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(54) Title: 1,3,3-(TRISUBSTITUTED)CYCLOHEXANE DIMERS AND RELATED COMPOUNDS

(57) Abstract

This invention relates to certain 1,3,3-(trisubstituted)cyclohexane dimers and related compounds which are useful in treating allergic and inflammatory diseases and for inhibiting the production of Tumor Necrosis Factor (TNF).

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1,3,3-(Trisubstituted)cyclohexane Dimers and Related Compounds

Field of Invention

The present invention relates to novel 1,3,3-(trisubstituted)cyclohexane dimers and related compounds, pharmaceutical compositions containing these compounds, and their use in treating allergic and inflammatory diseases and for inhibiting the production of Tumor Necrosis Factor (TNF).

Background of the Invention

Bronchial asthma is a complex, multifactorial disease characterized by reversible narrowing of the airway and hyperreactivity of the respiratory tract to external stimuli.

Identification of novel therapeutic agents for asthma is made difficult by the fact that multiple mediators are responsible for the development of the disease. Thus, it seems unlikely that eliminating the effects of a single mediator will have a substantial effect on all three components of chronic asthma. An alternative to the "mediator approach" is to regulate the activity of the cells responsible for the pathophysiology of the disease.

One such way is by elevating levels of cAMP (adenosine cyclic 3',5'-monophosphate). Cyclic AMP has been shown to be a second messenger mediating the biologic responses to a wide range of hormones, neurotransmitters and drugs; [Krebs Endocrinology Proceedings of the 4th International Congress Excerpta Medica, 17-29, 1973]. When the appropriate agonist binds to specific cell surface receptors, adenylate cyclase is activated, which converts Mg^{+2}-ATP to cAMP at an accelerated rate.

Cyclic AMP modulates the activity of most, if not all, of the cells that contribute to the pathophysiology of extrinsic (allergic) asthma. As such, an elevation of cAMP would produce beneficial effects including: 1) airway smooth muscle relaxation, 2) inhibition of mast cell mediator release, 3) suppression of neutrophil degranulation, 4) inhibition of basophil degranulation, and 5) inhibition of monocyte and macrophage activation. Hence, compounds that activate adenylate cyclase or inhibit phosphodiesterase should be effective in suppressing the inappropriate activation of airway smooth muscle and a wide variety of inflammatory cells. The principal cellular mechanism for the inactivation of cAMP is hydrolysis of the 3'-phosphodiester bond by one or more of a family of isozymes referred to as cyclic nucleotide phosphodiesterases (PDEs).

It has now been shown that a distinct cyclic nucleotide phosphodiesterase (PDE) isozyme, PDE IV, is responsible for cAMP breakdown in airway smooth muscle and inflammatory cells. [Torphy, "Phosphodiesterase Isozymes: Potential Targets for Novel Anti-asthmatic Agents" in New Drugs for Asthma, Barnes, ed. IBC

Technical Services Ltd., 1989]. Research indicates that inhibition of this enzyme not only produces airway smooth muscle relaxation, but also suppresses degranulation of mast cells, basophils and neutrophils along with inhibiting the activation of monocytes and neutrophils. Moreover, the beneficial effects of PDE IV inhibitors are markedly potentiated when adenylate cyclase activity of target cells is elevated by appropriate hormones or autocoids, as would be the case *in vivo*. Thus PDE IV inhibitors would be effective in the asthmatic lung, where levels of prostaglandin E_2 and prostacyclin (activators of adenylate cyclase) are elevated. Such compounds would offer a unique approach toward the pharmacotherapy of bronchial asthma and possess significant therapeutic advantages over agents currently on the market.

The compounds of this invention also inhibit the production of Tumor Necrosis Factor (TNF), a serum glycoprotein. Excessive or unregulated TNF production has been implicated in mediating or exacerbating a number of diseases including rheumatoid arthritis, rheumatoid spondylitis, osteoarthritis, gouty arthritis and other arthritic conditions; sepsis, septic shock, endotoxic shock, gram negative sepsis, toxic shock syndrome, adult respiratory distress syndrome, cerebral malaria, chronic pulmonary inflammatory disease, silicosis, pulmonary sarcoidosis, bone resorption diseases, reperfusion injury, graft vs. host reaction, allograft rejections, fever and myalgias due to infection, such as influenza, cachexia secondary to infection or malignancy, cachexia secondary to human acquired immune deficiency syndrome (AIDS), AIDS, ARC (AIDS related complex), keloid formation, scar tissue formation, Crohn's disease, ulcerative colitis, or pyresis, in addition to a number of autoimmune diseases, such as multiple sclerosis, autoimmune diabetes and systemic lupus erythematosis.

AIDS results from the infection of T lymphocytes with Human Immunodeficiency Virus (HIV). At least three types or strains of HIV have been identified, i.e., HIV-1, HIV-2 and HIV-3. As a consequence of HIV infection, T-cell-mediated immunity is impaired and infected individuals manifest severe opportunistic infections and/or unusual neoplasms. HIV entry into the T lymphocyte requires T lymphocyte activation. Viruses such as HIV-1 or HIV-2 infect T lymphocytes after T cell activation and such virus protein expression and/or replication is mediated or maintained by such T cell activation. Once an activated T lymphocyte is infected with HIV, the T lymphocyte must continue to be maintained in an activated state to permit HIV gene expression and/or HIV replication.

Cytokines, specifically TNF, are implicated in activated T-cell-mediated HIV protein expression and/or virus replication by playing a role in maintaining T lymphocyte activation. Therefore, interference with cytokine activity such as by inhibition of cytokine production, notably TNF, in an HIV-infected individual aids in limiting the maintenance of T cell activation, thereby reducing the progression of HIV

infectivity to previously uninfected cells which results in a slowing or elimination of the progression of immune dysfunction caused by HIV infection. Monocytes, macrophages, and related cells, such as kupffer and glial cells, have also been implicated in maintenance of the HIV infection. These cells, like T cells, are targets for viral replication and the level of viral replication is dependent upon the activation state of the cells. [See Rosenberg *et al.*, The Immunopathogenesis of HIV Infection, Advances in Immunology, Vol. 57, 1989]. Monokines, such as TNF, have been shown to activate HIV replication in monocytes and/or macrophages [See Poli *et al.*, Proc. Natl. Acad. Sci., 87:782-784, 1990], therefore, inhibition of monokine production or activity aids in limiting HIV progression as stated above for T cells.

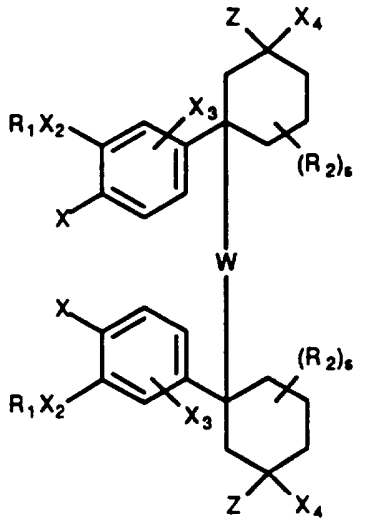
TNF has also been implicated in various roles with other viral infections, such as the cytomegalovirus (CMV), influenza virus, adenovirus, and the herpes virus for similar reasons as those noted.

TNF is also associated with yeast and fungal infections. Specifically *Candida albicans* has been shown to induce TNF production *in vitro* in human monocytes and natural killer cells. [See Riipi *et al.*, Infection and Immunity, 58(9):2750-54, 1990; and Jafari *et al.*, Journal of Infectious Diseases, 164:389-95, 1991. See also Wasan *et al.*, Antimicrobial Agents and Chemotherapy, 35,(10):2046-48, 1991; and Luke *et al.*, Journal of Infectious Diseases, 162:211-214,1990].

The ability to control the adverse effects of TNF is furthered by the use of the compounds which inhibit TNF in mammals who are in need of such use. There remains a need for compounds which are useful in treating TNF-mediated disease states which are exacerbated or caused by the excessive and/or unregulated production of TNF.

Summary of the Invention

The compounds of this invention are represented by Formula (I):



(I)

wherein:

R_1 is independently selected from $-(CR_4R_5)_nC(O)O(CR_4R_5)_mR_6$, $-(CR_4R_5)_nC(O)NR_4(CR_4R_5)_mR_6$, $-(CR_4R_5)_nO(CR_4R_5)_mR_6$, or $-(CR_4R_5)_rR_6$ wherein the alkyl moieties is unsubstituted or substituted with one or more fluorines;

m is 0 to 2;

n is 1 to 4;

r is 0 to 6;

R_4 and R_5 are independently selected from hydrogen or C_{1-2} alkyl;

R_6 is independently selected from hydrogen, methyl, hydroxyl, aryl, halo substituted aryl, aryloxyC_{1-3} alkyl, halo substituted aryloxyC_{1-3} alkyl, indanyl, indenyl, C_{7-11} polycycloalkyl, tetrahydrofuranyl, furanyl, tetrahydropyranyl, pyranyl, tetrahydrothienyl, thienyl, tetrahydrothiopyranyl, thiopyranyl, C_{3-6} cycloalkyl, or a C_{4-6} cycloalkyl containing one or two unsaturated bonds, wherein the cycloalkyl or heterocyclic moiety is unsubstituted or substituted by 1 to 3 methyl groups, one ethyl group, or an hydroxyl group;

provided that:

a) when R_6 is hydroxyl, then m is 2; or

b) when R_6 is hydroxyl, then r is 2 to 6; or

c) when R_6 is 2-tetrahydropyranyl, 2-tetrahydrothiopyranyl, 2-tetrahydrofuranyl, or 2-tetrahydrothienyl, then m is 1 or 2; or

d) when R_6 is 2-tetrahydropyranyl, 2-tetrahydrothiopyranyl, 2-tetrahydrofuranyl, or 2-tetrahydrothienyl, then r is 1 to 6;

e) when n is 1 and m is 0, then R_6 is other than H in $-(CR_4R_5)_nO(CR_4R_5)_mR_6$;

X is independently selected from YR_2, fluorine, NR_4R_5, or formyl amine;

Y is independently selected from O or S(O)m';

m' is 0, 1, or 2;

X_2 is independently selected from O or NR_8;

X_3 is independently selected from hydrogen or X;

R_2 is independently selected from the group consisting of $-CH_3$ and $-CH_2CH_3$ optionally substituted by 1 or more fluorines;

s is 0 to 4;

W is alkyl of 2 to 6 carbons, alkenyl of 2 to 6 carbon atoms or alkynyl of 2 to 6 carbon atoms;

Z is independently $CR_8R_8OR_{14}$, $CR_8R_8OR_{15}$, $CR_8R_8SR_{14}$, $CR_8R_8SR_{15}$, $CR_8R_8S(O)_{m'}R_7$, $CR_8R_8NR_{10}R_{14}$, $CR_8R_8NR_{10}S(O)_2NR_{10}R_{14}$, $CR_8R_8NR_{10}S(O)_2R_7$, $CR_8R_8NR_{10}C(Y')R_{14}$, $CR_8R_8NR_{10}C(O)OR_7$, $CR_8R_8NR_{10}C(Y')NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)SR_9$,

$CR_8R_8NR_{10}C(CR_4NO_2)SR_9$, $CR_8R_8C(O)OR_{14}$, $CR_8R_8C(Y')NR_{10}R_{14}$, $CR_8R_8C(NR_{10})NR_{10}R_{14}$, CR_8R_8CN, CR_8R_8(tetrazolyl), CR_8R_8(imidazolyl), CR_8R_8(imidazolidinyl), CR_8R_8(pyrazolyl), CR_8R_8(thiazolyl), CR_8R_8(thiazolidinyl), CR_8R_8(oxazolyl), CR_8R_8(oxazolidinyl), CR_8R_8(triazolyl), CR_8R_8(isoxazolyl), CR_8R_8(oxadiazolyl), CR_8R_8(thiadiazolyl), CR_8R_8(morpholinyl), CR_8R_8(piperidinyl), CR_8R_8(piperazinyl), CR_8R_8(pyrrolyl), $CR_8R_8C(NOR_8)R_{14}$, $CR_8R_8C(NOR_{14})R_8$, $CR_8R_8NR_{10}C(NR_{10})SR_9$, $CR_8R_8NR_{10}C(NR_{10})NR_{10}R_{14}$, $CR_8R_8NR_{10}C(O)C(O)NR_{10}R_{14}$, or $CR_8R_8NR_{10}C(O)C(O)OR_{14}$;

X_5 is H, R_9, OR_8, CN, $C(O)R_8$, $C(O)OR_8$, $C(O)NR_8R_8$, or NR_8R_8;

X_4 is independently H, R_9, OR_8, CN, $C(O)R_8$, $C(O)OR_8$, $C(O)NR_8R_8$, or NR_8R_8;

Y' is independently selected from O or S;

R_7 is $-(CR_4R_5)_qR_{12}$ or C_{1-6} alkyl wherein the R_{12} or C_{1-6} alkyl group is unsubstituted or substituted one or more times by methyl or ethyl unsubstituted or substituted by 1-3 fluorines, -F, -Br, -Cl, $-NO_2$, $-NR_{10}R_{11}$, $-C(O)R_8$, $-CO_2R_8$, $-O(CH_2)_qR_8$, -CN, $-C(O)NR_{10}R_{11}$, $-O(CH_2)_qC(O)NR_{10}R_{11}$, $-O(CH_2)_qC(O)R_9$, $-NR_{10}C(O)NR_{10}R_{11}$, $-NR_{10}C(O)R_{11}$, $-NR_{10}C(O)OR_9$, $-NR_{10}C(O)R_{13}$, $-C(NR_{10})NR_{10}R_{11}$, $-C(NCN)NR_{10}R_{11}$, $-C(NCN)SR_9$, $-NR_{10}C(NCN)SR_9$, $-NR_{10}C(NCN)NR_{10}R_{11}$, $-NR_{10}S(O)_2R_9$, $-S(O)_{m'}R_9$, $-NR_{10}C(O)C(O)NR_{10}R_{11}$, $-NR_{10}C(O)C(O)R_{10}$, or R_{13};

q is 0, 1, or 2;

R_{12} is independently selected from R_{13}, C_{3-7} cycloalkyl, (2-, 3- or 4-pyridyl), pyrimidyl, pyrazolyl, (1- or 2-imidazolyl), pyrrolyl, piperazinyl, piperidinyl, morpholinyl, furanyl, (2- or 3-thienyl), quinolinyl, naphthyl, or phenyl;

R_8 is independently selected from hydrogen or R_9;

R_9 is independently selected from C_{1-4} alkyl optionally substituted by one to three fluorines;

R_{10} is independently selected from OR_8 or R_{11};

R_{11} is independently selected from hydrogen, or C_{1-4} alkyl optionally substituted by one to three fluorines; or when R_{10} and R_{11} are as $NR_{10}R_{11}$ they may together with the nitrogen form a 5 to 7 membered ring comprised of carbon or carbon and at least one additional heteroatom selected from O, N, or S;

R_{13} is independently selected from oxazolidinyl, oxazolyl, thiazolyl, pyrazolyl, triazolyl, tetrazolyl, imidazolyl, imidazolidinyl, thiazolidinyl, isoxazolyl, oxadiazolyl, or thiadiazolyl, and each of these heterocyclic rings is connected through a carbon atom and

R_{14} is hydrogen or R_7; or when R_8 and R_{14} are as NR_8R_{14} they may together with the nitrogen form a 5 to 7 membered ring comprised of carbon or carbon and one or more additional heteroatoms selected from O, N, or S;

R_{15} is C(O)R_{14}, C(O)NR_4R_{14}, S(O)$_2R_7$, or S(O)$_2$NR_4R_{14};
or the pharmaceutically acceptable salts thereof.

This invention also relates to the pharmaceutical compositions comprising a compound of Formula (I) and a pharmaceutically acceptable carrier or diluent.

The invention also relates to a method of mediation or inhibition of the enzymatic activity (or catalytic activity) of PDE IV in mammals, including humans, which comprises administering to a mammal in need thereof an effective amount of a compound of Formula (I) as shown below.

The invention further provides a method for the treatment of allergic and inflammatory disease which comprises administering to a mammal, including humans, in need thereof, an effective amount of a compound of Formula (I).

The invention also provides a method for the treatment of asthma which comprises administering to a mammal, including humans, in need thereof, an effective amount of a compound of Formula (I).

This invention also relates to a method of inhibiting TNF production in a mammal, including humans, which method comprises administering to a mammal in need of such treatment, an effective TNF inhibiting amount of a compound of Formula (I). This method may be used for the prophylactic treatment or prevention of certain TNF mediated disease states amenable thereto.

This invention also relates to a method of treating a human afflicted with a human immunodeficiency virus (HIV), which comprises administering to such human an effective TNF inhibiting amount of a compound of Formula (I).

Compounds of Formula (I) are also useful in the treatment of additional viral infections, where such viruses are sensitive to upregulation by TNF or will elicit TNF production *in vivo*.

In addition, compounds of Formula (I) are also useful in treating yeast and fungal infections, where such yeast and fungi are sensitive to upregulation by TNF or will elicit TNF production *in vivo*.

Detailed Description of the Invention

This invention also relates to a method of mediating or inhibiting the enzymatic activity (or catalytic activity) of PDE IV in a mammal in need thereof and to inhibiting the production of TNF in a mammal in need thereof, which comprises administering to said mammal an effective amount of a compound of Formula (I).

Phosphodiesterase IV inhibitors are useful in the treatment of a variety of allergic and inflammatory diseases including: asthma, chronic bronchitis, atopic dermatitis, urticaria, allergic rhinitis, allergic conjunctivitis, vernal conjunctivitis, eosinophilic granuloma, psoriasis, rheumatoid arthritis, septic shock, ulcerative colitis, Crohn's disease, reperfusion injury of the myocardium and brain, chronic glomerulonephritis, endotoxic shock and adult respiratory distress syndrome. In

addition, PDE IV inhibitors are useful in the treatment of diabetes insipidus and central nervous system disorders such as depression and multi-infarct dementia.

The viruses contemplated for treatment herein are those that produce TNF as a result of infection, or those which are sensitive to inhibition, such as by decreased replication, directly or indirectly, by the TNF inhibitors of Formula (I). Such viruses include, but are not limited to HIV-1, HIV-2 and HIV-3, cytomegalovirus (CMV), influenza, adenovirus and the Herpes group of viruses, such as, but not limited to, *Herpes zoster* and *Herpes simplex.*

This invention more specifically relates to a method of treating a mammal, afflicted with a human immunodeficiency virus (HIV), which comprises administering to such mammal an effective TNF inhibiting amount of a compound of Formula (I).

The compounds of this invention may also be used in association with the veterinary treatment of animals, other than in humans, in need of inhibition of TNF production. TNF mediated diseases for treatment, therapeutically or prophylactically, in animals include disease states such as those noted above, but in particular viral infections. Examples of such viruses include, but are not limited to feline immunodeficiency virus (FIV) or other retroviral infection such as equine infectious anemia virus, caprine arthritis virus, visna virus, maedi virus and other lentiviruses.

The compounds of this invention are also useful in treating yeast and fungal infections, where such yeast and fungi are sensitive to upregulation by TNF or will elicit TNF production *in vivo*. A preferred disease state for treatment is fungal meningitis. Additionally, the compounds of Formula (I) may be administered in conjunction with other drugs of choice for systemic yeast and fungal infections. Drugs of choice for fungal infections, include but are not limited to the class of compounds called the polymixins, such as Polymycin B, the class of compounds called the imidazoles, such as clotrimazole, econazole, miconazole, and ketoconazole; the class of compounds called the triazoles, such as fluconazole, and itranazole, and the class of compound called the Amphotericins, in particular Amphotericin B and liposomal Amphotericin B.

The compounds of Formula (I) may also be used for inhibiting and/or reducing the toxicity of an anti-fungal, anti-bacterial or anti-viral agent by administering an effective amount of a compound of Formula (I) to a mammal in need of such treatment. Preferably, a compound of Formula (I) is administered for inhibiting or reducing the toxicity of the Amphotericin class of compounds, in particular Amphotericin B.

The term "C_{1-3} alkyl", "C_{1-4} alkyl", "C_{1-6} alkyl" or "alkyl" groups as used herein is meant to include both straight or branched chain radicals of 1 to 10, unless the chain length is limited thereto, including, but not limited to methyl, ethyl, n-propyl, isopropyl, n-butyl, sec-butyl, isobutyl, *tert*-butyl, and the like.

"Alkenyl" means both straight or branched chain radicals of 1 to 6 carbon lengths, unless the chain length is limited thereto, including but not limited to vinyl, 1-propenyl, 2-propenyl, 2-propynyl, or 3-methyl-2-propenyl.

The term "cycloalkyl" or "cycloalkyl alkyl" means groups of 3-7 carbon atoms, such as cyclopropyl, cyclopropylmethyl, cyclopentyl, or cyclohexyl.

"Aryl" or "aralkyl", unless specified otherwise, means an aromatic ring or ring system of 6-10 carbon atoms, such as phenyl, benzyl, phenethyl, or naphthyl. Preferably the aryl is monocyclic, i.e, phenyl. The alkyl chain is meant to include both straight or branched chain radicals of 1 to 4 carbon atoms.

"Heteroaryl" means an aromatic ring system containing one or more heteroatoms, such as imidazolyl, triazolyl, oxazolyl, pyridyl, pyrimidyl, pyrazolyl, pyrrolyl, furanyl, or thienyl.

"Halo" means all halogens, i.e., chloro, fluoro, bromo, or iodo.

"Inhibiting the production of IL-1" or "inhibiting the production of TNF" means:

a) a decrease of excessive *in vivo* IL-1 or TNF levels, respectively, in a human to normal levels or below normal levels by inhibition of the *in vivo* release of IL-1 by all cells, including but not limited to monocytes or macrophages;

b) a down regulation, at the translational or transcriptional level, of excessive *in vivo* IL-1 or TNF levels, respectively, in a human to normal levels or below normal levels; or

c) a down regulation, by inhibition of the direct synthesis of IL-1 or TNF levels as a postranslational event.

The phrase "TNF mediated disease or disease states" means any and all disease states in which TNF plays a role, either by production of TNF itself, or by TNF causing another cytokine to be released, such as but not limited to IL-1 or IL-6. A disease state in which IL-1, for instance is a major component, and whose production or action, is exacerbated or secreted in response to TNF, would therefore be considered a disease state mediated by TNF. As TNF-ß (also known as lymphotoxin) has close structural homology with TNF-α (also known as cachectin), and since each induces similar biologic responses and binds to the same cellular receptor, both TNF-α and TNF-ß are inhibited by the compounds of the present invention and thus are herein referred to collectively as "TNF" unless specifically delineated otherwise. Preferably TNF-α is inhibited.

"Cytokine" means any secreted polypeptide that affects the functions of cells, and is a molecule which modulates interactions between cells in immune, inflammatory, or hematopoietic responses. A cytokine includes, but is not limited to, monokines and lymphokines regardless of which cells produce them.

The cytokine inhibited by the present invention for use in the treatment of a HIV-infected human must be a cytokine which is implicated in (a) the initiation and/or maintenance of T cell activation and/or activated T cell-mediated HIV gene expression and/or replication, and/or (b) any cytokine-mediated disease associated problem such as cachexia or muscle degeneration. Preferrably, this cytokine is TNF-α.

All of the compounds of Formula (I) are useful in the method of inhibiting the production of TNF, preferably by macrophages, monocytes or macrophages and monocytes, in a mammal, including humans, in need thereof. All of the compounds of Formula (I) are useful in the method of inhibiting or mediating the enzymatic or catalytic activity of PDE IV and in treatment of disease states mediated thereby.

Preferred compounds are as follows:

While the following preferred compounds are more or less described in terms of preferring a symetrical molecule, each substituent described herein above, and below, may be independently varied based on the definitions of each provided herein. For example R_1 may be a cyclopentyl group and a CF_3 group within the same molecule of a given embodiment of Formula (I). Similarly each and every one of the other groups may be independently selected, or may be the same, in any given embodiment of this invention.

When R_1 is an alkyl substituted by 1 or more halogens, the halogens are preferably fluorine and chlorine, more preferably a C_{1-4} alkyl substituted by 1 or more fluorines. The preferred halo-substituted alkyl chain length is one or two carbons, and most preferred are the moieties $-CF_3$, $-CH_2F$, $-CHF_2$, $-CF_2CHF_2$, $-CH_2CF_3$, and $-CH_2CHF_2$. Preferred R_1 substitutents are CH_2-cyclopropyl, CH_2-C_{5-6} cycloalkyl, C_{4-6} cycloalkyl with or without an OH group, C_{7-11} polycycloalkyl, (3- or 4-cyclopentenyl), phenyl, tetrahydrofuran-3-yl, benzyl or C_{1-2} alkyl optionally substituted by 1 or more fluorines, $-(CH_2)_{1-3}C(O)O(CH_2)_{0-2}CH_3$, $-(CH_2)_{1-3}O(CH_2)_{0-2}CH_3$, and $-(CH_2)_{2-4}OH$.

When the R_1 term contains the moiety (CR_4R_5), the R_4 and R_5 terms are independently hydrogen or alkyl. This allows for branching of the individual methylene units as $(CR_4R_5)_n$ or $(CR_4R_5)_m$; each repeating methylene unit is independent of the other, e.g., $(CR_4R_5)_n$ wherein n is 2 can be $-CH_2CH(-CH_3)-$, for instance. The individual hydrogen atoms of the repeating methylene unit or the branching hydrocarbon can optionally be substituted by fluorine independent of each other to yield, for instance, the preferred R_1 substitutions, as noted above.

When R_1 is a C_{7-11} polycycloalkyl, examples are bicyclo[2.2.1]-heptyl, bicyclo[2.2.2]octyl, bicyclo[3.2.1]octyl, tricyclo[5.2.1.$0^{2,6}$]decyl, etc. additional examples of which are described in Saccamano *et al.*, WO 87/06576, published 5 November 1987.

W is preferably alkyl, alkenyl or alkynyl of 3 to 5 carbon atoms, and where it is alkenyl or alkynyl, that one or two double or triple bonds be present.

Z is preferably $CR_8R_8OR_{14}$, $CR_8R_8OR_{15}$, $CR_8R_8SR_{14}$, $CR_8R_8SR_{15}$, $CR_8R_8S(O)_{m'}R_7$, $CR_8R_8NR_{10}R_{14}$, $CR_8R_8NS(O)_2NR_{10}R_{14}$, $CR_8R_8NS(O)_2R_7$, $CR_8R_8NR_{10}C(O)R_{14}$, $CR_8R_8NR_{10}C(O)OR_7$, $CR_8R_8NR_{10}C(O)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)SR_9$, $CR_8R_8NR_{10}C(CR_4NO_2)SR_9$, $CR_8R_8C(O)OR_{14}$, $CR_8R_8C(O)NR_{10}R_{14}$, $CR_8R_8C(NR_{10})NR_{10}R_{14}$, CR_8R_8CN, CR_8R_8(oxadiazolyl), CR_8R_8(thiadiazolyl), $CR_8R_8C(NOR_8)R_{14}$, $CR_8R_8C(NOR_{14})R_8$, $CR_8R_8NR_{10}C(NR_{10})SR_9$, $CR_8R_8NR_{10}C(NR_{10})NR_{10}R_{14}$, $CR_8R_8NR_{10}C(O)C(O)NR_{10}R_{14}$, or $CR_8R_8NR_{10}C(O)C(O)OR_{14}$; most preferred are those compounds wherein the R_8 group of Z is H and the R_{14} group of Z is R_4.

X_4 is preferably H, OH, OCH_3, CN, $C(O)R_8$, C(O)OH, $C(O)OCH_3$, $C(O)NH_2$, $CON(CH_3)_2$, NH_2, or $N(CH_3)_2$. The most preferred X_4 groups are H, OH, CN, C(O)OH, $C(O)NH_2$ or NH_2.

Preferred X groups are those wherein X is YR_2 and Y is oxygen. The preferred X_2 group is oxygen. The preferred X_3 is hydrogen. Preferred R_2 groups, where applicable, are C_{1-2} alkyl unsubstituted or substituted by 1 or more halogens. The halogen atoms are preferably fluorine and chlorine, more preferably fluorine. More preferred R_2 groups are those wherein R_2 is methyl, or the fluoro-substituted alkyls, specifically a C_{1-2} alkyl, such as a $-CF_3$, $-CHF_2$, or $-CH_2CHF_2$ moiety. Most preferred are the $-CHF_2$ and $-CH_3$ moieties.

Preferred R_7 moieties include optionally substituted $-(CH_2)_{1-2}$(cyclopropyl), $-(CH_2)_{0-2}$(cyclobutyl), $-(CH_2)_{0-2}$(cyclopentyl) with or without an OH group, $-(CH_2)_{0-2}$(cyclohexyl), $-(CH_2)_{0-2}$(2-, 3- or 4-pyridyl), $-(CH_2)_{1-2}$(2-imidazolyl), $-(CH_2)_2$(4-morpholinyl), $-(CH_2)_2$(4-piperazinyl), $-(CH_2)_{1-2}$(2-thienyl), $-(CH_2)_{1-2}$(4-thiazolyl), and $-(CH_2)_{0-2}$phenyl;

Preferred rings when R_{10} and R_{11} in the moiety $-NR_{10}R_{11}$ together with the nitrogen to which they are attached form a 5 to 7 membered ring containing at least one additional heteroatom selected from O, N or S include, but are not limited to 1-imidazolyl, 2-(R_8)-1-imidazolyl, 1-pyrazolyl, 3-(R_8)-1-pyrazolyl, 1-triazolyl, 2-triazolyl, 5-(R_8)-1-triazolyl, 5-(R_8)-2-triazolyl, 5-(R_8)-1-tetrazolyl, 5-(R_8)-2-tetrazolyl, 1-tetrazolyl, 2-tetrazloyl, morpholinyl, piperazinyl, 4-(R_8)-1-piperazinyl, or pyrrolyl ring.

Preferred rings when R_{10} and R_{14} in the moiety $-NR_{10}R_{14}$ together with the nitrogen to which they are attached form a 5 to 7 membered ring containing at least one additional heteroatom selected from O, N or S include, but are not limited to 1-imidazolyl, 1-pyrazolyl, 1-triazolyl, 2-triazolyl, 1-tetrazolyl, 2-tetrazolyl, morpholinyl, piperazinyl, and pyrrolyl. The respective rings may be additionally substituted, where

applicable, on an available nitrogen or carbon by the moiety R7 as described herein for Formula (I). Illustrations of such carbon substitutions includes, but are not limited to, 2-(R7)-1-imidazolyl, 4-(R7)-1-imidazolyl, 5-(R7)-1-imidazolyl, 3-(R7)-1-pyrazolyl, 4-(R7)-1-pyrazolyl, 5-(R7)-1-pyrazolyl, 4-(R7)-2-triazolyl, 5-(R7)-2-triazolyl, 4-(R7)-1-triazolyl, 5-(R7)-1-triazolyl, 5-(R7)-1-tetrazolyl, and 5-(R7)-2-tetrazolyl. Applicable nitrogen substitution by R7 includes, but is not limited to, 1-(R7)-2-tetrazolyl, 2-(R7)-1-tetrazolyl, 4-(R7)-1-piperazinyl. Where applicable, the ring can be substituted one or more times by R7.

Preferred groups for $NR_{10}R_{14}$ which contain a heterocyclic ring are 5-(R_{14})-1-tetrazolyl, 2-(R_{14})-1-imidazolyl, 5-(R_{14})-2-tetrazolyl, or 4-(R_{14})-1-piperazinyl.

Preferred rings for R_{13} include (2-, 4- or 5-imidazolyl), (3-, 4- or 5-pyrazolyl), (4- or 5-triazolyl[1,2,3]), (3- or 5-triazolyl[1,2,4]), (5-tetrazolyl), (2-, 4- or 5-oxazolyl), (3-, 4- or 5-isoxazolyl), (3- or 5-oxadiazolyl[1,2,4]), (2-oxadiazolyl[1,3,4]), (2-thiadiazolyl[1,3,4]), (2-, 4-, or 5-thiazolyl), (2-, 4-, or 5-oxazolidinyl), (2-, 4-, or 5-thiazolidinyl), or (2-, 4-, or 5-imidazolidinyl).

When the R7 group is optionally substituted by a heterocyclic ring such as imidazolyl, pyrazolyl, triazolyl, tetrazolyl, or thiazolyl, the heterocyclic ring itself may be optionally substituted by R8 either on an available nitrogen or carbon atom, such as 1-(R8)-2-imidazolyl, 1-(R8)-4-imidazolyl, 1-(R8)-5-imidazolyl, 1-(R8)-3-pyrazolyl, 1-(R8)-4-pyrazolyl, 1-(R8)-5-pyrazolyl, 1-(R8)-4-triazolyl, or 1-(R8)-5-triazolyl. Where applicable, the ring may be substituted one or more times by R_8.

Preferred are those compounds of the Formula (I) wherein R_1 is -CH_2-cyclopropyl, -CH_2-C_{5-6} cycloalkyl, -C_{4-6} cycloalkyl unsubstituted or substituted with an hydroxyl group, tetrahydrofuran-3-yl, (3- or 4-cyclopentenyl), benzyl or -C_{1-2} alkyl optionally substituted by 1 or more fluorines, and -$(CH_2)_{2-4}$ OH; R_2 is methyl or fluoro-substituted alkyl, and W is alkynyl of 2 to 4 carbon atoms.

Most preferred are those compounds wherein R_1 is -CH_2-cyclopropyl, cyclopentyl, 3-hydroxycyclopentyl, methyl or CF_2H; X is YR_2; Y is oxygen; X_2 is oxygen; X_3 is hydrogen; X_4 is hydrogen, R_2 is CF_2H or methyl, W is 1,3-butadiynyl, and in Z the R_8 group is H and the R_{14} group of Z is R_4.

Exemplified compound is:

1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-hydroxymethylcyclohexan]-3-yl}buta-1,3-diyne, and

1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-aminomethylcyclohexan]-3-yl}buta-1,3-diyne.

Pharmaceutically acceptable salts of the instant compounds, where they can be prepared, are also intended to be covered by this invention. These salts will be ones which are acceptable in their application to a pharmaceutical use. By that it is meant

that the salt will retain the biological activity of the parent compound and the salt will not have untoward or deleterious effects in its application and use in treating diseases.

Pharmaceutically acceptable salts are prepared in a standard manner. The parent compound, dissolved in a suitable solvent, is treated with an excess of an organic or inorganic acid, in the case of acid addition salts of a base, or an excess of organic or inorganic base where the molecule contains a COOH for example.

Pharmaceutical compositions of the present invention comprise a pharmaceutical carrier or diluent and some amount of a compound of the formula (I). The compound may be present in an amount to effect a physiological response, or it may be present in a lesser amount such that the user will need to take two or more units of the composition to effect the treatment intended. These compositions may be made up as a solid, liquid or in a gaseous form. Or one of these three forms may be transformed to another at the time of being administered such as when a solid is delivered by aerosol means, or when a liquid is delivered as a spray or aerosol.

The nature of the composition and the pharmaceutical carrier or diluent will, of course, depend upon the intended route of administration, for example parenterally, topically, orally or by inhalation.

For topical administration the pharmaceutical composition will be in the form of a cream, ointment, liniment, lotion, pastes, aerosols, and drops suitable for administration to the skin, eye, ear, or nose.

For parenteral administration the pharmaceutical composition will be in the form of a sterile injectable liquid such as an ampule or an aqueous or non-aqueous liquid suspension.

For oral administration the pharmaceutical composition will be in the form of a tablet, capsule, powder, pellet, atroche, lozenge, syrup, liquid, or emulsion.

When the pharmaceutical composition is employed in the form of a solution or suspension, examples of appropriate pharmaceutical carriers or diluents include: for aqueous systems, water; for non-aqueous systems, ethanol, glycerin, propylene glycol, corn oil, cottonseed oil, peanut oil, sesame oil, liquid parafins and mixtures thereof with water; for solid systems, lactose, kaolin and mannitol; and for aerosol systems, dichlorodifluoromethane, chlorotrifluoroethane and compressed carbon dioxide. Also, in addition to the pharmaceutical carrier or diluent, the instant compositions may include other ingredients such as stabilizers, antioxidants, preservatives, lubricants, suspending agents, viscosity modifiers and the like, provided that the additional ingredients do not have a detrimental effect on the therapeutic action of the instant compositions.

The pharmaceutical preparations thus described are made following the conventional techniques of the pharmaceutical chemist as appropriate to the desired end product.

In these compositions, the amount of carrier or diluent will vary but preferably will be the major proportion of a suspension or solution of the active ingredient. When the diluent is a solid it may be present in lesser, equal or greater amounts than the solid active ingredient.

Usually a compound of formula I is administered to a subject in a composition comprising a nontoxic amount sufficient to produce an inhibition of the symptoms of a disease in which leukotrienes are a factor. Topical formulations will contain between about 0.01 to 5.0% by weight of the active ingredient and will be applied as required as a preventative or curative agent to the affected area. When employed as an oral, or other ingested or injected regimen, the dosage of the composition is selected from the range of from 50 mg to 1000 mg of active ingredient for each administration. For convenience, equal doses will be administered 1 to 5 times daily with the daily dosage regimen being selected from about 50 mg to about 5000 mg.

No unacceptable toxicological effects are expected when these compounds are administered in accordance with the present invention.

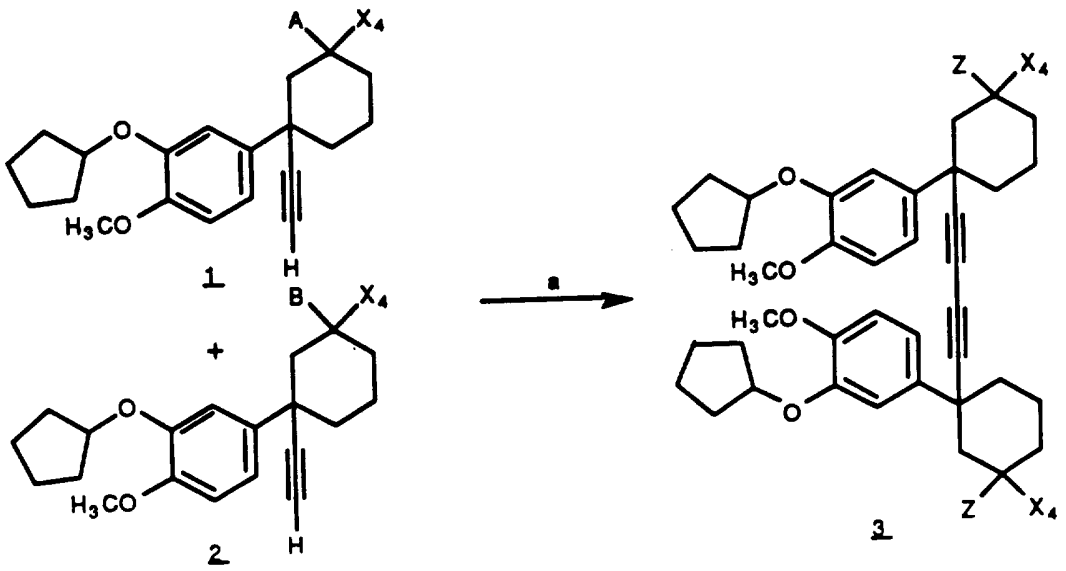
The following examples are set forth to illustrate the invention. These examples are not intended to limit the scope of the invention in any manner or fashion. Reference is made to the claims for what is reserved to the inventor hereunder.

Methods Of Preparation

Synthetic Scheme(s) With Textual Description

Compounds of Formula (I), wherein W is a 1,3-butadiyne and wherein A and B represent Z as defined in relation to Formula (I) or a group convertible to Z and wherein X_4 represents X_4 as defined in relation to Formula (I) or a group convertible to X_4, may be prepared by the processes disclosed herein which comprise, for example, coupling of a molecule of the Formula 1-Scheme 1 with a molecule of the Formula 2-Scheme 1 using an appropriate metal salt, such as cupric acetate, in a suitable solvent, such as DMF or pyridine, or a combination, such as pyridine/methanol/water, as in the method of Eglington and Galbraith (J. Chem. Soc., 1959, 889), to provide a compound of the Formula 3-Scheme 1.

Scheme 1



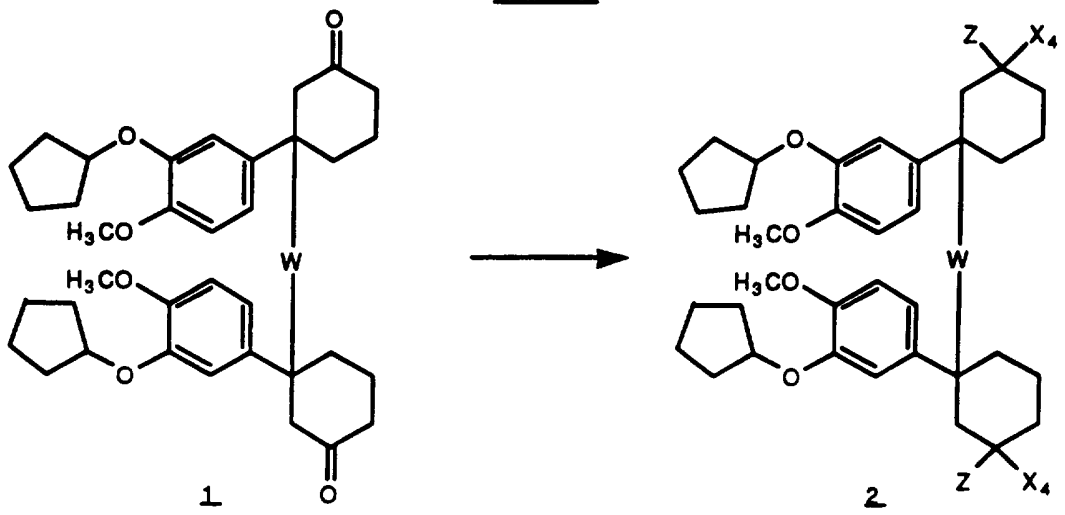
a) $Cu(OAc)_2 \cdot H_2O$, DMF or C_5H_5N

Reduction of a compound of the Formula (I), wherein W is a 1,3-butadiyne and wherein Z represents Z as defined in relation to Formula (I) or a group convertible to Z and wherein X4 represents X4 as defined in relation to Formula (I) or a group convertible to X4, to a compound of the Formula (I) wherein W is a fully saturated hydrocarbon chain (*i.e.*, n-butyl) may be accomplished using, *e.g.*, palladium metal according to the method of Tedeschi (J. Org. Chem., 1962, 27, 2398), or, *e.g.*, platinum oxide according to the method of Jutz (Ber., 1958, 91, 1867) or that of Suzuki and Kurosawa (Chem. Lett., 1980, 1177). Reduction of a compound of the Formula (I), wherein W is a 1,3-butadiyne and wherein Z represents Z as defined in relation to Formula (I) or a group convertible to Z and wherein X4 represents X4 as defined in relation to Formula (I) or a group convertible to X4, to provide a compound of the Formula (I) wherein W is a 1,3-butadiene may be accomplished using, *e.g.*, the hydroboration-protonolysis procedure of Zweifel and Polston (J. Am. Chem. Soc., 1970, 92, 4068), or, *e.g.*, the hydroalumination-protonolysis procedure of Zweifel *et al.* (Synthesis, 1977, 52).

Alternatively, compounds of the Formula (1), wherein W, X4 and Z represent W, X4 and Z as defined in relation to Formula (I) or a group convertible to W, X4 or Z, may be prepared from the corresponding ketones as, *e.g.*, compound 1-Scheme 2, by the synthetic procedures described in United States patent applications 08/131054 and PCT application PCT/US94/10816 ; syntheses of such ketone starting materials are described in co-pending U.S. applications 08/130215 filed 01 October 1993 and PCT/US94/10815 filed 23 September 1994 or co-pending USSN 08/130213 and PCT

application PCT/US94/10767 filed on 01 October 1993 and 23 September 1994 respectively.

Scheme 2



Depending upon the exact nature of the Z and X_4 groups of the compounds of the Formula (I), the Zand X_4 groups may require protection during the coupling and/or reductive steps described herein, followed by deprotection, to provide the Formula (I) compound, as in processes described in co-pending U.S. application filed on even date herewith and identified as P50301; such protective groups are well known to those skilled in the art. (See: Greene, T. and Wuts, P.G.M., Protecting Groups in Organic Synthesis, 2nd Ed., John Wiley and Sons, New York, 1991.)

Preparation of the remaining compounds of the Formula (I) may be accomplished by procedures analogous to those described above and in the Examples, *infra.*

It will be recognized that compounds of the Formula (I) may exist in distinct diastereomeric forms possessing distinct physical and biological properties; such isomers may be separated by standard chromatographic methods.

Experimental Examples

Example 1

Preparation of 1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-hydroxymethylcyclohexan]-3-yl}buta-1,3-diyne

A suspension of 1,4-*bis*-{[methyl *c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-cyclohexane carboxylate]-3-yl}buta-1,3-diyne (0.35 g, 0.52 mmol, prepared as described in co-pending U.S. application identified as P50298 and filed on even date herewith) in tetrahydrofuran (3.0 mL) with methanol (0.025 mL) and lithium borohydride (0.04 g, 1.56 mmol) is stirred overnight at room temperature under an argon atmosphere. The reaction mixture is partitioned between methylene chloride and

acidic water, is extracted three times, is dried (magnesium sulfate) and is evaporated. Purification by flash column chromatography provides the product.

Example 2

Preparation of 1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-aminomethylcyclohexan]-3-yl}buta-1,3-diyne

A solution of 1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-hydroxymethylcyclohexan]-3-yl}buta-1,3-diyne (0.11 g, 0.16 mmol) in tetrahydrofuran (2 mL) under an argon atmosphere is treated with triphenylphosphine (0.08 g, 0.32 mmol), phthalimide (0.04 g, 0.32 mmol) and then diethylazodicarboxylate (0.06 mL, 0.32 mmol) is added dropwise. The reaction flask is covered with foil and the mixture is stirred at room temperature for 30 h. The solvent is evaporated and the residue is purified by flash column chromatography, to provide the product phthalimide, which is dissolved in ethanol (0.5 mL) under an argon atmosphere and is stirred with hydrazine hydrate (0.16 mL, 0.3 mmol) for 3 days. The precipitate is removed by filtration, the filtrate is applied to a silica column and the product is eluted.

UTILITY EXAMPLES

EXAMPLE A

Inhibitory effect of compounds of Formula (I) on *in vitro* TNF production by human monocytes

The inhibitory effect of compounds of Formula (I) on *in vitro* TNF production by human monocytes may be determined by the protocol as described in Badger *et al.*, EPO published Application 0 411 754 A2, February 6, 1991, and in Hanna, WO 90/15534, December 27, 1990.

EXAMPLE B

Two models of endotoxic shock have been utilized to determine *in vivo* TNF activity for the compounds of Formula (I). The protocol used in these models is described in Badger *et al.*, EPO published Application 0 411 754 A2, February 6, 1991, and in Hanna, WO 90/15534, December 27, 1990.

The compound of Example 1 herein demonstrated a positive *in vivo* response in reducing serum levels of TNF induced by the injection of endotoxin.

EXAMPLE C

Isolation of PDE Isozymes

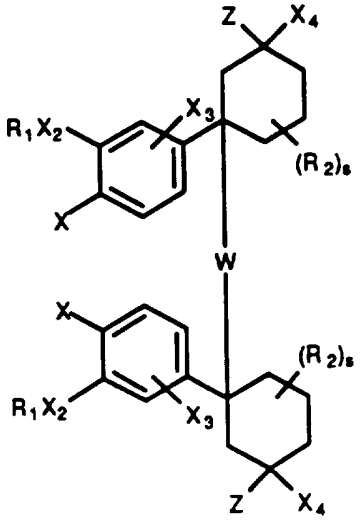
The phosphodiesterase inhibitory activity and selectivity of the compounds of Formula (I) can be determined using a battery of five distinct PDE isozymes. The tissues used as sources of the different isozymes are as follows: 1) PDE Ib, porcine aorta; 2) PDE Ic, guinea-pig heart; 3) PDE III, guinea-pig heart; 4) PDE IV, human monocyte; and 5) PDE V (also called "Ia"), canine trachealis. PDEs Ia, Ib, Ic and III

are partially purified using standard chromatographic techniques [Torphy and Cieslinski, Mol. Pharmacol., 37:206-214, 1990]. PDE IV is purified to kinetic homogeneity by the sequential use of anion-exchange followed by heparin-Sepharose chromatography [Torphy *et al.*, J. Biol. Chem., 267:1798-1804, 1992].

Phosphodiesterase activity is assayed as described in the protocol of Torphy and Cieslinski, Mol. Pharmacol., 37:206-214, 1990. Positive IC_{50}'s in the nanomolar to μM range for compounds of the workings examples described herein for Formula (I) have been demonstrated.

What is claimed is

1. A compound of Formula (I):



(I)

wherein:

R_1 is independently selected from $-(CR_4R_5)_nC(O)O(CR_4R_5)_mR_6$, $-(CR_4R_5)_nC(O)NR_4(CR_4R_5)_mR_6$, $-(CR_4R_5)_nO(CR_4R_5)_mR_6$, or $-(CR_4R_5)_rR_6$ wherein the alkyl moieties is unsubstituted or substituted with one or more fluorines;

m is 0 to 2;

n is 1 to 4;

r is 0 to 6;

R_4 and R_5 are independently selected from hydrogen or C_{1-2} alkyl;

R_6 is independently selected from hydrogen, methyl, hydroxyl, aryl, halo substituted aryl, aryloxyC_{1-3} alkyl, halo substituted aryloxyC_{1-3} alkyl, indanyl, indenyl, C_{7-11} polycycloalkyl, tetrahydrofuranyl, furanyl, tetrahydropyranyl, pyranyl, tetrahydrothienyl, thienyl, tetrahydrothiopyranyl, thiopyranyl, C_{3-6} cycloalkyl, or a C_{4-6} cycloalkyl containing one or two unsaturated bonds, wherein the cycloalkyl or heterocyclic moiety is unsubstituted or substituted by 1 to 3 methyl groups, one ethyl group, or an hydroxyl group;

provided that:

a) when R_6 is hydroxyl, then m is 2; or

b) when R_6 is hydroxyl, then r is 2 to 6; or

c) when R_6 is 2-tetrahydropyranyl, 2-tetrahydrothiopyranyl, 2-tetrahydrofuranyl, or 2-tetrahydrothienyl, then m is 1 or 2; or

d) when R_6 is 2-tetrahydropyranyl, 2-tetrahydrothiopyranyl, 2-tetrahydrofuranyl, or 2-tetrahydrothienyl, then r is 1 to 6;

e) when n is 1 and m is 0, then R_6 is other than H in $-(CR_4R_5)_nO(CR_4R_5)_mR_6$;

X is independently selected from YR_2, fluorine, NR_4R_5, or formyl amine;

Y is independently selected from O or $S(O)_{m'}$;

m' is 0, 1, or 2;

X_2 is independently selected from O or NR_8;

X_3 is independently selected from hydrogen or X;

R_2 is independently selected from the group consisting of $-CH_3$ and $-CH_2CH_3$ optionally substituted by 1 or more fluorines;

s is 0 to 4;

W is alkyl of 2 to 6 carbons, alkenyl of 2 to 6 carbon atoms or alkynyl of 2 to 6 carbon atoms;

Z is independently $CR_8R_8OR_{14}$, $CR_8R_8OR_{15}$, $CR_8R_8SR_{14}$, $CR_8R_8SR_{15}$, $CR_8R_8S(O)_{m'}R_7$, $CR_8R_8NR_{10}R_{14}$, $CR_8R_8NR_{10}S(O)_2NR_{10}R_{14}$, $CR_8R_8NR_{10}S(O)_2R_7$, $CR_8R_8NR_{10}C(Y')R_{14}$, $CR_8R_8NR_{10}C(O)OR_7$, $CR_8R_8NR_{10}C(Y')NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $CR_8R_8NR_{10}C(NCN)SR_9$, $CR_8R_8NR_{10}C(CR_4NO_2)SR_9$, $CR_8R_8C(O)OR_{14}$, $CR_8R_8C(Y')NR_{10}R_{14}$, $CR_8R_8C(NR_{10})NR_{10}R_{14}$, CR_8R_8CN, CR_8R_8(tetrazolyl), CR_8R_8(imidazolyl), CR_8R_8(imidazolidinyl), CR_8R_8(pyrazolyl), CR_8R_8(thiazolyl), CR_8R_8(thiazolidinyl), CR_8R_8(oxazolyl), CR_8R_8(oxazolidinyl), CR_8R_8(triazolyl), CR_8R_8(isoxazolyl), CR_8R_8(oxadiazolyl), CR_8R_8(thiadiazolyl), CR_8R_8(morpholinyl), CR_8R_8(piperidinyl), CR_8R_8(piperazinyl), CR_8R_8(pyrrolyl), $CR_8R_8C(NOR_8)R_{14}$, $CR_8R_8C(NOR_{14})R_8$, $CR_8R_8NR_{10}C(NR_{10})SR_9$, $CR_8R_8NR_{10}C(NR_{10})NR_{10}R_{14}$, $CR_8R_8NR_{10}C(O)C(O)NR_{10}R_{14}$, or $CR_8R_8NR_{10}C(O)C(O)OR_{14}$;

X_5 is H, R_9, OR_8, CN, $C(O)R_8$, $C(O)OR_8$, $C(O)NR_8R_8$, or NR_8R_8;

X_4 is independently H, R_9, OR_8, CN, $C(O)R_8$, $C(O)OR_8$, $C(O)NR_8R_8$, or NR_8R_8;

Y' is independently selected from O or S;

R_7 is $-(CR_4R_5)_qR_{12}$ or C_{1-6} alkyl wherein the R_{12} or C_{1-6} alkyl group is unsubstituted or substituted one or more times by methyl or ethyl unsubstituted or substituted by 1-3 fluorines, -F, -Br, -Cl, $-NO_2$, $-NR_{10}R_{11}$, $-C(O)R_8$, $-CO_2R_8$, $-O(CH_2)_qR_8$, -CN, $-C(O)NR_{10}R_{11}$, $-O(CH_2)_qC(O)NR_{10}R_{11}$, $-O(CH_2)_qC(O)R_9$, $-NR_{10}C(O)NR_{10}R_{11}$, $-NR_{10}C(O)R_{11}$, $-NR_{10}C(O)OR_9$, $-NR_{10}C(O)R_{13}$, $-C(NR_{10})NR_{10}R_{11}$, $-C(NCN)NR_{10}R_{11}$, $-C(NCN)SR_9$, $-NR_{10}C(NCN)SR_9$, $-NR_{10}C(NCN)NR_{10}R_{11}$, $-NR_{10}S(O)_2R_9$, $-S(O)_{m'}R_9$, $-NR_{10}C(O)C(O)NR_{10}R_{11}$, $-NR_{10}C(O)C(O)R_{10}$, or R_{13};

q is 0, 1, or 2;

R_{12} is independently selected from R_{13}, C_{3-7} cycloalkyl, (2-, 3- or 4-pyridyl), pyrimidyl, pyrazolyl, (1- or 2-imidazolyl), pyrrolyl, piperazinyl, piperidinyl, morpholinyl, furanyl, (2- or 3-thienyl), quinolinyl, naphthyl, or phenyl;

R_8 is independently selected from hydrogen or R_9;

R_9 is independently selected from C_{1-4} alkyl optionally substituted by one to three fluorines;

R_{10} is independently selected from OR_8 or R_{11};

R_{11} is independently selected from hydrogen, or C_{1-4} alkyl optionally substituted by one to three fluorines; or when R_{10} and R_{11} are as $NR_{10}R_{11}$ they may together with the nitrogen form a 5 to 7 membered ring comprised of carbon or carbon and at least one additional heteroatom selected from O, N, or S;

R_{13} is independently selected from oxazolidinyl, oxazolyl, thiazolyl, pyrazolyl, triazolyl, tetrazolyl, imidazolyl, imidazolidinyl, thiazolidinyl, isoxazolyl, oxadiazolyl, or thiadiazolyl, and each of these heterocyclic rings is connected through a carbon atom and

R_{14} is hydrogen or R_7; or when R_8 and R_{14} are as NR_8R_{14} they may together with the nitrogen form a 5 to 7 membered ring comprised of carbon or carbon and one or more additional heteroatoms selected from O, N, or S;

R_{15} is $C(O)R_{14}$, $C(O)NR_4R_{14}$, $S(O)_2R_7$, or $S(O)_2NR_4R_{14}$;

or the pharmaceutically acceptable salts thereof.

2. A compound according to claim 1 wherein R_1 is -CH_2-cyclopropyl, cyclopentyl, 3-hydroxycyclopentyl, methyl or CF_2H; X is YR_2; Y is oxygen; X_2 is oxygen; X_3 is hydrogen; X_4 is hydrogen, R_2 is CF_2H or methyl, W is 1,3-butadiynyl, and in Z the R_8 group is H and the R_{14} group of Z is R_4.

3. A compound according to claim 2 which is

1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-hydroxymethylcyclohexan]-3-yl}buta-1,3-diyne, or

1,4-*bis*-{[*c*-3-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-aminomethylcyclohexan]-3-yl}buta-1,3-diyne.

4. A pharmaceutical composition comprising a compound of Formula (I) according to claim 1 and a pharmaceutically acceptable excipient.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/13267

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :C07C 229/00, 69/76, 59/00, 55/28, 233/00, 41/00
US CL :560/019, 055/076; 562/433, 465, 489; 564/161; 568/031
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)

U.S. : 560/019, 055/076; 562/433, 465, 489; 564/161; 568/031

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

STN CAS STRUCTURE, FILE CA, FILE MEDLINE, FILE BIOSIS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CHEMICAL ABSTRACTS, VOLUME 123 ISSUED, 1995, CHRISTENSEN S., "Preparation of Cyanocyclohexane Compounds as Tumor Necrosis Factors". ABSTRACT NO. 143338 WO, A, 9509836.	1-4

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

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	
"E" earlier document 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	
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"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	
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Date of the actual completion of the international search 01 FEBRUARY 1996	Date of mailing of the international search report 14 FEB 1996
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