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(54) Titre : 4,4-(disubstituted)cyclohexan-1-ols monomers and related compounds.

(57) Abrégé :

The present invention relates to novel 4,4-(disubstituted) cyclohexan-1-ols monomers 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).

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4.4-(disubstituted)cyclohexan-1-ols monomers and related compounds

Field of Invention

The present invention relates to novel 4.4-(disubstituted)cyclohexan-1-ols monomers 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.

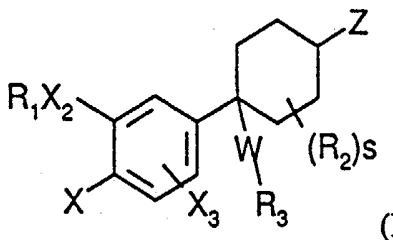
TNF has also been implicated in various roles with other viral infections, such as the cytomegalovirus (CMV), influenza virus, adenovirus, and the herpes virus for similar reasons as those noted.

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

Compounds of the Formula (I):



(I)

wherein:

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

m is 0 to 2;

n is 1 to 4;

r is 0 to 6;

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

R_6 is 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 YR_2, fluorine, NR_4R_5, or formyl amine;

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

m' is 0, 1, or 2;

X_2 is O or NR_8;

X_3 is hydrogen or X;

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

R_2 is independently selected from $-CH_3$ or $-CH_2CH_3$ optionally substituted by 1 or more halogens;

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;

R_3 is $COOR_{14}$, $C(O)NR_4R_{14}$ or R_7;

Z is OR_{14}, OR_{15}, SR_{14}, $S(O)_{m'}R_7$, $S(O)_2NR_{10}R_{14}$, $NR_{10}R_{14}$, $NR_{14}C(O)R_9$, $NR_{10}C(Y')R_{14}$, $NR_{10}C(O)OR_7$, $NR_{10}C(Y')NR_{10}R_{14}$, $NR_{10}S(O)_2NR_{10}R_{14}$, $NR_{10}C(NCN)NR_{10}R_{14}$, $NR_{10}S(O)_2R_7$, $NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $NR_{10}C(NCN)SR_9$, $NR_{10}C(CR_4NO_2)SR_9$, $NR_{10}C(NR_{10})NR_{10}R_{14}$, $NR_{10}C(O)C(O)NR_{10}R_{14}$,or $NR_{10}C(O)C(O)OR_{14}$;

Y' is 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, $-NO_2$, $-NR_{10}R_{11}$, $-C(O)R_8$, $-CO_2R_8$, $-O(CH_2)_{2-4}OR_8$, $-O(CH_2)_qR_8$, -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 R_{13}, C_3-C_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 C_{1-4} alkyl optionally substituted by one to three fluorines;

R_{10} is OR_8 or R_{11};

R_{11} is hydrogen, or C_{1-4} alkyl unsubstituted or 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 one or more additional heteroatoms selected from O, N, or S;

R_{13} is 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 each may be unsubstituted or substituted by one or two C_{1-2} alkyl groups unsubstituted or substituted on the methyl with 1 to 3 fluoro atoms;

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;

provided that:

(f) R_7 is not C_{1-4} alkyl unsubstituted or substituted by one to three fluorines;

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, his 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.

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.

Preferred compounds are as follows:

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 for the compounds of Formula (I) are CH_2-cyclopropyl, CH_2-C_{5-6} cycloalkyl, C_{4-6} cycloalkyl unsubstituted or substituted with OHC_{7-11} polycycloalkyl, (3- or 4-cyclopentenyl), phenyl, tetrahydrofuran-3-yl, benzyl or C_{1-2} alkyl unsubstituted or 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 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 unsubstituted or 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. It is most preferred that W is acetylene or 1,3-butadiynyl.

Z is preferably OR_{14}, OR_{15}, SR_{14}, $S(O)_{m'}R_7$, $S(O)_2NR_{10}R_{14}$, $NR_{10}R_{14}$, $NR_{14}C(O)R_9$, $NR_{10}C(O)R_{14}$, $NR_{10}C(O)OR_7$, $NR_{10}C(O)NR_{10}R_{14}$, $NR_{10}S(O)_2NR_{10}R_{14}$, $NR_{10}C(NCN)NR_{10}R_{14}$, $NR_{10}S(O)_2R_7$, $NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $NR_{10}C(NCN)SR_9$, $NR_{10}C(CR_4NO_2)SR_9$, $NR_{10}C(NR_{10})NR_{10}R_{14}$, $NR_{10}C(O)C(O)NR_{10}R_{14}$, or $NR_{10}C(O)C(O)OR_{14}$.

Preferred X groups for Formula (I) are those wherein X is YR_2 and Y is oxygen. The preferred X_2 group for Formula (I) is that wherein X_2 is oxygen. The preferred X_3 group for Formula (I) is that wherein X_3 is hydrogen. Preferred R_2 groups, where applicable, is a 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 unsubstituted or substituted $-(CH_2)_{1-2}$(cyclopropyl), $-(CH_2)_{0-2}$(cyclobutyl), $-(CH_2)_{0-2}$(cyclopentyl) unsubstituted

or substituted by OH, -$(CH_2)_{0-2}$(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 comprised of carbon or carbon and at least one 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 may form a 5 to 7 membered ring comprised of carbon or carbon and at least one 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 R_7 as described herein for Formula (I). Illustrations of such carbon substitutions includes, but is not limited to, 2-(R_7)-1-imidazolyl, 4-(R_7)-1-imidazolyl, 5-(R_7)-1-imidazolyl, 3-(R_7)-1-pyrazolyl, 4-(R_7)-1-pyrazolyl, 5-(R_7)-1-pyrazolyl, 4-(R_7)-2-triazolyl, 5-(R_7)-2-triazolyl, 4-(R_7)-1-triazolyl, 5-(R_7)-1-triazolyl, 5-(R_7)-1-tetrazolyl, and 5-(R_7)-2-tetrazolyl. Applicable nitrogen substitution by R_7 includes, but is not limited to, 1-(R_7)-2-tetrazolyl, 2-(R_7)-1-tetrazolyl, 4-(R_7)-1-piperazinyl. Where applicable, the ring may be substituted one or more times by R_7.

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, 4-(R_{14})-1-piperazinyl, or 4-(R_{15})-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 R_7 group is unsubstituted or substituted by a heterocyclic ring such as imidazolyl, pyrazolyl, triazolyl, tetrazolyl, or thiazolyl, the heterocyclic ring itself may be unsubstituted or substituted by R_8 either on an available nitrogen or carbon atom, such as 1-(R_8)-2-imidazolyl, 1-(R_8)-4-imidazolyl, 1-(R_8)-5-imidazolyl, 1-(R_8)-3-pyrazolyl, 1-(R_8)-4-pyrazolyl, 1-(R_8)-5-pyrazolyl, 1-(R_8)-4-triazolyl, or 1-(R_8)-5-triazolyl. Where applicable, the ring may be substituted one or more times by R_8.

Preferred are those compounds of Formula (I) wherein R_1 is -CH_2-cyclopropyl, -CH_2-C_{5-6} cycloalkyl, -C_{4-6} cycloalkyl unsubstituted or substituted by OH, tetrahydrofuran-3-yl, (3- or 4-cyclopentenyl), benzyl or -C_{1-2} alkyl unsubstituted or substituted by 1 or more fluorines, and -$(CH_2)_{2-4}$ OH; R_2 is methyl or fluoro-substituted alkyl, W is 1,3-butadiynyl; and X is YR_2.

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; and R_2 is CF_2H or methyl, W is acetylene or 1,3-butadiynyl, and R_3 is $C(O)OR_{14}$, or R_7.

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-ol],

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(3-trifluoromethyl[1,2,4]oxadiazol-5-yl)phenyl]ethynyl)cyclohexan-1-ol],

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,3,4]oxadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol], and

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,3,4]thiadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol].

It will be recognized that some of the compounds of Formula (I) may exist in both racemic and optically active forms; some may also exist in distinct diastereomeric forms possessing distinct physical and biological properties. All of these compounds are considered to be within the scope of the present invention.

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.

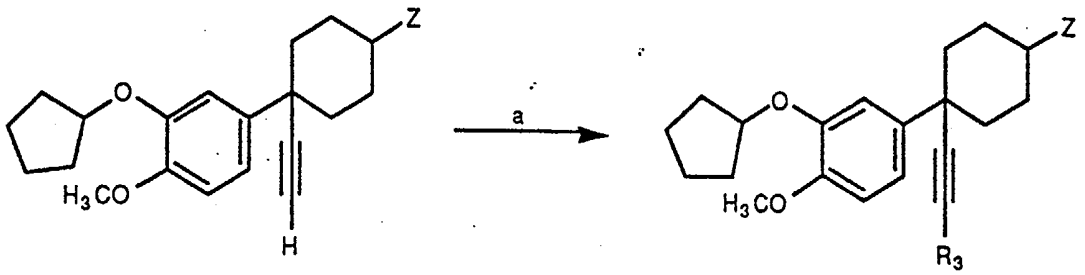
No unacceptable toxicological effects are expected when these compounds are administered in accordance with the present invention.

Methods Of Preparation

Synthetic Scheme(s) With Textual Description

Compounds of Formula (I) may be prepared by the processes disclosed herein which comprise reacting a terminal acetylene, wherein Z represents Z as defined in relation to Formula (I) or a group convertible to Z, as, *e.g.*, compound 1-Scheme 1, with an appropriate halide, R3X, wherein R3 represents R3 as defined in relation to Formula (I) or a group convertible to R3, in the presence of a suitable catalyst, such as a copper (I) halide and a bivalent or zerovalent palladium compound in the presence of, *e.g.*, triphenylphosphine, in a suitable solvent, such as an amine, as in the procedure of Brandsma *et al.* (Syn. Comm., 1990, 20, 1889), provides a compound of the Formula 2-Scheme 1. Compounds of the Formula 1-Scheme 1 may be prepared by procedures analogous to those described in copending U.S. application 07/862111, 07/968761 and PCT application number PCT/US93/02516 published under WIPO publication number WO93/19751.

Scheme 1

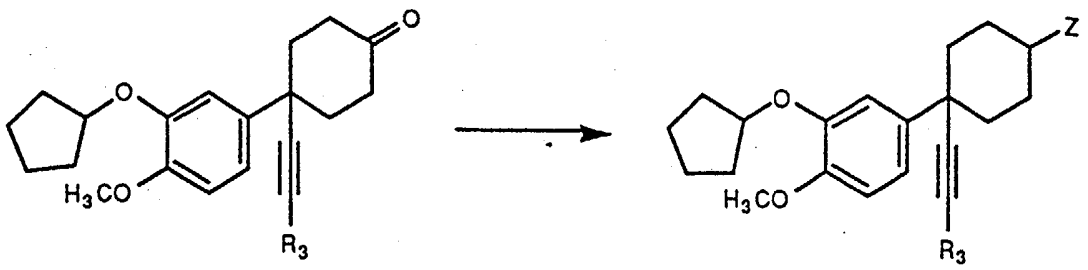


1 2

a) $Pd(PPh_3)_4$, PPh_3, CuI, R_3X, piperidine

Alternatively, compounds of the Formula (I), wherein Z and R3 represent Z and R3 as defined in relation to Formula (I) or a group convertible to Z or R3, may be prepared from the corresponding ketones as, *e.g.*, compound 1-Scheme 2, by the synthetic procedures described in PCT application number PCT/US93/01990 and PCT/US93/02325 published as WIPO publication number WO93/19750 .

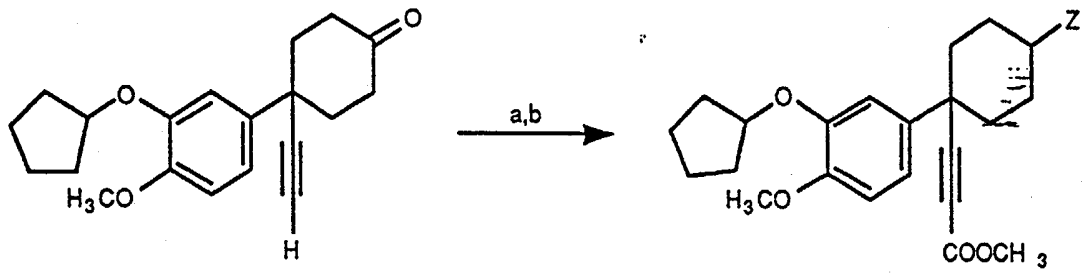
Scheme 2



1 2

Alternatively, oxidative carbonylation of a terminal acetylene as, *e.g.*, compound 1-Scheme 3, using an appropriate metal salt, such as a copper salt with a catalytic amount of a palladium salt, in the presence of a suitable base as an acid trap, such as sodium acetate, in a suitable alcohol, such as methanol, as in the method of Tsuji *et al.* (Tet. Lett., 1980, 21, 849), then provides the compound of the Formula 2-Scheme 3; such compounds may then be converted to other compounds of the Formula (I) by manipulation of the ketone as described above and by independent manipulation of the carboxylic ester moiety using standard transesterification or amidation conditions. Syntheses of such ketone starting materials are described in published PCT application PCT/US93/02045 (WIPO publication number WO 93/19748) or published PCT application PCT/US93/02325 (WIPO publication number WO/93/19750).

Scheme 3



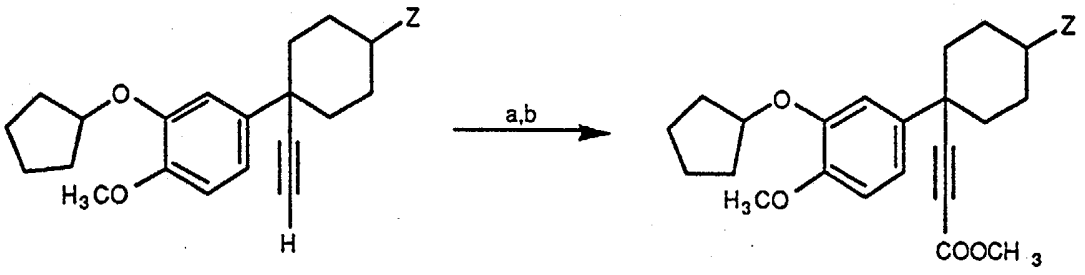
1 2

a) $PdCl_2$, $CuCl_2$, NaO_2CCH_3, CO, CH_3OH; as in Scheme 2

Likewise, oxidative carbonylation of a terminal acetylene as, *e.g.*, compound 1-Scheme 4, wherein Z represents Z as defined in relation to Formula (I) or a group convertible to Z, using an appropriate metal salt, such as a copper salt with a catalytic amount of a palladium salt, in the presence of a suitable base as an acid trap, such as

sodium acetate, in a suitable alcohol, such as methanol, as in the method of Tsuji *et al.* (Tet. Lett., 1980, 21, 849), then provides the compound of the Formula 2-Scheme 4; such compounds may then be converted to other compounds of the Formula (I) by manipulation of the carboxylic ester moiety using standard transesterification or amidation conditions.

Scheme 4



1 2

a) $PdCl_2$, $CuCl_2$, NaO_2CCH_3, CO, CH_3OH

Compounds where Z is a group other than -OH can be prepared by methods known in the art and in particular by manipulation of the -OH. Such methods are described in co-pending U.S. application 07/968753 and PCT application serial number PCT/US93/02325 (WIPO publication number WO/93/19750).

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 some 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.

The following examples are given to further illustrate the described invention. These examples are intented solely for illustrating the invention and should not be read to limit the invention in any manner. Reference is made to the claims for what is reserved to the inventors hereunder.

Experimentals

Example 1

Preparation of *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(4-pyridylethynyl)-cyclohexan-1-ol]

1a) *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol] and *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol]

To a solution of 4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-one (0.34 g, 1.1 mmol, prepared as described in published PCT application PCT/US93/001990 (WIPO publication number WO 93/19748) or PCT/US93/02325 (WIPO publication number WO/93/19750) in 1,2-dimethoxyethane (5 mL) under an argon atmosphere was added sodium borohydride (0.08 g, 2.2 mmol) and the mixture was stirred at room temperature for 0.5 h. Water was added, the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 3:7 ethyl acetate:hexanes, provided *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol] (described in U. S. Patent application in PCT application number PCT/US93/02516 published under WIPO publication number WO93/19751 as *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol]) as a wax. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.14 (d, J=2.3 Hz, 1H), 7.04 (dd, J=8.5, 2.3 Hz, 1H), 6.82 (d, J=8.5 Hz, 1H), 4.79 (m, 1H), 3.83 (s, 3H), 3.68 (m, 1H), 2.46 (s, 1H), 1.7 - 2.1 (m, 14H), 1.6 (m, 2H).

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol] also was isolated from this procedure as a colorless oil. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.17 (d, J=1.9 Hz, 1H), 7.10 (d, J=8.4 Hz, 1H), 6.84 (d, J=8.4 Hz, 1H), 4.80 (m, 1H), 4.13 (br s, 1H), 3.84 (s, 3H), 2.38 (s, 1H), 2.15 (m, 4H), 1.7 - 2.0 (m, 10H), 1.75 (m, 2H).

1b) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(4-pyridylethynyl)cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexan-1-ol] (0.15 g, 0.48 mmol) and 4-bromopyridine (0.75g, 5 mmol) in piperidine (2 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)-palladium(0) (0.022 g, 4%), copper (I) iodide (0.005 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h. Ammonium chloride was added and the mixture was extracted three times with dichloromethane, the extract was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 3:1 ethyl acetate/hexanes, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(4-pyridylethynyl)-cyclohexan-1-ol] as a pale yellow solid, which was triturated from ether-hexanes. mp 183 - 184°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.6 (br, 2H), 7.35 (m, 2H), 7.14 (d, J=2 Hz, 1H), 7.06 (dd, J=8.5, 2Hz, 1H), 6.85 (d, J=8.5Hz, 1H), 4.79 (m, 1H), 3.85 (s, 3H), 3.7 (m, 1H), 1.8 - 2.1 (m, 14H), 1.6 (m, 2H).

Example 2

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexan-1-ol] To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.14 g, 0.43 mmol) and 2-bromopyridine (0.40 mL, 4.3 mmol) in piperidine (2 mL) under an argon atmosphere were added tetrakis(triphenyl-phosphine)palladium(0) (0.020 g, 4%), copper(I) iodide (0.005 g, 6%) and a small crystal of

triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h. Ammonium chloride was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 75:25 ethyl acetate:hexanes, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexan-1-ol] as a white solid (0.14 g, 84%), mp 49-51°C. Anal. ($C_{25}H_{29}NO_3 \cdot 0.5\ H_2O$) calcd: C, 74.97; H, 7.55; N, 3.50; found: C, 74.90; H, 7.52; N, 3.33.

Example 3

Resolution of (+/-)-3-(3-cyclopentyloxy-4-methoxyphenyl)-3-ethynyl-cyclohexan-1-one

The compound from Example 1b was resolved in the following manner to give enantiomeric oils: HPLC R_t = 15.5 min (enantiomer 1 = E1), 23.2 min (enantiomer 2 = E2) (Diacel Chiralpak AS; 21.2 x 250 mm; hexane:isopropanol, 4:1; 10 mL/min; UV detection at 295 nm).

Example 4

Preparation of (+/-) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-phenylethynyl-cyclohexan-1-one To a solution of the compound of Example 1b (0.125 g, 0.4 mmol) and iodobenzene (0.4 mL, 2.0 mmol) in piperidine (6 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was refluxed for 5 h, then concentrated *in vacuo*. The residue was diluted with ethyl acetate (100 mL), was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 2:1 hexanes/ethyl acetate, followed by trituration from ether/hexanes, provided the title compound as white solid (0.09 g, 58%), m.p. 90-91°C.

Example 5

Preparation of (+/-) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-carbomethoxyphenyl)ethynyl-cyclohexan-1-one

5a) methyl 3-iodobenzoate

Methyl 3-iodobenzoate was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 40-41°C.

5b) (+/-) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-carbomethoxyphenyl)ethynyl-cyclohexan-1-one

To a solution of the compound from Example 1b (0.30 g, 0.96 mmol) and methyl 3-iodobenzoate (0.30 g, 1.15 mmol) in triethylamine (10 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was refluxed for 0.5 h and was then concentrated *in vacuo*. The residue was partitioned between water and ethyl acetate. The organic phase was dried (Na_2SO_4) and was evaporated. Purification by flash chromatography,

eluting with 2:1 hexanes/ethyl acetate, provided the title compound as a pale yellow oil (0.35 g, 80%). Anal ($C_{28}H_{30}O_5 \cdot 1.0\ H_2O$) calcd: C, 72.39; H, 6.94; found: C, 72.47; H, 6.80.

Example 6

Preparation of (+/-) 3-(3-carboxyphenylethynyl)-3-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-one To a solution of the compound from Example 5(b) in 5:5:2 THF/methanol/water (10 mL) under an argon atmosphere was added sodium hydroxide (0.60 g, 1.5 mmol). The mixture was heated at 60°C for 2 h and was then concentrated *in vacuo*. The residue was extracted from 3N HCl with ethyl acetate, was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 98:2:0.3 chloroform/methanol/acetic acid, provided a white solid, m.p. 71-73°C.

Example 7

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3[3-(5-methyl-[1,3,4]thiadiazol-2-yl)phenylethynyl]cyclohexan-1-one7a) 1-iodo-3-(5-methyl-[1,3,4]thiadiazol-2-yl)benzene

1-Iodo-3-(5-methyl-[1,3,4]thiadiazol-2-yl)benzene was prepared by standard chemistry well known to those versed in the art and is white solid, m.p. 86-89°C.

7b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(5-methyl-[1,3,4]thiadiazol-2-yl)phenylethynyl]cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.10 g, 0.32 mmol) and 1-iodo-3-(5-methyl-[1,3,4]thiadiazol-2-yl)benzene (0.10 g, 0.32 mmol) in triethylamine (5 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palldium(0), copper(I) iodide and triphenylphosphine. The mixture was refluxed for 0.20 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 1:1 hexanes/ethyl acetate provided the title compound as a white solid (0.135 g, 87%); m.p. 97-99°C.

The enantiomer was prepared in a similar manner, starting with the compound from Example 3 (E2), as a white solid, m.p. 97-99°C.

Example 8

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(5-methyl-[1,3,4]oxadiazol-2-yl)phenylethynyl]cyclohexan-1-one

8a) 1-iodo-3-(5-methyl-[1,3,4]oxadizol-2-yl)benzene

1- Iodo-3-(5-methyl-[1,3,4]oxadiazol-2-yl)benzene was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 104-105°C.

8b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(5-methyl-[1,3,4]oxadiazol-2-yl)phenylethynyl]cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.125 g, 0.4 mmol) and 1-iodo-3-(5-methyl-[1,3,4]oxadiazol-2-yl)benzene (0.09 g, 0.32 mmol) in triethylamine (3 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)-palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h , was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 2:1 ethyl acetate/hexanes, followed by recrystallization from ethyl acetate/hexanes, provided the title compound as a white solid (0.11 g, 61%), m.p. 117-119°C.

The enantiomer was prepared in a similar manner, starting with the compound from Example 3 (E2), as a white solid, m.p. 117-119°C.

Example 9

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(3-methyl-[1,2,4]oxadiazol-5-yl)phenylethynyl]cyclohexan-1-one

9a) 1-iodo-3-(3-methyl-[1,2,4]oxadiazol-5-yl)benzene

1-Iodo-3-(3-methyl-[1,2,4]oxadiazol-5-yl)benzene was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 101.5-103°C.

9b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(3-methyl-[1,2,4]oxadiazol-5-yl)phenylethynyl]cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.125 g, 0.4 mmol) and 1-iodo-3-(3-methyl-[1,2,4]oxadiazol-5-yl)benzene (0.09 g, 0.32 mmol) in triethylamine (3mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)-palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. The residue was purified by flash chromatography, eluting with 2:1 hexanes/ethyl acetate, followed by trituration from hexanes/ethyl acetate, to provide the title compound as a white solid, m.p. 122 123°C.

The enantiomer was prepared in a similar manner, starting with the compound from Example 3 (E2), as awhite solid, m.p. 122-123°C.

Example 10

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(5-methyl-[1,2,4]oxadiazol-3-yl)phenylethynyl]cyclohexan-1-one

10a) 1-iodo-3-(5-methyl-[1,2,4]oxadiazol-3-yl)benzene

1-iodo-3-(5-methyl-[1,2,4]oxadiazol-3-yl)benzene was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 86-87°C.

10b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-[3-(5-methyl-[1,2,4]oxadiazol-3-yl)phenylethynyl]cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.125 g, 0.4 mmol) and 1-iodo-3-(5-methyl-[1,2,4]oxadiazol-3-yl)benzene (0.09 g, 0.32 mmol) in triethylamine (3 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)-palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 2:1 hexanes/ethyl acetate, followed by trituration from hexanes/ethyl acetate, provided the title compound as colorless crystals (0.12 g, 67%), m.p. 116-118°C.

The enantiomer was prepared in a similar manner, starting with the compound from Example 3 (E2), as colorless crystals, m.p.116-118°C.

Example 11

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-cyanophenylethynyl)cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.125 g, 0.4 mmol) and 3-iodobenzonitrile (Transworld, 0.09 g, 0.4 mmol) in triethylamine (3mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. The residue was purified by flash chromatography, eluting with 2:1 hexanes/ethyl acetate, to provide the title compound as a clear yellow glass (0.12 g, 73%). MS(EI) m/e 414 $[M+H]^+$.

The enantiomer was prepared in similar manner, starting with the compound from Example 3 (E2), as a clear yellow glass.

Example 12

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-nitrophenylethynyl)cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.2 g, 0.64 mmol) and 3-iodonitrobenzene (Aldrich, 0.16 g, 0.64 mmol) in triethylamine (4 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried

($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 3:1 hexanes/ethyl acetate, provided the title compound as yellow solid (0.25 g, 90%), m.p. 46-48°C.

The enantiomer was prepared in a similar manner, starting with the compound from Example 3 (E2), as a yellow solid. m.p. 46-48°C.

Example 13

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(2-hydroxyethoxyphenylethynyl)cyclohexan-1-one

13a) 2-hydroxyethoxy-1-iodobenzene

2-hydroxyethoxy-1-iodobenzene was prepared by standard chemistry well known to those versed in the art and is a colorless oil. ^1H NMR(400 MHz, $CDCl_3$) δ 7.77 (dd, J=7.9, 1.3 Hz, 1H), 7.3 (t, J=7H, 1H), 6.84 (d, J=7.9 Hz, 1H), 6.74 (t, J=7.9 Hz, 1H), 4.13 (t, J=4.3 Hz, 2H), 3.99 (t, J=4.3 Hz, 2H), 2.2 (br s, 1H).

13b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(2-hydroxyethoxyphenylethynyl)-cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.25 g, 0.8 mmol) and 2-hydroxyethoxy-1-iodobenzene (0.21 g, 0.8 mmol) in triethylamine (5 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 1 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was partitioned between ethyl acetate and water. The organic phase was washed with brine, was dried ($MgSO_4$) and was evaporated. Purification by flash chromatography, eluting with 1:1 hexanes/ethyl acetate, provided the title compound as a white solid (0.05 g, 14%), m.p. 93-94°C.

Example 14

Preparation of 3-(3-acetamidophenylethynyl)-3-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-one

14a) 3-acetamido-1-iodobenzene

3-acetamido-1-iodobenzene was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 117-118°C.

14b) 3-(3-acetamidophenylethynyl)-3-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.2 g, 0.64 mmol) and 3-acetamido-1-iodobenzene (0.17 g, 0.64 mmol) in triethylamine (5 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.3 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was purified by flash chromatography, eluting with 1:1 hexanes/ethyl acetate, to provide the title compound as tan solid (0.17 g, 60%), m.p. 58-60°C.

Example 15

Preparation of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-methanesulfonamidophenylethynyl)cyclohexan-1-one

15a) 1-iodo-3-methanesulfonamidobenzene

1-iodo-3-methanesulfonamidobenzene was prepared by standard chemistry well known to those versed in the art and is light-pink solid, m.p. 102-103°C.

15b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-methanesulfonamidophenylethynyl)cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.2 g, 0.64 mmol) and 1-iodo-3-methanesulfonamidobenzene (0.19 g, 0.64 mmol) in triethylamine (5 mL) under an argon atmosphere was added trace tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.3 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was purified by flash chromatography, eluting with 1:1 hexanes/ethyl acetate, to provide the title compound as a tan solid (0.18 g, 58%), m.p. 59-62°C.

Example 16

Preparation of 3-(3-aminophenylethynyl)-3-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-one

16a) 1-iodo-3-trifluoroacetamidobenzene

1-iodo-3-trifluoroacetamidobenzene was prepared by standard chemistry well known to those versed in the art and is a white solid, m.p. 120-121°C.

16b) 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-trifluoroacetamidophenylethynyl)-cyclohexan-1-one

To a solution of the compound from Example 3 (E1) (0.5 g. 1.6 mmol) and 1-iodo-3-trifluoroacetamidobenzene (0.5 g, 1.6 mmol) in triethylamine (10 mL) under an argon atmosphere was added a small amount of tetrakis(triphenylphosphine)palladium(0), copper(I) iodide and triphenylphosphine. The mixture was heated at 80°C for 0.2 h, was cooled to room temperature and was concentrated *in vacuo*. The residue was purified by flash chromatography, eluting with 3:1 hexanes/ethyl acetate, to give the title compound as a pale yellow solid (0.62 g, 78%), m.p. 63-65°C.

16c) 3-(3-aminophenylethynyl)-3-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-one

To a solution of 3-(3-cyclopentyloxy-4-methoxyphenyl)-3-(3-trifluoroacetamidophenylethynyl)cyclohexan-1-one (0.62 g, 1.24 mmol) in 95:5 methanol/water (10 mL) under an argon atmosphere was added potassium carbonate (0.86 g, 6.2 mmol). The mixture was refluxed for 6 h and was stirred for 18 h at room temperature. The solid precipitate was collected and purified by trituration from ethyl

acetate/hexanes to provide the title compound as a white solid (0.39 g, 77%), m.p. 100-102°C.

Example 17

cis-[4-(4-cyanothien-2-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol]17a) 2-bromo-4-cyanothiophene

2-Bromo-5-cyanothiophene was prepared by standard chemistry well known to those versed in the art and is a colorless oil. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J=2.2Hz, 1 H), 7.25 (d, J=2.2 Hz, 1H) ppm.

17b) *cis*-[4-(4-cyanothien-2-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.20 g, 0.64 mmol) and 2-bromo-4-cyanothiophene (0.12 g, 0.64 mmol) in triethylamine (5 mL) under an argon atmosphere were added tetrakis(triphenyl-phosphine)palladium(0) (0.030 g, 4%), copper(I) iodide (0.008 g, 6%), and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h. Hydrochloric acid (5 %) was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 1:1 ethyl acetate:hexanes, followed by trituration from dichloromethane-hexanes, provided *cis*-[4-(4-cyanothien-2-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-ol] as a pale yellow solid (0.12 g, 45%), mp 70-71°C. Anal. ($C_{25}H_{27}NO_3S$) calcd: C, 71.23; H, 6.46; N, 3.30; found: C, 71.24; H, 6.72; N, 3.14.

Example 18

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[4-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexan-1-ol]

18a) 2-bromo-4-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene

2-Bromo-4-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene was prepared by standard chemistry well known to those versed in the art and is a white solid, mp 72-73°C.

18b) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[4-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.25 g, 0.8 mmol) and 2-bromo-4-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene (0.20 g, 0.8 mmol) in triethylamine (5 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.038 g, 4%), copper(I) iodide (0.009 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 70-75°C for 0.5 h. Hydrochloric acid (5%) was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 1:1 ethyl acetate:hexanes, provided

cis [4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[4-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexan-1-ol], which was further triturated from dichloromethane-hexanes to give a white solid (0.20 g, 53%), mp 142-143°C. Anal. ($C_{27}H_{30}N_2O_4S \cdot 0.75\ H_2O$) calcd: C, 65.90; H, 6.45; N, 5.69; found: C, 66.06; H, 6.42; N, 5.50

Example 19

cis-[4-(2-aminopyrimidin-4-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol]

19a) 4-iodo-2-thiomethylpyrimidine

4-Iodo-2-thiomethylpyrimidine was prepared following literature procedure (A.J. Majeed, Ø. Antonsen, T. Benneche, K. Undheim. *Tetrahedron* 1989, *45*, 993-1006).

19b) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylthiopyrimidin-4-ylethynyl) cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.30 g, 0.95 mmol) and and 4-iodo-2-thiomethylpyrimidine(0.50 g, 2.5 mmol, as a mixture of 4-iodo-2-thiomethylpyrimidine and 4-chloro-2-thiomethylpyrimidine) in triethylamine (2 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.044 g, 4%) and copper(I) iodide (0.010 g, 6%), and the mixture was heated at 80-85°C for 0.5 h. Ammonium chloride was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 1:1 ethyl acetate:hexanes, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylthiopyrimidin-4-ylethynyl)cyclohexan-1-ol] as a yellow oil (0.36 g, 87%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.45 (d, J=5.0 Hz, 1 H), 7.15 (d, J=2.3 Hz, 1 H), 7.03 (dd, J=8.5, 2.3 Hz, 1 H), 7.01 (d, J=5.0 Hz, 1 H), 6.84 (d, J=8.5 Hz, 1 H), 4.81 (m, 1 H), 3.84 (s, 3 H), 3.72 (m, 1 H), 2.57 (s, 3 H), 2.14 (br d, J=12 Hz, 2 H), 2.05 (m, 2 H), 1.8 - 2.0 (m, 10 H), 1.6 (m, 2 H) ppm.

19c) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylsulfonylpyrimidin-4-ylethynyl)cyclohexan-1-ol]

To a solution of *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylthiopyrimidin-4-ylethynyl)cyclohexan-1-ol] (0.36 g, 0.82 mmol) in chloroform (5mL) at -10°C under an argon atmosphere was dropwise added over 20 min. a solution of 3-chloroperoxybenzoic acid (0.34 g, 1.97 mmol) in chloroform (3 mL). The reaction was stirred 3h at -10°C, then 3 h at room temperature. A second portion of 3-chloroperoxybenzoic acid (0.11 g, 0.62 mmol) in chloroform (1 mL) was added and stirring was continued for 1.5 h. The reaction was quenched with sodium carbonate (5%), was extracted three times with dichloromethane, was dried (potassium carbonate) and was evaporated. Purification by flash chromatography, eluting with

2.5:97.5 methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylsulfonylpyrimidin-4-ylethynyl) cyclohexan-1-ol] as a white foam (0.31 g, 81%), mp 75-77°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.84 (d, J=5.3 Hz, 1 H), 7.54 (d, J=5.3 Hz, 1H), 7.10 (d, J=2.3 Hz, 1 H), 7.04 (dd, J=8.5, 2.3 Hz, 1 H), 6.85 (d, J=8.5 Hz, 1 H), 4.81 (m, 1 H), 3.85 (s, 3 H), 3.73 (m, 1 H), 3.38 (s, 3 H), 2.20 (br d, J=12 Hz, 2 H), 2.06 (m, 2 H), 1.8 - 2.0 (m, 10 H), 1.6 (m, 2 H) ppm.

19d) *cis*- [4-(2-aminopyrimidin-4-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol]

Into a solution of *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-methylsulfonylpyrimidin-4-ylethynyl) cyclohexan-1-ol] (0.31 g, 0.66mmol) in methanol (5 mL) at -78°C was condensed liquid ammonia (5 mL). The pressure tube was sealed and the reaction was stirred at room temperature for 2 h. After cooling, the solvents were evaporated. Purification by flash chromatography, eluting with 4:96 methanol:dichloromethane, followed by trituration from dichloromethane-ether-hexanes, provided *cis*-[4-(2-aminopyrimidin-4-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)- cyclohexan-1-ol] as a white solid (0.19 g, 74%), mp 173-174°C. Anal. ($C_{24}H_{29}N_3O_3 \cdot 0.25\ H_2O$) calcd: C, 69.96; H, 7.22; N, 10.20; found: C, 69.66; H, 7.10; N, 10.11.

Example 20

cis-[4-(2-aminopyrimidin-5-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.20 g, 0.64 mmol) and and 2-amino-5-bromopyrimidine (0.55 g, 3.2 mmol) in piperidine (2 mL) under an argon atmosphere were added tetrakis(triphenyl-phosphine)palladium(0) (0.030 g, 4%), copper(I) iodide (0.006 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h. Water was added and the mixture was extracted three times with dichloromethane, was dried (potassium carbonate) and was evaporated. Purification by two successive flash chromatographies, eluting first with 5:95 methanol:dichloromethane, then with 3:97 methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-aminopyrimidin-5-ylethynyl) cyclohexan-1-ol] as a tan-brown solid (0.076 g, 29%), mp 136-137°C. Anal. ($C_{24}H_{29}N_3O_3 \cdot 0.75\ H_2O$) calcd: C, 68.47; H, 7.30; N, 9.98; found: C, 68.25; H, 7.09; N, 9.78.

Example 21

cis-[4-(thiazol-2-ylethynyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.15 g, 0.48 mmol) and and 2-bromothiazole (0.20 mL, 2.4 mmol) in triethylamine (1.5 mL) under an argon atmosphere were added tetrakis(triphenyl phosphine)palladium(0) (0.022 g, 4%), copper(I) iodide (0.006 g, 6%) and a small.

crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 1 h. Ammonium chloride was added and the mixture was extracted three times with dichloromethane, dried (magnesium sulfate), and evaporated. Purification by two successive flash chromatographies, eluting first with 6:4 ethyl acetate:hexanes, then with 2:98 methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-aminopyrimidin-5-ylethynyl) cyclohexan-1-ol] as an off-white foam (0.13 g, 68%), mp 45-48°C. Anal. ($C_{23}H_{27}NO_3S \cdot 0.5\ H_2O$) calcd: C, 67.95; H, 6.94; N, 3.45; found: C, 67.91; H, 6.76; N, 3.39.

Example 22

trans-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine]

22a) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexyl-1-amine]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (1.0 g, 3.18 mmol), phthalimide (0.70 g, 4.77 mmol) and triphenylphosphine (1.25 g, 4.77 mmol) in tetrahydrofuran (32 mL) was dropwise added diethyl azodicarboxylate (0.75 mL, 4.77 mmol), and the solution was stirred under an argon atmosphere at room temperature for 2 h. Evaporation and purification by flash chromatography, eluting with 2:8 ethyl acetate hexanes, provided the intermediate phthalimide (1.43 g) as a waxy white solid, mp 45-52°C. This was dissolved in 2:1 ethanol:tetrahydrofuran (30mL), was treated with hydrazine hydrate (1.55 mL, 32 mmol) and was stirred under an argon atmosphere at room temperature for 4 days. Water was added and the mixture was extracted three times with 10:90 methanol:dichloromethane, was dried (potassium carbonate) and was evaporated. Purification by flash chromatography, eluting with 0.5:5:95 ammonium hydroxide:methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexyl-1-amine] as a colorless oil (0.71 g, 72%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.17 (d, J=2.2 Hz, 1H), 7.09 (dd, J=8.5, 2.2 Hz, 1H), 6.82 (d, J=8.5 Hz, 1H), 4.81 (m, 1H), 3.82 (s, 3 H), 3.26 (br s, 1H), 2.36 (s, 1H), 2.1-2.2 (m, 4 H), 1.8 - 2.0 (m, 10 H), 1.6, (m, 2H) ppm.

22b) *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexane]

A mixture of *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexyl-1-amine] (0.55 g, 1.75 mmol) and di-*tert*.-butyldicarbonate (0.42 g, 1.93mmol) in dichloromethane (8mL) was stirred 20 h and was evaporated. Purification by flash chromatography, eluting with 2:8 ethyl acetate:hexanes provided, *cis* -[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexane] as a colorless oil (0.70 g, 97%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.13 (d, J=2.2 Hz, 1H), 7.02(dd, J=8.5, 2.2 Hz, 1H), 6.84 (d, J=8.5 Hz, 1H), 4.81 (m, 1H), 4.64 (m, 1 H),3.84 (s, 3 H), 2.36 (s, 1H), 2.05 (m, 2 H), 1.6 - 2.0 (m, 14 H), 1.45, (s, 9 H) ppm.

22c) *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl-cyclohexane]

To a solution of *cis* -[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexane] (0.35 g, 0.85 mmol) and 2-bromopyridine (0.80 mL, 8.5 mmol) in piperidine (2.5 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.039 g, 4%), copper(I) iodide (0.010 g, 6%)

and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h in the dark. Water was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 25:75 ethyl acetate:hexanes ,provided *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl-cyclohexane] as a light yellow solid (0.30 g, 72%), mp 69-70°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.57 (d, J=4 Hz, 1 H), 7.66 (dt, J=8, 4 Hz, 1 H), 7.42 (d, J=8 Hz, 1 H), 7.26 (br, 1 H), 7.17 (d, J=2.2 Hz, 1H), 7.09 (dd, J=8.5, 2.2 Hz, 1H), 6.85 (d, J=8.5 Hz, 1H), 4.82 (m, 1H), 4.64 (br s, 1 H), 3.85 (s, 3 H), 2.2 (m, 2H), 1.8 - 2.1 (m, 12 H), 1.6 (m, 2 H),1:45, (s, 9 H) ppm.

22d) *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine]

To a solution of *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynylcyclohexane] (0.30 g, 0.61mmol) in dichloromethane (5 mL) at 0°C under an argon atmosphere was added trifluoroacetic acid (0.60 mL, 7.89 mmol). The reaction was stirred at room temperature for 6 h, was cooled to 0°C, quenched with sodium bicarbonate, was diluted with water, was extracted with three times dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 0.7:7:93 ammonium hydroxide:methanol:dichloromethane provided *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine] as a very viscous oil (0.19 g, 82%). ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.59 (d, J=4 Hz, 1 H), 7.63 (dt, J=7.8, 4 Hz, 1 H), 7.41 (d, J=7.8 Hz, 1 H), 7.26 (m, 1 H), 7.22 (m, 2H), 6.81 (d, J=8.5 Hz, 1H), 4.84 (m, 1H), 3.81 (s, 3 H), 3.4 (br s, 1 H), 2.31 (m, 4H), 1.8 - 2.0 (m, 10 H), 1.6 (m, 2 H) ppm. Anal. ($C_{25}H_{30}N_2O_2 \cdot 0.5\ H_2O$) calcd: C, 75.16; H, 7.82; N, 7.01; found: C, 75.42; H, 7.77; N, 6.91.

Example 23

trans-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-formamide].

To a preparation of acetic formic anhydride (0.035 mL, 0.38 mmol) at 0°C under an argon atmosphere was added a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine] (0.096 g, 0.24 mmol) in

tetrahydrofuran (1.5 mL). The mixture was stirred for 3 h at room temperature, was diluted with dichloromethane, was washed with sodium bicarbonate and water, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatograhy, eluting with 5:95 methanol:dichloromethane, provided *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-formamide] (which contains a trace of acetamide) as a white foam (0.08 g, 79%), mp 75-76°C. Anal. ($C_{26}H_{30}N_2O_3 \cdot 0.375\ H_2O$) calcd: C, 73.43; H, 7.26; N, 6.59; found: C, 73.46; H, 7.29; N, 6.25.

Example 24

trans-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine], cyclohexylsulfamate salt(24a) 2-bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene

2-Bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene was prepared by standard chemistry well known to those versed in the art and is a white solid, mp 48-49°C.

24b) *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexane]

To a solution of *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexane] (0.30 g, 0.73 mmol) and 2-bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene (0.18 g, 0.73 mmol) in triethylamine (5 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.033 g, 4%) and copper(I) iodide (0.008 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 1 h. Water was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 2:8 ethyl acetate:hexanes, followed by trituration from dichloromethane-hexanes, provided *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexane] as a yellow foam (0.38 g), containing ~ 40 % of 1,4-*bis*-{[*t*-4-(3-cyclopentyloxy-4-methoxyphenyl)-*r*-1-cyclohexyl-1-amine]-4-yl}buta-1,3-diyne by ^{1}H-NMR.

24c) *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine], cyclohexylsulfamate salt

A solution of *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexane] (0.38 g, containing 40 % of the dimer) in dichloromethane (10 mL) at 0°C under an argon atmosphere was treated with trifluoroacetic acid (0.50 mL, 6.5 mmol) and the mixture was stirred for 24 h at room temperature. The solution was quenched with sodium bicarbonate at 0°C, was diluted with water, was extracted three times with 10:90 methanol:dichloromethane, was dried (potassium carbonate) and was

evaporated. Purification by flash chromatogaphy, eluting with 0.5:5:95 ammonium hydroxide:methanol:dichloromethane, provided *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine] as a glassy solid (0.18 g, 59 %). This was dissolved in acetone (0.5 mL) and added to a solution of cyclohexylsulfamic acid (0.066 g, 0.37 mmol) in acetone (0.5 mL). The salt was isolated and the free amine was recovered. A second chromatography using the same solvent system provided free amine (0.048 g), which was treated with cyclohexylsulfamic acid (0.018 g, 0.10 mmol) in acetone (1 mL). After the addition of ether (20 mL), the precipitate was filtered off to provide *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine], cyclohexylsulfamate salt (0.043 g, 18%) as a white solid, mp 134-135°C. Anal. ($C_{33}H_{44}N_4O_6S_2 \cdot 0.5\ H_2O$) calcd: C, 59.52; H, 6.81; N, 8.41; found: C, 59.37; H, 6.71; N, 8.46.

Example 25

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine]

25a) *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexane]

A solution of 4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-one (0.82g, 2.63 mmol), ammonium acetate (2.03 g, 26 mmol), sodium cyanoborohydride (0.17 g, 2.63 mmol) and several 4Å molecular sieves in methanol (10 mL) was stirred under an argon atmosphere at room temperature for 3 days. Several crystals of methyl orange were added, then hydrogen chloride-saturated methanol to ~ pH 3. The reaction was made basic with sodium hydroxide (10 %), was extracted with 10:90 methanol:dichloromethane, was dried (potassium carbonate) and was evaporated to provide crude *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexyl-1-amine] as a yellow oil (0.88 g, 100 %). A solution of the intermediate in dichloromethane (15 mL) was treated with di-*tert*.-butyldicarbonate (0.63g, 2.89 mmol), was stirred 5 h and was evaporated. Purification by flash chromatography, eluting with 15: 85 ethyl acetate:hexanes, provided *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexane] as a white foam (0.57 g, 53%, ^{1}H-NMR shows ~ 20 % *cis* isomer), mp.39-43°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 7.11 (d, J=2.2 Hz, 1H), 7.04 (dd, J=8.5, 2.2 Hz, 1H), 6.82 (d, J=8.5 Hz, 1H), 4.80 (m, 1H), 4.6 (m, 0.2 H), 4.5 (m, 0.8 H), 4.0 (m, 0.2 H), 3.84 (s, 0.6 H), 3.83 (s, 2.4 H), 2.43 (s, 0.8 H), 2.36 (s, 0.2 H), 1.6 - 2.1 (m, 16 H), 1.46, (s, 9 H) ppm.

25b) *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynylcyclohexane

To a solution of *trans*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynylcyclohexane] (0.45 g, 1.09 mmol) and 2-bromopyridine (1.0

mL, 11 mmol) in piperidine (3 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.050 g, 4%), copper(I) iodide (0.012 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 0.5 h in the dark. Water was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatography, eluting with 2:8 ethyl acetate:hexanes, provided *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynylcyclohexane] as a yellow foam (0.41 g, 78%, contains ~ 35 % trans isomer by ^{1}H-NMR), mp 40-43°C. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.4 (m , 1 H), 7.65 (m, 1 H), 7.4 (d, 1 H), 7.1 (m, 3 H), 6.85 (m, 1 H), 4.8 (m, 1H), 4.6 (m, 0.65 H), 3.85 (s, 1 H), 3.84 (s, 2 H), 3.55 (m. 0.65 H), 1.5 - 2.2 (m, 16 H), 1.45, (s, 9 H) ppm.

25c) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine]

To a solution of *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynylcyclohexane] (0.41 g, 0.84 mmol) in dichloromethane (5 mL) at 0°C under an argon atmosphere was added trifluoroacetic acid (0.65 mL, 8.4 mmol). The reaction was stirred at room temperature for 20 h, was cooled to 0°C, was quenched with sodium bicarbonate, was diluted with water, was extracted twice with 10:90 methanol:dichloromethane, was dried (potassium carbonate) and was evaporated. Purification by flash chromatography, eluting with 0.5:5:95 ammonium hydroxide:methanol:dichloromethane, followed by trituration from ether, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine] as a white solid (0.23 g, 69%, containing ~ 20 % of the *trans* isomer), mp 78-80°C. Anal. ($C_{25}H_{30}N_2O_2$) calcd: C, 66.06; H, 6.65; N, 6.16; found: C, 65.73; H, 6.96; N, 5.98.

Example 26

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-formamide]

To a preparation of acetic formic anhydride (0.057 mL, 0.64 mmol) at 0°C under an argon atmosphere was added a solution of *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-amine] (0.16 g, 0.40 mmol) in tetrahydrofuran (1.5 mL). The mixture was stirred for 3 h at room temperature, was diluted with dichloromethane, was washed with sodium bicarbonate and water, was dried (magnesium sulfate) and was evaporated. Purification by flash chromatograhy, eluting with 5:95 methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-pyridylethynyl)cyclohexyl-1-formamide] (which contains a trace of acetamide) as a white foam (0.08 g, 79%), mp 80-81°C. Anal. ($C_{26}H_{30}N_2O_3 \cdot 0.375\ H_2O$) calcd: C, 73.43; H, 7.26; N, 6.59; found: C, 73.46; H, 7.29; N, 6.25.

Example 29

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexyl-1-amine], cyclohexylsulfamate salt

29a) 2-bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene

2-Bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene was prepared by standard chemistry well known to those versed in the art and is a white solid, mp 48-49°C.

29b) *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl] cyclohexane]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexyl-1-amine] (0.21 g, 0.52 mmol) and 2-bromo-5-(5-methyl-[1,2,4]oxadiazol-2-yl)thiophene (0.13 g, 0.52 mmol) in triethylamine (5 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium(0) (0.024 g, 4%), copper(I) iodide (0.006 g, 6%) and a small crystal of triphenylphosphine, and the mixture was heated at 80-85°C for 1 h. Ammonium chloride was added and the mixture was extracted three times with dichloromethane, was dried (magnesium sulfate) and was evaporated. Purification by two successive flash chromatographies, eluting first with 2:8 ethyl acetate:hexanes, then with 2:8 acetone:hexanes, provided *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexane] as a white foam (0.20 g, 69%, contains ~ 20 % dimer impurity by ^{1}H-NMR), mp 60-68°C .

29c) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine], cyclohexylsulfamate salt

A solution of *cis*-[1-*tert*-butoxycarbonylamino-4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexane] (0.21 g, containing 20 % of the dimer) in dichloromethane (5 mL) at 0°C under an argon atmosphere was treated with trifluoroacetic acid (0.28 mL, 3.6 mmol) and was stirred 24 h at room temperature. The solution was quenched with sodium bicarbonate at 0°C, was diluted with water, was extracted three times with 10:90 methanol:dichloromethane, was dried (potassium carbonate) and was evaporated. Purification by flash chromatogaphy, eluting with 0.3:3:97 ammonium hydroxide:methanol:dichloromethane, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine] as a colorless glass (0.11 g, 0.24 mmol, 69%). This intermediate was dissolved in acetone (0.5 mL) and was added to a solution of cyclohexylsulfamic acid (0.045 g, 0.24 mmol) in acetone (1 mL). After the addition of ether, the precipitate was filtered off to provide *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-[5-(5-methyl-[1,2,4]oxadiazol-2-yl)thien-2-ylethynyl]cyclohexyl-1-amine], cyclohexylsulfamate salt

(0.14 g, 58%) as a white solid, mp 152-154°C. Anal. ($C_{33}H_{44}N_4O_6S_2$) calcd: C, 60.34; H, 6.75; N, 8.53; found: C, 60.01; H, 6.63; N, 8.32.

Example 30

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(3-methyl[1,2,4]oxadiazol-5-yl)phenyl]ethynyl)cyclohexan-1-ol],

30a) 5-(3-iodophenyl)-3-methyl[1,2,4]oxadiazole

5-(3-Iodophenyl)-3-methyl[1,2,4]oxadiazole was prepared by standard chemistry well known to those versed in the art and is a white solid, mp 102-103 °C.

30b) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(3-methyl[1,2,4]oxadiazol-5-yl)phenyl]ethynyl)cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.11 g, 0.35 mmol) and 5-(3-iodophenyl)-3-methyl[1,2,4]oxadiazole (0.15 g, 0.52 mmol) in triethylamine (4 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium (0.017 g, 0.015 mmol), copper(I) iodide (0.004 g, 0.021 mmol) and a small crystal of triphenylphosphine. After heating the mixture at 70°C for 1.5 h., the reaction was quenched by addition of aqueous ammonium chloride solution, and the solvent was concentrated. The mixture was extracted three times with methylene chloride, and the organic phase was washed with water, was dried (sodium sulfate) and was evaporated. Purification by flash chromatography, eluting with 45:55 ethyl acetate:hexanes and crystallizing from ethyl ether, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(3-methyl[1,2,4]oxadiazol-5-yl)phenyl]ethynyl)cyclohexan-1-ol] as a white solid (0.144 g, 87%), mp 71.5-73.5 °C. Anal. ($C_{29}H_{32}N_2O_4$) calcd: C, 73.71; H, 6.83, N, 5.93 found: C, 73.60; H, 6.91, N, 5.76.

Example 31

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,3,4]oxadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol],

31a) 2-(3-iodophenyl)-5-methyl[1,3,4]oxadiazole

2-(3-Iodophenyl)-5-methyl[1,3,4]oxadiazole was prepared by standard chemistry well known to those versed in the art and is a white solid, mp 112-113.5 °C.

31b) *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,3,4]oxadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol]

To a solution of *trans*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-ethynyl-cyclohexan-1-ol] (0.125 g, 0.40 mmol) and 2-(3-iodophenyl)-5-methyl[1,3,4]oxadiazole (0.171 g, 0.60 mmol) in triethylamine (7 mL) under an argon atmosphere were added tetrakis(triphenylphosphine)palladium (0.020 g, 0.017 mmol), copper(I) iodide (0.0042 g, 0.022 mmol) and a small crystal of triphenylphosphine. After heating the mixture at 75°C for 1.75 h, the reaction was quenched by addition of aqueous ammonium chloride solution, and the solvent was concentrated. The mixture

was extracted three times with methylene chloride, and the organic phase was washed with water, was dried (sodium sulfate) and was evaporated. Purification by flash chromatography, eluting with 40 to 50% ethyl acetate in methylene chloride and crystallizing from ethyl ether, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,3,4]oxadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol] as a white solid (0.119 g, 63%), mp 117.5-119 °C. Anal. ($C_{29}H_{32}N_2O_4 \cdot 1/8H_2O$) calcd: C, 73.36; H, 6.85, N, 5.90 found: C, 73.25; H, 6.94, N, 5.75. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.12 (s , 1H), 7.98 (d-d, J=1.4 Hz;J=7.9 Hz, 1H), 7.60 (d-d, J=1.3 Hz, J=7.8 Hz, 1H), 7.46 (t, J=7.8 Hz, 1H), 7.19 (d, J=2.2, 1H), 7.10 (d-d, J=2.1 Hz, J=8.5 Hz, 1H), 6.85 (d, J=8.5 Hz, 1H), 4.81 (p, J=4.3 Hz, 1H), 3.85 (s, 3H), 3.73 (m, 1H), 2.63 (s, 3H), 2.2-1.8 (m, 14H), 1.7-1.5 (m, 7H with H_2O).

Example 32

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-ol].

To a solution of 4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-one (0.084 g, 0.18 mmol, prepared as described in co-pending application P50283 filed on even date herewith) in 1,2-dimethoxyethane (3 mL) under an argon atmosphere was added dropwise a solution of sodium borohydride (0.015 g, 0.40 mmol) in 1,2-dimethoxyethane (5 mL). After 2 h stirring at room temperature, the reaction was quenched by addition of aqueous ammonium chloride solution. The solvent was concentrated and the residue was extracted into methylene chloride, was washed with water, was dried (sodium sulfate) and was evaporated. Purification by flash chromatography, eluting with 35% ethyl acetate in hexanes and crystallizing from ethyl ether, provided *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-ol] as a white solid (0.050 g, 58%), mp 101-103 °C. Anal. ($C_{29}H_{32}N_2O_4.1/5H_2O$) calcd: C, 73.15; H, 6.86, N, 5.88 found: C, 73.1F; H, 6.85, N, 5.85. ^{1}H-NMR (400 MHz, $CDCl_3$) δ 8.18 (s , 1H), 8.00 (d, J=7.9 Hz, 1H), 7.58 (d, J=7.8 Hz, 1H), 7.43 (t, J=7.8 Hz, 1H), 7.19 (d, J=2.2, 1H), 7.10 (d-d, J=2.1 Hz, J=8.5 Hz, 1H), 6.85 (d, J=8.5 Hz, 1H), 4.82 (p, J=4.3 Hz, 1H), 3.85 (s, 3H), 3.72 (m, 1H), 2.67 (s, 3H), 2.2-1.8 (m, 13H), 1.7-1.5 (m, 6H with H_2O).

The other compounds of this invention may be prepared by proceeding in a similar manner, but substituting the appropriate starting materials and intermediates for those recited in this Example. Examples are:

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-ol],

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(3-trifluoromethyl[1,2,4]oxadiazol-5-yl)phenyl]ethynyl)cyclohexan-1-ol],

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,3,4]oxadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol], and

cis-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-trifluoromethyl[1,3,4]thiadiazol-2-yl)phenyl]ethynyl)cyclohexan-1-ol].

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

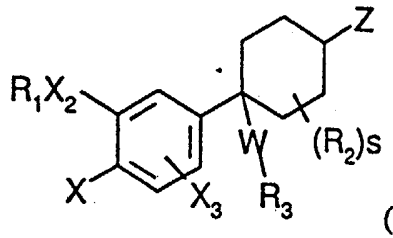
Isolation of PDE Isozymes

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 $-(CR_4R_5)_nC(O)O(CR_4R_5)_mR_6$, $-(CR_4R_5)_nC(O)NR_4(CR_4R_5)_mR_6$, $-(CR_4R_5)_nO(CR_4R_5)_mR_6$, or $-(CR_4R_5)_rR_6$ wherein the alkyl moieties unsubstituted or substituted with one or more halogens;

m is 0 to 2;

n is 1 to 4;

r is 0 to 6;

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

R_6 is 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 YR_2, fluorine, NR_4R_5, or formyl amine;

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

m' is 0, 1, or 2;

X_2 is O or NR_8;

X_3 is hydrogen or X;

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

R_2 is independently selected from $-CH_3$ or $-CH_2CH_3$ optionally substituted by 1 or more halogens;

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;

R_3 is $COOR_{14}$, $C(O)NR_4R_{14}$ or R_7;

Z is OR_{14}, OR_{15}, SR_{14}, $S(O)_{m'}R_7$, $S(O)_2NR_{10}R_{14}$, $NR_{10}R_{14}$, $NR_{14}C(O)R_9$, $NR_{10}C(Y')R_{14}$, $NR_{10}C(O)OR_7$, $NR_{10}C(Y')NR_{10}R_{14}$, $NR_{10}S(O)_2NR_{10}R_{14}$, $NR_{10}C(NCN)NR_{10}R_{14}$, $NR_{10}S(O)_2R_7$, $NR_{10}C(CR_4NO_2)NR_{10}R_{14}$, $NR_{10}C(NCN)SR_9$, $NR_{10}C(CR_4NO_2)SR_9$, $NR_{10}C(NR_{10})NR_{10}R_{14}$, $NR_{10}C(O)C(O)NR_{10}R_{14}$,or $NR_{10}C(O)C(O)OR_{14}$;

Y' is 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, $-NO_2$, $-NR_{10}R_{11}$, $-C(O)R_8$, $-CO_2R_8$, $-O(CH_2)_{2-4}OR_8$, $-O(CH_2)_qR_8$, -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 R_{13}, $(CH_2)_q$, C_3-C_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 C_{1-4} alkyl optionally substituted by one to three fluorines;

R_{10} is OR_8 or R_{11};

R_{11} is hydrogen, or C_{1-4} alkyl unsubstituted or 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 one or more additional heteroatoms selected from O, N, or S;

R_{13} is 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 each may be unsubstituted or substituted by one or two C_{1-2} alkyl groups unsubstituted or substituted on the methyl with 1 to 3 fluoro atoms;

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;

provided that:

(f) R_7 is not C_{1-4} alkyl unsubstituted or substituted by one to three fluorines;

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; and R_2 is CF_2H or methyl, W is acetylene or 1,3-butadiynyl, and R_3 is $C(O)OR_{14}$, or R_7.

3. A compound which is

cis-[4-[(2-aminopyrimidin-5-yl)ethynyl]-4-(3-cyclopentyloxy-4-methoxyphenyl)-cyclohexan-1-ol] or, *cis*-[4-(3-cyclopentyloxy-4-methoxyphenyl)-4-(2-[3-(5-methyl[1,2,4]oxadiazol-3-yl)phenyl]ethynyl)cyclohexan-1-ol].

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