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(54) **Title:** SUBSTITUTED PYRAZOLE AZETIDINES AS SPHINGOSINE RECEPTOR MODULATORS

(57) **Abstract:** The present invention relates to substituted pyrazole azetidines, processes for preparing them, pharmaceutical compositions containing them and their use as pharmaceuticals as modulators of sphingosine-1-phosphate receptors.



SUBSTITUTED PYRAZOLE AZETIDINES AS SPHINGOSINE RECEPTOR MODULATORS

By inventors: Janet A. Takeuchi, Ling Li, Ken Chow and Wha-Bin Im

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RELATED APPLICATIONS

This application claims the benefit of United States Provisional Patent Application Serial No. 61/764,751 filed February 14, 2013, the disclosure of which is hereby incorporated in its entirety herein by reference.

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FIELD OF THE INVENTION

The present invention relates to substituted pyrazole azetidines, processes for preparing them, pharmaceutical compositions containing them and their use as pharmaceuticals as modulators of sphingosine-1-phosphate receptors. The invention also relates to the use of these compounds and their pharmaceutical compositions to treat disorders associated with sphingosine-1-phosphate (S1P) receptor modulation.

15

BACKGROUND OF THE INVENTION

Sphingosine-1 phosphate is stored in relatively high concentrations in human platelets, which lack the enzymes responsible for its catabolism, and it is released into the blood stream upon activation of physiological stimuli, such as growth factors, cytokines, and receptor agonists and antigens. It may also have a critical role in platelet aggregation and thrombosis and could aggravate cardiovascular diseases. On the other hand the relatively high concentration of the metabolite in high-density lipoproteins (HDL) may have beneficial implications for atherogenesis. For example, there are recent suggestions that sphingosine-1-phosphate, together with other lysolipids such as sphingosylphosphorylcholine and lysosulfatide, are responsible for the beneficial clinical effects of HDL by stimulating the production of the potent antiatherogenic signaling molecule nitric oxide by the vascular endothelium. In addition, like lysophosphatidic acid, it is a marker for certain types of cancer, and there is evidence that its role in cell division or

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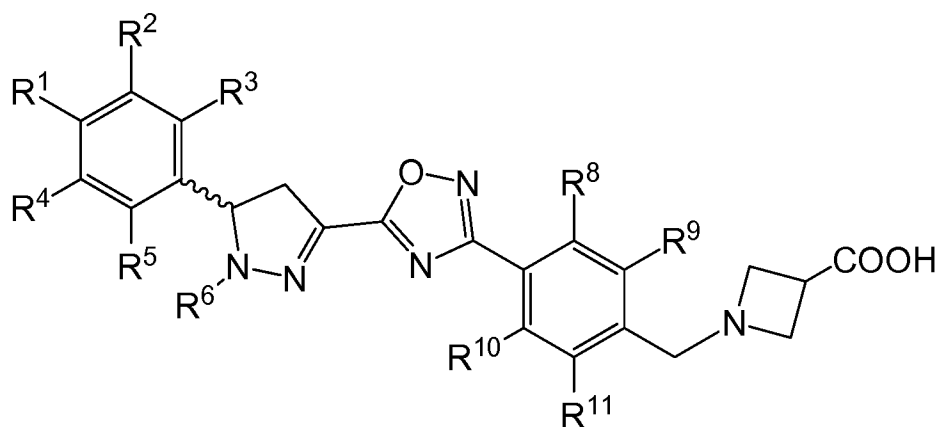
proliferation may have an influence on the development of cancers. These are currently topics that are attracting great interest amongst medical researchers, and the potential for therapeutic intervention in sphingosine-1-phosphate metabolism is under active investigation.

5

SUMMARY OF THE INVENTION

We have now discovered a group of novel compounds which are potent sphingosine-1-phosphate modulators. As such, the compounds described herein are useful in treating a wide variety of disorders associated with modulation of sphingosine-1-phosphate receptors. The term “modulator” as used herein, includes but is not limited to: receptor agonist, antagonist, inverse agonist, inverse antagonist, partial agonist, partial antagonist. This invention describes compounds of **Formula I**, which have sphingosine-1-phosphate receptor biological activity. The compounds in accordance with the present invention are thus of use in medicine, for example in the treatment of humans with diseases and conditions that are alleviated by S1P modulation.

In one embodiment of the invention, there are provided compounds having the **Formula I** below and pharmaceutically accepted salts thereof, its enantiomers, diastereoisomers, hydrates, solvates, crystal forms and individual isomers, tautomers or a pharmaceutically acceptable salt thereof,



Formula I

wherein:

R^1 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^2 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

5 R^3 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^4 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

10 R^5 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^6 is H, optionally substituted C_{6-10} aryl, optionally substituted heterocycle or optionally substituted C_{1-6} alkyl;

R^7 is H, OH or optionally substituted C_{1-6} alkyl;

15 R^8 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^9 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^{10} is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

20 R^{11} is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^{12} is H or optionally substituted C_{1-6} alkyl;

R^{13} is H or optionally substituted C_{1-6} alkyl; and

R^{14} is H or optionally substituted C_{1-6} alkyl.

25 In another embodiment, the invention provides a compound having **Formula I** wherein

R^1 is H, halogen or optionally substituted C_{1-6} alkyl;

R^2 is H, halogen or optionally substituted C_{1-6} alkyl;

R^3 is H, halogen or optionally substituted C_{1-6} alkyl;

30 R^4 is H, halogen or optionally substituted C_{1-6} alkyl;

R^5 is H, halogen or optionally substituted C_{1-6} alkyl;

R^6 is optionally substituted C_{1-6} alkyl;

R⁸ is H, halogen or optionally substituted C₁₋₆ alkyl;
R⁹ is H, halogen or optionally substituted C₁₋₆ alkyl;
R¹⁰ is H, halogen or optionally substituted C₁₋₆ alkyl; and
R¹¹ is H, halogen or optionally substituted C₁₋₆ alkyl.

5 In another embodiment, the invention provides a compound having **Formula I** wherein

R¹ is H or optionally substituted C₁₋₆ alkyl;
R² is H or optionally substituted C₁₋₆ alkyl;
R³ is H or optionally substituted C₁₋₆ alkyl;
10 R⁴ is H or optionally substituted C₁₋₆ alkyl;
R⁵ is H or optionally substituted C₁₋₆ alkyl;
R⁶ is C₁₋₃alkyl;
R⁸ is H or halogen;
R⁹ is H or halogen;
15 R¹⁰ is H or halogen; and
R¹¹ is H or halogen.

In another embodiment, the invention provides a compound having **Formula I** wherein

R¹ is H;
20 R² is H;
R³ is H;
R⁴ is H;
R⁵ is H;
R⁶ is methyl, ethyl or n-propyl;
25 R⁸ is H;
R⁹ is H or halogen;
R¹⁰ is H or halogen; and
R¹¹ is H or halogen.

In another embodiment, the invention provides a compound having **Formula I**
30 wherein

5 R¹ is H;
 R² is H;
 R³ is H;
 R⁴ is H;
 R⁵ is H;
 R⁶ is methyl, ethyl or n-propyl;
 R⁸ is H;
 R⁹ is H or F;
 10 R¹⁰ is H or F; and
 R¹¹ is H or F.

The term "alkyl", as used herein, refers to saturated, monovalent hydrocarbon moieties having linear or branched moieties or combinations thereof and containing 1 to 6 carbon atoms. One methylene (-CH₂-) group, of
 15 the alkyl can be replaced by oxygen, sulfur, sulfoxide, nitrogen, carbonyl, carboxyl, sulfonyl, or by a divalent C₃₋₆ cycloalkyl. Alkyl groups can be substituted by halogen, amino, hydroxyl, cycloalkyl, amino, carboxylic acid, phosphonic acid groups, sulphonic acid groups, phosphoric acid.

The term "heterocycle" as used herein, refers to a 3 to 10
 20 membered ring, which can be aromatic or non-aromatic, saturated or non-saturated, containing at least one heteroatom selected from O or N or S or combinations of at least two thereof, interrupting the carbocyclic ring structure. Heterocycle can be monocyclic or polycyclic. The heterocyclic ring can be interrupted by a C=O; the S heteroatom can be oxidized. Heterocyclic ring
 25 moieties can be substituted by halogen, -SC₁₋₆ alkyl, -S(O)₂C₁₋₆ alkyl, -S(O)C₁₋₆ alkyl, sulfonamide, amide, nitro, cyano, -OC₁₋₆ alkyl, -C₁₋₆ alkyl, -C₂₋₆ alkenyl, -C₂₋₆ alkynyl, ketone, amine, C₃₋₈ cycloalkyl, aldehydes, esters, carboxylic acid, phosphonic acid, sulfonic acid or hydroxyl groups.

The term "aryl" as used herein, refers to an organic moiety derived from
 30 an aromatic hydrocarbon consisting of a ring containing 6 to 10 carbon atoms by removal of one hydrogen. Aryl can be monocyclic or polycyclic. Aryl can be

substituted by halogen, -SC₁₋₆ alkyl, -S(O)₂C₁₋₆ alkyl, -S(O)C₁₋₆ alkyl, sulfonamide, amide, nitro, cyano, -OC₁₋₆ alkyl, -C₁₋₆ alkyl, -C₂₋₆ alkenyl, -C₂₋₆ alkynyl, ketone, amine, C₃₋₈ cycloalkyl, aldehyde, ester, carboxylic acid, phosphonic acid, sulfonic acid or hydroxyl groups. Usually aryl is phenyl.

5 Preferred substitution site on aryl are meta and para positions.

The term "cycloalkyl", as used herein, refers to a monovalent or divalent group of 3 to 8 carbon atoms, derived from a saturated cyclic hydrocarbon. Cycloalkyl groups can be monocyclic or polycyclic. Cycloalkyl can
10 be substituted by 1 to 3 C₁₋₃ alkyl groups or 1 or 2 halogens.

The term "halogen", as used herein, refers to an atom of chlorine, bromine, fluorine, iodine.

The term "hydroxyl" as used herein, represents a group of formula
"OH".

15 The term "carbonyl" as used herein, represents a group of formula "C=O".

The term "carboxyl" as used herein, represents a group of formula "C(O)O-".

20 The term "sulfonyl" as used herein, represents a group of formula "SO₂".

The term "sulfate" as used herein, represents a group of formula "O-S(O)₂O-".

The term "carboxylic acid" as used herein, represents a group of formula "C(O)OH".

25 The term "sulfoxide" as used herein, represents a group of formula "S=O".

The term "phosphonic acid" as used herein, represents a group of formula "P(O)(OH)₂".

30 The term "phosphoric acid" as used herein, represents a group of formula "(O)P(O)(OH)₂".

The term "sulphonic acid" as used herein, represents a group of formula "S(O)₂OH".

The term "amino" as used herein, represents a group of formula " NH_2 ".

The formula "H", as used herein, represents a hydrogen atom.

The formula "O", as used herein, represents an oxygen atom.

5 The formula "N", as used herein, represents a nitrogen atom.

The formula "S", as used herein, represents a sulfur atom.

The formula "F", as used herein, represents a fluorine atom.

Compounds of the invention are:

10 1-{2-ethyl-4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;

1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-2,6-difluorobenzyl}azetidine-3-carboxylic acid;

15 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-3-fluorobenzyl}azetidine-3-carboxylic acid;

1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;

1-{4-[5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;

20 1-{4-[5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid.

Some compounds of Formula I and some of their intermediates have at least one stereogenic center in their structure. This stereogenic center may be present in an R or S configuration, said R and S notation is used in correspondence with the rules described in Pure Appl. Chem. (1976), 45, 11-13.

The term "pharmaceutically acceptable salts" refers to salts or complexes that retain the desired biological activity of the above identified compounds and exhibit minimal or no undesired toxicological effects. The "pharmaceutically acceptable salts" according to the invention include

therapeutically active, non-toxic base or acid salt forms, which the compounds of Formula I are able to form.

The acid addition salt form of a compound of Formula I that
5 occurs in its free form as a base can be obtained by treating the free base with an appropriate acid such as an inorganic acid, for example, an inorganic acid, such as hydrochloric acid, hydrobromic acid, sulfuric acid, phosphoric acid, nitric acid and the like; or an organic acid such as for example, acetic, hydroxyacetic, propanoic, lactic, pyruvic, malonic, fumaric acid, maleic acid,
10 oxalic acid, tartaric acid, succinic acid, malic acid, ascorbic acid, benzoic acid, tannic acid, pamoic acid, citric, methylsulfonic, ethanesulfonic, benzenesulfonic, formic and the like (Handbook of Pharmaceutical Salts, P.Heinrich Stahl & Camille G. Wermuth (Eds), Verlag Helvetica Chimica Acta-Zürich, 2002, 329-345).

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Compounds of Formula I and their salts can be in the form of a solvate, which is included within the scope of the present invention. Such solvates include for example hydrates, alcoholates and the like.

20 With respect to the present invention reference to a compound or compounds, is intended to encompass that compound in each of its possible isomeric forms and mixtures thereof unless the particular isomeric form is referred to specifically.

Compounds according to the present invention may exist in
25 different polymorphic forms. Although not explicitly indicated in the above formula, such forms are intended to be included within the scope of the present invention.

The compounds of the invention are indicated for use in treating
30 or preventing conditions in which there is likely to be a component involving the sphingosine-1-phosphate receptors.

In another embodiment, there are provided pharmaceutical compositions including at least one compound of the invention in a pharmaceutically acceptable carrier.

5 In a further embodiment of the invention, there are provided methods for treating disorders associated with modulation of sphingosine-1-phosphate receptors. Such methods can be performed, for example, by administering to a subject in need thereof a pharmaceutical composition containing a therapeutically effective amount of at least one compound of the
10 invention.

These compounds are useful for the treatment of mammals, including humans, with a range of conditions and diseases that are alleviated by S1P modulation: not limited to the treatment of diabetic retinopathy, other
15 retinal degenerative conditions, dry eye, angiogenesis and wounds.

Therapeutic utilities of S1P modulators are ocular diseases, such as but not limited to: wet and dry age-related macular degeneration, diabetic retinopathy, retinopathy of prematurity, retinal edema, geographic atrophy,
20 glaucomatous optic neuropathy, chorioretinopathy, hypertensive retinopathy, ocular ischemic syndrome, prevention of inflammation-induced fibrosis in the back of the eye, various ocular inflammatory diseases including uveitis, scleritis, keratitis, and retinal vasculitis; or systemic vascular barrier related diseases such as but not limited to: various inflammatory diseases, including
25 acute lung injury, its prevention, sepsis, tumor metastasis, atherosclerosis, pulmonary edemas, and ventilation-induced lung injury; or autoimmune diseases and immunosuppression such as but not limited to: rheumatoid arthritis, Crohn's disease, Graves' disease, inflammatory bowel disease, multiple sclerosis, Myasthenia gravis, Psoriasis, ulcerative colitis, autoimmune
30 uveitis, renal ischemia/perfusion injury, contact hypersensitivity, atopic dermatitis, and organ transplantation; or allergies and other inflammatory diseases such as but not limited to: urticaria, bronchial asthma, and other

airway inflammations including pulmonary emphysema and chronic obstructive pulmonary diseases; or cardiac protection such as but not limited to: ischemia reperfusion injury and atherosclerosis; or wound healing such as but not limited to: scar-free healing of wounds from cosmetic skin surgery, ocular surgery, GI surgery, general surgery, oral injuries, various mechanical, heat and burn injuries, prevention and treatment of photoaging and skin ageing, and prevention of radiation-induced injuries; or bone formation such as but not limited to: treatment of osteoporosis and various bone fractures including hip and ankles; or anti-nociceptive activity such as but not limited to: visceral pain, pain associated with diabetic neuropathy, rheumatoid arthritis, chronic knee and joint pain, tendonitis, osteoarthritis, neuropathic pains; or central nervous system neuronal activity in Alzheimer's disease, age-related neuronal injuries; or in organ transplant such as renal, corneal, cardiac or adipose tissue transplant; inflammatory skin diseases, scleroderma, dermatomyositis, atopic dermatitis, lupus erythematosus, epidermolysis bullosa, and bullous pemphigoid. Topical use of S1P (sphingosine) compounds is of use in the treatment of various acne diseases, acne vulgaris, and rosacea.

In still another embodiment of the invention, there are provided methods for treating disorders associated with modulation of sphingosine-1-phosphate receptors. Such methods can be performed, for example, by administering to a subject in need thereof a therapeutically effective amount of at least one compound of the invention, or any combination thereof, or pharmaceutically acceptable salts, hydrates, solvates, crystal forms and individual isomers, enantiomers, and diastereomers thereof.

The present invention concerns the use of a compound of Formula I or a pharmaceutically acceptable salt thereof, for the manufacture of a medicament for the treatment of ocular disease, wet and dry age-related macular degeneration, diabetic retinopathy, retinopathy of prematurity, retinal edema, geographic atrophy, glaucomatous optic neuropathy, chorioretinopathy, hypertensive retinopathy, ocular ischemic syndrome, prevention of

inflammation-induced fibrosis in the back of the eye, various ocular inflammatory diseases including uveitis, scleritis, keratitis, and retinal vasculitis; or systemic vascular barrier related diseases , various inflammatory diseases, including acute lung injury, its prevention, sepsis, tumor metastasis, 5 atherosclerosis, pulmonary edemas, and ventilation-induced lung injury; or autoimmune diseases and immunosuppression , rheumatoid arthritis, Crohn's disease, Graves' disease, inflammatory bowel disease, multiple sclerosis, Myasthenia gravis, Psoriasis, ulcerative colitis, autoimmune uveitis, renal ischemia/perfusion injury, contact hypersensitivity, atopic dermatitis, and organ 10 transplantation; or allergies and other inflammatory diseases , urticaria, bronchial asthma, and other airway inflammations including pulmonary emphysema and chronic obstructive pulmonary diseases; or cardiac protection , ischemia reperfusion injury and atherosclerosis; or wound healing, scar-free healing of wounds from cosmetic skin surgery, ocular surgery, GI surgery, 15 general surgery, oral injuries, various mechanical, heat and burn injuries, prevention and treatment of photoaging and skin ageing, and prevention of radiation-induced injuries; or bone formation, treatment of osteoporosis and various bone fractures including hip and ankles; or anti-nociceptive activity , visceral pain, pain associated with diabetic neuropathy, rheumatoid arthritis, 20 chronic knee and joint pain, tendonitis, osteoarthritis, neuropathic pains; or central nervous system neuronal activity in Alzheimer's disease, age-related neuronal injuries; or in organ transplant such as renal, corneal, cardiac or adipose tissue transplant; inflammatory skin diseases, scleroderma, dermatomyositis, atopic dermatitis, lupus erythematosus, epidermolysis 25 bullosa, and bullous pemphigoid.

The actual amount of the compound to be administered in any given case will be determined by a physician taking into account the relevant circumstances, such as the severity of the condition, the age and weight of the 30 patient, the patient's general physical condition, the cause of the condition, and the route of administration.

The patient will be administered the compound orally in any acceptable form, such as a tablet, liquid, capsule, powder and the like, or other routes may be desirable or necessary, particularly if the patient suffers from nausea. Such other routes may include, without exception, transdermal, 5 parenteral, subcutaneous, intranasal, via an implant stent, intrathecal, intravitreal, topical to the eye, back to the eye, intramuscular, intravenous, and intrarectal modes of delivery. Additionally, the formulations may be designed to delay release of the active compound over a given period of time, or to carefully control the amount of drug released at a given time during the course of 10 therapy.

In another embodiment of the invention, there are provided pharmaceutical compositions including at least one compound of the invention in a pharmaceutically acceptable carrier thereof. The phrase "pharmaceutically 15 acceptable" means the carrier, diluent or excipient must be compatible with the other ingredients of the formulation and not deleterious to the recipient thereof.

Pharmaceutical compositions of the present invention can be used in the form of a solid, a solution, an emulsion, a dispersion, a patch, a micelle, a liposome, and the like, wherein the resulting composition contains 20 one or more compounds of the present invention, as an active ingredient, in admixture with an organic or inorganic carrier or excipient suitable for enteral or parenteral applications. Invention compounds may be combined, for example, with the usual non-toxic, pharmaceutically acceptable carriers for tablets, pellets, capsules, suppositories, solutions, emulsions, suspensions, and any 25 other form suitable for use. The carriers which can be used include glucose, lactose, gum acacia, gelatin, mannitol, starch paste, magnesium trisilicate, talc, corn starch, keratin, colloidal silica, potato starch, urea, medium chain length triglycerides, dextrans, and other carriers suitable for use in manufacturing preparations, in solid, semisolid, or liquid form. In addition auxiliary, stabilizing, 30 thickening and coloring agents and perfumes may be used. Invention compounds are included in the pharmaceutical composition in an amount sufficient to produce the desired effect upon the process or disease condition.

Pharmaceutical compositions containing invention compounds may be in a form suitable for oral use, for example, as tablets, troches, lozenges, aqueous or oily suspensions, dispersible powders or granules, emulsions, hard
5 or soft capsules, or syrups or elixirs. Compositions intended for oral use may be prepared according to any method known in the art for the manufacture of pharmaceutical compositions and such compositions may contain one or more agents selected from the group consisting of a sweetening agent such as sucrose, lactose, or saccharin, flavoring agents such as peppermint, oil of
10 wintergreen or cherry, coloring agents and preserving agents in order to provide pharmaceutically elegant and palatable preparations. Tablets containing invention compounds in admixture with non-toxic pharmaceutically acceptable excipients may also be manufactured by known methods. The excipients used may be, for example, (1) inert diluents such as calcium
15 carbonate, lactose, calcium phosphate or sodium phosphate; (2) granulating and disintegrating agents such as corn starch, potato starch or alginic acid; (3) binding agents such as gum tragacanth, corn starch, gelatin or acacia, and (4) lubricating agents such as magnesium stearate, stearic acid or talc. The tablets may be uncoated or they may be coated by known techniques to delay
20 disintegration and absorption in the gastrointestinal tract and thereby provide a sustained action over a longer period. For example, a time delay material such as glyceryl monostearate or glyceryl distearate may be employed.

In some cases, formulations for oral use may be in the form of hard gelatin
25 capsules wherein the invention compounds are mixed with an inert solid diluent, for example, calcium carbonate, calcium phosphate or kaolin. They may also be in the form of soft gelatin capsules wherein the invention compounds are mixed with water or an oil medium, for example, peanut oil, liquid paraffin or olive oil.

30 The pharmaceutical compositions may be in the form of a sterile injectable suspension. This suspension may be formulated according to known methods using suitable dispersing or wetting agents and suspending agents. The sterile

injectable preparation may also be a sterile injectable solution or suspension in a non-toxic parenterally-acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil may be employed including synthetic mono- or diglycerides, fatty acids (including oleic acid), naturally occurring vegetable oils like sesame oil, coconut oil, peanut oil, cottonseed oil, etc., or synthetic fatty vehicles like ethyl oleate or the like. Buffers, preservatives, antioxidants, and the like can be incorporated as required.

Pharmaceutical compositions containing invention compounds may be in a form suitable for topical use, for example, as oily suspensions, as solutions or suspensions in aqueous liquids or nonaqueous liquids, or as oil-in-water or water-in-oil liquid emulsions. Pharmaceutical compositions may be prepared by combining a therapeutically effective amount of at least one compound according to the present invention, or a pharmaceutically acceptable salt thereof, as an active ingredient with conventional ophthalmically acceptable pharmaceutical excipients and by preparation of unit dosage suitable for topical ocular use. The therapeutically efficient amount typically is between about 0.001 and about 5% (w/v), preferably about 0.001 to about 2.0% (w/v) in liquid formulations.

For ophthalmic application, preferably solutions are prepared using a physiological saline solution as a major vehicle. The pH of such ophthalmic solutions should preferably be maintained between 4.5 and 8.0 with an appropriate buffer system, a neutral pH being preferred but not essential. The formulations may also contain conventional pharmaceutically acceptable preservatives, stabilizers and surfactants. Preferred preservatives that may be used in the pharmaceutical compositions of the present invention include, but are not limited to, benzalkonium chloride, chlorobutanol, thimerosal, phenylmercuric acetate and phenylmercuric nitrate. A preferred surfactant is, for example, Tween 80. Likewise, various preferred vehicles may be used in the ophthalmic preparations of the present invention. These vehicles include, but are not limited to, polyvinyl alcohol, povidone, hydroxypropyl methyl

cellulose, poloxamers, carboxymethyl cellulose, hydroxyethyl cellulose cyclodextrin and purified water.

Tonicity adjustors may be added as needed or convenient. They include, but are not limited to, salts, particularly sodium chloride, potassium chloride, mannitol and glycerin, or any other suitable ophthalmically acceptable tonicity adjustor.

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

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

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

The ingredients are usually used in the following amounts:

Ingredient	Amount (% w/v)
active ingredient	about 0.001 to about 5
preservative	0-0.10
vehicle	0-40
tonicity adjustor	0-10
buffer	0.01-10
pH adjustor	q .s. pH 4.5-7.8
antioxidant	as needed
surfactant	as needed
purified water	to make 100%

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

5 The ophthalmic formulations of the present invention are conveniently packaged in forms suitable for metered application, such as in containers equipped with a dropper, to facilitate application to the eye. Containers suitable for drop wise application are usually made of suitable inert, non-toxic plastic material, and generally contain between about 0.5 and about 15 ml solution.

10 One package may contain one or more unit doses. Especially preservative-free solutions are often formulated in non-resalable containers containing up to about ten, preferably up to about five units doses, where a typical unit dose is from one to about 8 drops, preferably one to about 3 drops. The volume of one drop usually is about 20-35 μ l.

15 Invention compounds may also be administered in the form of suppositories for rectal administration of the drug. These compositions may be prepared by mixing the invention compounds with a suitable non-irritating excipient, such as cocoa butter, synthetic glyceride esters of polyethylene

20 glycols, which are solid at ordinary temperatures, but liquefy and/or dissolve in the rectal cavity to release the drug.

 Since individual subjects may present a wide variation in severity of symptoms and each drug has its unique therapeutic characteristics, the

25 precise mode of administration and dosage employed for each subject is left to the discretion of the practitioner.

 The compounds and pharmaceutical compositions described herein are useful as medicaments in mammals, including humans, for treatment of

30 diseases and/or alleviations of conditions which are responsive to treatment by agonists or functional antagonists of sphingosine-1-phosphate receptors.

 Thus, in further embodiments of the invention, there are provided methods for

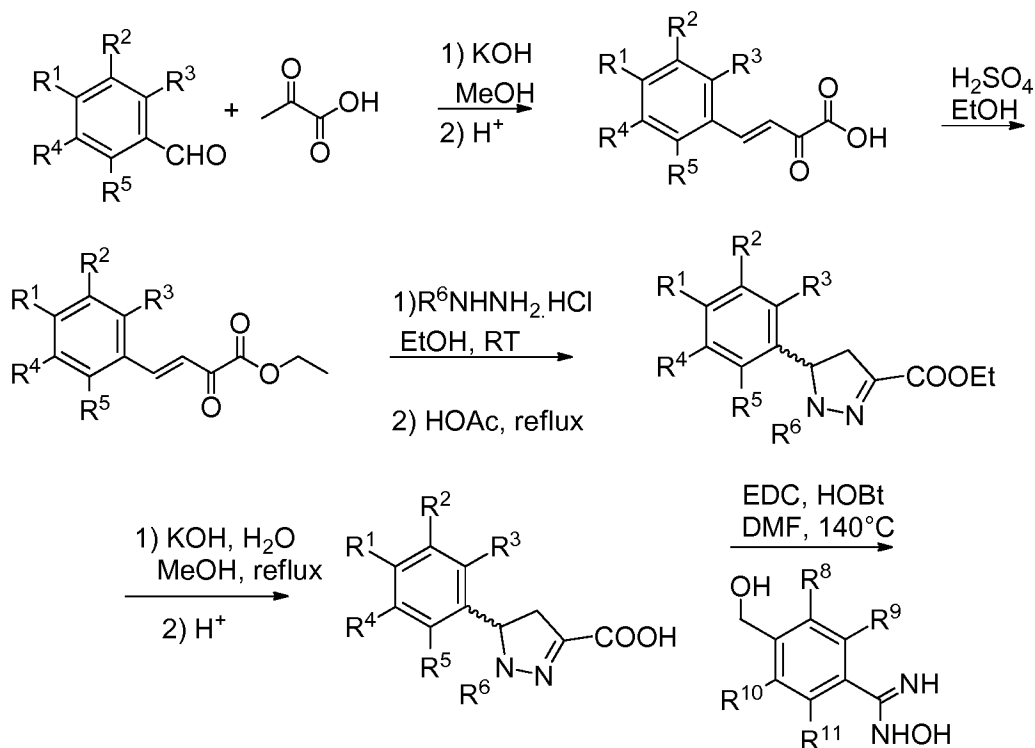
treating a disorder associated with modulation of sphingosine-1-phosphate receptors. Such methods can be performed, for example, by administering to a subject in need thereof a pharmaceutical composition containing a therapeutically effective amount of at least one invention compound. As used

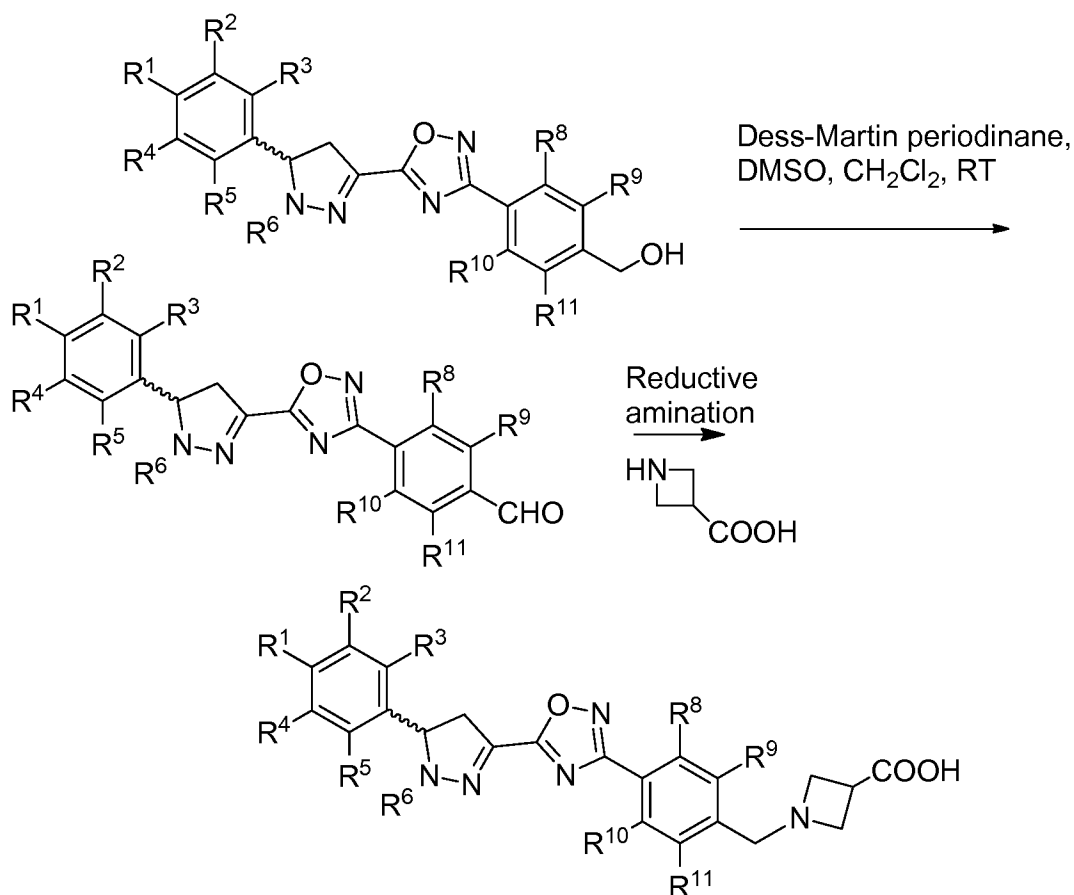
5 herein, the term "therapeutically effective amount" means the amount of the pharmaceutical composition that will elicit the biological or medical response of a subject in need thereof that is being sought by the researcher, veterinarian, medical doctor or other clinician. In some embodiments, the subject in need thereof is a mammal. In some embodiments, the mammal is human.

10

The present invention concerns also processes for preparing the compounds of Formula I. The compounds of Formula I according to the invention can be prepared analogously to conventional methods as understood by the person skilled in the art of synthetic organic chemistry. The synthetic

15 schemes set forth below, illustrate how compounds according to the invention can be made.

Scheme 1



The following abbreviations are used in **Scheme 1** and in the examples:

	RT	room temperature
5	CD ₃ OD	deuterated methanol
	CDCl ₃	deuterated chloroform
	MPLC	medium pressure liquid chromatography
	Na ₂ SO ₄	sodium sulfate
	DMSO	dimeythsulfonamide
10	EtOH	ethanol
	KOH	potassium hydroxide
	DMF	dimethylformamide
	MeOH	methanol
	HCl	hydrochloric acid
15	EtNHNH ₂ HCl	hydrazine

	SiO ₂	silicagel
	CH ₂ Cl ₂ or DCM	dichloromethane
	EDC	N-(3-dimethylaminopropyl)-N'-ethylcarbodiimide
	hydrochloride	
5	HOBt	1-hydroxybenzotriazole
	H ⁺	acid
	H ₂ SO ₄	sulfuric acid
	NaOH	sodium hydroxide

10 Those skilled in the art will be able to routinely modify and/or adapt the following scheme to synthesize any compounds of the invention covered by Formula I.

15 **DETAILED DESCRIPTION OF THE INVENTION**

 It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention claimed. As used herein, the use of the singular includes the plural unless specifically stated otherwise.

20 It will be readily apparent to those skilled in the art that some of the compounds of the invention may contain one or more asymmetric centers, such that the compounds may exist in enantiomeric as well as in diastereomeric forms. Unless it is specifically noted otherwise, the scope of the present invention includes all enantiomers, diastereomers and racemic
25 mixtures. Some of the compounds of the invention may form salts with pharmaceutically acceptable acids or bases, and such pharmaceutically acceptable salts of the compounds described herein are also within the scope of the invention.

30 The present invention includes all pharmaceutically acceptable isotopically enriched compounds. Any compound of the invention may contain one or more isotopic atoms enriched or different than the natural ratio such as

deuterium ^2H (or D) in place of protium ^1H (or H) or use of ^{13}C enriched material in place of ^{12}C and the like. Similar substitutions can be employed for N, O and S. The use of isotopes may assist in analytical as well as therapeutic aspects of the invention. For example, use of deuterium may increase the in vivo half-life by altering the metabolism (rate) of the compounds of the invention. These compounds can be prepared in accord with the preparations described by use of isotopically enriched reagents.

The following examples are for illustrative purposes only and are not intended, nor should they be construed as limiting the invention in any manner. Those skilled in the art will appreciate that variations and modifications of the following examples can be made without exceeding the spirit or scope of the invention.

As will be evident to those skilled in the art, individual isomeric forms can be obtained by separation of mixtures thereof in conventional manner. For example, in the case of diastereoisomeric isomers, chromatographic separation may be employed.

Compound names were generated with ACDLabs version 8.00 or 12.5 and in some cases Chem Bio Draw Ultra version 12.0; and Intermediates and reagent names used in the examples were generated with software such as ACD version 12.05, Chem Bio Draw Ultra version 12.0 or Auto Nom 2000 from MDL ISIS Draw 2.5 SP1.

In general, characterization of the compounds is performed according to the following methods:
NMR spectra are recorded on 300 and/or 600 MHz Varian and acquired at room temperature; or at 60 MHz on a Varian T-60 spectrometer or at 300 MHz on a Varian Inova system.
Chemical shifts are given in ppm referenced either to internal TMS or to the solvent signal.

All the reagents, solvents, catalysts for which the synthesis is not described are purchased from chemical vendors such as Sigma Aldrich, Fluka, Bio-Blocks, Combi-blocks, TCI, VWR, Lancaster, Oakwood, Trans World Chemical, Alfa, AscentScientific LLC., Fisher, Maybridge, Frontier, Matrix, Ukrorgsynth,
5 Toronto, Ryan Scientific, SiliCycle, Anaspec, Syn Chem, Chem-Impex, MIC-scientific, Ltd; however some known intermediates, were prepared according to published procedures.

Compounds of the invention were purified according to either of the following methods below:

10 Added amino modified silica gel to organic solution (MeOH/CHCl₃) and concentrated. Auto column on a silica gel-amine column with 70% MeOH, 0.5% acetic acid in dichloromethane gave product after removal of solvents, and drying under vacuum.

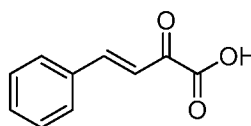
 Product titration with methanol, filtered, and washed with
15 methanol to give product after removal of solvents, and drying under vacuum.

 Column chromatography (Auto-column) on a Teledyne-ISCO CombiFlash with a silica column, unless noted otherwise.

Example 1

Intermediate 1

20 (E)-2-Oxo-4-phenylbut-3-enoic acid



In a 2L 3-necked flask equipped with a mechanical stirrer, dropping funnel and thermometer was placed benzaldehyde (119.8 g, 1.13 mol) and
25 pyruvic acid (99.44 g, 1.13 mol) in methanol (100 mL) under argon. The reaction mixture was cooled to 10 °C. A freshly prepared solution of potassium hydroxide (95.2 g, 1.7 mol) in methanol (350 mL) was added over 30 min. During the addition, the solution turned yellow and eventually a precipitate was formed. The reaction was allowed to warm to room temperature and was
30 placed in a refrigerator overnight. The granular solid in the flask was collected,

and was suspended over a cold mixture of methanol (500 mL) and ether (500 mL). After stirring for 1 hr, the solid was collected and dried in a dessicator under high vacuum to give 185 g of a solid. This solid was dissolved in water (1500 mL) and extracted with ethyl acetate (2 × 200 mL). The aqueous layer
5 was acidified with 3M HCl to pH 2 and extracted with dichloromethane (5 × 250 mL). The combined organic layers were washed with brine (2 × 250 mL), dried over magnesium sulfate (30 g) and concentrated under reduced pressure to give 84 g of **intermediate 1** as an oil which solidified (32%).

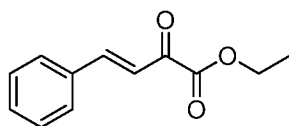
^1H NMR (60 MHz, CDCl_3): δ (ppm) 9.5 (s, 1H), 8.2-7.2 (m, 7H).

10

Example 2

Intermediate 2

(E)-Ethyl 2-oxo-4-phenylbut-3-enoate



15

A solution of **intermediate 1** (63.4 g, 0.36 mol) in 20% sulfuric acid in ethanol (500 mL, w/w) was stirred at room temperature overnight and then was concentrated under reduced pressure. Water (750 mL) was added to the residue and it was extracted with ethyl acetate (3 × 250 mL). The combined
20 organic layers were washed with saturated sodium bicarbonate (2 × 100 mL), brine (100 mL), dried over magnesium sulfate (15 g), and concentrated under reduced pressure to give 60 g of **intermediate 2** as a yellow oil (82%).

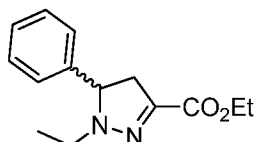
^1H NMR (60 MHz, CDCl_3): δ (ppm) 7.9-7.1 (m, 7H), 4.4 (q, 2H), 1.4 (t, 3H).

25

Example 3

Intermediate 3

5 Ethyl 1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazole-3-carboxylate



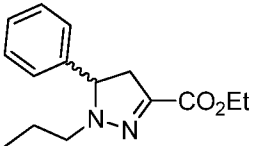
To a solution of **intermediate 2** (28.6 g, 0.14 mol) dissolved in ethanol
 10 (300 mL) ethyl hydrazide (21.0 g, 0.14 mol) was added. Acetic acid (100 mL)
 and 3M HCl in dioxane (35 mL) were added to produce a solution. The solution
 was heated to reflux for 1 hr then cooled to room temperature and
 concentrated. The residue was taken-up in ethyl acetate (250 mL) and washed
 with water (2x200 mL), saturated sodium bicarbonate (2x200 mL), and brine
 15 (200 mL). The organic layer was filtered with phase separation paper and
 concentrated to give an oil (35 g). The product was purified with a column of
 silica gel (500 g SiO₂, 30 g Na₂SO₄). It was eluted with 10% to give
intermediate 3 as an oil (17.3 g, 50%).

¹H NMR (60 MHz, CDCl₃): δ ppm 7.3 (s, 5H), 4.8-4.1 (m, 3H), 4.4-2.8
 20 (m, 4H), 1.4 (t, 3H), 1.2 (t, 3H).

Intermediates 4 and 5 were prepared from **Intermediate 2**, in a similar
 manner to the procedure described in **Example 3** for **Intermediate 3**. The
 results are tabulated below in **Table 1**.

25 **Table 1**

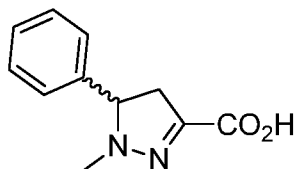
Interm. No.	Structure IUPAC Name	¹ H NMR δ (ppm)
		¹ H NMR (60 MHz, CDCl ₃): δ 7.3 (s, 5H), 4.4 (m, 1H), 4.3 (qt, 2H), 3.5-2.9 (m, 2H), 1.4

4	Ethyl 1-methyl-5-phenyl-4,5-dihydro-1H-pyrazole-3-carboxylate	(t, 3H).
5	 Ethyl 5-phenyl-1-propyl-4,5-dihydro-1H-pyrazole-3-carboxylate	¹ H NMR (60 MHz, CDCl ₃): δ 7.2 (s, 5H), 4.8-4.2 (m, 3H), 3.7-2.8 (m, 4H), 2.0-1.2 (m, 5H), 0.9 (t, 3H).

Example 4

Intermediate 6

5 1-Methyl-5-phenyl-4,5-dihydro-1H-pyrazole-3-carboxylic acid



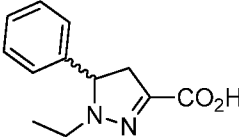
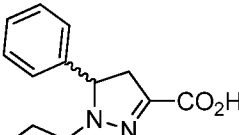
Potassium hydroxide (1.51 g, 27 mmol) was dissolved in water (10 mL) and a solution of **intermediate 4** (3.13 g, 13.5 mmol) in methanol (30 mL) was added. After 30 min, crushed ice (50 g) and water (50 mL) were added and the solution was acidified with 1 M HCl (40 mL). The precipitated solid was collected and washed with water (75 mL), then dried to a powder giving **intermediate 6** (2.65 g, 96%).

¹H NMR (60 MHz, CDCl₃): δ 7.9 (s, 1H), 7.2 (s, 5H), 4.6 (m, 1H), 3.5-2.9 (m, 2H), 3.0 (s, 3H).

15

Intermediates 7 and 8 were prepared from **Intermediates 3 or 5**, in a similar manner to the procedure described in **Example 4** for **Intermediate 6**. The results are tabulated below in **Table 2**.

Table 2

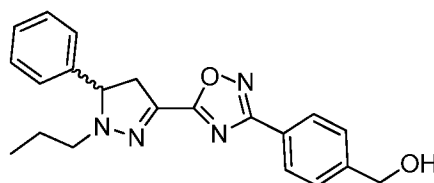
Interm. No.	Structure IUPAC Name	Interm. No.	¹ H NMR δ (ppm)
7	 1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazole-3-carboxylic acid	3	¹ H NMR (60 MHz, CDCl ₃): δ 8.3 (s, 1H), 7.0 (s, 5H), 4.5 (t, 1H), 3.3-2.7 (m, 4H), 1.1 (t, 3H).
8	 5-phenyl-1-propyl-4,5-dihydro-1H-pyrazole-3-carboxylic acid	5	¹ H NMR (60 MHz, CDCl ₃): δ 7.2 (s, 5H), 4.6 (t, 1H), 3.6-2.4 (m, 4H), 1.8-1.3 (m, 2H), 0.8 (t, 3H).

5 Example 5

Intermediate 9

(4-(5-(5-Phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)phenyl)methanol

10



15

To a solution of **intermediate 8** (3.2 g, 13.8 mmol) in DMF (40 mL) was added EDC (2.6 g, 13.8 mmol) and HOBt (2.1 g, 13.8 mmol). The solution was stirred for 30 min before N-hydroxy-4-(hydroxymethyl)benzimidamide (2.28 g, 13.8 mmol) was added and the solution was heated at 140 °C for 90 min. The solution was then cooled to room temperature and filtered to remove a small

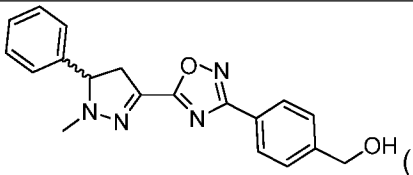
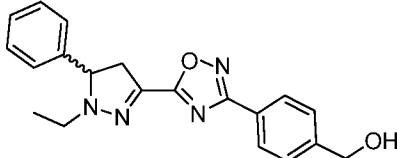
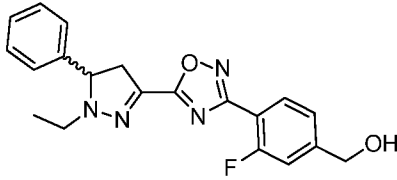
amount of insoluble material. The filtrate was slowly added to vigorously stirred ice water (200 mL) and a gooey precipitate formed. The water was decanted and the precipitate was rinsed with water (50 mL) then taken up in DCM (50 mL). The DCM layer was washed with brine (50 mL), filtered and concentrated to give an oil (3.8 g). The oil was purified with a column of silica gel (60 g SiO₂ gel, 30 g Na₂SO₄). The column was eluted with 35% ethyl acetate in hexanes to give **intermediate 9** as a viscous oil (3.2 g, 87%).

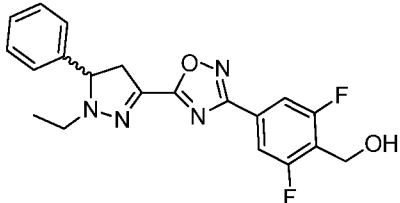
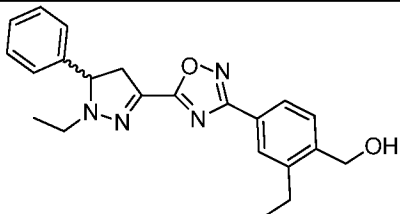
¹H NMR (60 MHz, CDCl₃): δ 8.0 (d, 2H), 7.4-7.0 (m, 7H), 4.-4.5 (m, 3H), 3.9-2.8 (m, 4H), 2.6 (bs, 1H), 2.0-1.3 (m, 2H), 0.9 (t, 3H).

10

Intermediates 10 through **14** were prepared from **Intermediates 6** or **7** in a similar manner to the procedure described in **Example 5** for **intermediate 14**. The results are tabulated below in **Table 3**.

Table 3

Interm. No.	Structure IUPAC Name	Interm. No.	¹ H NMR δ (ppm)
10	 4-(5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)phenylmethanol	6	¹ H NMR (60 MHz, CDCl ₃): δ 7.9 (d, 2H), 7.3 (d, 2H), 7.2 (s, 5H), 4.7 (m, 3H), 3.7-3.3 (m, 2H), 3.0 (s, 3H).
11	 (4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)phenyl)methanol	7	¹ H NMR (60 MHz, CDCl ₃): δ 7.9 (d, 2H), 7.2 (d, 2H), 7.1 (s, 5H), 4.7 (m, 3H), 3.7-3.2 (m, 4H), 2.6 (s, 1H), 1.2 (t, 3H).
12	 (4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)-2-fluorophenyl)methanol	7	¹ H NMR (60 MHz, CDCl ₃): δ 7.9 (t, 1H), 7.3 (m, 5H), 7.3-7.0 (m, 2H), 4.7 (m, 3H), 3.6-2.9 (m, 4H), 1.3 (t, 3H).

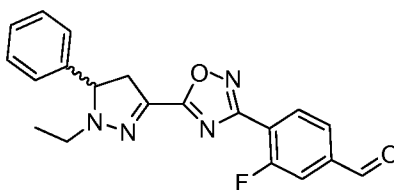
	dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)-3-fluorophenyl)methanol		
13	 (4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)-2,6-difluorophenyl)methanol	7	¹ H NMR (60 MHz, CDCl ₃): δ 7.7-7.3 (m, 7H), 5.0-4.8 (m, 3H), 3.6-3.2 (m, 4H), 1.3 (t, 3H).
14	 (2-ethyl-4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)phenyl)methanol	7	¹ H NMR (60 MHz, CDCl ₃): δ 8.0-7.8 (m, 2H), 7.6-7.2 (m, 6H), 4.9-4.8 (m, 4H), 4.4-2.4 (m, 5H), 1.3 (t, 3H).

Example 6

5

Intermediate 15

4-(5-(1-Ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)-3-fluorobenzaldehyde



10

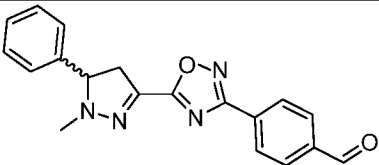
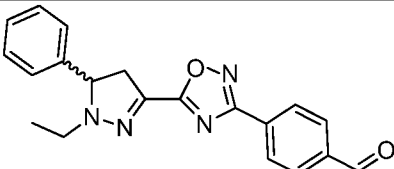
To a solution of alcohol **intermediate 12** (2.98 g, 8.2 mmol) in DCM (40 mL) at 5 °C was added a solution of Dess-Martin periodinane (3.8 g, 9.0 mmol)

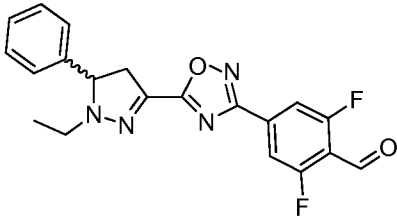
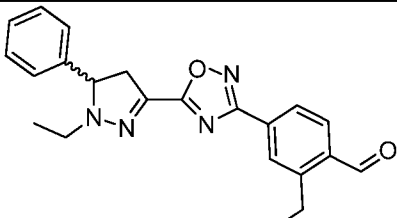
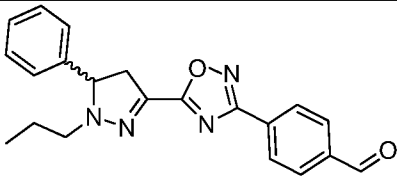
in DCM (60 mL) dropwise over 30 min. Thirty minutes after the addition the reaction was diluted with DCM (75 mL), washed with 1 M NaOH (3x75 mL) and brine (75 mL), filtered and concentrated to give an oil that solidified. The solid was triturated with 5% ethyl acetate in hexanes (25 mL, 30 min). The resulting tan solid was **intermediate 15** (1.95 g, 65%).

¹H NMR (300 MHz, CDCl₃): δ 10.1 (s, 1H), 8.3 (t, 1H), 7.8 (m, 2H), 7.4 (m, 5H), 4.8 (t, 1H), 3.7 (dd, 1H), 3.4 (m, 1H), 3.2 (m, 2H), 1.2 (t, 3H).

Intermediates 16 through 20 were prepared from **Intermediates 10** through **14**, in a similar manner to the procedure described in **Example 6** for **Intermediate 15**. The results are tabulated below in **Table 4**.

Table 4

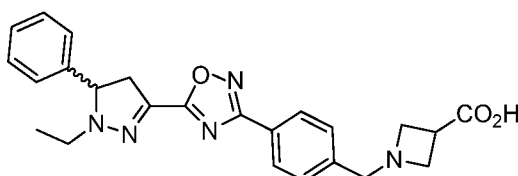
Interm. No.	Structure IUPAC Name	Interm. No.	¹ H NMR δ (ppm)
16	 4-(5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)benzaldehyde	10	¹ H NMR (300 MHz, CDCl ₃): δ 10.1 (s, 1H), 8.4 (d, 2H), 8.0 (d, 2H), 6.9 (m, 5H), 4.6 (t, 1H), 3.7 (dd, 1H), 3.2 (dd, 1H), 3.0 (s, 3H).
17	 4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)benzaldehyde	11	¹ H NMR (300 MHz, CDCl ₃): δ 10.1 (s, 1H), 8.4 (d, 2H), 8.0 (d, 2H), 7.8 (m, 5H), 4.6 (t, 1H), 3.6 (dd, 1H), 3.4 (m, 1H), 3.2 (m, 2H), 1.3 (t, 3H).
18		13	¹ H NMR (300 MHz, CDCl ₃): δ 10.2 (s, 1H), 7.6 (d, 2H), 7.2 (s, 5H), 4.7 (t, 1H), 3.6 (dd, 1H), 3.3 (m, 1H), 3.1 (m, 2H), 1.1 (t, 3H).

	 4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)-2,6-difluorobenzaldehyde		
19	 2-ethyl-4-(5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)benzaldehyde	14	¹ H NMR (300 MHz, CDCl ₃): δ 10.4 (s, 1H), 8.2 (d, 2H), 7.9 (d, 2H), 6.9 (s, 5H), 4.8 (t, 1H), 3.7 (dd, 1H), 3.4 (m, 1H), 3.2 (m, 4H), 1.3 (t, 3H), 1.2 (t, 3H).
20	 4-(5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl)benzaldehyde	9	¹ H NMR (300 MHz, CDCl ₃): δ 10.1 (s, 1H), 8.4 (d, 2H), 8.0 (d, 2H), 6.9 (m, 5H), 4.8 (t, 1H), 3.7 (dd, 1H), 3.2 (m, 3H), 1.6 (m, 2H), 0.8 (t, 3H)

Example 7

Compound 1

5

1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid

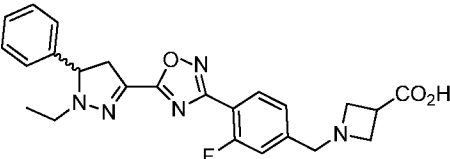
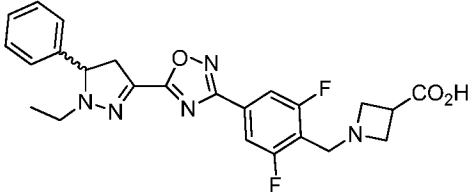
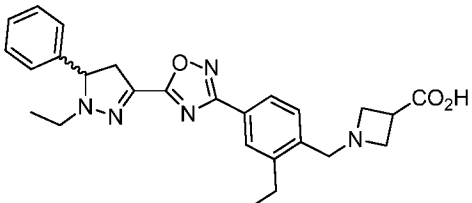
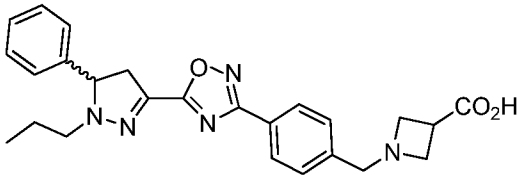
To a solution of **Intermediate 17** (91 mg, 0.26 mmol) in methanol (10 mL) was added 3-azetidinecarboxylic acid ([CAS 36476-78-5] 28 mg, 0.27 mmol). After the reaction mixture was stirred at RT for 2.5h, sodium borohydride (15 mg, 0.39 mmol) was added. After the mixture was stirred at RT for 1.5h, the mixture was concentrated and purified by MPLC (100% methanol in ethyl acetate) to give 47 mg of **Compound 1** as a colorless solid.

¹H NMR (600 MHz, CDCl₃) δ 7.95-8.05 (m, 2H), 7.36 (d, *J*=4.40 Hz, 7H), 4.67-4.76 (m, 1H), 3.80 (br. s., 2H), 3.59 (d, *J*=4.70 Hz, 5H), 3.26-3.39 (m, 1H), 3.02-3.21 (m, 3H), 1.18 (t, *J*=7.19 Hz, 3H)

Compounds 2 through **6** were prepared from **Intermediates 15** through **20**, in a similar manner to the procedure described in **Example 7** for **compound 1**. The results are tabulated below in **Table 5**.

Table 5

Cmpd No.	Structure IUPAC Name	Interm. No.	¹ H NMR δ (ppm)
2	 1-{4-[5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-	16	¹ H NMR (600 MHz, CDCl ₃) δ 7.95 (d, <i>J</i> =8.22 Hz, 2H), 7.35 (d, <i>J</i> =4.40 Hz, 4H), 7.27-7.32 (m, 3H), 4.47-4.53 (m, 1H), 3.47-3.65 (m, 5H),

	carboxylic acid		3.36 (br. s., 2H), 2.98-3.12 (m, 2H), 2.91-2.97 (m, 3H)
3	 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-3-fluorobenzyl}azetidine-3-carboxylic acid	15	¹ H NMR (600 MHz, CDCl ₃) δ 7.92 (t, <i>J</i> =7.63 Hz, 1H), 7.27-7.37 (m, 5H), 7.07-7.18 (m, 2H), 4.68-4.75 (m, 1H), 3.49-3.68 (m, 5H), 3.39 (br. s., 2H), 3.27-3.36 (m, 1H), 3.00-3.16 (m, 3H), 1.16 (t, <i>J</i> =7.19 Hz, 3H)
4	 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-2,6-difluorobenzyl}azetidine-3-carboxylic acid	18	¹ H NMR (600 MHz, CDCl ₃) δ 7.64 (d, <i>J</i> =7.63 Hz, 2H), 7.30-7.41 (m, 5H), 4.73-4.82 (m, 1H), 3.77 (br. s., 2H), 3.51-3.69 (m, 5H), 3.34-3.44 (m, 1H), 3.08-3.22 (m, 3H), 1.21 (s, 3H)
5	 1-{2-ethyl-4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid	19	¹ H NMR (600 MHz, CDCl ₃) δ 7.90 (s, 2H), 7.28-7.42 (m, 6H), 4.66-4.78 (m, 1H), 3.85 (br. s., 2H), 3.72-3.80 (m, 2H), 3.57-3.69 (m, 3H), 3.35 (dd, <i>J</i> =7.04, 13.50 Hz, 1H), 3.22 (br. s., 1H), 3.05-3.18 (m, 2H), 2.63 (d, <i>J</i> =7.34 Hz, 2H), 1.13-1.22 (m, 6H)
6	 1-{4-[5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid	20	¹ H NMR (600 MHz, CD ₃ OD) δ 8.07 (d, <i>J</i> =7.92 Hz, 2H), 7.52 (d, <i>J</i> =7.92 Hz, 2H), 7.37-7.45 (m, 4H), 7.32-7.37 (m, 1H), 4.78-4.86 (m, 1H), 4.03 (s, 2H), 3.87 (t, <i>J</i> =8.95 Hz, 2H), 3.75

	oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid		(t, $J=8.36$ Hz, 2H), 3.62-3.71 (m, 1H), 3.31 (dd, $J=1.76$, 2.64 Hz, 2H), 3.12 (m, 2H), 1.61-1.71 (m, 2H), 0.88 (t, $J=7.34$ Hz, 3H)
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Biological examples

5 **In vitro assay**

Compounds were tested for S1P1 activity using the GTP $\gamma^{35}\text{S}$ binding assay. These compounds may be assessed for their ability to activate or block activation of the human S1P1 receptor in cells stably expressing the S1P1 receptor.

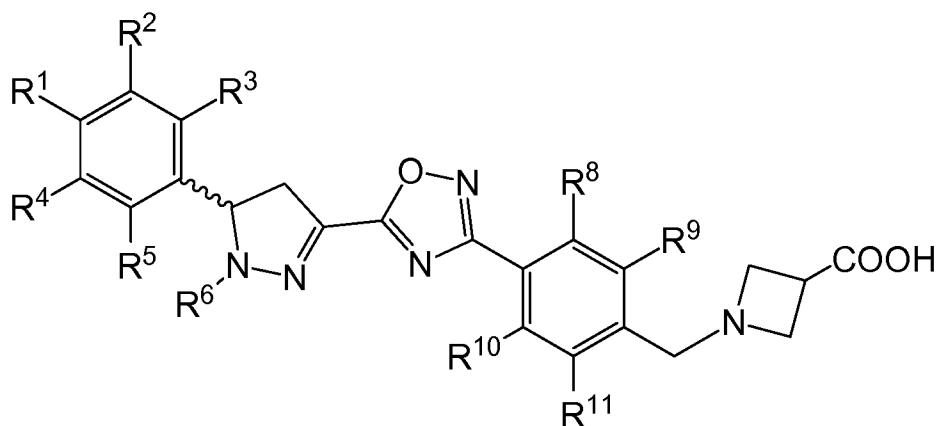
- 10 GTP $\gamma^{35}\text{S}$ binding was measured in the medium containing (mM) HEPES 25, pH 7.4, MgCl_2 10, NaCl 100, dithiothreitol 0.5, digitonin 0.003%, 0.2 nM GTP $\gamma^{35}\text{S}$, and 5 μg membrane protein in a volume of 150 μL . Test compounds were included in the concentration range from 0.08 to 5,000 nM unless indicated otherwise. Membranes were incubated with 100 μM 5'-
- 15 adenylylimidodiphosphate for 30 min, and subsequently with 10 μM GDP for 10 min on ice. Drug solutions and membrane were mixed, and then reactions were initiated by adding GTP $\gamma^{35}\text{S}$ and continued for 30 min at 25 °C. Reaction mixtures were filtered over Whatman GF/B filters under vacuum, and washed three times with 3 mL of ice-cold buffer (HEPES 25, pH7.4, MgCl_2 10 and NaCl
- 20 100). Filters were dried and mixed with scintillant, and counted for ^{35}S activity using a β -counter. Agonist-induced GTP $\gamma^{35}\text{S}$ binding was obtained by subtracting that in the absence of agonist. Binding data were analyzed using a non-linear regression method. In case of antagonist assay, the reaction mixture contained 10 nM S1P in the presence of test antagonist at
- 25 concentrations ranging from 0.08 to 5000 nM.

Table: Activity potency: S1P1 receptor from GTP $\gamma^{35}\text{S}$: nM, (EC_{50})

IUPAC name Structure	S1P1 EC_{50} (nM)
1-{4-[5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid	75
1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid	252
1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-2,6-difluorobenzyl}azetidine-3-carboxylic acid	51
1-{2-ethyl-4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid	24

What is claimed is:

1. A compound represented by Formula I, its enantiomers, diastereoisomers, tautomers, or a pharmaceutically acceptable salt thereof,



Formula I

wherein:

R^1 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^2 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^3 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^4 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^5 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^6 is H, optionally substituted C_{6-10} aryl, optionally substituted heterocycle or optionally substituted C_{1-6} alkyl;

R^7 is H, OH or optionally substituted C_{1-6} alkyl;

R^8 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R^9 is H, halogen or optionally substituted C_{1-6} alkyl, CN, NO_2 , $C(O)R^7$, $NR^{12}R^{13}$ or OR^{14} ;

R¹⁰ is H, halogen or optionally substituted C₁₋₆ alkyl, CN, NO₂, C(O)R⁷, NR¹²R¹³ or OR¹⁴;

R¹¹ is H, halogen or optionally substituted C₁₋₆ alkyl, CN, NO₂, C(O)R⁷, NR¹²R¹³ or OR¹⁴;

5 R¹² is H or optionally substituted C₁₋₆ alkyl;

R¹³ is H or optionally substituted C₁₋₆ alkyl; and

R¹⁴ is H or optionally substituted C₁₋₆ alkyl.

2. The compound according to claim 1 wherein:

10 R¹ is H, halogen or optionally substituted C₁₋₆ alkyl;

R² is H, halogen or optionally substituted C₁₋₆ alkyl;

R³ is H, halogen or optionally substituted C₁₋₆ alkyl;

R⁴ is H, halogen or optionally substituted C₁₋₆ alkyl;

R⁵ is H, halogen or optionally substituted C₁₋₆ alkyl;

15 R⁶ is optionally substituted C₁₋₆ alkyl;

R⁸ is H, halogen or optionally substituted C₁₋₆ alkyl;

R⁹ is H, halogen or optionally substituted C₁₋₆ alkyl;

R¹⁰ is H, halogen or optionally substituted C₁₋₆ alkyl; and

R¹¹ is H, halogen or optionally substituted C₁₋₆ alkyl.

20 3. The compound according to claim 1 wherein:

R¹ is H or optionally substituted C₁₋₆ alkyl;

R² is H or optionally substituted C₁₋₆ alkyl;

R³ is H or optionally substituted C₁₋₆ alkyl;

R⁴ is H or optionally substituted C₁₋₆ alkyl;

25 R⁵ is H or optionally substituted C₁₋₆ alkyl;

R⁶ is C₁₋₃alkyl;

R⁸ is H or halogen;

R⁹ is H or halogen;

R¹⁰ is H or halogen; and

30 R¹¹ is H or halogen.

4. The compound according to claim 1 wherein:

R¹ is H;

R² is H;

R³ is H;

5 R⁴ is H;

R⁵ is H;

R⁶ is methyl, ethyl or n-propyl;

R⁸ is H;

R⁹ is H or halogen;

10 R¹⁰ is H or halogen; and

R¹¹ is H or halogen.

5. The compound according to claim 1 wherein:

R¹ is H;

15 R² is H;

R³ is H;

R⁴ is H;

R⁵ is H;

R⁶ is methyl, ethyl or n-propyl;

20 R⁸ is H;

R⁹ is H or F;

R¹⁰ is H or F; and

R¹¹ is H or F.

25 6. The compound according to claim 1 selected from:

1-{2-ethyl-4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;

1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-2,6-difluorobenzyl}azetidine-3-carboxylic acid;

30 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-3-fluorobenzyl}azetidine-3-carboxylic acid;

- 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;
1-{4-[5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid; and
5 1-{4-[5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid.

7. A pharmaceutical composition comprising as active ingredient a therapeutically effective amount of a compound according to claim 1 and a
10 pharmaceutically acceptable adjuvant, diluents or carrier.

8. The pharmaceutical composition according to claim 7 wherein the compound is selected from:

- 1-{2-ethyl-4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;
15 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-2,6-difluorobenzyl}azetidine-3-carboxylic acid;
1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]-3-fluorobenzyl}azetidine-3-carboxylic acid;
20 1-{4-[5-(1-ethyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid;
1-{4-[5-(1-methyl-5-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid; and
1-{4-[5-(5-phenyl-1-propyl-4,5-dihydro-1H-pyrazol-3-yl)-1,2,4-oxadiazol-3-yl]benzyl}azetidine-3-carboxylic acid.

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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/016300

A. CLASSIFICATION OF SUBJECT MATTER
INV. C07D413/14 A61K31/4245
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07D A61K

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

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

EPO-Internal, BIOSIS, CHEM ABS Data, EMBASE, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 03/062252 A1 (MERCK & CO INC [US]; BUGIANESI ROBERT L [US]; DOHERTY GEORGE A [US]; G) 31 July 2003 (2003-07-31) Formula I; page 3, lines 27-31; claims 1,2,37 page 8, lines 9-10 page 11, lines 5-11 page 27, lines 7-9,19,26 -----	1-8
A	WO 2010/085584 A1 (SQUIBB BRISTOL MYERS CO [US]; DYCKMAN ALARIC J [US]; PITTS WILLIAM J []) 29 July 2010 (2010-07-29) Formula I; paragraphs [0001], [0010]; example 10; table 1 -----	1-8



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

24 March 2014

Date of mailing of the international search report

02/04/2014

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/016300

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		WO 2010085584 A1 29-07-2010	
