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1-(amino)indanes and (1,2-dihydro-3-amino)-benzofurans, benzothiophenes and indoles

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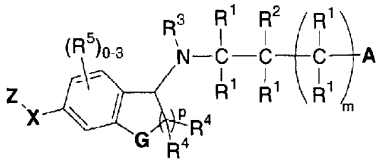
(54) Title: 1-(AMINO)INDANES AND (1,2-DIHYDRO-3-AMINO)-BENZOFURANS, BENZOTHIOPHENES AND INDOLES



(I)

(57) Abstract: The present invention encompasses compounds of Formula (I): as well as the pharmaceutically acceptable salts and hydrates thereof. The compounds are useful for treating immune mediated diseases and conditions, such as bone marrow, organ and tissue transplant rejection. Pharmaceutical compositions and methods of use are included.

TITLE OF THE INVENTION

1-(AMINO)INDANES AND (1,2-DIHYDRO-3-AMINO)-BENZOFURANS, BENZOTHIOPHENES AND INDOLES AS EDG RECEPTOR AGONISTS

BACKGROUND OF THE INVENTION

The present invention is related to compounds that are $S1P_1$/Edg1 receptor agonists and thus have immunosuppressive activities by modulating leukocyte trafficking, sequestering lymphocytes in secondary lymphoid tissues, and interfering with cell:cell interactions required for an efficient immune response. The invention is also directed to pharmaceutical compositions containing such compounds and methods of treatment or prevention.

Immunosuppressive agents have been shown to be useful in a wide variety of autoimmune and chronic inflammatory diseases, including systemic lupus erythematosis, chronic rheumatoid arthritis, type I diabetes mellitus, inflammatory bowel disease, biliary cirrhosis, uveitis, multiple sclerosis and other disorders such as Crohn's disease, ulcerative colitis, bullous pemphigoid, sarcoidosis, psoriasis, autoimmune myositis, Wegener's granulomatosis, ichthyosis, Graves ophthalmopathy, atopic dermatitis and asthma. They have also proved useful as part of chemotherapeutic regimens for the treatment of cancers, lymphomas and leukemias.

Although the underlying pathogenesis of each of these conditions may be quite different, they have in common the appearance of a variety of autoantibodies and/or self-reactive lymphocytes. Such self-reactivity may be due, in part, to a loss of the homeostatic controls under which the normal immune system operates. Similarly, following a bone-marrow or an organ transplantation, the host lymphocytes recognize the foreign tissue antigens and begin to produce both cellular and humoral responses including antibodies, cytokines and cytotoxic lymphocytes which lead to graft rejection.

One end result of an autoimmune or a rejection process is tissue destruction caused by inflammatory cells and the mediators they release. Anti-inflammatory agents such as NSAIDs act principally by blocking the effect or secretion of these mediators but do nothing to modify the immunologic basis of the disease. On the other hand, cytotoxic agents, such as cyclophosphamide, act in such a nonspecific fashion that both the normal and autoimmune responses are shut off. Indeed, patients treated with such nonspecific immunosuppressive agents are as likely to succumb to infection as they are to their autoimmune disease.

Cyclosporin A is a drug used to prevent rejection of transplanted organs. FK-506 is another drug approved for the prevention of transplant organ rejection, and in particular, liver transplantation. Cyclosporin A and FK-506 act by inhibiting the body's immune system from mobilizing its vast arsenal of natural protecting agents to reject the transplant's foreign protein. Cyclosporin A was approved for the treatment of severe psoriasis and has been approved by European regulatory agencies for the treatment of atopic dermatitis.

Though they are effective in delaying or suppressing transplant rejection, Cyclosporin A and FK-506 are known to cause several undesirable side effects including nephrotoxicity, neurotoxicity, and gastrointestinal discomfort. Therefore, an immunosuppressant without these side effects still remains to be developed and would be highly desirable.

The immunosuppressive compound FTY720 is a lymphocyte sequestration agent currently in clinical trials. FTY720 is metabolized in mammals to a compound that is a potent agonist of sphingosine 1-phosphate receptors. Agonism of sphingosine 1-phosphate receptors modulates leukocyte trafficking, induces the sequestration of lymphocytes (T-cells and B-cells) in lymph nodes and Peyer's patches without lymphodepletion, anddisrupts splenic architecture, thereby interfering with T cell dependent and independent antibody responses. Such immunosuppression is desirable to prevent rejection after organ transplantation and in the treatment of autoimmune disorders.

Sphingosine 1-phosphate is a bioactive sphingolipid metabolite that is secreted by hematopoietic cells and stored and released from activated platelets. Yatomi, Y., T. Ohmori, G. Rile, F. Kazama, H. Okamoto, T. Sano, K. Satoh, S. Kume, G. Tigyi, Y. Igarashi, and Y. Ozaki. 2000. *Blood.* 96:3431-8. It acts as an agonist on a family of G protein-coupled receptors to regulate cell proliferation, differentiation, survival, and motility. Fukushima, N., I. Ishii, J.J.A. Contos, J.A. Weiner, and J. Chun. 2001. Lysophospholipid receptors. Annu. Rev. Pharmacol. Toxicol. 41:507-34; Hla, T., M.-J. Lee, N. Ancellin, J.H. Paik, and M.J. Kluk. 2001. Lysophospholipids - Receptor revelations. *Science.* 294:1875-1878; Spiegel, S., and S. Milstien. 2000. Functions of a new family of sphingosine-1-phosphate receptors. *Biochim. Biophys. Acta.* 1484:107-16; Pyne, S., and N. Pyne. 2000. Sphingosine 1-phosphate signalling via the endothelial differentiation gene family of G-protein coupled receptors. *Pharm. & Therapeutics.* 88:115-131. Five sphingosine 1-phosphate receptors have been identified ($S1P_1$, $S1P_2$, $S1P_3$, $S1P_4$, and $S1P_5$, also known as endothelial differentiation genes Edg1, Edg5, Edg3, Edg6, Edg8), that have widespread cellular and tissue distribution and are well conserved in human and

rodent species (see Table). Binding to S1P receptors elicits signal transduction through Gq-, Gi/o, G12-, G13-, and Rho-dependent pathways. Ligand-induced activation of $S1P_1$ and $S1P_3$ has been shown to promote angiogenesis, chemotaxis, and adherens junction assembly through Rac- and Rho-, *see* Lee, M.-J., S. Thangada, K.P. Claffey, N. Ancellin, C.H. Liu, M. Kluk, M. Volpi, R.I. Sha'afi, and T. Hla. 1999. *Cell.* 99:301-12, whereas agonism of $S1P_2$ promotes neurite retraction, *see* Van Brocklyn, J.R., Z. Tu, L.C. Edsall, R.R. Schmidt, and S. Spiegel. 1999. *J. Biol. Chem.* 274:4626-4632, and inhibits chemotaxis by blocking Rac activation, *see* Okamoto, H., N. Takuwa, T. Yokomizo, N. Sugimoto, S. Sakurada, H. Shigematsu, and Y. Takuwa. 2000. *Mol. Cell. Biol.* 20:9247-9261. $S1P_4$ is localized to hematopoietic cells and tissues, *see* Graeler, M.H., G. Bernhardt, and M. Lipp. 1999. *Curr. Top. Microbiol. Immunol.* 246:131-6, whereas $S1P_5$ is primarily a neuronal receptor with some expression in lymphoid tissue, *see* Im, D.S., C.E. Heise, N. Ancellin, B.F. O'Dowd, G.J. Shei, R.P. Heavens, M.R. Rigby, T. Hla, S. Mandala, G. McAllister, S.R. George, and K.R. Lynch. 2000. *J. Biol. Chem.* 275:14281-6.

Administration of sphingosine 1-phosphate to animals induces systemic sequestration of peripheral blood lymphocytes into secondary lymphoid organs, thus resulting in therapeutically useful immunosuppression, *see* Mandala, S., R. Hajdu, J. Bergstrom, E. Quackenbush, J. Xie, J. Milligan, R. Thornton, G.-J. Shei, D. Card, C. Keohane, M. Rosenbach, J. Hale, C.L. Lynch, K. Rupprecht, W. Parsons, H. Rosen. 2002. *Science.* 296:346-349. However, sphingosine 1-phosphate also has cardiovascular and bronchoconstrictor effects that limit its utility as a therapeutic agent. Intravenous administration of sphingosine 1-phosphate decreases the heart rate, ventricular contraction and blood pressure in rats, *see* Sugiyama, A., N.N. Aye, Y. Yatomi, Y. Ozaki, and K. Hashimoto. 2000. *Jpn. J. Pharmacol.* 82:338-342. In human airway smooth muscle cells, sphingosine 1-phosphate modulates contraction, cell growth and cytokine production that promote bronchoconstriction, airway inflammation and remodeling in asthma, *see* Ammit, A.J., A.T. Hastie, L. C. Edsall, R.K. Hoffman, Y. Amrani, V.P. Krymskaya, S.A. Kane, S.P. Peters, R.B. Penn, S. Spiegel, R.A. Panettieri. Jr. 2001, *FASEB J.* 15:1212-1214. The undesirable effects of sphingosine 1-phosphate are associated with its non-selective, potent agonist activity on all S1P receptors.

The present invention encompasses compounds which are agonists of the $S1P_1$/Edg1 receptor having selectivity over the $S1P_3$/Edg3 receptor. An $S1P_1$/Edg1 receptor selective agonist has advantages over current therapies and extends the therapeutic window of

lymphocyte sequestration agents, allowing better tolerability with higher dosing and thus improving efficacy as monotherapy.

While the main use for immunosuppressants is in treating bone marrow, organ and transplant rejection, other uses for such compounds include the treatment of arthritis, in particular, rheumatoid arthritis, insulin and non-insulin dependent diabetes, multiple sclerosis, psoriasis, inflammatory bowel disease, Crohn's disease, lupus erythematosis and the like.

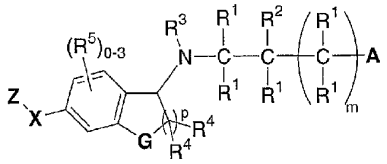
Thus, the present invention is focused on providing immunosuppressant compounds that are safer and more effective than prior compounds. These and other objects will be apparent to those of ordinary skill in the art from the description contained herein.

Summary of S1P receptors

Name	Synonyms	Coupled G proteins	mRNA expression
$S1P_1$	Edg1, LP_{B1}	$G_{i/o}$	Widely distributed, endothelial cells
$S1P_2$	Edg5, LP_{B2}, AGR16, H218	$G_{i/o}$, G_q, $G_{12/13}$	Widely distributed, vascular smooth muscle cells
$S1P_3$	Edg3, LP_{B3}	$G_{i/o}$, G_q, $G_{12/13}$	Widely distributed, endothelial cells
$S1P_4$	Edg6, LP_{C1}	$G_{i/o}$	Lymphoid tissues, lymphocytic cell lines
$S1P_5$	Edg8, LP_{B4}, NRG1	$G_{i/o}$	Brain, spleen

SUMMARY OF THE INVENTION

The present invention encompasses compounds of Formula I:



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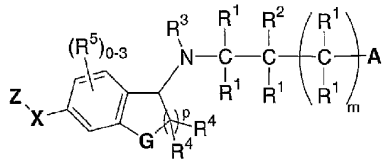
as well as the pharmaceutically acceptable salts and hydrates thereof. The compounds are useful for treating immune mediated diseases and conditions, such as bone marrow, organ and tissue transplant rejection. Pharmaceutical compositions and methods of use are included.

DETAILED DESCRIPTION OF THE INVENTION

The present invention encompasses compounds represented by Formula I:



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or a pharmaceutically acceptable salt or hydrate thereof, wherein:

m is 0 or 1;

p is 1, 2 or 3;

G is selected from the group consisting of $-C(R^4)_2-$, -O-, -S(O)k-, wherein k is 0, 1 or 2, and $-N(R^4)-$,

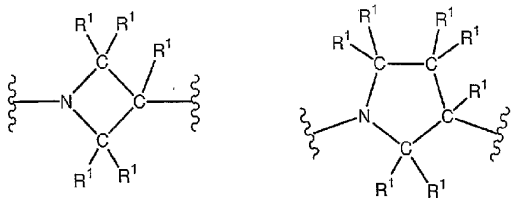
A is selected from the group consisting of: $-CO_2H$, $-PO_3H_2$, $-PO_2H$, $-SO_3H$, $-PO(C_{1-3}alkyl)OH$ and 1*H*-tetrazol-5-yl;

each R^1 is independently selected from the group consisting of: hydrogen, halo, hydroxy, C_{1-6}alkyl and C_{1-5}alkoxy, each C_{1-6}alkyl and C_{1-5}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy;

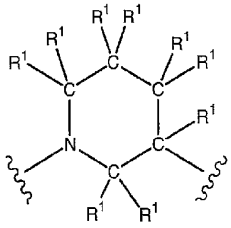
R^2 is selected from the group consisting of: hydrogen, halo, hydroxy, C_{1-6}alkyl and C_{1-5}alkoxy, said C_{1-6}alkyl and C_{1-5}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy;

R^3 is selected from the group consisting of: hydrogen and C_{1-4}alkyl, optionally substituted with from one up to the maximum number of substitutable positions with a substituent independently selected from the group consisting of: halo and hydroxy;

or R^2 and R^3 may be joined together to form a 4, 5 or 6-membered monocyclic ring defined as follows:



or



each R^4 is independently selected from the group consisting of: hydrogen and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted from one up to the maximum number of substitutable positions with halo,

each R^5 is independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-3}alkoxy, said C_{1-4}alkyl and C_{1-3}alkoxy optionally substituted from one up to the maximum number of substitutable positions with halo,

Z is selected from the group consisting of:

(1) C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or –CHOH-C_{1-6}alkyl, said C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl and –CHOH-C_{1-6}alkyl optionally substituted with phenyl and C_{3-6}cycloalkyl, and

(2) phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

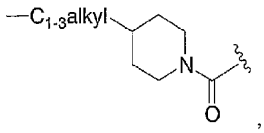
(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of : halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy,

or **Z** is not present;

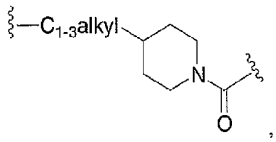
when **Z** is not present then **X** is selected from the group consisting of: phenyl, C_{5-16}alkyl, C_{5-16}alkenyl, C_{5-16}alkynyl, -CHOH-C_{4-15}alkyl, -CHOH-C_{4-15}alkenyl, -CHOH-C_{4-15}alkynyl, C_{4-15}alkoxy, -O-C_{4-15}alkenyl, -O-C_{4-15}alkynyl, C_{4-15}alkylthio, -S-C_{4-15}alkenyl, -S-C_{4-15}alkynyl, -CH_2-C_{3-14}alkoxy, -CH_2-O-C_{3-14}alkenyl, -CH_2-O-C_{3-14}alkynyl, -(C=O)-C_{4-15}alkyl, -(C=O)-C_{4-15}alkenyl, -(C=O)-C_{4-15}alkynyl, -(C=O)-O-C_{3-14}alkyl, -(C=O)-O-C_{3-14}alkenyl, -(C=O)-O-C_{3-14}alkynyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkenyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkynyl, -N(R^6)(R^7)-(C=O)-C_{3-14}alkyl, -N(R^6)(R^7)-(C=O)-C_{3-14}alkenyl and -N(R^6)(R^7)-(C=O)-C_{3-14}alkynyl,

when **Z** is phenyl or HET^1, optionally substituted as defined above, then **X** is selected from the group consisting of: -C_{1-6}alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C_{1-4}alkyl-,



, phenyl and HET^2, said phenyl and HET^2 each optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-}

4alkyl and C_{1-4}alkoxy, and wherein when **X** is -C_{1-6}alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C_{1-4}alkyl-, or



, the point of attachment of the group **Z** is on the alkyl,

and

when **Z** is C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or –CHOH-C_{1-6}alkyl, optionally substituted as defined above, then **X** is phenyl, said phenyl optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy;

R^6 and R^7 are independently selected from the group consisting of: hydrogen, C_{1-9}alkyl and -$(CH_2)_p$-phenyl, wherein p is 1 to 5 and phenyl is optionally substituted with 1-3 substituents independently selected from the group consisting of: C_{1-3}alkyl and C_{1-3}alkoxy, each optionally substituted with 1-3 halo groups; and

HET^1 and HET^2 are each independently selected from the group consisting of: benzimidazolyl, benzofuranyl, benzopyrazolyl, benzotriazolyl, benzothiophenyl, benzoxazolyl, carbazolyl, carbolinyl, cinnolinyl, furanyl, imidazolyl, indolinyl, indolyl, indolazinyl, indazolyl, isobenzofuranyl, isoindolyl, isoquinolyl, isothiazolyl, isoxazolyl, naphthyridinyl, oxadiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridopyridinyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, quinazolinyl, quinolyl, quinoxalinyl, thiadiazolyl, thiazolyl, thienyl, triazolyl, azetidinyl, 1,4-dioxanyl, hexahydroazepinyl, piperazinyl, piperidinyl, pyrrolidinyl, morpholinyl, thiomorpholinyl, dihydrobenzimidazolyl, dihydrobenzofuranyl, dihydrobenzothiophenyl, dihydrobenzoxazolyl, dihydrofuranyl, dihydroimidazolyl, dihydroindolyl, dihydroisooxazolyl, dihydroisothiazolyl, dihydrooxadiazolyl, dihydrooxazolyl, dihydropyrazinyl, dihydropyrazolyl, dihydropyridinyl, dihydropyrimidinyl, dihydropyrrolyl, dihydroquinolinyl, dihydrotetrazolyl,

dihydrothiadiazolyl, dihydrothiazolyl, dihydrothienyl, dihydrotriazolyl, dihydroazetidinyl, methylenedioxybenzoyl, tetrahydrofuranyl, and tetrahydrothienyl.

An embodiment of the invention encompasses a compound of Formula I wherein p is 1.

Another embodiment of the invention encompasses a compound of Formula I wherein:

Z is phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of : halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy,

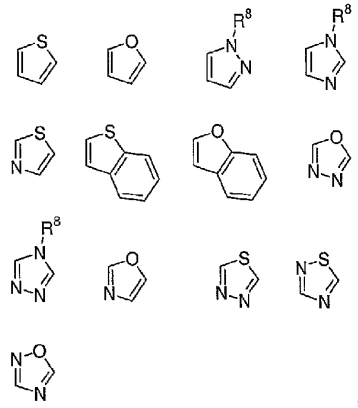
or **Z** is not present;

when **Z** is not present then **X** is selected from the group consisting of: C_{7-12}alkyl, C_{7-12}alkenyl, C_{7-12}alkynyl, C_{6-11}alkoxy, -O-C_{6-11}alkenyl, -O-C_{6-11}alkynyl, -(C=O)-C_{6-11}alkyl, -(C=O)-C_{6-11}alkenyl, -(C=O)-C_{6-11}alkynyl, -(C=O)-O-C_{5-10}alkyl, -(C=O)-O-C_{5-19}alkenyl, and -(C=O)-O-C_{5-10}alkynyl;

and

when **Z** is phenyl or HET^1, optionally substituted as defined above, then **X** is selected from the group consisting of -C_{1-5}alkyl-, -C_{1-4}alkoxy-, -(C=O)-C_{1-4}alkyl-, -(C=O)-O-C_{1-3}alkyl-, phenyl and HET^2, and wherein when **X** is -C_{1-4}alkoxy-, -(C=O)-C_{1-5}alkyl- or -(C=O)-O-C_{1-4}alkyl-, the point of attachment of the group **Z** is on the alkyl.

Another embodiment of the invention encompasses a compound of Formula I wherein HET^1 and HET^2 are indepedently selected from the group consisting of:



wherein R^8 is selected from hydrogen, hydroxy and halo.

Another embodiment of the invention encompasses a compound of Formula I wherein m is 0.

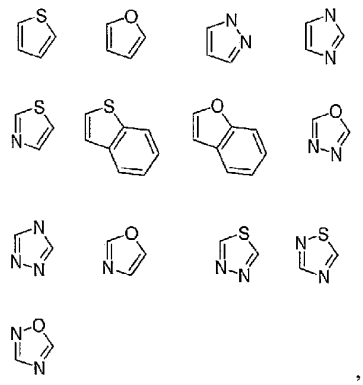
Another embodiment of the invention encompasses a compound of Formula I wherein m is 1.

Another embodiment of the invention encompasses a compound of Formula I wherein **X** is selected from the group consisting of: C_{7-12}alkyl, C_{7-12}alkenyl, C_{7-12}alkynyl, C_{6-11}alkoxy, -O-C_{6-11}alkenyl, -O-C_{6-11}alkynyl, -(C=O)-C_{6-11}alkyl, -(C=O)-C_{6-11}alkenyl, -(C=O)-C_{6-11}alkynyl, -(C=O)-O-C_{5-10}alkyl, -(C=O)-O-C_{5-19}alkenyl, and -(C=O)-O-C_{5-10}alkynyl and **Z** is not present.

Another embodiment of the invention encompasses a compound of Formula I wherein:

X is methoxy and **Z** is HET^1 substituted with phenyl and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and said phenyl optionally substituted with 1 to 5 substituents independently selected from the group conisting of: halo and C_{1-4}alkyl, optionally substituted

with 1-3 halo groups. Within this embodiment is encompasses a compound of Formula **I** wherein **Z** is selected from the group consisting of:



,

wherein **Z** is substituted with phenyl and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and said phenyl optionally substituted with 1 to 5 substituents independently selected from the group conisting of: halo and C_{1-4}alkyl, optionally substituted with 1-3 halo groups.

Another embodiment of the invention encompasses a compound of Formula I wherein:

X is HET^2, optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy, and

Z is phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of : halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy.

Within this embodient of the invention is encompassed a compound of Formula I wherein **X** is 1,2,4-oxadiazole. Also within this embodient of the invention is encompassed a compound of Formula I wherein **X** is 1,2,4-oxadiazole and **Z** is phenyl, optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy.

Another embodiment of the invention encompasses a compound of Formula I wherein:

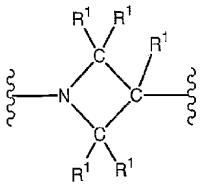
Z is C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or –CHOH-C_{1-6}alkyl, said C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl and –CHOH-C_{1-6}alkyl optionally substituted with phenyl and C_{3-6}cycloalkyl, and

X is phenyl, said phenyl optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy.

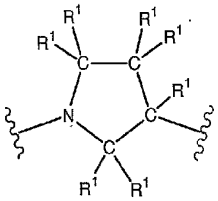
Another embodiment of the invention encompasses a compound of Formula I wherein **G** is $-CH_2-$. Within this embodiment is encompassed a compound of Formula I wherein m = 0 and **A** is $-CO_2H$.

Another embodiment of the invention encompasses a compound of Formula I wherein R^2 and R^3 are not joined together to form a ring.

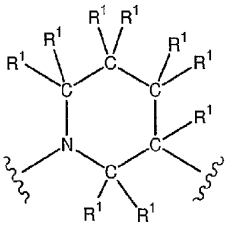
Another embodiment of the invention encompasses a compound of Formula I wherein R^2 and R^3 are joined together to form a 4-membered monocyclic ring defined as follows:



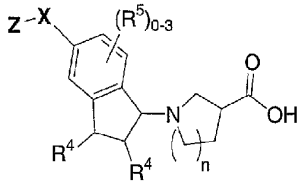
Another embodiment of the invention encompasses a compound of Formula I wherein R^2 and R^3 are joined together to form a 5-membered monocyclic ring defined as follows:



Another embodiment of the invention encompasses a compound of Formula I wherein R^2 and R^3 are joined together to form a 6-membered monocyclic ring defined as follows:



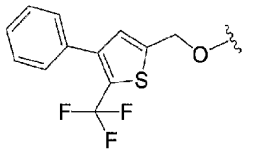
Another embodiment of the invention encompasses a compound of Formula II:

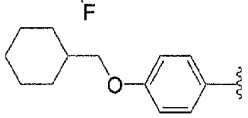


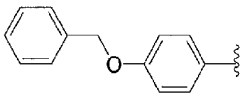
II

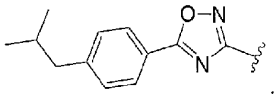
or a pharmaceutically acceptable salt or hydrate thereof, wherein n is 0 or 1, and all other variables are defined as above.

Another embodiment of the invention encompasses a compound of Formula II wherein n is 0 and –**X**-**Z** is selected from the following group:

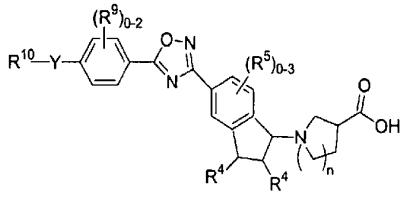








Another embodiment of the invention encompasses a compound of Formula III



III

or a pharmaceutically acceptable salt or hydrate thereof, wherein:

n is 0 or 1,

Y is oxygen or a bond,

R^{10} is C_{1-4}alkyl,

each R^9 is independently halo, C_{1-4}alkyl or C_{1-4}alkoxy, and all other variables are defined as above.

Another embodiment of the invention encompasses a compound of Formula III wherein n is 0, each R^4 is hydrogen and R^5 and R^9 are both not present.

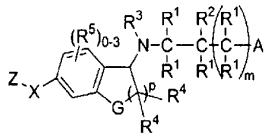
The invention also encompasses a compound selected from the following:

(1) (RS)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof.

(2) (R)-1-(5-(5-(4-(2-Methylporopyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof, and

(3) (S)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof.

According to one aspect of this invention there is provided a compound represented by Formula I :



(I)

or a pharmaceutically acceptable salt or hydrate thereof, wherein:

m is 0;

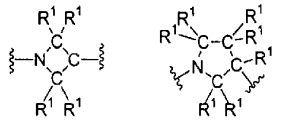
p is 1;

G is $-C(R^4)_2$,

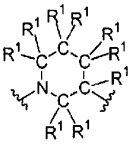
A is selected from the group consisting of: $-CO_2H$, $-PO_3H_2$, $-PO_2H$, $-SO_3H$, $-PO(C_{1-3}alkyl)OH$ and 1H-tetrazol-5-yl;

each R^1 is independently selected from the group consisting of: hydrogen, halo, hydroxy, C_{1-6}alkyl and C_{1-5}alkoxy, each C_{1-6}alkyl and C_{1-5}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy;

R^2 and R^3 are joined together to form a 4 or 5-membered monocyclic ring defined as follows:



or



each R^4 is independently selected from the group consisting of: hydrogen and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted from one up to the maximum number of substitutable positions with halo,

each R^5 is independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-3}alkoxy, said C_{1-4}alkyl and C_{1-3}alkoxy optionally substituted from one up to the maximum number of substitutable positions with halo,

Z is selected from the group consisting of:

(1) C_{1-8}alkyl, C_{1-8}alkoxy, $-(C=O)-C_{1-6}$alkyl or $-CHOH-C_{1-6}$alkyl, said C_{1-8}alkyl, C_{1-8}alkoxy, $-(C=O)-C_{1-6}$alkyl and-$CHOH-C_{1-6}$alkyl optionally substituted with phenyl and C_{3-6}cycloalkyl, and

(2) phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

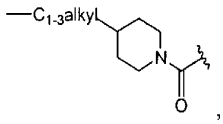
(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of: halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy,

or Z is not present;

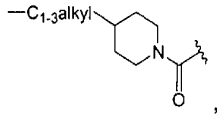
when Z is not present then X is selected from the group consisting of: phenyl, C_{5-16}alkyl, C_{5-16}alkynyl, -CHOH-C_{4-15}alkyl, -CHOH-C_{4-15}alkenyl, -CHOH-C_{4-15}alkynyl, C_{4-15}alkoxy, -O-C_{4-15}alkenyl, -O-C_{4-15}alkynyl, C_{4-15}alkylthio, -S-C_{4-15}alkenyl, -S-C_{4-15}alkynyl, -CH_2-C_{3-14}alkoxy, -CH_2-O-C_{3-14}alkenyl, -CH_2-O-C_{3-14}alkynyl, -(C=O)-C_{4-15}alkyl, - (C=O)-C_{4-15}alkenyl, -(C=O)-C_{4-15}alkynyl, -(C=O)-O-C_{3-14}alkyl, -(C=O)-O-C_{3-14}alkenyl, -(C=O)-O-C_{3-14}alkynyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkenyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkynyl, -N(R^6)(R^7)—(C=O)-C_{3-4}alkyl, -N(R^6)(R^7)-(C=O)-C_{3-14}alkenyl and-N(R^6)(R^7)-(C=O)-C_{3-14}alkynyl,

when Z is phenyl or HET^1, optionally substituted as defined above, then X is selected from the group consisting of : -C_{1-6}alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C_{1-4}alkyl-,



,

phenyl and HET^2, said phenyl and HET^2 each optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy, and wherein when X is –C_{1-6}alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C $_{1-4}$alkyl-, or



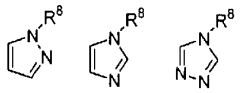
,

the point of attachment of the group Z is on the alkyl, and

when Z is C1-$_8$alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or -CHOH-C_{1-6}alkyl, optionally substituted as defined above, then X is phenyl, said phenyl optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy;

R^6 and R^7 are independently selected from the group consisting of: hydrogen, C_{1-9}alkyl and $-(CH_2)_p$-phenyl, wherein p is 1 to 5 and phenyl is optionally substituted with 1-3 substituents independently selected from the group consisting of: C_{1-3}alkyl and C_{1-3}alkoxy, each optionally substituted with 1-3 halo groups; and

HET^1 and HET^2 are each independently selected from the group consisting of: benzimidazolyl, benzofuranyl, benzopyrazolyl, benzotriazolyl, benzothiophenyl, benzoxazolyl, carbazolyl, carbolinyl, cinnolinyl, furanyl, imidazolyl, indolinyl, indolyl, indolazinyl, indazolyl, isobenzofuranyl, isoindolyl, isoquinolyl, isothiazolyl, isoxazolyl, naphthyridinyl, oxadiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridopyridinyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, quinazolinyl, quinolyl, quinoxalinyl, thiadiazolyl, thiazolyl, thienyl, triazolyl, azetidinyl, 1,4-dioxanyl, hexahydroazepinyl, piperazinyl, piperidinyl, pyrrolidinyl, morpholinyl, thiomorpholinyl, dihydrobenzimidazolyl, dihydrobenzofuranyl, dihydrobenzothiophenyl, dihydrobenzoxazolyl, dihydrofuranyl, dihydroimidazolyl, dihydroindolyl, dihydroisooxazolyl, dihydroisothiazolyl, dihydrooxadiazolyl, dihydrooxazolyl, dihydropyrazinyl, dihydropyrazolyl, dihydropyridinyl, dihydropyrimidinyl, dihydropyrrolyl, dihydroquinolinyl, dihydrotetrazolyl, dihydrothiadiazolyl, dihydrothiazolyl, dihydrothienyl, dihydrotriazolyl, dihydroazetidinyl, methylenedioxybenzoyl, tetrahydrofuranyl, and tetrahydrothienyl or



where R^8 is hydroxyl or halo.

The invention also encompasses a method of treating an immunoregulatory abnormality in a mammalian patient in need of such treatment comprising administering to said patient a compound of Formula I in an amount that is effective for treating said immunoregulatory abnormality.

Within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is an autoimmune or chronic inflammatory disease selected from the group consisting of: systemic lupus erythematosis, chronic rheumatoid arthritis, type I diabetes mellitus, inflammatory bowel disease, biliary cirrhosis, uveitis, multiple sclerosis, Crohn's disease, ulcerative colitis, bullous pemphigoid, sarcoidosis, psoriasis, autoimmune myositis, Wegener's granulomatosis, ichthyosis, Graves ophthalmopathy and asthma.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is bone marrow or organ transplant rejection or graft-versus-host disease.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is selected from the group consisting of: transplantation of organs or tissue, graft-versus-host diseases brought about by transplantation, autoimmune syndromes including rheumatoid arthritis, systemic lupus erythematosus, Hashimoto's thyroiditis, multiple sclerosis, myasthenia gravis, type I diabetes, uveitis, posterior uveitis, allergic encephalomyelitis, glomerulonephritis, post-infectious autoimmune diseases including rheumatic fever and post-infectious glomerulonephritis, inflammatory and hyperproliferative skin diseases, psoriasis, atopic dermatitis, contact dermatitis, eczematous dermatitis, seborrhoeic dermatitis, lichen planus, pemphigus, bullous pemphigoid, epidermolysis bullosa, urticaria, angioedemas, vasculitis, erythema, cutaneous eosinophilia, lupus erythematosus, acne, alopecia areata, keratoconjunctivitis, vernal conjunctivitis, uveitis associated with Behcet's disease, keratitis, herpetic keratitis, conical cornea, dystrophia epithelialis corneae, corneal leukoma, ocular pemphigus, Mooren's ulcer, scleritis, Graves' opthalmopathy, Vogt-Koyanagi-Harada syndrome, sarcoidosis, pollen allergies, reversible obstructive airway disease, bronchial asthma, allergic asthma, intrinsic asthma, extrinsic asthma, dust asthma, chronic or inveterate asthma, late asthma and airway hyper-responsiveness, bronchitis, gastric ulcers, vascular damage caused by ischemic diseases and thrombosis, ischemic bowel diseases, inflammatory bowel diseases, necrotizing enterocolitis, intestinal lesions associated with thermal burns, coeliac diseases, proctitis, eosinophilic gastroenteritis, mastocytosis, Crohn's disease, ulcerative colitis, migraine, rhinitis,

eczema, interstitial nephritis, Goodpasture's syndrome, hemolytic-uremic syndrome, diabetic nephropathy, multiple myositis, Guillain-Barre syndrome, Meniere's disease, polyneuritis, multiple neuritis, mononeuritis, radiculopathy, hyperthyroidism, Basedow's disease, pure red cell aplasia, aplastic anemia, hypoplastic anemia, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, agranulocytosis, pernicious anemia, megaloblastic anemia, anerythroplasia, osteoporosis, sarcoidosis, fibroid lung, idiopathic interstitial pneumonia, dermatomyositis, leukoderma vulgaris, ichthyosis vulgaris, photoallergic sensitivity, cutaneous T cell lymphoma, arteriosclerosis, atherosclerosis, aortitis syndrome, polyarteritis nodosa, myocardosis, scleroderma, Wegener's granuloma, Sjogren's syndrome, adiposis, eosinophilic fascitis, lesions of gingiva, periodontium, alveolar bone, substantia ossea dentis, glomerulonephritis, male pattern alopecia or alopecia senilis by preventing epilation or providing hair germination and/or promoting hair generation and hair growth, muscular dystrophy, pyoderma and Sezary's syndrome, Addison's disease, ischemia-reperfusion injury of organs which occurs upon preservation, transplantation or ischemic disease, endotoxin-shock, pseudomembranous colitis, colitis caused by drug or radiation, ischemic acute renal insufficiency, chronic renal insufficiency, toxinosis caused by lung-oxygen or drugs, lung cancer, pulmonary emphysema, cataracta, siderosis, retinitis pigmentosa, senile macular degeneration, vitreal scarring, corneal alkali burn, dermatitis erythema multiforme, linear IgA ballous dermatitis and cement dermatitis, gingivitis, periodontitis, sepsis, pancreatitis, diseases caused by environmental pollution, aging, carcinogenesis, metastasis of carcinoma and hypobaropathy, disease caused by histamine or leukotriene-C4 release, Behcet's disease, autoimmune hepatitis, primary biliary cirrhosis, sclerosing cholangitis, partial liver resection, acute liver necrosis, necrosis caused by toxin, viral hepatitis, shock, or anoxia, B-virus hepatitis, non-A/non-B hepatitis, cirrhosis, alcoholic cirrhosis, hepatic failure, fulminant hepatic failure, late-onset hepatic failure, "acute-on-chronic" liver failure, augmentation of chemotherapeutic effect, cytomegalovirus infection, HCMV infection, AIDS, cancer, senile dementia, trauma, and chronic bacterial infection.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is multiple sclerosis.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is rheumatoid arthritis.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is systemic lupus erythematosus.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is psoriasis.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is rejection of transplanted organ or tissue.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is inflammatory bowel disease.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is a malignancy of lymphoid origin including acute and chronic lymphocytic leukemias and lymphomas.

Also within this embodiment is encompassed the above method wherein the immunoregulatory abnormality is insulin and non-insulin dependent diabetes.

The invention also encompasses a method of suppressing the immune system in a mammalian patient in need of immunosuppression comprising administering to said patient an immunosuppressing effective amount of a compound of Formula I.

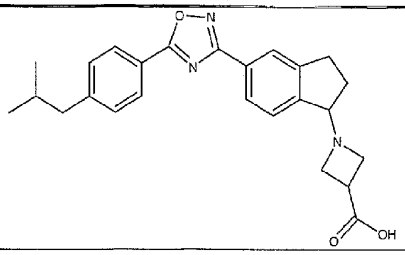
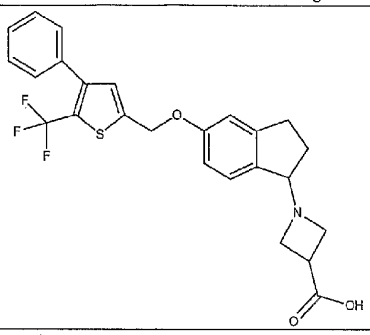
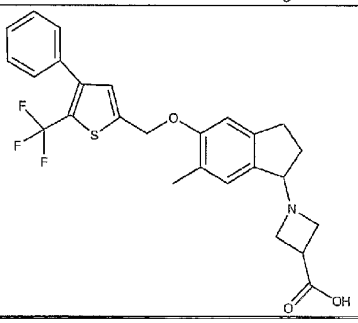
The invention also encompasses a pharmaceutical composition comprised of a compound of Formula I in combination with a pharmaceutically acceptable carrier.

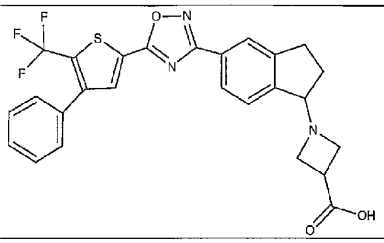
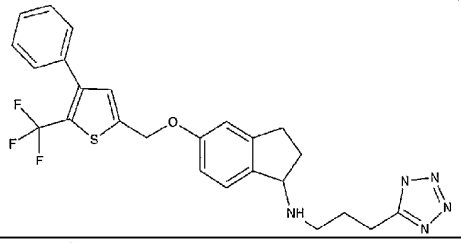
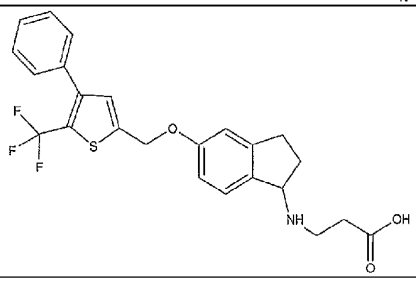
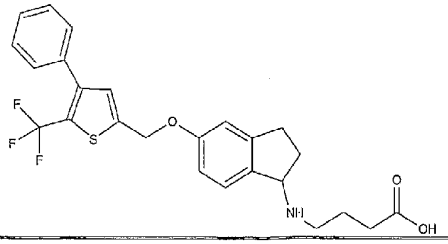
The invention also encompasses a method of treating a respiratory disease or condition in a mammalian patient in need of such treatment comprising administering to said patient a compound of Formula I in an amount that is effective for treating said respiratory disease or condition. Within this embodiment is encompasses the above method wherein the respiratory disease or condition is selected from the group consisting of: asthma, chronic bronchitis, chronic obstructive pulmonary disease, adult respiratory distress syndrome, infant respiratory distress syndrome, cough, eosinophilic granuloma, respiratory syncytial virus bronchiolitis, bronchiectasis, idiopathic pulmonary fibrosis, acute lung injury and bronchiolitis obliterans organizing pneumonia.

Also, within this embodiment is encompassed the above method wherein the patient also has a respiratory disease or condition.

Also, within this embodiment is encompassed the above method wherein the patient is also suffering from a cardiovascular disease or condition. Exemplifying the invention are the following compounds:

Example No.	Structure

Example No.	Structure
1	
3	
4	

Example No.	Structure
5	
6	
7	
8	

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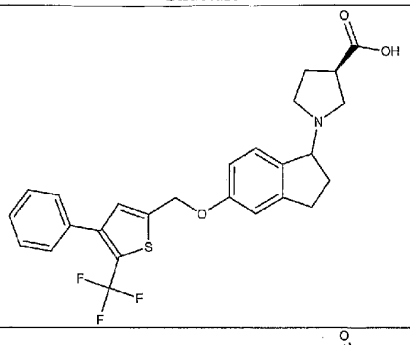
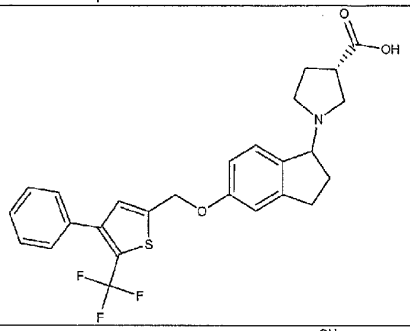
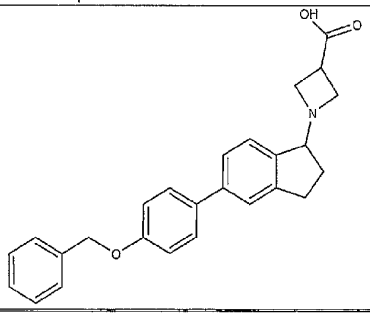
9	
10	
11	

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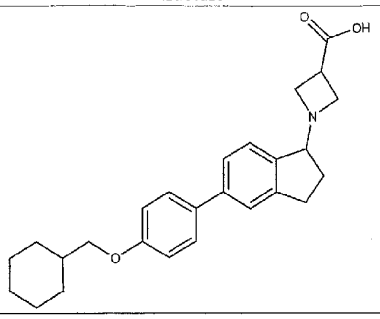
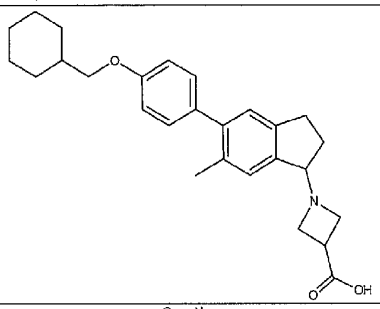
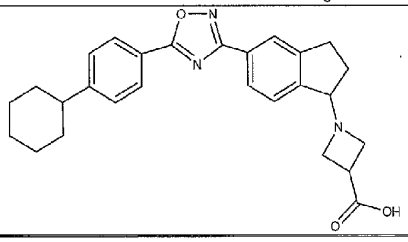
12	
13	
14	

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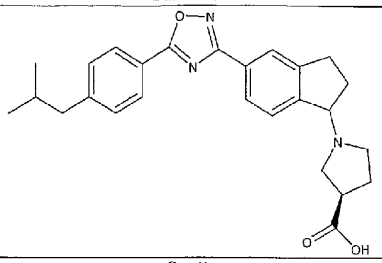
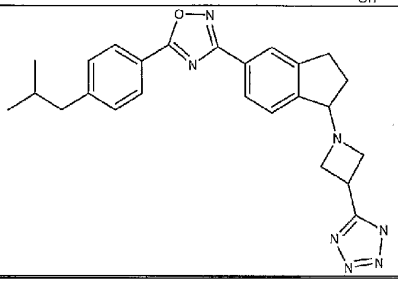
15	
16	

The invention is described using the following definitions unless otherwise indicated.

When a nitrogen atom appears in a formula of the present specification, it is understood that sufficient hydrogen atoms or substituents are present to satisfy the valency of the nitrogen atom.

The term "halogen" or "halo" includes F, Cl, Br, and I.

The term "alkyl" means linear or branched structures and combinations thereof, having the indicated number of carbon atoms. Thus, for example, C_{1-6}alkyl includes methyl, ethyl, propyl, 2-propyl, s- and t-butyl, butyl, pentyl, hexyl, 1,1-dimethylethyl, cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl.

The term "alkoxy" means alkoxy groups of a straight, branched or cyclic configuration having the indicated number of carbon atoms. C_{1-6}alkoxy, for example, includes methoxy, ethoxy, propoxy, isopropoxy, and the like.

The term "alkylthio" means alkylthio groups having the indicated number of carbon atoms of a straight, branched or cyclic configuration. C_{1-6}alkylthio, for example, includes methylthio, propylthio, isopropylthio, and the like.

The term "alkenyl" means linear or branched structures and combinations thereof, of the indicated number of carbon atoms, having at least one carbon-to-carbon double bond, wherein hydrogen may be replaced by an additional carbon-to-carbon double bond. C_{2-6}alkenyl, for example, includes ethenyl, propenyl, 1-methylethenyl, butenyl and the like.

The term "alkynyl" means linear or branched structures and combinations thereof, of the indicated number of carbon atoms, having at least one carbon-to-carbon triple bond. C_{3-6}alkynyl, for example, includes , propenyl, 1-methylethenyl, butenyl and the like.

The term "cycloalkyl" means mono-, bi- or tri-cyclic structures, optionally combined with linear or branched structures, the indicated number of carbon atoms. Examples of cycloalkyl groups include cyclopropyl, cyclopentyl, cycloheptyl, adamantyl, cyclododecylmethyl, 2-ethyl-1- bicyclo[4.4.0]decyl, and the like.

The term "aryl" is defined as a mono- or bi-cyclic aromatic ring system and includes, for example, phenyl, naphthyl, and the like.

The term "aralkyl" means an alkyl group as defined above of 1 to 6 carbon atoms with an aryl group as defined above substituted for one of the alkyl hydrogen atoms, for example, benzyl and the like.

The term "aryloxy" means an aryl group as defined above attached to a molecule by an oxygen atom (aryl-O) and includes, for example, phenoxy, naphthoxy and the like.

The term "aralkoxy" means an aralkyl group as defined above attached to a molecule by an oxygen atom (aralkyl-O) and includes, for example, benzyloxy, and the like.

The term "arylthio" is defined as an aryl group as defined above attached to a molecule by an sulfur atom (aryl-S) and includes, for example, thiophenyoxy, thionaphthoxy and the like.

The term "aroyl" means an aryl group as defined above attached to a molecule by an carbonyl group (aryl-C(O)-) and includes, for example, benzoyl, naphthoyl and the like.

The term "aroyloxy" means an aroyl group as defined above attached to a molecule by an oxygen atom (aroyl-O) and includes, for example, benzoyloxy or benzoxy, naphthoyloxy and the like.

The term "treating" encompasses not only treating a patient to relieve the patient of the signs and symptoms of the disease or condition but also prophylactically treating an asymptomatic patient to prevent the onset or progression of the disease or condition. The term "amount effective for treating" is intended to mean that amount of a drug or pharmaceutical agent that will elicit the biological or medical response of a tissue, a system, animal or human that is being sought by a researcher, veterinarian, medical doctor or other clinician. The term also encompasses the amount of a pharmaceutical drug that will prevent or reduce the risk of occurrence of the biological or medical event that is sought to be prevented in a tissue, a system, animal or human by a researcher, veterinarian, medical doctor or other clinician.

The invention described herein includes pharmaceutically acceptable salts and hydrates. Pharmaceutically acceptable salts include both the metallic (inorganic) salts and organic salts; a list of which is given in *Remington's Pharmaceutical Sciences*, 17th Edition, pg. 1418 (1985). It is well known to one skilled in the art that an appropriate salt form is chosen based on physical and chemical stability, flowability, hydroscopicity and solubility. As will be understood by those skilled in the art, pharmaceutically acceptable salts include, but are not limited to salts of inorganic acids such as hydrochloride, sulfate, phosphate, diphosphate, hydrobromide, and nitrate or salts of an organic acid such as malate, maleate, fumarate, tartrate, succinate, citrate, acetate, lactate, methanesulfonate, p-toluenesulfonate or pamoate, salicylate and stearate. Similarly pharmaceutically acceptable cations include, but are not limited to sodium, potassium, calcium, aluminum, lithium and ammonium (especially ammonium salts with secondary amines). Preferred salts of this invention for the reasons cited above include potassium, sodium, calcium and ammonium salts. Also included within the scope of this invention are crystal forms, hydrates and solvates of the compounds of Formula I.

For purposes of this Specification, "pharmaceutically acceptable hydrate" means the compounds of the instant invention crystallized with one or more molecules of water to form a hydrated form.

The invention also includes the compounds falling within Formula I in the form of one or more stereoisomers, in substantially pure form or in the form of a mixture of stereoisomers. All such isomers are encompassed within the present invention.

By virtue of their S1P1/Edg1 agonist activity, the compounds of the present invention are immunoregulatory agents useful for treating or preventing automimmune or chronic inflammatory diseases. The compounds of the present invention are useful to suppress

the immune system in instances where immunosuppression is in order, such as in bone marrow, organ or transplant rejection, autoimmune and chronic inflammatory diseases, including systemic lupus erythematosis, chronic rheumatoid arthritis, type I diabetes mellitus, inflammatory bowel disease, biliary cirrhosis, uveitis, multiple sclerosis, Crohn's disease, ulcerative colitis, bullous pemphigoid, sarcoidosis, psoriasis, autoimmune myositis, Wegener's granulomatosis, ichthyosis, Graves ophthalmopathy and asthma.

More particularly, the compounds of the present invention are useful to treat or prevent a disease or disorder selected from the group consisting of: transplantation of organs or tissue, graft-versus-host diseases brought about by transplantation, autoimmune syndromes including rheumatoid arthritis, systemic lupus erythematosus, Hashimoto's thyroiditis, multiple sclerosis, myasthenia gravis, type I diabetes, uveitis, posterior uveitis, allergic encephalomyelitis, glomerulonephritis, post-infectious autoimmune diseases including rheumatic fever and post-infectious glomerulonephritis, inflammatory and hyperproliferative skin diseases, psoriasis, atopic dermatitis, contact dermatitis, eczematous dermatitis, seborrhoeic dermatitis, lichen planus, pemphigus, bullous pemphigoid, epidermolysis bullosa, urticaria, angioedemas, vasculitis, erythema, cutaneous eosinophilia, lupus erythematosus, acne, alopecia areata, keratoconjunctivitis, vernal conjunctivitis, uveitis associated with Behcet's disease, keratitis, herpetic keratitis, conical cornea, dystrophia epithelialis corneae, corneal leukoma, ocular pemphigus, Mooren's ulcer, scleritis, Graves' opthalmopathy, Vogt-Koyanagi-Harada syndrome, sarcoidosis, pollen allergies, reversible obstructive airway disease, bronchial asthma, allergic asthma, intrinsic asthma, extrinsic asthma, dust asthma, chronic or inveterate asthma, late asthma and airway hyper-responsiveness, bronchitis, gastric ulcers, vascular damage caused by ischemic diseases and thrombosis, ischemic bowel diseases, inflammatory bowel diseases, necrotizing enterocolitis, intestinal lesions associated with thermal burns, coeliac diseases, proctitis, eosinophilic gastroenteritis, mastocytosis, Crohn's disease, ulcerative colitis, migraine, rhinitis, eczema, interstitial nephritis, Goodpasture's syndrome, hemolytic-uremic syndrome, diabetic nephropathy, multiple myositis, Guillain-Barre syndrome, Meniere's disease, polyneuritis, multiple neuritis, mononeuritis, radiculopathy, hyperthyroidism, Basedow's disease, pure red cell aplasia, aplastic anemia, hypoplastic anemia, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, agranulocytosis, pernicious anemia, megaloblastic anemia, anerythroplasia, osteoporosis, sarcoidosis, fibroid lung, idiopathic interstitial pneumonia, dermatomyositis, leukoderma vulgaris, ichthyosis vulgaris, photoallergic sensitivity, cutaneous T cell lymphoma,

arteriosclerosis, atherosclerosis, aortitis syndrome, polyarteritis nodosa, myocardosis, scleroderma, Wegener's granuloma, Sjogren's syndrome, adiposis, eosinophilic fascitis, lesions of gingiva, periodontium, alveolar bone, substantia ossea dentis, glomerulonephritis, male pattern alopecia or alopecia senilis by preventing epilation or providing hair germination and/or promoting hair generation and hair growth, muscular dystrophy, pyoderma and Sezary's syndrome, Addison's disease, ischemia-reperfusion injury of organs which occurs upon preservation, transplantation or ischemic disease, endotoxin-shock, pseudomembranous colitis, colitis caused by drug or radiation, ischemic acute renal insufficiency, chronic renal insufficiency, toxinosis caused by lung-oxygen or drugs, lung cancer, pulmonary emphysema, cataracta, siderosis, retinitis pigmentosa, senile macular degeneration, vitreal scarring, corneal alkali burn, dermatitis erythema multiforme, linear IgA ballous dermatitis and cement dermatitis, gingivitis, periodontitis, sepsis, pancreatitis, diseases caused by environmental pollution, aging, carcinogenesis, metastasis of carcinoma and hypobaropathy, disease caused by histamine or leukotriene-C4 release, Behcet's disease, autoimmune hepatitis, primary biliary cirrhosis, sclerosing cholangitis, partial liver resection, acute liver necrosis, necrosis caused by toxin, viral hepatitis, shock, or anoxia, B-virus hepatitis, non-A/non-B hepatitis, cirrhosis, alcoholic cirrhosis, hepatic failure, fulminant hepatic failure, late-onset hepatic failure, "acute-on-chronic" liver failure, augmentation of chemotherapeutic effect, cytomegalovirus infection, HCMV infection, AIDS, cancer, senile dementia, trauma, and chronic bacterial infection.

The compounds of the present invention are also useful for treating or preventing Alzheimer's Disease.

Also embodied within the present invention is a method of preventing or treating resistance to transplantation or transplantation rejection of organs or tissues in a mammalian patient in need thereof, which comprises administering a therapeutically effective amount of the compound of Formula I.

A method of suppressing the immune system in a mammalian patient in need thereof, which comprises administering to the patient an immune system suppressing amount of the compound of Formula I is yet another embodiment.

Most particularly, the method described herein encompasses a method of treating or preventing bone marrow or organ transplant rejection which is comprised of admininstering to a mammalian patient in need of such treatment or prevention a compound of Formula I, or a

pharmaceutically acceptable salt or hydrate thereof, in an amount that is effective for treating or preventing bone marrow or organ transplant rejection.

The compounds of the present invention are also useful for treating a respiratory dieases or condition, such as asthma, chronic bronchitis, chronic obstructive pulmonary disease, adult respiratory distress syndrome, infant respiratory distress syndrome, cough, eosinophilic granuloma, respiratory syncytial virus bronchiolitis, bronchiectasis, idiopathic pulmonary fibrosis, acute lung injury and bronchiolitis obliterans organizing pneumonia

Furthermore, the compounds of the present invention are selective agonists of the $S1P_1$/Edg1 receptor having selectivity over $S1P_3$/Edg3 receptor. An Edg1 selective agonist has advantages over current therapies and extends the therapeutic window of lymphocytes sequestration agents, allowing better tolerability with higher dosing and thus improving efficacy as monotherapy.

The present invention also includes a pharmaceutical formulation comprising a pharmaceutically acceptable carrier and the compound of Formula I or a pharmaceutically acceptable salt or hydrate thereof. A preferred embodiment of the formulation is one where a second immunosuppressive agent is also included. Examples of such second immunosuppressive agents are, but are not limited to azathioprine, brequinar sodium, deoxyspergualin, mizaribine, mycophenolic acid morpholino ester, cyclosporin, FK-506, rapamycin, FTY720 and ISAtx247 (Isotechnika). Methods of co-administering a compound of Formula I with a second immunosuppressive agent, including one or more of the above, is also encompassed within the invention.

The present compounds, including salts and hydrates thereof, are useful in the treatment of autoimmune diseases, including the prevention of rejection of bone marrow transplant, foreign organ transplants and/or related afflictions, diseases and illnesses.

The compounds of this invention can be administered by any means that effects contact of the active ingredient compound with the site of action in the body of a warm-blooded animal. For example, administration, can be oral, topical, including transdermal, ocular, buccal, intranasal, inhalation, intravaginal, rectal, intracisternal and parenteral. The term "parenteral" as used herein refers to modes of administration which include subcutaneous, intravenous, intramuscular, intraarticular injection or infusion, intrasternal and intraperitoneal.

The compounds can be administered by any conventional means available for use in conjunction with pharmaceuticals, either as individual therapeutic agents or in a combination

of therapeutic agents. They can be administered alone, but are generally administered with a pharmaceutical carrier selected on the basis of the chosen route of administration and standard pharmaceutical practice.

The dosage administered will be dependent on the age, health and weight of the recipient, the extent of disease, kind of concurrent treatment, if any, frequency of treatment and the nature of the effect desired. Usually, a daily dosage of active ingredient compound will be from about 0.1-2000 milligrams per day. Ordinarily, from 1 to 100 milligrams per day in one or more applications is effective to obtain desired results. These dosages are the effective amounts for the treatment of autoimmune diseases, the prevention of rejection of foreign organ transplants and/or related afflictions, diseases and illnesses.

The active ingredient can be administered orally in solid dosage forms, such as capsules, tablets, troches, dragées, granules and powders, or in liquid dosage forms, such as elixirs, syrups, emulsions, dispersions, and suspensions. The active ingredient can also be administered parenterally, in sterile liquid dosage forms, such as dispersions, suspensions or solutions. Other dosages forms that can also be used to administer the active ingredient as an ointment, cream, drops, transdermal patch or powder for topical administration, as an ophthalmic solution or suspension formation, i.e., eye drops, for ocular administration, as an aerosol spray or powder composition for inhalation or intranasal administration, or as a cream, ointment, spray or suppository for rectal or vaginal administration.

Gelatin capsules contain the active ingredient and powdered carriers, such as lactose, starch, cellulose derivatives, magnesium stearate, stearic acid, and the like. Similar diluents can be used to make compressed tablets. Both tablets and capsules can be manufactured as sustained release products to provide for continuous release of medication over a period of hours. Compressed tablets can be sugar coated or film coated to mask any unpleasant taste and protect the tablet from the atmosphere, or enteric coated for selective disintegration in the gastrointestinal tract.

Liquid dosage forms for oral administration can contain coloring and flavoring to increase patient acceptance.

In general, water, a suitable oil, saline, aqueous dextrose (glucose), and related sugar solutions and glycols such as propylene glycol or polyethylene gycols are suitable carriers for parenteral solutions. Solutions for parenteral administration preferably contain a water soluble salt of the active ingredient, suitable stabilizing agents, and if necessary, buffer

substances. Antioxidizing agents such as sodium bisulfite, sodium sulfite, or ascorbic acid, either alone or combined, are suitable stabilizing agents. Also used are citric acid and its salts and sodium EDTA. In addition, parenteral solutions can contain preservatives, such as benzalkonium chloride, methyl- or propylparaben, and chlorobutanol.

Suitable pharmaceutical carriers are described in *Remington's Pharmaceutical Sciences*, A. Osol, a standard reference text in this field.

For administration by inhalation, the compounds of the present invention may be conveniently delivered in the form of an aerosol spray presentation from pressurized packs or nebulisers. The compounds may also be delivered as powders which may be formulated and the powder composition may be inhaled with the aid of an insufflation powder inhaler device. The preferred delivery system for inhalation is a metered dose inhalation (MDI) aerosol, which may be formulated as a suspension or solution of a compound of Formula I in suitable propellants, such as fluorocarbons or hydrocarbons.

For ocular administration, an ophthalmic preparation may be formulated with an appropriate weight percent solution or suspension of the compounds of Formula I in an appropriate ophthalmic vehicle, such that the compound is maintained in contact with the ocular surface for a sufficient time period to allow the compound to penetrate the corneal and internal regions of the eye.

Useful pharmaceutical dosage-forms for administration of the compounds of this invention can be illustrated as follows:

CAPSULES

A large number of unit capsules are prepared by filling standard two-piece hard gelatin capsules each with 100 milligrams of powdered active ingredient, 150 milligrams of lactose, 50 milligrams of cellulose, and 6 milligrams magnesium stearate.

SOFT GELATIN CAPSULES

A mixture of active ingredient in a digestible oil such as soybean oil, cottonseed oil or olive oil is prepared and injected by means of a positive displacement pump into gelatin to form soft gelatin capsules containing 100 milligrams of the active ingredient. The capsules are washed and dried.

TABLETS

A large number of tablets are prepared by conventional procedures so that the dosage unit is 100 milligrams of active ingredient, 0.2 milligrams of colloidal silicon dioxide, 5

milligrams of magnesium stearate, 275 milligrams of microcrystalline cellulose, 11 milligrams of starch and 98.8 milligrams of lactose. Appropriate coatings may be applied to increase palatability or delay absorption.

INJECTABLE

A parenteral composition suitable for administration by injection is prepared by stirring 1.5% by weight of active ingredient in 10% by volume propylene glycol. The solution is made to volume with water for injection and sterilized.

SUSPENSION

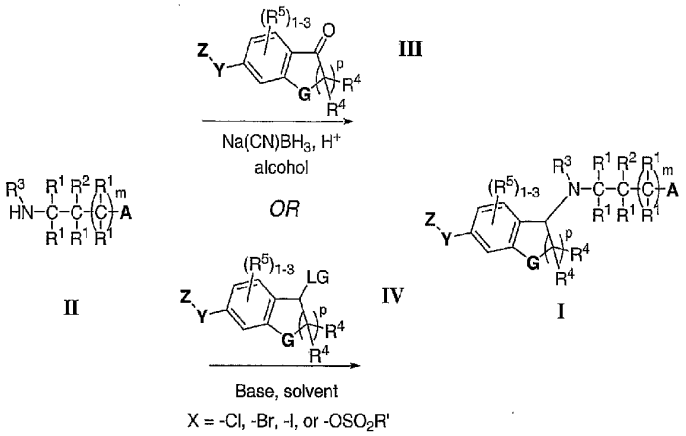
An aqueous suspension is prepared for oral administration so that each 5 milliliters contain 100 milligrams of finely divided active ingredient, 100 milligrams of sodium carboxymethyl cellulose, 5 milligrams of sodium benzoate, 1.0 grams of sorbitol solution, U.S.P., and 0.025 milliliters of vanillin.

The same dosage forms can generally be used when the compounds of this invention are administered stepwise or in conjunction with another therapeutic agent. When drugs are administered in physical combination, the dosage form and administration route should be selected depending on the compatibility of the combined drugs. Thus the term coadministration is understood to include the administration of the two agents concomitantly or sequentially, or alternatively as a fixed dose combination of the two active components.

METHODS OF SYNTHESIS

Two general methods that can be employed to prepare compounds **I** in the current invention are depicted in Scheme 1. Combining **II** with an ketone **III** in the presence of an appropriate reducing agent (e.g., sodium cyanoborohydride, sodium triacetoxyborohydride, sodium borohydride) in a compatible solvent (e.g., methanol, ethanol, acetonitrile, methylene chloride) can afford compounds of structure **I**. Alternatively, intermediates **II** can be combined with a halide or sulfonate ester **IV** in the presence of an appropriate base (e.g., sodium carbonate, potassium carbonate, triethylamine, N,N-diisopropylethylamine) in a compatible solvent (e.g., methanol, ethanol, acetonitrile) at or above room temperature to give compounds of structure **I**. In cases where **A** in structure **II** would interfere with the transformation to **I**, an appropriate protecting group (Greene & Wuts, eds., "Protecting Groups in Organic Synthesis", John Wiley & Sons, Inc.) that would mask **A** and allow for the liberation of **A** after coupling with either **III** or **IV** can be employed. The individual stereoisomers of **I** can be obtained by methods known to those skilled in the art which include (but are not limited to): stereospecific synthesis, resolution of salts of **I** or any of the intermediates used in its preparation with enantiopure acids or bases, resolution of **I** or any of the intermediates used in its preparation by HPLC employing enantiopure stationary phases.

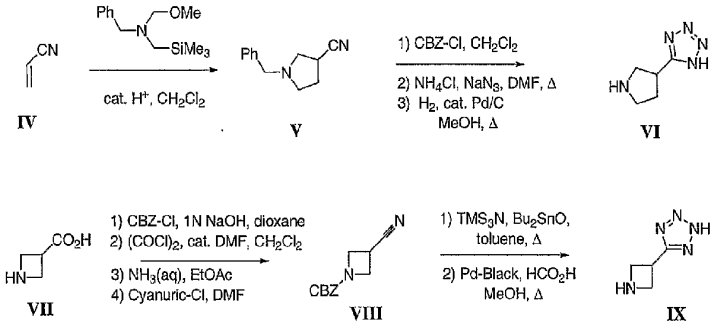
Scheme 1



Intermediates **II** may be available from commercial sources (e.g., azetidine-3-carboxylic acid, where R_1 = H, R_2 and R_3 are joined to form an azetidine ring, m = 0, **A** = carboxylic acid) or they can be prepared according to published procedures (e.g., representative syntheses of pyrrolidine-3-(R)-carboxylic acid and pyrrolidine-3-(S)-carboxylic acid are described by Gmeiner, O.; et. al. in *Synthesis*, **1998**, 1491; a representative synthesis of 5-(3-aminopropyl)-1H-tetrazole has been described by Rival, Y., et. al. in *Synthetic Communications*, **2000**, 1587). Several methods that can be used to prepare compounds that could be employed as intermediate **II** in Scheme 1 above are shown in Scheme 2. For cases where R_1 = H, R_2 and R_3 are joined to form a pyrrolidine ring, m = 0 and **A** = 5-tetrazolyl, acrylonitrile (**IV**) can be reacted with N-methoxymethyl-N-trisilylmethyl benzyl amine in the presence of a catalytic amount of an acid (e.g., trifluoroacetic acid, phosphoric acid) in an appropriate solvent (e.g., methylene chloride, acetonitrile) to a give compound of the structure **V**. Converting the N-benzyl group of **V** to a benzyl carbamate followed by tetrazole formation (e.g., ammonium chloride, sodium azide, DMF at elevated temperature; trimethyltin azide, toluene, reflux) then catalytic hydrogenation can give **VI**. For cases where R_1 = H, R_2 and R_3 are joined to form an azetidine ring, m = 0 and **A** = 5-tetrazolyl, azetidine-3-carboxylic acid (**VII**) can be reacted with benzyl chloroformate in the presence of base (e.g., aqueous sodium hydroxide, triethyl amine) in an appropriate solvent (e.g., dioxane, methylene chloride) and the carboxylic acid can be

converted to a nitrile using methods known by those skilled in the art (see Larock, "Comprehensive Organic Transformations, A Guide to Functional Group Preparations", VCH Publishers, Inc.) to give a compound of structure **VIII**. Converting the nitrile to the tetrazole (e.g., trimethylsilyl azide, dibutyltin oxide, toluene, reflux), followed by catalytic hydrogenation can give **IX**.

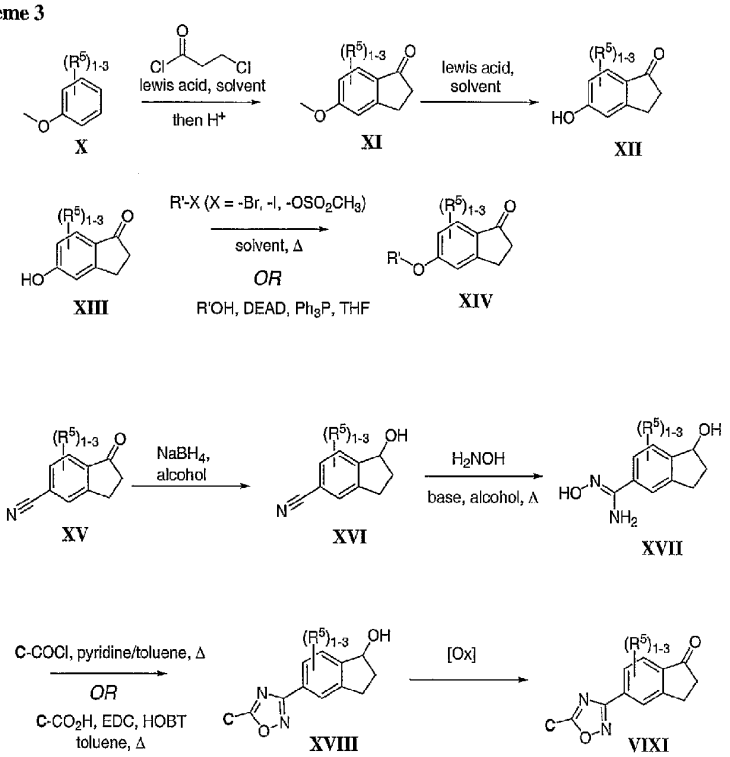
Scheme 2



Several methods that can be used to prepare compounds that can be employed as intermediate **III** in Scheme 1 above are shown in Scheme 3. For cases where R_4 = H, R_5 = alkyl or halo, and **D** = -CH_2-, **Y** = -O- and p = 1, an appropriately substituted anisole (**X**) can be combined with 3-chloropropionyl chloride in the presence of an appropriate Lewis acid (e.g., aluminum trichloride, boron trifluoride) in an appropriate solvent (e.g., methylene chloride, 1,2-dichloroethane) at elevated temperatures followed by treatment with a protic acid (e.g., sulfuric acid) at elevated temperature to give compounds of structure **XI**. Cleavage of the methyl ether using the appropriate Lewis acid (e.g., aluminum trichloride, boron tribromide, trimethylsilyl iodide) in an appropriate solvent (e.g. methylene chloride, acetonitrile) can give **XII**. For cases where **Z** = alkyl or substituted alkyl, **XIII** can be combined with an alkyl halide or sulfonate ester in the presence of an appropriate base (e.g., sodium carbonate, potassium carbonate, triethylamine, N,N-diisopropylethylamine) in a compatible solvent (e.g., methanol, ethanol, acetonitrile) at or above room temperature to give compounds of structure **XIV**. Alternatively,

XIII can be combined with an alcohol or substituted alcohol, a dialkyl azodicarboxylate (e.g., diethyl azodicarboxylate, diisopropylazodicarboxylate) and triphenylphosphine in an appropriate solvent (THF, toluene, methylene chloride) to give **XIV**. For cases where **Y** is 1,2,4-oxadiazolyl, **XV** (Reich, S.; et. al., *Journal of Medicinal Chemistry*, **2000**, 1670) can be reduced to the corresponding alcohol (e.g., sodium borohydride) in an appropriate solvent (e.g., methanol, ethanol) and then combined with hydroxylamine HCl in the presence of a neutralizing base (e.g., triethylamine, sodium bicarbonate) in an appropriate solvent (e.g., methanol, ethanol, N,N-dimethyl formamide) at or above room temperature to afford N-hydroxyamidine **XVII**. N-Hydroxyamidine **XVII** can be treated with an acid chloride in an appropriate solvent (xylenes, toluene) in the presence of an amine base (pyridine, DBU, triethylamine) with heating to give an intermediate **XVIII**. Alternatively, **XVII** can be treated with a carboxylic acid, a carbodiimide (e.g., N,N'-dicyclohexylcarbodiimide, 1-[3-(dimethylamino)propyl]-3-ethylcarbodiimide) and 1-hydroxybenzotriazole in an appropriate solvent (xylenes, toluene, DMF, 1,2-dichloroethane) to give **XVIII**. Prepared by either manner, the hydroxyl group of **XVIII** can be converted to ketone **XIX** by mild oxidation (treatment with oxalyl chloride and DMSO at –78°C in dichloromethane followed by a trialkylamine base and warming (Swern oxidation) or treatment with Dess-Martin periodinane in dichloromethane).

Scheme 3

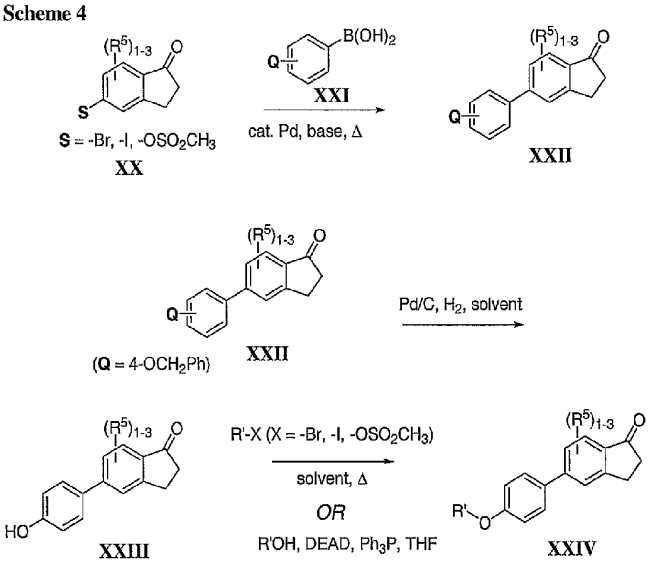


X XI XII XIII XIV XV XVI XVII XVIII VIXI

Several other methods that can be used to prepare compounds that can be employed as intermediates **III** in Scheme 1 above are shown in Scheme 4. For cases where **Z** = substituted phenyl and **Y** is a single bond, **XX** can be reacted with a substituted phenyl boronic acid (**XX1**) can be reacted in the presence of a palladium catalyst (e.g., tetrakis(triphenylphosphine)palladium, 2-dicyclohexylphosphoino)biphenyl and palladium acetate) in the presence of an appropriate base (e.g., potassium carbonate, potassium fluoride) in an appropriate solvent (e.g., 1,4-dioxane, THF) at or above room temperature to give **XXII**. In cases where **Q** is 4-benzyloxy, removal of the benzyl group (Pd/C, H_2, methanol) gives

intermediate **XXIII** which can be converted to intermediate **XXIV** using the procedures described for the conversion of intermediate **XIII** to **XIV**.

Scheme 4



Methods for preparing the compounds of this invention are further illustrated in the following examples. Alternative routes will be easily discernible to practitioners in the field.

GENERAL

Concentration of solutions was carried out on a rotary evaporator under reduced pressure. Conventional flash chromatography was carried out on silica gel (230-400 mesh). Flash chromatography was also carried out using a Biotage Flash Chromatography apparatus (Dyax Corp.) on silica gel (32-63 mM, 60 Å pore size) in pre-packed cartridges of the size noted. NMR spectra were obtained in $CDCl_3$ solution unless otherwise noted. Coupling constants (J) are in

hertz (Hz). Abbreviations: diethyl ether (ether), triethylamine (TEA), N,N-diisopropylethylamine (DIEA) sat'd aqueous (sat'd), rt (rt), hour(s) (h), minute(s) (min).

HPLC METHODS

HPLC A: YMC ODS A, 5μ, 4.6 x 50 mm column, gradient 10:90-95:5 v/v $CH_3CN:H_2O$ + 0.05% TFA over 4.5 min, then hold at 95:5 v/v $CH_3CN:H_2O$ + 0.05% TFA for 1.5 min; 2.5 mL/min, 254 nm

HPLC B: YMC-Pack Pro C18, 5μ, 20 mm x 150 mm column, gradient 10:90-80:20 v/v $CH_3CN:H_2O$ + 0.1% TFA over 23 minutes then hold at 100:0 v/v $CH_3CN:H_2O$ + 0.1% TFA for 7 min; 20 mL/min, 254 nm.

PREPARATION OF INDANONE INTERMEDIATES

Indanone 1

5-Octyloxy-1-indanone

A solution of 5-hydroxy-1-indanone (1.00 g, 6.74 mmol), 1-iodooctane (1.34 mL, 7.42 mmol) and potassium carbonate (1.40 g, 10.12 mmol) were stirred together in acetonitrile at 80°C. After 3 h, the reaction was cooled, placed onto silica gel and eluted with 15% ethyl acetate/hexane to give 1.14 g of a white solid: ^1H NMR (500 MHz , $CDCl_3$): δ 7.67 (d, J=9.2 Hz, 1 H), 6.88-6.90 (m, 2H), 4.03 (t, J=6.55 Hz, 2H), 3.08 (t, J=5.9 Hz, 2H), 2.67 (t, J=6.0 Hz, 2H), 1.80 (m, 2H), 1.42-1.50 (m, 2H), 1.24-1.38 (m, 8H), 0.89 (t, J=7.0 Hz, 3H); ESI-MS 261.1 (M+H).

Indanone 2

5-((4-Phenyl-5-trifluoromethyl-2-thienyl)methoxy)-1-indanone

Step A: (E/Z)-2-Phenyl-3-chloro-4,4,4-trifluoro-2-butanal

Phosphorous oxychloride (7.5 mL, 80 mmol) was added to 15 mL of DMF at 0 °C. The resulting mixture was warmed to rt and stirred for 1 h. A solution of 5.0 g (26.6 mmol) of 1,1,1-trifluoromethyl-3-phenyl-2-propanone in 1 mL of DMF was added and the resulting mixture was stirred at 70 °C for 20 h. The reaction mixture was cooled to rt, poured onto 150 g

of ice and stirred at ambient temperature for 1 h. The quenched mixture was extracted with 200 mL of ether. The extract was washed with 200 mL of water, dried and concentrated. Chromatography on a Biotage 40 M cartridge using hexanes (4L) as the eluant afforded 5.1 g (82%) of the title compound.

Step B: Ethyl (4-phenyl-5-trifluoromethyl)thiophene-2-carboxylate

Ethyl mercaptoacetate (2.75 mL, 25.0 mmol) was added to a suspension of 600 mg (25 mmol) of sodium hydride in 45 mL of THF maintaining the internal temperature at 25 °C. A solution of 5.10 g (21.7 mmol) of (E/Z)-2-phenyl-3-chloro-4,4,4-trifluoro-2-butanal (from Step A) was added and the resulting mixture was stirred at rt for 20 h. The reaction was quenched with 50 mL of saturated NH_4Cl and the resulting mixture was partitioned between 250 mL of ether and 100 mL of water. The organic layer was separated, dried and concentrated. Chromatography on a Biotage 40 M cartridge using hexanes (1L), then 4:1 v/v hexanes/CH_2Cl_2 (1L) as the eluant afforded 5.10 g (78%) of the title compound: ^1H NMR (400 MHz) δ 1.40 (t, J= 7.2, 3H), 4.39 (q, J= 7.2, 2H), 7.42 (app s, 5H), 7.74 (q, J=1.6, 1H).

Step C: (4-Phenyl-5-trifluoromethyl)thiophene-2-carboxylic acid

A solution of 5.10 g (17.0 mmol) of ethyl 4-phenyl-5-trifluoromethyl-thiophene-2-carboxylate (from Step B) in 20 mL of ethanol was treated with 10 mL of 5.0 N NaOH and stirred at rt for 30 min. The ethanol was removed *in vacuo*. The residual aqueous mixture was acidified to pH 2 with 1 N HCl, then extracted with 300 mL of 1:1 v/v ethyl acetate/ether. The extract was separated, dried and concentrated. Recrystallization from 200 mL of 20:1 v/v hexanes/ether afforded 4.30 g (93%) of the title compound: ^1H NMR (500 MHz) δ 7.43 (app s, 5H), 7.84 (app s, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 121.7 (q, J= 269), 128.5, 128.6, 128.8, 132.5 (q, J= 36), 133.3, 133.8, 137.5, 144.8, 167.0

Step D: 2-Hydroxymethyl-4-phenyl-5-trifluoromethyl-thiophene

A solution of 2.10 g (7.7 mmol) of 4-phenyl-5-trifluoromethyl-thiophene-2-carboxylic acid (Step C) in 20 mL of THF was treated with 5.0 mL of 2.0 M borane dimethylsulfide complex in THF. The resulting solution was heated at reflux for 3 h, cooled to rt, quenched with 10 mL of MeOH and concentrated. Chromatography on a Biotage 40M

cartridge using 9:1 v/v hexanes/ethyl acetate as the eluant afforded 1.95 g (98%) of the title compound: ^{1}H NMR (500 MHz) δ 2.05 (app s, 1H), 4.87 (s, 2H), 6.99 (s, 1H), 7.41 (app s, 5H).

Step E: 5-((4-Phenyl-5-trifluoromethyl-2-thienyl)methoxy)-1-indanone

A solution of 0.25 g (0.97 mmol) of 2-hydroxymethyl-4-phenyl-5-trifluoromethyl-thiophene (from Step D), 0.17 g (1.16 mmol) of 5-hydroxy-1-indanone and 0.31 g (0.16 mmol) of triphenylphosphine in 2.5 mL of THF at 0°C was treated with 0.18 mL (0.16 mmol) of diethylazodicarboxylate. The resulting mixture was warmed to rt, and stirred for 2 h. The reaction was loaded onto silica gel and eluted with 33% ethyl acetate/hexanes to give 0.35 g (0.90 mmol, 78%) of the title compound as a white solid: ^{1}H NMR (500 MHz) δ 7.76 (d, J=8.3 Hz, 1H), 7.42-7.47 (m, 5H), 7.14 (s, 1H), 7.01-7.03 (m, 2H), 5.34 (s, 2H), 3.15 (t, J=5.9 Hz, 2H), 2.72 (t, J=6.0 Hz, 2H); ESI-MS 388.9 (M+H).

Indanone 3

5-[(4-Phenyl-5-trifluoromethyl-2-thienyl)methoxy]-6-methyl-1-indanone

Step A: 5-Hydroxy-6-methyl-1-indanone

To a stirred suspension of aluminum chloride (3.0 g, 22.2 mmol) and *o*-cresol (2.0 g, 18.5 mmol) in methylene chloride (10 mL) was added 4-chloropropionyl chloride (2.0 mL, 20.4 mmol). After stirring overnight at rt, the reaction was quenched by the addition of methanol followed by 2N hydrochloric acid. The product was extracted in methylene chloride (3 x 30 mL), dried over magnesium sulfate and concentrated *in vacuo* to give a colorless oil. This oil was treated with concentrated sulfuric acid (10 mL) at 90°C for 1 h, diluted with water (50 mL) and the product extracted into methylene chloride (3 x 30 mL). The combined organics were dried over magnesium sulfate and concentrated *in vacuo*. Silica gel chromatography eluting with 33% ethyl acetate/hexanes gave 0.47 g of the title compound: ^{1}H NMR (500 MHz , $CDCl_3$): δ 7.56 (s, 1H), 6.81 (s, 1H), 5.36 (s, 1H, OH), 3.04 (t, J=5.9 Hz, 2H), 2.65 (t, J=5.8 Hz, 2H), 2.28 (s, 3H)

Step B: 5-[(4-Phenyl-5-trifluoromethyl-2-thienyl)methoxy]-6-methyl-1-indanone

The title compound was prepared using a procedure analogous to that described in Indanone 3, Step E substituting 5-hydroxy-6-methyl-1-indanone (from Step B) for 5-hydroxy-1-

indanone: ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.58 (s, 1H), 7.40-7.45 (m, 5H), 7.10 (s, 1H), 6.92 (s, 1H), 3.09 (t, J=5.8 Hz, 2H), 2.68 (t, J=5.8 Hz, 2H), 2.30 (s, 3H).

Indanone 4

3-(1-Oxo-5-indanyl)-5-(4-(2-methylpropyl)phenyl)-1,2,4-oxadiazole

Step A: 5-Cyano-1-hydroxyindane

A solution of 5-cyano-1-indanone (3.40 g, 21.63 mmol, prepared according to Reich, S. H., et.al. *J. Med. Chem.*, **2000**, *43*, 1670-1683) in methanol (50 mL) was treated with sodium borohydride (0.25 g, 6.48 mmol). After stirring for 3 h, the reaction was diluted with methylene chloride (50 mL) and washed with saturated aqueous sodium bicarbonate (50 mL). The aqueous layer was further extracted with methylene chloride (2 50 mL). The extracts were combined, dried over magnesium sulfate and concentrated *in vacuo*. Silica gel chromatography eluting with 40% ethyl acetate/hexanes gave 2.45 g (15.40 mmol, 71%) of the title compound as a white solid: ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.48-7.54 (m, 3H), 5.25-5.29 (m, 1H), 3.03-3.10 (m, 2H), 2.81-2.89 (m, 2H), 2.52-2.59 (m, 2H), 1.94-2.01 (m, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 150.1, 144.2, 130.9, 128.6, 125.0, 119.1, 111.8, 75.9, 35.8, 29.5.

Step B: N-Hydroxy (1-hydroxy-5-indanyl)amidine

A solution of 5-cyano-1-hydroxyindane (2.45 g, 15.44 mmol, from Step A), hydroxylamine hydrochloride (1.60 g, 23.17 mmol) and sodium bicarbonate (6.5 g, 77.04 mmol) in methanol (40 mL) was heated to 60°C and stirred overnight. The reaction was filtered and concentrated to give a white foam: ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.54-7.62 (m, 3H), 5.25 (t, J=6.8 Hz, 1H), 3.06-3.14 (m, 2H), 2.86-2.94 (m, 2H), 2.48-2.58 (m, 2H), 1.94-2.02 (m, 2H).

Step C: 3-(1-Oxo-5-indanyl)-5-(4-(2-methylpropyl)phenyl)-1,2,4-oxadiazole

A solution of 4-(2-methylpropyl)benzoic acid (2.74 g, 15.44 mmol), 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (2.95 g, 15.44 mmol) and 1-hydroxybenzotriazole hydrate (2.08 g, 15.44 mmol) in DMF (50 mL) was stirred at rt for 30 min. N-Hydroxy (1-hydroxy-5-indanyl)amidine (from Step B) was added and the reaction was first stirred at rt for 1 h, then heated to 80°C for 18 h. The reaction was cooled, diluted with water (100 mL) and the product extracted into methylene chloride (2 x 100 mL). The combined organics were dried over magnesium sulfate and concentrated *in vacuo* to give an oil. This oil

was dissolved in methylene chloride (30 mL) and Dess-martin periodinane (5 g) was added. After stirring for 1 h, 2N NaOH (100 mL) was added to the reaction and the product extracted into methylene chloride (3 x 100 mL). The combined organics were dried over magnesium sulfate and concentrated *in vacuo*. Silica gel chromatography eluting with 15% ethyl acetate/hexanes gave 1.6 g (4.48 mmol) of the title compound as a yellow solid: ^{1}H NMR (500 MHz , $CDCl_3$) δ 8.31 (s, 1H), 8.20 (d, J=8.0 Hz, 1H), 8.13 (d, J=8.2 Hz, 2H), 7.88 (d, J=8.0 Hz, 1H), 7.34 (d, J=8.3 Hz, 2H), 3.25 (t, J=6.0 Hz, 2H), 2.77 (t, J=6.0 Hz, 2H), 2.58 (d, J=7.1 Hz, 2H), 1.90-1.98 (m, 1H), 0.94 (d, J=6.6 Hz, 6H); ESI-MS 333.1 (M+H).

Indanone 5

3-(1-Oxo-5-indanyl)-5-(4-cyclohexylphenyl)-1,2,4-oxadiazole

The title compound was prepared using a procedure analogous to Indanone 4 substituting 4-cyclohexylbenzoic acid for 4-isobutylbenzoic acid in Step C: ^{1}H NMR (500 MHz , $CDCl_3$) δ 8.31 (s, 1H), 8.20 (d, J=8.0 Hz, 1H), 8.14 (d, J=8.3 Hz, 2H), 7.89 (d, J=8.0 Hz, 1H), 7.41 (d, J=8.5 Hz, 2H), 3.25 (t, J=6.0 Hz, 2H), 2.78 (t, J=6.0 Hz, 2H), 2.54-2.64 (m, 1H), 1.22-1.98 (m, 10H); ESI-MS 359.1 (M+H).

Indanone 6

3-(1-Oxo-5-indanyl)-5-(4-phenyl-5-trifluoromethyl-2-thienyl)-1,2,4-oxadiazole

The title compound was prepared using a procedure analogous to Indanone 4 substituting 4-phenyl-5-trifluoromethyl-thiophene-2-carboxylic acid (from Indanone 2, Step C) for 4-isobutylbenzoic acid in Step C: ^{1}H NMR (500 MHz , $CDCl_3$) δ 8.30 (s, 1H), 8.18 (d, J=8.0 Hz, 1H), 7.93 (d, J=1.2 Hz, 1H), 7.90 (d, J=8.0 Hz, 1H), 7.44-7.50 (m, 5H), 3.29 (t, J=6.0 Hz, 2H), 2.82 (t, J=6.0 Hz, 2H).

Indanone 7

5-(4-(Cyclohexylmethoxy)phenyl)-6-methyl-1-indanone

Step A: 5-(Trifluoromethanesulfonyloxy)-6-methyl-1-indanone

To a solution of 5-hydroxy-6-methyl-1-indanone (1.69 g, 10.43 mmol, from Indanone 3, Step A) and 2,6-lutidine (1.80 mL, 11.47 mmol) in methylene chloride at 0°C was added trifluoromethansulfonic anhydride (1.90 mL, 11.47 mmol). After 30 min, the reaction was quenched with 2N hydrochloric acid (50 mL) and the product extracted into methylene chloride

(100 mL). The organic layer was separated, dried over magnesium sulfate and concentrated *in vacuo*. Silica gel chromatography eluting with 15% ethyl acetate/hexanes gave a yellow solid (0.25 g): ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.70 (s, 1H), 7.39 (s, 1H), 3.16 (t, J=6.0 Hz, 2H), 2.74 (t, J=6.0 Hz, 2H), 2.42 (s, 3H); ESI-MS 295.0 (M+H).

Step B: 5-(4-Benzyloxyphenyl)-6-methyl-1-indanone

A solution of 5-(trifluoromethanesulfonyloxy)-6-methyl-1-indanone 0.15 g, 0.51 mmol, from Step A), 4-benzyloxyphenyl boronic acid (0.17 g, 0.77 mmol), palladium acetate (5.7 mg, 0.025 mmol), tricyclohexylphosphine (8.6 mg, 0.030 mmol) and potassium fluoride (0.098 g, 1.68 mmol) in tetrahydrofuran (2.5 mL) was stirred at rt. After 5 min, the reaction was loaded onto silica gel and the product eluted with 25% ethyl acetate/hexanes to give a yellow solid (0.20 g): ESI-MS 329.1 (M+H).

Step C: 5-(4-(Cyclohexylmethoxy)phenyl)-6-methyl-1-indanone

A solution of 5-(4-benzyloxyphenyl)-6-methyl-1-indanone (0.20 g, from Step B) and palladium on carbon (0.10 g, 10%) in a 1:1 solution of methanol/ethyl acetate (10 mL) was stirred under 1 atm H_2 at rt. After 1 h, the reaction was filtered and concentrated to give a yellow solid (0.094 g). A solution of this solid, bromomethyl cyclohexane (0.067 g, 0.78 mmol) and potassium carbonate (0.17 g, 1.18 mmol) was stirred in acetonitrile (5 mL) at 50°C. After 24 h, the reaction was cooled, loaded onto silica gel and the product eluted with 25% ethyl acetate/hexanes to give a white solid (0.035 g): ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.65 (s, 1H), 7.31 (s, 1H), 7.25 (d, J=8.7 Hz, 2H), 6.96 (d, J=8.7 Hz, 2H), 3.80 (d, J=6.2 Hz, 2H), 3.12 (t, J=5.8 Hz, 2H), 2.71 (t, J=6.0 Hz, 2H), 2.30 (s, 3H), 1.68-1.92 (m, 6H), 1.18-1.38 (m, 3H), 1.04-1.13 (m, 2H); ESI-MS 335.5 (M+H).

Indanone 8

5-(4-Benzyloxyphenyl)-1-indanone

A solution of 4-benzyloxyphenyl boronic acid (0.15 g, 0.66 mmol), 5-bromo-1-indanone (0.10 g, 0.44 mmol), palladium acetate (2.0 mg, 0.009 mmol), tricyclohexylphosphine (7.0 mg, 0.018 mmol) and potassium fluoride (0.077 g, 1.32 mmol) in dioxane (2.5 mL) was stirred at 75°C for 3 h. The reaction mixture was filtered through celite. Silica gel chromatography eluting with 25% ethyl acetate/hexane gave 0.05 g of desired product:

^{1}H NMR (500 MHz , $CDCl_3$) δ 7.85 (d, J=8.0 Hz, 1H), 7.68 (s, 1H), 7.62 (t, 3H), 7.51 (d, J=7.3 Hz, 2H), 7.46 (t, J=7.5 Hz, 2H), 7.38-7.42 (m, 1H), 7.13 (d, J=8.7 Hz, 2H), 5.18 (s, 2H), 3.23 (t, J=5.8 Hz, 2H), 2.78 (t, J=6.0 Hz, 2H).

Indanone 9

5-(4-(Cyclohexylmethoxy)phenyl)-1-indanone

Step A: 5-(4-Hydroxyphenyl)-1-indanone

Indanone 8 (0.13 g, 0.41 mmol) was dissolved in THF (4 mL) and 10% Pd/C (0.05 g) was added. The reaction was stirred under 1 atm H_2 for 16 h. The reaction mixture was filtered through celite and silica gel chromatography eluting with 15% ethyl acetate/hexane yielded 52 mg of desired product: ^{1}H NMR (500 MHz , $CDCl_3$) δ 7.84 (d, J=7.8 Hz, 1H), 7.66 (s, 1H), 7.55-7.62 (m, 3H), 6.98 (d, J-8.3 Hz, 2H), 6.75 (s, 2H), 3.22 (s, 2H), 2.78 (s, 2H).

Step B: 5-(4-(Cyclohexylmethoxy)phenyl)-1-indanone

A solution of 5-(4-hydroxyphenyl)-1-indanone (0.52 g, 0.23 mmol, from Step A), bromomethylcyclohexane (0.53 g, 0.30 mmol) and potassium carbonate (0.58 g, 0.42 mmol) in acetonitrile (2.5 mL) was stirred at 80°C for 16 h. The reaction mixture was cooled, diluted with ethyl acetate and washed with water. Silica gel chromatography eluting with 10% ethyl acetate/hexane yielded 0.29 g of product. ^{1}H NMR (500 MHz , $CDCl_3$): δ 7.83 (d, J=7.8 Hz, 1H), 7.67 (s, 1H), 7.60 (d, J=8.3 Hz, 3H), 7.03 (d, J=8.2 Hz, 2H), 3.85 (s, 2H), 3.21 (s, 2H), 2.78 (s, 2H), 2.08 (s, 1H), 1.90-1.98 (m, 2H), 1.80-1.86 (m, 2H), 1.20-1.42 (m, 4H), 1.07-1.18 (m, 2H).

PREPARATION OF EXAMPLES

EXAMPLE 1

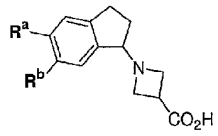
(+/-)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid, trifluoroacetic acid salt

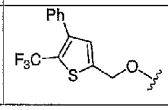
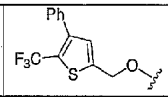
A suspension of Indanone 4 (0.050 g, 0.151 mmol), azetidine-3-carboxylic acid (0.023 g, 0.226 mmol) and sodium cyanoborohydride (9.3 mg, 0.151 mmol) was heated in methanol (1 mL) at 60°C. After 4 h, the solution was cooled. Direct HPLC purification (HPLC B) gave the title compound (0.53 g): ^{1}H NMR (500 MHz , CD_3OD) δ 8.19 (s, 1H), 8.13-8.15 (m,

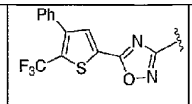
3H), 7.74 (d, J=7.8 Hz, 1H), 7.44 (d, J=8.0 Hz, 2H), 5.06 (dd, J=2.5, 7.8 Hz, 1H), 4.52-4.60 (m, 2H), 4.41-4.48 (m, 2H), 3.71 (m, 1H), 3.27 (dt, J=8.15, 16.7 Hz, 1H), 3.13 (ddd, J=3.7, 9.2, 16.7 Hz, 1H), 2.56-2.66 (m, 3H), 2.22-2.30 (m, 1H), 1.92-2.00 (m, 1H), 0.96 (d, J=6.6 Hz, 6H); ESI-MS 418.1 (M+H).

EXAMPLES 3-5

The following Examples were prepared using a procedure analogous to that described in Example 1 substituting the appropriate Indanone for Indanone 4.

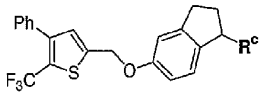


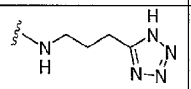
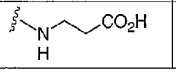
EXAMPLE	Indanone	Ra	Rb	HPLC A (min)	LC-MS (M+H)
3	2		-H	2.98	474
^{1}H NMR (500 MHz , CD_3OD) δ 7.50 (d, J=8.5 Hz, 1H), 7.40-7.45 (m, 5H), 7.22 (s, 1H), 7.09 (s, 1H), 7.01 (dd, J=2.3, 8.5 Hz, 1H), 5.38 (s, 2H), 4.24-4.60 (m, 5H), 3.60-3.70 (m, 1H), 3.14 (dt, J=8.3, 16.7 Hz, 1H), 2.99 (ddd, J=1.5, 9.6, 16.7 Hz, 1H), 2.48-2.58 (m, 1H), 2.13-2.22 (m, 1H)					
4	3		-CH_3	3.07	488
^{1}H NMR (500 MHz , CD_3OD) δ 7.42-7.47 (m, 5H), 7.38 (s, 1H), 7.24 (s, 1H), 7.09 (s, 1H), 5.41 (s, 2H), 4.84-4.90 (m, 1H), 4.30-4.50 (m, 4H), 3.60-3.65 (m, 1H), 3.15 (dt, J=8.2, 16.4 Hz, 1H), 2.98 (ddd, J=2.1, 9.2, 16.5, 1H), 2.48-2.56 (m, 1H), 2.31 (s, 3H), 2.16-2.22 (m, 1H)					

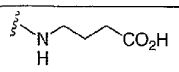
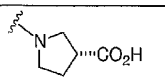
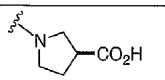
5	6		H-	3.28	512
^{1}H NMR (500 MHz , CD_3OD) δ 8.19 (s, 1H), 8.14 (d, J=8.3 Hz, 1H), 8.07 (d, J=1.4 Hz, 1H), 7.75 (d, J=8.0 Hz, 1H), 7.50-7.54 (m, 4H), 7.45 (d, J=2.3 Hz, 1H), 5.06 (dd, J=2.7, 7.7 Hz, 1H), 4.54-4.62 (m, 2H), 4.42-4.48 (m, 2H), 3.71 (quint, J=8.4 Hz, 1H), 3.28 (dt, J=8.0, 16.5 Hz, 1H), 3.13 (ddd, J=3.7, 9.2, 16.7, 1H), 2.58-2.68 (m, 2H), 2.22-2.30 (m, 1H)					

EXAMPLES 6-10

The following Examples were prepared using a procedure analogous to that described in EXAMPLE 1 substituting Indanone 2 for Indanone 4 and the appropriate amino acid for azetidine carboxylic acid.

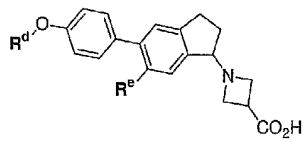


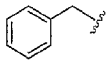
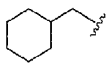
EXAMPLE	**Rc**	HPLC A (min)	LC-MS (M+H)
6		3.05	500
7		2.93	462
^{1}H NMR (500 MHz , CD_3OD) δ 7.50 (d, J=8.5 Hz, 1H), 7.40-7.44 (m, 5H), 7.22 (s, 1H), 7.08 (s, 1H), 7.02 (dd, J=2.5, 8.4 Hz, 1H), 5.39 (s, 2H), 4.78 (dd, J=3.2, 7.8 Hz, 1H), 3.28-3.34 (m, 2H), 3.19 (dt, J=7.8, 16.5 Hz, 1H), 2.71 (m, 2H), 2.56-2.64 (m, 1H), 2.26-2.34 (m, 1H)			

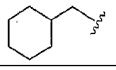
8		2.93	476
9		3.05	488
10		3.06	488

EXAMPLES 11-13

The following Examples were prepared using a procedure analogous to that described in Example 1 substituting the appropriate Indanone for Indanone 4.

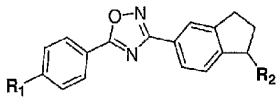


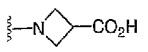
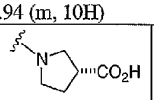
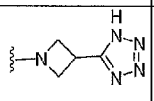
EXAMPLE	Indanone	R^d	R^e	HPLC A (min)	LC-MS (M+H)
11	8		H-	2.85	400
^{1}H NMR (500 MHz , CD_3OD) δ 7.57 (d, J=9.6 Hz, 4H), 7.47 (d, 2H), 7.39 (t, J=7.2 Hz, 2H), 7.30-7.36 (m, 1H), 7.09 (d, J=8.2 Hz, 2H), 5.15 (s, 2H), 4.49 (s, 2H), 4.32-4.42 (m, 2H), 3.58-3.66 (m, 1H), 3.48-3.54 (m, 1H), 3.16-3.24 (m, 1H), 3.02-3.12 (m, 1H), 2.51-2.60 (m, 1H), 2.18-2.26 (m, 1H), 1.30 (s, 1H), 1.19 (t, 1H)					
12	9		H-	3.32	406

13	7		CH_3-	3.38	420

EXAMPLES 14-16

The following Examples were prepared using a procedure analogous to that described in Example 1 substituting the appropriate Indanone for Indanone 4 and the appropriate amine for azetidine-3-carboxylic acid.



EXAMPLE	Indanone	R_1	R_2	HPLC A (min)	LC-MS (M+H)
14	5			3.40	441
^{1}H NMR (500 MHz , CD_3OD) δ 8.18 (s, 1H), 8.12-8.15 (m, 3H), 7.74 (d, J=8.1 Hz, 1H), 7.49 (d, J=8.3 Hz, 2H), 5.05 (dd, J=2.8, 7.6 Hz, 1H), 4.52-4.60 (m, 2H), 4.40-4.46 (m, 2H), 3.64-3.74 (m, 1H), 3.26 (dt, J=8.0, 16.4 Hz, 1H), 3.13 (ddd, J=3.4, 9.4, 16.7, 1H), 2.56-2.70 (m, 2H), 2.20-2.28 (m, 1H), 1.26-1.94 (m, 10H)					
15	4			3.10	432
16	4			3.20	442

^{1}H NMR (500 MHz , $CDCl_3$) δ 8.13 (s, 1H), 8.06-8.10 (m, 2H), 7.63 (d, J=7.8 Hz, 1H), 7.31 (d, J=8.0 Hz, 1H), 4.97 (d, J=6.6 Hz, 1H), 4.40-4.65 (m, 5H), 3.34-3.37 (m, 1H), 3.08-3.11 (m, 1H), 2.55-2.65 (m, 1H), 2.56 (d, J=7.3 Hz, 2H), 1.92 (m, 1H), 0.93 (d, J=6.7 Hz, 6H)

Example 17

(R or S)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid, trifluoroacetic acid salt

Step A: Methyl (±)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl)-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylate

A suspension of Indanone 4 (1.00 g, 3.01 mmol), methyl azetidine-3-carboxylate hydrochloride salt (0.50 g, 3.31 mmol) and sodium cyanoborohydride (0.093 g, 1.50 mmol) was heated in methanol (1 mL) at 60°C. After 18 h, the reaction was cooled and the resulted solid collected by filtration to give 0.51 g of product as a white solid. The organic washes were collected, concentrated and chromatographed over silica gel eluting with 60% ethyl acetate/hexanes to give an additional 0.6 g of product as an oil: ^{1}H NMR (500 MHz , CD_3OD) δ 8.11 (d, J=8.3 Hz, 2H), 8.4 (s, 1H), 7.99 (d, J=7.9 Hz, 1H), 7.39 (d, J=8.0 Hz, 1H), 7.32 (d, J=8.3 Hz, 2H), 3.95 (dd, J=3.7, 6.9 Hz, 1H), 3.72 (s, 3H), 3.64 (t, J=7.5 Hz, 1H), 3.59 (t, J=7.4 Hz, 1H), 3.53 (t, J=7.3 Hz, 1H), 3.43 (t, J=7.4 Hz, 1H), 3.35 (quint, J=7.8 Hz, 1H), 3.12 (dt, J=7.9, 16.0 Hz, 1H), 2.89 (ddd, J=4.6, 8.7, 16.0, 1H), 2.57 (d, J=7.4 Hz, 2H), 2.12-2.20 (m, 1H), 1.94-2.02 (m, 1H), 1.93 (m, 1H), 0.93 (d, J=6.6 Hz, 6H); ESI-MS 432.2 (M+H).

Preparative HPLC (Chiralcel OD 2 x 25 cm column, 98:2 v/v n-heptane/2-propanol, 8 mL/min, λ = 254 nm) was used to resolve the enantiomers. For Enantiomer 1, t = 19.2 min. For Enantiomer 2, t = 21.6 min.

Step B: (R or S)-1-{5-[5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl}azetidine-3-carboxylic acid TFA salt

A solution of methyl 1-(5-(5-(4-(2-methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl)-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylate, Enantiomer 1 (from Step A, 0.10 g, 0.23 mmol) and sodium hydroxide (1N aqueous solution, 0.6 mL) were heated in methanol (1 mL) at

60°C. After 2 h, the reaction was cooled and acidified with trifluoroacetic acid. HPLC purification (HPLC B) gave the title compound as a white solid: ^{1}H NMR (500 MHz , CD_3OD) δ 8.19 (s, 1H), 8.13-8.15 (m, 3H), 7.74 (d, J=7.8 Hz, 1H), 7.44 (d, J=8.0 Hz, 2H), 5.06 (dd, J=2.5, 7.8 Hz, 1H), 4.52-4.60 (m, 2H), 4.41-4.48 (m, 2H), 3.71 (m, 1H), 3.27 (dt, J=8.15, 16.7 Hz, 1H), 3.13 (ddd, J=3.7, 9.2, 16.7 Hz, 1H), 2.56-2.66 (m, 3H), 2.22-2.30 (m, 1H), 1.92-2.00 (m, 1H), 0.96 (d, J=6.6 Hz, 6H); ESI-MS 418.1 (M+H).

Example 18

(S or R)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid, trifluoroacetic acid salt

The title compound was prepared from methyl 1-(5-(5-(4-(2-methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl)-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylate, Enantiomer 2 (from Example 17, Step A) using a procedure analogous to that described in Example 17, Step B: ^{1}H NMR (500 MHz , CD_3OD) δ 8.19 (s, 1H), 8.13-8.15 (m, 3H), 7.74 (d, J=7.8 Hz, 1H), 7.44 (d, J=8.0 Hz, 2H), 5.06 (dd, J=2.5, 7.8 Hz, 1H), 4.52-4.60 (m, 2H), 4.41-4.48 (m, 2H), 3.71 (m, 1H), 3.27 (dt, J=8.15, 16.7 Hz, 1H), 3.13 (ddd, J=3.7, 9.2, 16.7 Hz, 1H), 2.56-2.66 (m, 3H), 2.22-2.30 (m, 1H), 1.92-2.00 (m, 1H), 0.96 (d, J=6.6 Hz, 6H); ESI-MS 418.1 (M+H).

Example 19

(R or S)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid

A solution of 4.5 g (8.1 mmol) of methyl (±)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl)-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylate, Enantiomer 1 (from Example 17, Step A) in 25 mL of MeOH was treated with 3.0 mL of 5.0 N NaOH and the resulting mixture was heated at reflux for 3 h. The mixture was cooled, diluted with 4:1 v/v CH_2Cl_2/MeOH and neutralized with concentrated HCl. The solids were filtered and the filtrate was concentrated. Chromatography on a Biotage 75S cartridge using 4 L of 17:3 v/v CH_2Cl_2/MeOH + 1% NH_4OH, then 4 L of 3:1 v/v CH_2Cl_2/MeOH + 1% NH_4OH afforded 2.60 g of the title compound: ^{1}H NMR (500 MHz , DMSO) δ 8.08 (d, J= 8.0 Hz, 2H), 7.93 (s, 1H), 7.88 (d, J= 7.5 Hz, 1H), 7.47 (d, J= 7.5 Hz, 1H), 7.44 (d, J= 8.0 Hz, 2H), 3.85-3.88 (m, 1H), 3.50

(app t, J= 7.5 Hz, 1H), 3.39 (app d, J= 7.5 Hz, 2H), 3.26 (app t, J= 7.5 Hz, 1H), 3.13-3.18 (m, 1H), 2.97-3.30 (m, 1H), 2.81-2.87 (m, 1H), 2.57 (app d, J= 7.5 Hz, 2H), 2.49 (t, J= 1.5 Hz, 1H), 2.03-2.11 (m, 1H), 1.83-1.89 (m, 1H), 0.88 (d, J= 6.5 Hz, 6H); ESI-MS 418.1 (M+H).

BIOLOGICAL ACTIVITY

The $S1P_1$/Edg1, $S1P_3$,/Edg3, $S1P_2$/Edg5, $S1P_4$/Edg6 or $S1P_5$ /Edg8 activity of the compounds of the present invention can be evaluated using the following assays:

Ligand Binding to Edg/S1P Receptors Assay

^{33}P-sphingosine-1-phosphate was synthesized enzymatically from γ^{33}P-ATP and sphingosine using a crude yeast extract with sphingosine kinase activity in a reaction mix containing 50 mM KH_2PO_4, 1 mM mercaptoethanol, 1 mM Na_3VO_4, 25 mM KF, 2 mM semicarbazide, 1 mM Na_2EDTA, 5 mM $MgCl_2$, 50 mM sphingosine, 0.1% TritonX-114, and 1 mCi γ^{33}P-ATP (NEN; specific activity 3000 Ci/mmol). Reaction products were extracted with butanol and ^{33}P-sphingosine-1-phosphate was purified by HPLC.

Cells expressing EDG/S1P receptors were harvested with enzyme-free dissociation solution (Specialty Media, Lavallette, NJ). They were washed once in cold PBS and suspended in binding assay buffer consisting of 50 mM HEPES-Na, pH 7.5, 5mM $MgCl_2$, 1mM $CaCl_2$, and 0.5% fatty acid-free BSA. ^{33}P-sphingosine-1-phosphate was sonicated with 0.1 nM sphingosine-1-phosphate in binding assay buffer; 100 µl of the ligand mixture was added to 100 µl cells (1 x 10^6 cells/ml) in a 96 well microtiter dish. Binding was performed for 60 min at room temperature with gentle mixing. Cells were then collected onto GF/B filter plates with a Packard Filtermate Universal Harvester. After drying the filter plates for 30 min, 40 µl of Microscint 20 was added to each well and binding was measured on a Wallac Microbeta Scintillation Counter. Non-specific binding was defined as the amount of radioactivity remaining in the presence of 0.5 µM cold sphingosine-1-phosphate.

Alternatively, ligand binding assays were performed on membranes prepared from cells expressing Edg/S1P receptors. Cells were harvested with enzyme-free dissociation solution and washed once in cold PBS. Cells were disrupted by homogenization in ice cold 20 mM HEPES pH 7.4, 10 mM EDTA using a Kinematica polytron (setting 5, for 10 seconds). Homogenates were centrifuged at 48,000 x g for 15 min at 4°C and the pellet was suspended in

20 mM HEPES pH 7.4, 0.1 mM EDTA. Following a second centrifugation, the final pellet was suspended in 20 mM HEPES pH 7.4, 100 mM NaCl, 10 mM $MgCl_2$. Ligand binding assays were performed as described above, using 0.5 to 2 μg of membrane protein.

Agonists and antagonists of Edg/S1P receptors can be identified in the ^{33}P-sphingosine-1-phosphate binding assay. Compounds diluted in DMSO, methanol, or other solvent, were mixed with probe containing ^{33}P-sphingosine-1-phosphate and binding assay buffer in microtiter dishes. Membranes prepared from cells expressing Edg/S1P receptors were added, and binding to ^{33}P-sphingosine-1-phosphate was performed as described. Determination of the amount of binding in the presence of varying concentrations of compound and analysis of the data by non-linear regression software such as MRLCalc (Merck Research Laboratories) or PRISM (GraphPad Software) was used to measure the affinity of compounds for the receptor. Selectivity of compounds for Edg/S1P receptors was determined by measuring the level of ^{33}P-sphingosine-1-phosphate binding in the presence of the compound using membranes prepared from cells transfected with each respective receptor ($S1P_1$/Edg1, $S1P_3$/Edg3, $S1P_2$/Edg5, $S1P_4$/Edg6, $S1P_5$/Edg8).

^{35}S-GTPγS Binding Assay

Functional coupling of S1P/Edg receptors to G proteins was measured in a ^{35}S-GTPγS binding assay. Membranes prepared as described in the Ligand Binding to Edg/S1P Receptors Assay (1-10 μg of membrane protein) were incubated in a 200 μl volume containing 20 mM HEPES pH 7.4, 100 mM NaCl, 10 mM $MgCl_2$, 5 μM GDP, 0.1% fatty acid-free BSA (Sigma, catalog A8806), various concentrations of sphingosine-1-phosphate, and 125 pM ^{35}S-GTPγS (NEN; specific activity 1250 Ci/mmol) in 96 well microtiter dishes. Binding was performed for 1 hour at room temperature with gentle mixing, and terminated by harvesting the membranes onto GF/B filter plates with a Packard Filtermate Universal Harvester. After drying the filter plates for 30 min, 40 μl of Microscint 20 was added to each well and binding was measured on a Wallac Microbeta Scintillation Counter.

Agonists and antagonists of S1P/Edg receptors can be discriminated in the ^{35}S-GTPγS binding assay. Compounds diluted in DMSO, methanol, or other solvent, were added to microtiter dishes to provide final assay concentrations of 0.01 nM to 10 μM. Membranes prepared from cells expressing S1P/Edg receptors were added, and binding to ^{35}S-GTPγS was performed as described. When assayed in the absence of the natural ligand or other known

agonist, compounds that stimulate ^{35}S-GTPγS binding above the endogenous level were considered agonists, while compounds that inhibit the endogenous level of ^{35}S-GTPγS binding were considered inverse agonists. Antagonists were detected in a ^{35}S-GTPγS binding assay in the presence of a sub-maximal level of natural ligand or known S1P/Edg receptor agonist, where the compounds reduced the level of ^{35}S-GTPγS binding. Determination of the amount of binding in the presence of varying concentrations of compound was used to measure the potency of compounds as agonists, inverse agonists, or antagonists of S1P/Edg receptors. To evaluate agonists, percent stimulation over basal was calculated as binding in the presence of compound divided by binding in the absence of ligand, multiplied by 100. Dose response curves were plotted using a non-linear regression curve fitting program MRLCalc (Merck Research Laboratories), and EC_{50} values were defined to be the concentration of agonist required to give 50% of its own maximal stimulation. Selectivity of compounds for S1P/Edg receptors was determined by measuring the level of ^{35}S-GTPγS binding in the presence of compound using membranes prepared from cells transfected with each respective receptor.

Intracellular Calcium Flux Assay

Functional coupling of S1P/Edg receptors to G protein associated intracellular calcium mobilization was measured using FLIPR (Fluorescence Imaging Plate Reader, Molecular Devices). Cells expressing S1P/Edg receptors were harvested and washed once with assay buffer (Hanks Buffered Saline Solution (BRL) containing 20mM HEPES, 0.1% BSA and 710 μg/ml probenicid (Sigma)). Cells were labeled in the same buffer containing 500 nM of the calcium sensitive dye Fluo-4 (Molecular Probes) for 1 hour at 37°C and 5% CO_2. The cells were washed twice with buffer before plating $1.5x10^5$ per well (90μl) in 96 well polylysine coated black microtiter dishes. A 96-well ligand plate was prepared by diluting sphingosine-1-phosphate or other agonists into 200 μl of assay buffer to give a concentration that was 2-fold the final test concentration. The ligand plate and the cell plate were loaded into the FLIPR instrument for analysis. Plates were equilibrated to 37°C. The assay was initiated by transferring an equal volume of ligand to the cell plate and the calcium flux was recorded over a 3 min interval. Cellular response was quantitated as area (sum) or maximal peak height (max). Agonists were evaluated in the absence of natural ligand by dilution of compounds into the appropriate solvent and transfer to the Fluo-4 labeled cells. Antagonists were evaluated by pretreating Fluo-4 labeled

cells with varying concentrations of compounds for 15 min prior to the initiation of calcium flux by addition of the natural ligand or other S1P/Edg receptor agonist.

Preparation of Cells Expressing S1P/Edg Receptors

Any of a variety of procedures may be used to clone $S1P_1$/Edg1, $S1P_3$/Edg3, $S1P_2$/Edg5, $S1P_4$/Edg6 or $S1P_5$/Edg8. These methods include, but are not limited to, (1) a RACE PCR cloning technique (Frohman, et al., 1988, *Proc. Natl. Acad. Sci. USA* 85: 8998-9002). 5′ and/or 3′ RACE may be performed to generate a full-length cDNA sequence; (2) direct functional expression of the Edg/S1P cDNA following the construction of an S1P/Edg-containing cDNA library in an appropriate expression vector system; (3) screening an S1P/Edg-containing cDNA library constructed in a bacteriophage or plasmid shuttle vector with a labeled degenerate oligonucleotide probe designed from the amino acid sequence of the S1P/Edg protein; (4) screening an S1P/Edg-containing cDNA library constructed in a bacteriophage or plasmid shuttle vector with a partial cDNA encoding the S1P/Edg protein. This partial cDNA is obtained by the specific PCR amplification of S1P/Edg DNA fragments through the design of degenerate oligonucleotide primers from the amino acid sequence known for other proteins which are related to the S1P/Edg protein; (5) screening an S1P/Edg-containing cDNA library constructed in a bacteriophage or plasmid shuttle vector with a partial cDNA or oligonucleotide with homology to a mammalian S1P/Edg protein. This strategy may also involve using gene-specific oligonucleotide primers for PCR amplification of S1P/Edg cDNA; or (6) designing 5′ and 3′ gene specific oligonucleotides using the S1P/Edg nucleotide sequence as a template so that either the full-length cDNA may be generated by known RACE techniques, or a portion of the coding region may be generated by these same known RACE techniques to generate and isolate a portion of the coding region to use as a probe to screen one of numerous types of cDNA and/or genomic libraries in order to isolate a full-length version of the nucleotide sequence encoding S1P/Edg.

It is readily apparent to those skilled in the art that other types of libraries, as well as libraries constructed from other cell types-or species types, may be useful for isolating an S1P/Edg-encoding DNA or an S1P/Edg homologue. Other types of libraries include, but are not limited to, cDNA libraries derived from other cells.

It is readily apparent to those skilled in the art that suitable cDNA libraries may be prepared from cells or cell lines which have S1P/Edg activity. The selection of cells or cell lines

for use in preparing a cDNA library to isolate a cDNA encoding S1P/Edg may be done by first measuring cell-associated S1P/Edg activity using any known assay available for such a purpose.

Preparation of cDNA libraries can be performed by standard techniques well known in the art. Well known cDNA library construction techniques can be found for example, in Sambrook et al., 1989, *Molecular Cloning: A Laboratory Manual*; Cold Spring Harbor Laboratory, Cold Spring Harbor, New York. Complementary DNA libraries may also be obtained from numerous commercial sources, including but not limited to Clontech Laboratories, Inc. and Stratagene.

An expression vector containing DNA encoding an S1P/Edg-like protein may be used for expression of S1P/Edg in a recombinant host cell. Such recombinant host cells can be cultured under suitable conditions to produce S1P/Edg or a biologically equivalent form. Expression vectors may include, but are not limited to, cloning vectors, modified cloning vectors, specifically designed plasmids or viruses. Commercially available mammalian expression vectors may be suitable for recombinant S1P/Edg expression.

Recombinant host cells may be prokaryotic or eukaryotic, including but not limited to, bacteria such as *E. coli*, fungal cells such as yeast, mammalian cells including, but not limited to, cell lines of bovine, porcine, monkey and rodent origin; and insect cells including but not limited to *Drosophila* and silkworm derived cell lines.

The nucleotide sequences for the various S1P/Edg receptors are known in the art. See, for example, the following:

S1P$_1$/Edg1 Human

Hla, T. and T. Maciag 1990 An abundant transcript induced in differentiating human endothelial cells encodes a polypeptide with structural similarities to G-protein coupled receptors. J. Biol Chem. 265:9308-9313, hereby incorporated by reference in its entirety.

WO91/15583, published on October 17, 1991, hereby incorporated by reference in its entirety.

WO99/46277, published on September 16, 1999, hereby incorporated by reference in its entirety.

S1P$_1$/Edg1 Mouse

WO0059529, published October 12, 2000, hereby incorporated by reference in its entirety.

U.S. No. 6,323,333, granted November 27, 2001, hereby incorporated by reference in its entirety.

S1P1/Edg1 Rat

Lado, D.C., C. S. Browe, A.A. Gaskin, J. M. Borden, and A. J. MacLennan. 1994 Cloning of the rat edg-1 immediate-early gene: expression pattern suggests diverse functions. Gene 149: 331-336, hereby incorporated by reference in its entirety.

U.S. No. 5,585,476, granted December 17, 1996, hereby incorporated by reference in its entirety.

U.S. No. 5856,443, granted January 5, 1999, hereby incorporated by reference in its entirety.

S1P3/Edg3 Human

An, S., T. Bleu, W. Huang, O.G. Hallmark, S. R. Coughlin, E.J. Goetzl 1997 Identification of cDNAs encoding two G protein-coupled receptors for lysosphingolipids FEBS Lett. 417:279-282, hereby incorporated by reference in its entirety.

WO 99/60019, published November 25, 1999, hereby incorporated by reference in its entirety.

U.S. No. 6,130,067, granted October 10, 2000, hereby incorporated by reference in its entirety.

S1P3/Edg3 Mouse

WO 01/11022, published February 15, 2001, hereby incorporated by reference in its entirety.

S1P3/Edg3 Rat

WO 01/27137, published April 19, 2001, hereby incorporated by reference in its entirety.

S1P2/Edg5 Human

An, S., Y. Zheng, T. Bleu 2000 Sphingosine 1-Phosphate-induced cell proliferation, survival, and related signaling events mediated by G Protein-coupled receptors Edg3 and Edg5. J. Biol. Chem 275: 288-296, hereby incorporated by reference in its entirety.

WO 99/35259, published July 15, 1999, hereby incorporated by reference in its entirety.

WO99/54351, published October 28, 1999, hereby incorporated by reference in its entirety.

WO 00/56135, published September 28, 2000, hereby incorporated by reference in its entirety.

S1P2/Edg5 Mouse

WO 00/60056, published October 12, 2000, hereby incorporated by reference in its entirety.

S1P2/Edg5 Rat

Okazaki, H., N. Ishizaka, T. Sakurai, K. Kurokawa, K. Goto, M. Kumada, Y. Takuwa 1993 Molecular cloning of a novel putative G protein-coupled receptor expressed in the cardiovascular system. Biochem. Biophys. Res. Comm. 190:1104-1109, hereby incorporated by reference in its entirety.

MacLennan, A.J., C. S. Browe, A.A. Gaskin, D.C. Lado, G. Shaw 1994 Cloning and characterization of a putative G-protein coupled receptor potentially involved in development. Mol. Cell. Neurosci. 5: 201-209, hereby incorporated by reference in its entirety.

U.S. No. 5,585,476, granted December 17, 1996, hereby incorporated by reference in its entirety.

U.S. No. 5856,443, granted January 5, 1999, hereby incorporated by reference in its entirety.

S1P4/Edg6 Human

Graler, M.H., G. Bernhardt, M. Lipp 1998 EDG6, a novel G-protein-coupled receptor related to receptors for bioactive lysophospholipids, is specifically expressed in lymphoid tissue. Genomics 53: 164-169, hereby incorporated by reference in its entirety.

WO 98/48016, published October 29, 1998, hereby incorporated by reference in its entirety.

U.S. No. 5,912,144, granted June 15, 1999, hereby incorporated by reference in its entirety.

WO 98/50549, published November 12, 1998, hereby incorporated by reference in its entirety.

U.S. No. 6,060,272, granted May 9, 2000, hereby incorporated by reference in its entirety.

WO 99/35106, published July 15, 1999, hereby incorporated by reference in its entirety.

WO 00/15784, published March 23, 2000, hereby incorporated by reference in its entirety.

WO 00/14233, published March 16, 2000, hereby incorporated by reference in its entirety.

S1P4/Edg6 Mouse

WO 00/15784, published March 23, 2000, hereby incorporated by reference in its entirety.

S1P5/Edg8 Human

Im, D.-S., J. Clemens, T.L. Macdonald, K.R. Lynch 2001 Characterization of the human and mouse sphingosine 1-phosphate receptor, S1P5 (Edg-8): Structure-Activity relationship of sphingosine 1-phosphate receptors. Biochemistry 40:14053-14060, hereby incorporated by reference in its entirety.

WO 00/11166, published March 2, 2000, hereby incorporated by reference in its entirety.

WO 00/31258, published June 2, 2000, hereby incorporated by reference in its entirety.

WO 01/04139, published January 18, 2001, hereby incorporated by reference in its entirety.

EP 1 090 925, published April 11, 2001, hereby incorporated by reference in its entirety.

S1P5/Edg8 Rat

Im, D.-S., C.E. Heise, N. Ancellin, B. F. O'Dowd, G.-J. Shei, R. P. Heavens, M. R. Rigby, T. Hla, S. Mandala, G. McAllister, S.R. George, K.R. Lynch 2000 Characterization of

a novel sphingosine 1-phosphate receptor, Edg-8. J. Biol. Chem. 275: 14281-14286, hereby incorporated by reference in its entirety.

WO 01/05829, published January 25, 2001, hereby incorporated by reference in its entirety.

Measurement of cardiovascular effects

The effects of compounds of the present invention on cardiovascular parameters can be evaluated by the following procedure:

Adult male rats (approx. 350 g body weight) were instrumented with femoral arterial and venous catheters for measurement of arterial pressure and intravenous compound administration, respectively. Animals were anesthetized with Nembutal (55 mg/kg, ip). Blood pressure and heart rate were recorded on the Gould Po-Ne-Mah data acquisition system. Heart rate was derived from the arterial pulse wave. Following an acclimation period, a baseline reading was taken (approximately 20 minutes) and the data averaged. Compound was administered intravenously (either bolus injection of approximately 5 seconds or infusion of 15 minutes duration), and data were recorded every 1 minute for 60 minutes post compound administration. Data are calculated as either the peak change in heart rate or mean arterial pressure or are calculated as the area under the curve for changes in heart rate or blood pressure versus time. Data are expressed as mean ± SEM. A one-tailed Student's paired t-test is used for statistical comparison to baseline values and considered significant at $p<0.05$.

The S1P effects on the rat cardiovascular system are described in Sugiyama, A., N.N. Aye, Y. Yatomi, Y. Ozaki, K. Hashimoto 2000
Effects of Sphingosine-1-Phosphate, a naturally occurring biologically active lysophospholipid, on the rat cardiovascular system. Jpn. J. Pharmacol. 82: 338-342, hereby incorporated by reference in its entirety.

Measurement of Mouse Acute Toxicity

A single mouse is dosed intravenously (tail vein) with 0.1 ml of test compound dissolved in a non-toxic vehicle and is observed for signs of toxicity. Severe signs may include death, seizure, paralysis or unconciousness. Milder signs are also noted and may include ataxia, labored breathing, ruffling or reduced activity relative to normal. Upon noting signs, the dosing solution is diluted in the same vehicle. The diluted dose is administered in the same fashion to a

second mouse and is likewise observed for signs. The process is repeated until a dose is reached that produces no signs. This is considered the estimated no-effect level. An additional mouse is dosed at this level to confirm the absence of signs.

Assessment of Lymphopenia

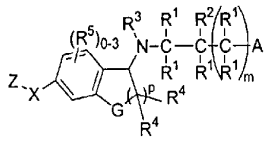
Compounds are administered as described in Measurement of Mouse Acute Toxicity and lymphopenia is assessed in mice at three hours post dose as follows. After rendering a mouse unconscious by CO_2 to effect, the chest is opened, 0.5 ml of blood is withdrawn via direct cardiac puncture, blood is immediately stabilized with EDTA and hematology is evaluated using a clinical hematology autoanalyzer calibrated for performing murine differential counts (H2000, CARESIDE, Culver City CA). Reduction in lymphocytes by test treatment is established by comparison of hematological parameters of three mice versus three vehicle treated mice. The dose used for this evaluation is determined by tolerability using a modification of the dilution method above. For this purpose, no-effect is desirable, mild effects are acceptable and severely toxic doses are serially diluted to levels that produce only mild effects.

In Vitro Activity of Examples

The examples disclosed herein have utility as immunoregulatory agents as demonstrated by their activity as potent and selective agonists of the $S1P_1$/Edg1 receptor over the S1PR3/Edg3 receptor as measured in the assays described above. In particular, the examples disclosed herein possess a selectivity for the $S1P_1$/Edg1 receptor over the S1PR3/Edg3 receptor of more than 100 fold as measured by the ratio of EC_{50} for the $S1P_1$/Edg1 receptor to the EC_{50} for the $S1P_3$/Edg3 receptor as evaluated in the ^{35}S-GTPγS binding assay described above and possess an EC_{50} for binding to the $S1P_1$/Edg1 receptor of less than 50 nM as evaluated by the ^{35}S-GTPγS binding assay described above.

The claims defining the invention are as follows:

1. A compound represented by Formula I :



(I)

or a pharmaceutically acceptable salt or hydrate thereof, wherein:

m is 0;

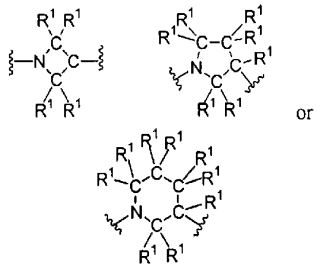
p is 1;

G is $-C(R^4)_2$,

A is selected from the group consisting of: $-CO_2H$, $-PO_3H_2$, $-PO_2H$, $-SO_3H$, $-PO(C_{1-3}alkyl)OH$ and 1H-tetrazol-5-yl;

each R^1 is independently selected from the group consisting of: hydrogen, halo, hydroxy, C_{1-6}alkyl and C_{1-5}alkoxy, each C_{1-6}alkyl and C_{1-5}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy;

R^2 and R^3 are joined together to form a 4 or 5-membered monocyclic ring defined as follows:



or

each R^4 is independently selected from the group consisting of: hydrogen and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted from one up to the maximum number of substitutable positions with halo,

each R^5 is independently selected from the group consisting of: halo, C_{1-4}alkyl and

C_{1-3}alkoxy, said C_{1-4}alkyl and C_{1-3}alkoxy optionally substituted from one up to the maximum number of substitutable positions with halo,

Z is selected from the group consisting of:

(1) C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or -CHOH-C_{1-6}alkyl, said C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl and-CHOH-C_{1-6}alkyl optionally substituted with phenyl and C_{3-6}cycloalkyl, and

(2) phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

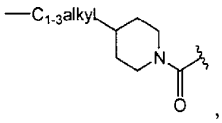
(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of: halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy,

or Z is not present;

when Z is not present then X is selected from the group consisting of: phenyl, C_{5-16}alkyl, C_{5-16}alkynyl, -CHOH-C_{4-15}alkyl, -CHOH-C_{4-15}alkenyl, -CHOH-C_{4-15}alkynyl, C_{4-15}alkoxy, -O-C_{4-15}alkenyl, -O-C_{4-15}alkynyl, C_{4-15}alkylthio, -S-C_{4-15}alkenyl, -S-C_{4-15}alkynyl, -CH_2-C_{3-14}alkoxy, -CH_2-O-C_{3-14}alkenyl, -CH_2-O-C_{3-14}alkynyl, -(C=O)-C_{4-15}alkyl, - (C=O)-C_{4-15}alkenyl, -(C=O)-C_{4-15}alkynyl, -(C=O)-O-C_{3-14}alkyl, -(C=O)-O-C_{3-14}alkenyl, -(C=O)-O-C_{3-14}alkynyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkenyl, -(C=O)-N(R^6)(R^7)-C_{3-14}alkynyl, -N(R^6)(R^7)—(C=O)-C_{3-4}alkyl, -N(R^6)(R^7)-(C=O)-C_{3-14}alkenyl and-N(R^6)(R^7)-(C=O)-C_{3-14}alkynyl,

when Z is phenyl or HET^1, optionally substituted as defined above, then X is selected from the group consisting of : -C_{1-6}alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C_{1-4}alkyl-,



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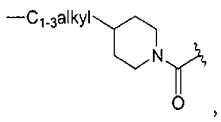
phenyl and HET^2, said phenyl and HET^2 each optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy, and wherein when X is $-C_{1-6}$alkyl-, -O-C_{1-5}alkyl-, -(C=O)-C_{1-5}alkyl-, -(C=O)-O-C_{1-4}alkyl-, -(C=O)-N(R^6)(R^7)-C_{1-4}alkyl-, or



the point of attachment of the group Z is on the alkyl, and

when Z is C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or -CHOH-C_{1-6}alkyl, optionally substituted as defined above, then X is phenyl, said phenyl optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy;

R^6 and R^7 are independently selected from the group consisting of: hydrogen, C_{1-9}alkyl and -$(CH_2)_p$-phenyl, wherein p is 1 to 5 and phenyl is optionally substituted with 1-3 substituents independently selected from the group consisting of: C_{1-3}alkyl and C_{1-3}alkoxy, each optionally substituted with 1-3 halo groups; and

HET^1 and HET^2 are each independently selected from the group consisting of: benzimidazolyl, benzofuranyl, benzopyrazolyl, benzotriazolyl, benzothiophenyl, benzoxazolyl, carbazolyl, carbolinyl, cinnolinyl, furanyl, imidazolyl, indolinyl, indolyl, indolazinyl, indazolyl, isobenzofuranyl, isoindolyl, isoquinolyl, isothiazolyl, isoxazolyl, naphthyridinyl, oxadiazolyl, oxazolyl, pyrazinyl, pyrazolyl, pyridopyridinyl, pyridazinyl, pyridyl, pyrimidyl, pyrrolyl, quinazolinyl, quinolyl, quinoxalinyl, thiadiazolyl, thiazolyl, thienyl, triazolyl, azetidinyl, 1,4-dioxanyl, hexahydroazepinyl, piperazinyl, piperidinyl, pyrrolidinyl, morpholinyl, thiomorpholinyl, dihydrobenzimidazolyl, dihydrobenzofuranyl, dihydrobenzothiophenyl, dihydrobenzoxazolyl, dihydrofuranyl, dihydroimidazolyl, dihydroindolyl, dihydroisooxazolyl, dihydroisothiazolyl, dihydrooxadiazolyl, dihydrooxazolyl, dihydropyrazinyl, dihydropyrazolyl, dihydropyridinyl, dihydropyrimidinyl, dihydropyrrolyl, dihydroquinolinyl, dihydrotetrazolyl, dihydrothiadiazolyl, dihydrothiazolyl, dihydrothienyl, dihydrotriazolyl, dihydroazetidinyl, methylenedioxybenzoyl, tetrahydrofuranyl, and tetrahydrothienyl or

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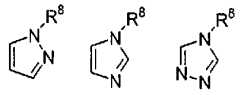


where R^8 is hydroxyl or halo.

2. The compound according to Claim 1 wherein:

Z is phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of: halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy,

or Z is not present;

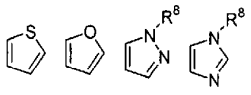
when Z is not present then X is selected from the group consisting of: C_{7-12}alkyl, C_{7-12}alkenyl, C_{7-12}alkynyl, C_{6-11}alkoxy, -O-C_{6-11}alkenyl, -O-C_{6-11}alkynyl, -(C=O)-C_{6-11}alkyl, -(C=O)-C_{6-11}alkenyl, -(C=O)-C_{6-11}alkynyl, -(C=O)-O-C_{5-10}alkyl, -(C=O)-O-C_{5-19}alkenyl, and-(C=O)-O-C_{5-10}alkynyl;

and

when Z is phenyl or HET^1, optionally substituted as defined above, then X is selected from the group consisting of -C_{1-5}alkyl-, -C_{1-4}alkoxy-, -(C=O)-C_{1-4}alkyl-, -(C=O)-O-C_{1-3}alkyl-, phenyl and HET^2, and wherein when X is -C_{1-4}alkoxy-, -(C=O)-C_{1-5}alkyl- or

-(C=O)-O-C_{1-4}alkyl-, the point of attachment of the group Z is on the alkyl.

3. The compound according to Claim 1 wherein HET^1 and HET^2 are independently selected from the group consisting of:



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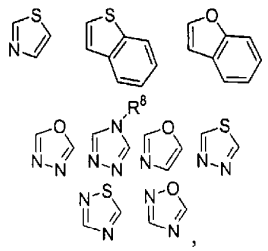

wherein R^8 is selected from hydrogen, hydroxy and halo.

4. The compound according to Claim 1 wherein X is selected from the group consisting of: C_{7-12}alkyl, C_{7-12}alkenyl, C_{7-12}alkynyl, C_{6-11}alkoxy, -O-C_{6-11}alkenyl, -O-C_{6-11}alkynyl, -(C=O)-C_{6-11}alkyl, -(C=O)-C_{6-11}alkenyl, -(C=O)-C_{6-11}alkynyl, -(C=O)-O-C_{5-10}alkyl-,-(C=O)-O-C_{5-19}alkenyl, and -(C=O)-O-C_{5-10}alkynyl and Z is not present.

5. The compound according to Claim 1 wherein:

X is methoxy and Z is HET^1 substituted with phenyl and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and said phenyl optionally substituted with 1 to 5 substituents independently selected from the group consisting of: halo and C_{1-4}alkyl, optionally substituted with 1-3 halo groups.

6. The compound according to Claim 1 wherein:

X is HET^2, optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy, and

Z is phenyl or HET^1, each optionally substituted with 1-3 substituents independently selected from the group consisting of:

(a) halo,

(b) phenyl, optionally substituted with 1 to 5 groups independently selected from the group consisting of: halo and C_{1-4}alkyl, said C_{1-4}alkyl optionally substituted with 1-3 halo groups, and

(c) C_{1-4}alkyl or C_{1-4}alkoxy, said C_{1-4}alkyl and C_{1-4}alkoxy optionally substituted from one up to the maximum number of substitutable positions with a substituent independently selected from halo and hydroxy.

7. The compound according to Claim 1 wherein:

Z is C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl or -CHOH-C_{1-6}alkyl, said C_{1-8}alkyl, C_{1-8}alkoxy, -(C=O)-C_{1-6}alkyl and -CHOH-C_{1-6}alkyl optionally substituted with phenyl and C_{3-6}cycloalkyl, and

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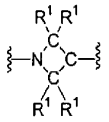
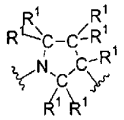
X is phenyl, said phenyl optionally substituted with 1-3 substituents independently selected from the group consisting of: halo, C_{1-4}alkyl and C_{1-4}alkoxy.

8 The compound according to Claim 1 wherein G is -CH_2-.

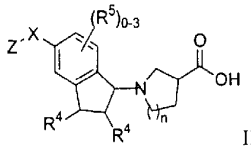
9. The compound according to Claim 1 wherein R^2 and R^3 are joined together to form a 4-membered monocyclic ring defined as follows:



10. The compound according to Claim 1 wherein R^2 and R^3 are joined together to form a 5-membered monocyclic ring defined as follows:



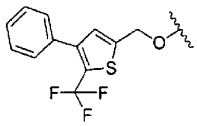
11. A compound according to Claim 1 of Formula II:



II

or a pharmaceutically acceptable salt or hydrate thereof, wherein n is 0 or 1.

12. The compound according to Claim 11 wherein n is 0 and –X-Z is selected from the following group:



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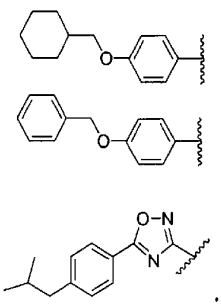
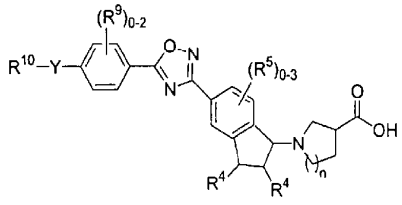


13. The compound according to Claim 11 of Formula III



III

or a pharmaceutically acceptable salt or hydrate thereof, wherein:

n is 0 or 1,

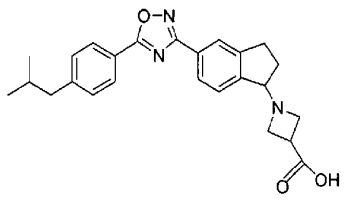
Y is oxygen or a bond,

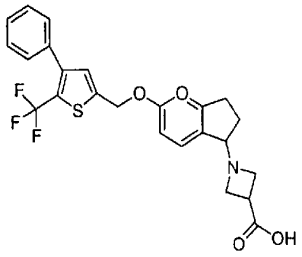
R_{10} is C_{1-4}alkyl,

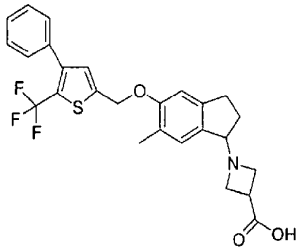
each R^9 is independently halo, C_{1-4}alkyl or C_{1-4}alkoxy.

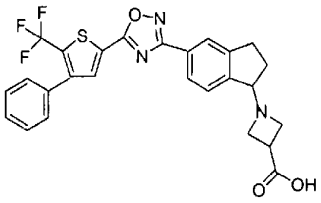
14. The compound according to Claim 13 wherein n is 0, each R^4 is hydrogen and R^5 and R^9 are both not present.

15. A compound or a pharmaceutically acceptable salt thereof selected from the following table:









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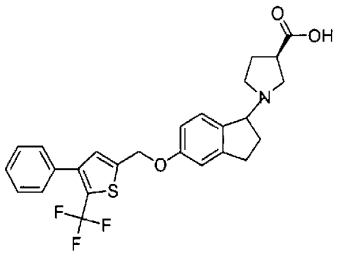

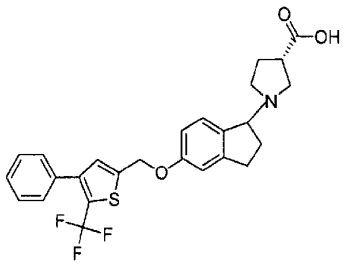

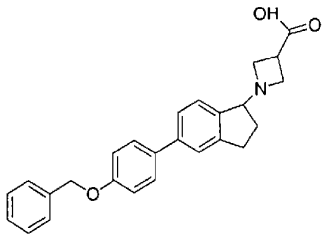

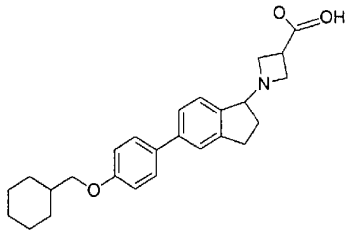

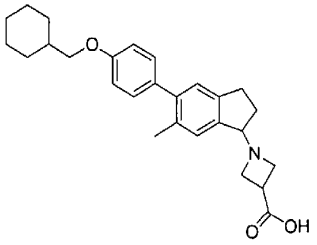

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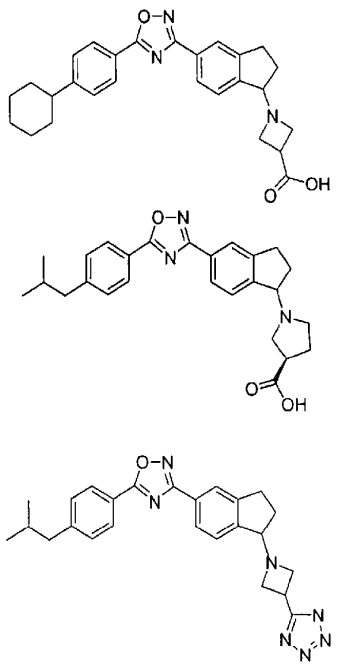

16. A compound selected from the following:

(1) (RS)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof,

(2) (R)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof, and

(3) (S)-1-(5-(5-(4-(2-Methylpropyl)phenyl)-1,2,4-oxadiazol-3-yl]-2,3-dihydro-1H-inden-1-yl)azetidine-3-carboxylic acid or a pharmaceutically acceptable salt thereof.

17. A pharmaceutical composition comprised of a compound in accordance with any one of claims 1 to 16, or a pharmaceutically acceptable salt thereof, in combination with a pharmaceutically acceptable carrier.

18. A method of (a) treating an immunoregulatory abnormality in a mammalian patient in need of such treatment; or (b) suppressing the immune system in a mammalian patient in need of immunosuppression; or (c) treating a respiratory disease or condition in a mammalian patient in need of such treatment, comprising administering to said patient

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an effect amount of a compound in accordance with any one of claims 1 to 16, or a pharmaceutically acceptable salt thereof.

19. The method according to claim 18 wherein the immunoregulatory abnormality is selected from the group consisting of: transplantation of organs or tissue, graft-versus-host diseases brought about by transplantation, autoimmune syndromes including rheumatoid arthritis, chronic rheumatoid arthritis, systemic lupus erythematosus, Hashimoto's thyroiditis, multiple sclerosis, myasthenia gravis, type I diabetes, uveitis, posterior uveitis, allergic encephalomyelitis, glomerulonephritis, post-infectious autoimmune diseases including rheumatic fever and pos-tinfectious glomerulonephritis, inflammatory and hyperproliferative skin diseases, psoriasis, atopic dermatitis, contact dermatitis, eczematous dermatitis, seborrhoeic dermatitis, lichen planus, pemphigus, bullous pemphigoid, epidermolysis bullosa, urticaria, angioedemas, vasculitis, erythema, cutaneous eosinophilia, lupus erythematosus, acne, alopecia areata, keratoconjunctivitis, vernal conjunctivitis, uveitis associated with Behcet's disease, keratitis, herpetic keratitis, conical cornea, dystrophia epithelialis cornea, corneal leukoma, ocular pemphigus, Mooren's ulcer, scleritis, Graves'opthalmopathy, Vogt-Koyanagi-Harada syndrome, sarcoidosis, pollen allergies, reversible obstructive airway disease, bronchial asthma, allergic asthma, intrinsic asthma, extrinsic asthma, dust asthma, chronic or inveterate asthma, late asthma and airway hyper-responsiveness, bronchitis, gastric ulcers, vascular damage caused by ischemic diseases and thrombosis, ischemic bowel diseases, inflammatory bowel diseases, necrotizing enterocolitis, intestinal lesions associated with thermal burns, coeliac diseases, proctitis, eosinophilic gastroenteritis, mastocytosis, Crohn's disease, ulcerative colitis, migraine, rhinitis, eczema, interstitial nephritis, Goodpasture's syndrome, hemolytic-uremic syndrome, diabetic nephropathy, multiple myositis, Guillain-Barre syndrome, Meniere's disease, polyneuritis, multiple neuritis, mononeuritis, radiculopathy, hyperthyroidism, Basedow's disease, pure red cell aplasia, aplastic anemia, hypoplastic anemia, idiopathic thrombocytopenic purpura, autoimmune hemolytic anemia, agranulocytosis, pernicious anemia, megaloblastic anemia, anerythroplasia, osteoporosis, sarcoidosis, fibroid lung, idiopathic interstitial pneumonia, dermatomyositis, leukoderma vulgaris, ichthyosis vulgaris, photoallergic sensitivity, cutaneous T cell lymphoma, arteriosclerosis, atherosclerosis, aortitis syndrome, polyarteritis nodosa, myocardosis, scleroderma, Wegener's granuloma, Sjogren's syndrome, adiposis, eosinophilic fascitis, lesions of gingiva, periodontium, alveolar bone, substantia ossea dentis, glomerulonephritis, male pattern alopecia or alopecia senilis by preventing epilation or providing hair germination

and/or promoting hair generation and hair growth, muscular dystrophy, pyoderma and Sezary's syndrome, Addison's disease, ischemia-reperfusion injury of organs which occurs upon preservation, transplantation or ischemic disease, endotoxin-shock, pseudomembranous colitis, colitis caused by drug or radiation, ischemic acute renal insufficiency, chronic renal insufficiency, toxinosis caused by lung-oxygen or drugs, lung cancer, pulmonary emphysema, cataracta, siderosis, retinitis pigmentosa, senile macular degeneration, vitreal scarring, corneal alkali burn, dermatitis erythema multiforme, linear IgA ballous dermatitis and cement dermatitis, gingivitis, periodontitis, sepsis, pancreatitis, diseases caused by environmental pollution, aging, carcinogenesis, metastasis of carcinoma and hypobaropathy, disease caused by histamine or leukotriene-C4 release, Behcet's disease, autoimmune hepatitis, primary biliary cirrhosis, sclerosing cholangitis, partial liver resection, acute liver necrosis, necrosis caused by toxin, viral hepatitis, shock, or anoxia, B-virus hepatitis, non-A/non-B hepatitis, cirrhosis, alcoholic cirrhosis, hepatic failure, fulminant hepatic failure, late-onset hepatic failure, "acute-on-chronic" liver failure, augmentation of chemotherapeutic effect, cytomegalovirus infection, HCMV infection, AIDS, cancer, senile dementia, trauma, and chronic bacterial infection.

20. Use of a compound in accordance with any one of claims 1 to 16, or a pharmaceutically acceptable salt thereof, in the manufacture of a medicament for (a) treating an immunoregulatory abnormality in a mammalian patient in need of such treatment; or (b) suppressing the immune system in a mammalian patient in need of immunosuppression; or (c) treating a respiratory disease or condition in a mammalian patient in need of such treatment.

Dated 24 December 2009

Merck & Co., Inc.

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SPRUSON & FERGUSON

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