride according to the procedure described
25 above for the unsubstituted amide (**Compound 2**). ¹H NMR (250 MHz, CDCl₃): δ 5.78 (br s, 1H), 5.47-5.27 (m, 4H), 4.20-4.17 (m, 1H), 4.06-4.00 (m, 2H), 2.31-1.87 (m, 13H), 1.72-1.26 (m, 13H), 1.12 (d, J=5.5 Hz, 6H), 0.85 (t, J=5.8 Hz, 3H).

30 7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoic acid N,N-dimethylamide
(**Compound 4**)

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-

octenyl)-cyclopentyl]-5-cis-heptenoate (**Compound 22**, 71 mg, 0.16 mmol) was converted to the title compound in 80% yield using *N,N*-dimethylamine and *N,N*-dimethylamine hydrochloride according to the procedure described above for the unsubstituted amide (**Compound 2**). ¹H NMR (250 MHz, CDCl₃): δ 5.48-5.36 (m, 4H), 4.19-4.16 (m, 1H), 4.07-4.02 (m, 1H), 2.95 (s, 6H), 2.40-1.83 (m, 12H), 1.71-1.27 (m, 12H), 0.86 (t, J=5.5 Hz, 3H).

N,N-Dimethyl 7α-[2α-hydroxyl-5β-(3α-hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenylamine (**Compound 30**)

Lithium aluminum hydride (0.37 mL of a 1.0 M solution in THF, 0.372 mmol) was added to a solution of 7α-[2α-hydroxyl-5β-(3α-hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenoic acid *N,N*-dimethylamide (**Compound 4**) in THF (0.19 mL) at 0°C. The reaction was allowed to warm to 23°C, stirred for 5 hours, and then recooled to 0°C before quenching with methanol. The mixture was diluted with EtOAc and washed with H₂O and brine. The organic portion was dried (MgSO₄), filtered and concentrated *in vacuo*. Purification of the residue by flash column chromatography (silica gel, 9:1 CH₂Cl₂/MeOH) afforded 26 mg (79%) of the title compound as a clear, yellow oil. ¹H NMR (250 MHz, CDCl₃): δ 5.47-5.36 (m, 4H), 4.18-4.15 (m, 1H), 4.05-3.99 (m, 1H), 2.39-1.85 (m, 11H), 2.29 (s, 6H), 1.67-1.27 (m, 15H), 0.86 (t, J=5.5 Hz, 3H).

7α-[2α-hydroxyl-5β-(3α-hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenol (**Compound 5**)

Methyl 7α-[2α-hydroxyl-5β-(3α-hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (**Compound 23**, 28 mg, 0.064 mmol) was converted to the title compound in 52% yield according to the procedure described above for the 7α-[2α-hydroxyl-5β-(3α-hydrox-

yl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenol
(Compound 1). ^1H NMR (250 MHz, CDCl_3): δ 5.98-5.90 (m, 2H), 5.58-5.45 (m, 4H), 4.71-4.67 (m, 1H), 4.12-4.06 (m, 1H), 3.65 (t, $J=5.3$ Hz, 2H), 3.08-3.04 (m, 1H),
5 2.39-2.02 (m, 4H), 1.81-1.28 (m, 16H), 0.89 (t, $J=5.8$ Hz, 3H).

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoic acid amide (Compound 8)

10 Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 23, 59 mg, 0.135 mmol) was converted to the title compound in 32% yield according to the procedure described above for the unsubstituted amide (Compound
15 2). ^1H NMR (250 MHz, CDCl_3): δ 5.95-5.31 (m, 8H), 4.63-4.58 (m, 1H), 4.07-4.03 (m, 1H), 3.05-2.98 (m, 1H), 2.31-1.78 (m, 7H), 1.75-1.18 (m, 10H), 0.86 (t, $J=5.8$ Hz, 3H).

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoic acid N-isopropylamide (Compound 9)

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 23, 53 mg, 0.122 mmol) was converted to the title
25 compound in 66% yield using N-isopropylamine and N-isopropylamine hydrochloride according to the procedure described above for the unsubstituted amide (Compound
30 2). ^1H NMR (250 MHz, CDCl_3): δ 5.95-5.86 (m, 2H), 5.59-5.36 (m, 5H), 4.65-4.63 (m, 1H), 4.09-3.99 (m, 2H), 3.06-3.01 (m, 1H), 2.39-2.02 (m, 6H), 1.78-1.24 (m, 13H), 1.12 (d, $J=5.5$ Hz, 3H), 1.11 (d, $J=5.5$ Hz, 3H), 0.87 (t, $J=4.5$ Hz, 3H).

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-

3-cyclopentenyl]-5-cis-heptenoic acid N,N-dimethylamide
(Compound 10)

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 23, 70 mg, 0.161 mmol) was converted to the title compound in 74% yield using N,N-dimethylamine and N,N-dimethylamine hydrochloride according to the procedure described above for the unsubstituted amide (Compound 2). ¹H NMR (250 MHz, CDCl₃): δ 5.95-5.86 (m, 2H), 5.51-5.35 (m, 4H), 4.64-4.61 (m, 1H), 4.06-4.02 (m, 1H), 3.05-3.01 (m, 1H), 2.96 (s, 3H), 2.91 (s, 3H), 2.38-2.09 (m, 7H), 1.78-1.23 (m, 12H), 0.86 (t, J=5.5 Hz, 3H).

N,N-Dimethyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenylamine (Compound 11)

7 α -[2 α -Hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoic acid N,N-dimethylamide (Compound 10, 24 mg, 0.066 mmol) was converted to the title compound in 34% yield according to the procedure described above for N,N-dimethyl

7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-cyclopentyl]-5-cis-heptenylamine (Compound 30). ¹H NMR (250 MHz, CDCl₃): δ 5.96-5.86 (m, 2H), 5.53-5.33 (m, 4H), 4.64-4.62 (m, 1H), 4.05-3.98 (m, 1H), 3.05-3.01 (m, 1H), 2.38-2.01 (m, 7H), 2.18 (s, 6H), 1.75-1.26 (m, 14H), 0.86 (t, J=5.8 Hz, 3H).

7 α -[2 α -t-butyl dimethylsilyloxy-5 β -(3 α -t-butyl dimethylsilyloxy-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenol (Compound 28)

A solution of methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenoate (Compound 23, 142 mg, 0.326 mmol), 2,6-

lutidine (0.17 mL, 1.30 mmol) and *t*-butyldimethylsilyl trifluoromethanesulfonate (0.30 mL, 1.30 mmol) in CH₂Cl₂ (0.65 mL) was stirred at 23°C for 16 hours. The reaction was quenched with saturated aqueous sodium bicarbonate and extracted with CH₂Cl₂. The organic portion was washed with 10% aq. citric acid, saturated aq. sodium bicarbonate, and brine. After drying over anhydrous Na₂SO₄ the organic portion was filtered and concentrated in vacuo to yield the bis-TBDMS ether as a yellow oil.

The bis-TBDMS ether was diluted with CH₂Cl₂, cooled to 0°C, and diisobutylaluminum hydride (2.45 mL of a 1.0 M solution in CH₂Cl₂, 2.45 mmol) was added dropwise. After stirring for 1 hour the reaction was quenched with 1 N NaOH, stirred for 0.5 hour, and extracted with CH₂Cl₂. The organic portion was dried (Na₂SO₄), filtered and concentrated in vacuo. Purification of the residue by flash column chromatography (silica gel, 9:1 hex/EtOAc) afforded 61 mg (79%) of the title compound as a clear, colorless oil. Characteristic peaks at δ 3.62 ppm (t, J=5.3 Hz, 2H, CH₂OH) and δ 0.86 ppm (s, 9H, SiC(CH₃)₃) and δ 0.85 ppm (s, 9H, SiC(CH₃)₃).

Methyl 7 α -[2 α -hydroxyl-5 β -(3 α -hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenyl ether
(Compound 6)

To a suspension of sodium hydride (4.0 mg, 0.168 mmol) in DMF (0.11 mL) cooled to 0°C was added 7 α -[2 α -*t*-butyldimethylsilyloxy-5 β -(3 α -*t*-butyldimethylsilyloxy-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenol (Compound 28, 31 mg, 0.056 mmol) in DMF (0.22 mL). After hydrogen evolution ceased iodomethane (16 μ L, 0.252 mmol) was added and the reaction mixture was

allowed to slowly warm to room temperature. The reaction was quenched with saturated aqueous ammonium chloride and extracted with Et₂O. The organic portion was dried (MgSO₄), filtered and concentrated in vacuo 5 to yield a clear, colorless oil.

The crude bis-TBDMS methyl ether was diluted with THF (0.5 mL) and tetrabutylammonium fluoride (0.22 mL of a 1.0 M solution in THF, 0.22 mmol) was added. The resultant solution was stirred for 16 hours at 23°C and 10 concentrated in vacuo. Purification of the residue by flash column chromatography (silica gel, 1:1 hex/EtOAc) afforded 11 mg (61%) of the title compound as a clear, colorless oil. ¹H NMR (250 MHz, CDCl₃): δ 5.95-5.86 (m, 2H), 5.53-5.35 (m, 4H), 4.66-4.62 (m, 1H), 4.07-154.00 (m, 1H), 3.35 (t, J=5.5 Hz, 2H), 3.30 (s, 3H), 3.05-3.01 (m, 1H), 2.36-2.03 (m, 5H), 1.79-1.25 (m, 16H), 0.87 (t, J=4.5 Hz, 3H).

7α-[2α-hydroxyl-5β-(3α-hydroxyl-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenyl pivalate (Compound 7)

20 To a solution of 7α-[2α-t-butyldimethylsilyloxy-5β-(3α-t-butyldimethylsilyloxy-1-trans-octenyl)-3-cyclopentenyl]-5-cis-heptenol (Compound 28, 70 mg, 0.127 mmol) and pyridine (0.25 mL) in CH₂Cl₂ (0.25 mL) cooled to 0°C was added trimethylacetyl chloride (32 25μL, 0.254 mmol). The reaction was allowed to warm to room temperature, stirred for 6 hours, and then quenched with saturated aq. ammonium chloride. The organic portion was separated and washed with 1 N HCl, saturated aq. sodium bicarbonate, brine and then dried 30 (Na₂SO₄), filtered and concentrated in vacuo to afford a slightly yellow oil.

The crude bis-TBDMS pivalate was diluted with THF (0.5 mL) and tetrabutylammonium fluoride (0.50 mL of a

1.0 M solution in THF, 0.50 mmol) was added. The resultant solution was stirred for 16 h at 23°C and concentrated in vacuo. Purification of the residue by flash column chromatography (silica gel, 1:1 hex/EtOAc) 5 afforded 33.7 mg (54%) of the title compound as a clear, colorless oil. ¹H NMR (250 MHz, CDCl₃): δ 5.96-5.86 (m, 2H), 5.52-5.35 (m, 4H), 4.68-4.63 (m, 1H), 4.08-4.00 (m, 4H), 3.06-3.01 (m, 1H), 2.38-2.06 (m, 4H), 1.80-1.26 (m, 14H), 1.17 (s, 9H), 0.88 (t, J=5.5 10Hz, 3H).

15

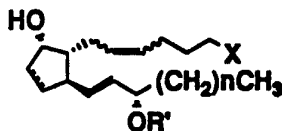
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WHAT IS CLAIMED IS:

1. A compound of the formula



where the dotted line represents a bond or the absence of a bond, the wavy lines represent bonds which are either in cis or trans configuration;

R_1 represents H, or $\text{CO}-R_2$ where R_2 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group;

15 X represents $\text{CO}-\text{NR}_3\text{R}_4$, CH_2OH , CH_2OR_5 , $\text{CH}_2\text{O}-\text{COR}_6$, and $\text{CH}_2-\text{NR}_3\text{R}_4$, where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group, and

n is an integer between 0 and 8.

2. A compound of Claim 1 where the dotted line represents a bond.

3. A compound of Claim 1 where the dotted line represents absence of a bond.

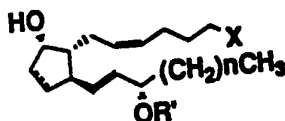
4. A compound of Claim 1 where the wavy lines attached to the olefinic bond represent that the olefinic bond is in the trans configuration.

5. A compound of Claim 1 where the wavy lines attached to the olefinic bond represent that the olefinic bond is in the cis configuration.

6. A compound of Claim 1 where X is $\text{CO}-\text{NR}_3\text{R}_4$.

7. A compound of Claim 1 where X is CH_2OH .

8. A compound of Claim 1 where X is CH_2OR_5 .
9. A compound of Claim 1 where X is $\text{CH}_2\text{O-COR}_6$.
10. A compound of Claim 1 where X is $\text{CH}_2\text{-NR}_3\text{R}_4$.
11. A compound of Claim 1 where n is 4.
- 5 12. A compound of the formula



10

where the dotted line represents a bond or the absence of a bond;

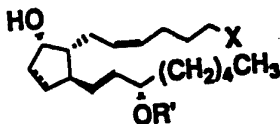
R_1 represents H, or CO-R_2 where R_2 is lower alkyl
 15 of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group;

X represents $\text{CO-NR}_3\text{R}_4$, CH_2OH , CH_2OR_5 , $\text{CH}_2\text{O-COR}_6$,
 20 and $\text{CH}_2\text{-NR}_3\text{R}_4$, where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group, and

n is an integer between 0 and 8.

- 25 13. A compound of Claim 12 wherein the dotted line represents absence of a bond.
14. A compound of Claim 13 wherein n is 4.
15. A compound of Claim 14 wherein R_1 is H.
16. A compound of Claim 15 wherein R_1 is CO-R_2 .
- 30 17. A compound of Claim 12 wherein the dotted line represents absence of a bond.
18. A compound of Claim 17 wherein n is 4.
19. A compound of Claim 18 wherein R_1 is H.

20. A compound of Claim 19 wherein R_1 is $CO-R_2$.
 21. A compound of the formula



where the dotted line represents a bond or the absence of a bond;

R_1 represents H, or $CO-R_2$ where R_2 is lower alkyl of 1 to 6 carbons, and

X represents $CO-NR_3R_4$, CH_2OH , CH_2OR_5 , CH_2O-COR_6 , and $CH_2-NR_3R_4$, where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl.

22. A compound of Claim 21 wherein R_1 is H.

23. A compound of Claim 22 wherein the dotted line represents absence of a bond and X is CH_2OH .

24. A compound of Claim 22 wherein the dotted line represents absence of a bond and X is $CONH_2$.

25. A compound of Claim 22 wherein the dotted line represents absence of a bond and X is $CONH-CH(CH_3)_2$.

26. A compound of Claim 22 wherein the dotted line represents absence of a bond and X is $CON(CH_3)_2$.

27. A compound of Claim 22 wherein the dotted line represents a bond and X is CH_2OH .

28. A compound of Claim 22 wherein the dotted line represents a bond and X is CH_2OCH_3 .

29. A compound of Claim 22 wherein the dotted line represents a bond and X is $CH_2OCO-C(CH_3)_3$.

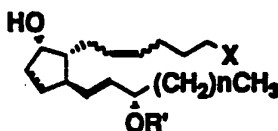
30. A compound of Claim 22 wherein the dotted line represents a bond and X is $CONH_2$.

31. A compound of Claim 22 wherein the dotted line represents a bond and X is $\text{CONH-CH}(\text{CH}_3)_2$.

32. A compound of Claim 22 wherein the dotted line represents a bond and X is $\text{CON}(\text{CH}_3)_2$.

5 33. A compound of Claim 22 wherein the dotted line represents a bond and X is $\text{CH}_2\text{N}(\text{CH}_3)_2$.

34. A method for lowering intraocular pressure in the eye of a mammal, which comprises administering to the mammal a pharmaceutical composition containing a
10 pharmaceutically acceptable excipient and an effective amount of a compound having the formula



15

where the dotted line represents a bond or the absence of a bond, the wavy lines represent bonds which are either in cis or trans configuration;

20 R_1 represents H, or CO-R_2 where R_2 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group;

X represents $\text{CO-NR}_3\text{R}_4$, CH_2OH , CH_2OR_5 , $\text{CH}_2\text{O-COR}_6$,
25 and $\text{CH}_2\text{-NR}_3\text{R}_4$, where R_3 and R_4 independently are H or lower alkyl, R_5 is lower alkyl of 1 to 6 carbons, and R_6 is lower alkyl of 1 to 6 carbons, carbocyclic aryl or heterocyclic aryl; or carbocyclic aryl or heteroaryl substituted lower alkyl group, and

30 n is an integer between 0 and 8.

35. The method of Claim 35 wherein the pharmaceutical composition is adapted for topical administration.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/10061

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 5 A61K31/557 C07C405/00

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 5 A61K C07C

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 practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP,A,0 242 580 (THE TRUSTEES OF COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK) 28 October 1987 see the whole document ---	1-35
Y	WO,A,88 10252 (IBI ISTITUTO BIOCHEMICO ITALIANO GIOVANNI LORENZINI S.P.A.) 29 December 1988 see claims ---	1-35
Y	WO,A,90 03170 (IBI ISTITUTO BIOCHEMICO ITALIANO GIOVANNI LORENZINI S.P.A.) 5 April 1990 see page 8; figure XII ---	1-35
	-/--	

Further documents are listed in the continuation of box C.

Patent family members are listed in 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 document 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

1 March 1994

Date of mailing of the international search report

09.03.94

Name and mailing address of the ISA

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 Fax: (+ 31-70) 340-3016

Authorized officer

Berte, M

INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 93/10061

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, Y	<p>DATABASE BIOSIS BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US AN=7925460 see abstract & INVEST. OPHTHALMOL. VISUAL SCI., vol.32, no.4, 1991 page 1257 WOODWARD D.F. ET AL. 'MARKED SPECIES DIFFERENCES IN THE PHARMACOLOGY OF PROSTANOID INDUCED OCULAR HYPOTENSION.' ----</p>	1-35
X	<p>FR,A,2 312 240 (SCHERING AG.) 24 December 1976 see claims ----</p>	1-33
X	<p>FR,A,2 386 523 (SCHERING AG.) 3 November 1978 see page 1 - page 2; figure I ----</p>	1-33
Y	<p>WO,A,92 13836 (ALLERGAN INC.) 20 August 1992 see the whole document -----</p>	1-35

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US93/10061

Box I Observations where certain claims were found unsearchable (Continuation of item 1 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:
Remark: Although claims 34, 35 are directed to a method of treatment of
(diagnostic method practised on) the human/animal body the search has been
carried out and based on the alleged effects of the compound/composition.
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:
Please see attached sheet ../..
3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 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 an additional fee, this Authority did not invite payment
of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report
covers 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. No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/210

II.

In view of the large number of compounds, which are designed by the general formulas of claim 1 the search has to be restricted for economic reasons.

The search was limited to the compounds for which pharmacological data was given and/or the compounds mentioned in the claims or examples.

(See Guidelines; Part B, Chapt.III, Paragraph 3.6)

Partially searched claims: 1-35

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. l. Application No

PCT/US 93/10061

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 93/10061

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