SULFONAMIDES AND DERIVATIVES THEREOF THAT MODULATE THE ACTIVITY OF ENDOTHELIN

RELATED APPLICATIONS

Benefit of priority is claimed to U.S. provisional application Serial No. 60/174,104 to Wu et al., filed December 31, 1999, entitled "SULFONAMIDES AND DERIVATIVES THEREOF THAT MODULATE THE ACTIVITY OF ENDOTHELIN". For U.S. purposes and where appropriate, the subject matter of the provisional application is incorporated herein in its entirety.

FIELD OF THE INVENTION

The present invention relates to compounds that modulate the activity of the endothelin family of peptides. In particular, the invention relates to the use of sulfonamides and sulfonamide derivatives as endothelin agonists and antagonists.

BACKGROUND OF THE INVENTION

The vascular endothelium releases a variety of vasoactive substances, including the endothelium-derived vasoconstrictor peptide, endothelin (ET) (see, e.g., Vanhoutte et al. (1986) Annual Rev. Physiol. 48: 307-320; Furchgott and Zawadski (1980) Nature 288: 373-376). Endothelin, which was originally identified in the culture supernatant of porcine aortic endothelial cells (see, Yanagisawa et al. (1988) Nature 332: 411-415), is a potent twenty-one amino acid peptide vasoconstrictor. It is a highly potent vasopressor known and is produced by numerous cell types, including the cells of the endothelium, trachea, kidney and brain. Endothelin is synthesized as a two hundred and three amino acid precursor preproendothelin that contains a signal sequence which is cleaved by an endogenous protease to produce a thirty-eight (human) or thirty-nine (porcine) amino acid peptide. This intermediate, referred to as big endothelin, is processed in vivo to the mature biologically active form by a putative endothelin-converting enzyme (ECE)

that appears to be a metal-dependent neutral protease (see, e.g., Kashiwabara et al. (1989) FEBS Lttrs. 247: 337-340). Cleavage is required for induction of physiological responses (see, e.g., von Geldern et al. (1991) Peptide Res. 4: 32-35). In porcine aortic endothelial cells, the thirty-nine amino acid intermediate, big endothelin, is hydrolyzed at the Trp^{21}-Val^{22} bond to generate endothelin-1 and a C-terminal fragment. A similar cleavage occurs in human cells from a thirty-eight amino acid intermediate. Three distinct endothelin isopeptides, endothelin-1, endothelin-2 and endothelin-3, that exhibit potent vasoconstrictor activity have been identified.

The family of three isopeptides endothelin-1, endothelin-2 and endothelin-3 are encoded by a family of three genes (see, Inoue et al. (1989) Proc. Natl. Acad. Sci. USA 86: 2863-2867; see, also Saida et al. (1989)J. Biol. Chem. 264: 14613-14616). The nucleotide sequences of the three human genes are highly conserved within the region encoding the mature 21 amino acid peptides and the C-terminal portions of the peptides are identical. Endothelin-2 is (Trp^6,Leu^7) endothelin-1 and endothelin-3 is (Thr^2,Phe^4,Thr^5,Tyr^6,Lys^7,Tyr^{14}) endothelin-1. These peptides are, thus, highly conserved at the C-terminal ends. Release of endothelins from cultured endothelial cells is modulated by a variety of chemical and physical stimuli and appears to be regulated at the level of transcription and/or translation. Expression of the gene encoding endothelin-1 is increased by chemical stimuli, including adrenaline, thrombin and Ca^{2+} ionophore. The production and release of endothelin from the endothelium is stimulated by angiotensin II, vasopressin, endotoxin, cyclosporine and other factors (see, Brooks et al. (1991) Eur. J. Pharm. 194:115-117), and is inhibited by nitric oxide. Endothelial cells appear to secrete short-lived endothelium-derived relaxing factors (EDRF), including nitric oxide or a related substance (Palmer et al. (1987)

Nature 327: 524-526), when stimulated by vasoactive agents, such as acetylcholine and bradykinin. Endothelin-induced vasoconstriction is also attenuated by atrial natriuretic peptide (ANP).

The endothelin peptides exhibit numerous biological activities in vitro and in vivo. Endothelin provokes a strong and sustained vasoconstriction in vivo in rats and in isolated vascular smooth muscle preparations; it also provokes the release of eicosanoids and endothelium-derived relaxing factor (EDRF) from perfused vascular beds. Intravenous administration of endothelin-1 and in vitro addition to vascular and other smooth muscle tissues produce long-lasting pressor effects and contraction, respectively (see, e.g., Bolger et al. (1991) Can. J. Physiol. Pharmacol. 69: 406-413). In isolated vascular strips, for example, endothelin-1 is a potent (EC_{50} = 4 x 10^{-10} M), slow acting, but persistent, contractile agent. In vivo, a single dose elevates blood pressure in about twenty to thirty minutes. Endothelin-induced vasoconstriction is not affected by antagonists to known neurotransmitters or hormonal factors, but is abolished by calcium channel antagonists. The effect of calcium channel antagonists, however, is most likely the result of inhibition of calcium influx, since calcium influx appears to be required for the long-lasting contractile response to endothelin.

Endothelin also mediates renin release, stimulates ANP release and induces a positive inotropic action in guinea pig atria. In the lung, endothelin-1 acts as a potent bronchoconstrictor (Maggi et al. (1989) Eur. J. Pharmacol. 160: 179-182). Endothelin increases renal vascular resistance, decreases renal blood flow, and decreases glomerular filtrate rate. It is a potent mitogen for glomerular mesangial cells and invokes the phosphoinostide cascade in such cells (Simonson et al. (1990) J. Clin. Invest. 85: 790-797).

There are specific high affinity binding sites (dissociation constants in the range of 2-6 x 10^{-10} M) for the endothelins in the vascular system and in other tissues, including the intestine, heart, lungs, kidneys, spleen, adrenal glands and brain. Binding is not inhibited by catecholamines, vasoactive peptides, neurotoxins or calcium channel antagonists. Endothelin binds and interacts with receptor sites that are distinct from other autonomic receptors and voltage dependent calcium channels. Competitive binding studies indicate that there are multiple classes of receptors with different affinities for the endothelin isopeptides. The sarafotoxins, a group of peptide toxins from the venom of the snake Atractaspis eingadensis that cause severe coronary vasospasm in snake bite victims, have structural and functional homology to endothelin-1 and bind competitively to the same cardiac membrane receptors (Kloog et al. (1989) Trends Pharmacol. Sci. 10: 212-214).

Two distinct endothelin receptors, designated ET_A and ET_B, have been identified and DNA clones encoding each receptor have been isolated (Arai et al. (1990) Nature 348: 730-732; Sakurai et al. (1990) Nature 348: 732-735). Based on the amino acid sequences of the proteins encoded by the cloned DNA, it appears that each receptor contains seven trans-membrane spanning domains and exhibits structural similarity to G-protein-coupled membrane proteins. Messenger RNA encoding both receptors has been detected in a variety of tissues, including heart, lung, kidney and brain. The distribution of receptor subtypes is tissue specific (Martin et al. (1989) Biochem. Biophys. Res. Commun. 162: 130-137). ET_A receptors appear to be selective for endothelin-1 and are predominant in cardiovascular tissues. ET_B receptors are predominant in noncardiovascular tissues, including the central nervous system and kidney, and interact with the three endothelin isopeptides (Sakurai et al. (1990) Nature 348: 732-734). In addition, ET_A

receptors occur on vascular smooth muscle, are linked to vasoconstriction and have been associated with cardiovascular, renal and central nervous system diseases; whereas ET_B receptors are located on the vascular endothelium, linked to vasodilation (Takayanagi et al. (1991) FEBS Lttrs. 282: 103-106) and have been associated with bronchoconstrictive disorders.

By virtue of the distribution of receptor types and the differential affinity of each isopeptide for each receptor type, the activity of the endothelin isopeptides varies in different tissues. For example, endothelin-1 inhibits ^{125}I-labelled endothelin-1 binding in cardiovascular tissues forty to seven hundred times more potently than endothelin-3. ^{125}I-labelled endothelin-1 binding in non-cardiovascular tissues, such as kidney, adrenal gland, and cerebellum, is inhibited to the same extent by endothelin-1 and endothelin-3, which indicates that ET_A receptors predominate in cardiovascular tissues and ET_B receptors predominate in non-cardiovascular tissues.

Endothelin plasma levels are elevated in certain disease states (see, e.g., International PCT Application WO 94/27979, and U.S. Patent No. 5,382,569, which disclosures are herein incorporated in their entirety by reference). Endothelin-1 plasma levels in healthy individuals, as measured by radioimmunoassay (RIA), are about 0.26-5 pg/ml. Blood levels of endothelin-1 and its precursor, big endothelin, are elevated in shock, myocardial infarction, vasospastic angina, kidney failure and a variety of connective tissue disorders. In patients undergoing hemodialysis or kidney transplantation or suffering from cardiogenic shock, myocardial infarction or pulmonary hypertension levels as high as 35 pg/ml have been observed (see, Stewart et al. (1991) Annals Internal Med. 114: 464-469). Because endothelin is likely to be a local, rather than a systemic, regulating factor, it is probable that the levels of endothelin at the endothelium/smooth muscle interface are much higher than circulating levels.

Elevated levels of endothelin have also been measured in patients suffering from ischemic heart disease (Yasuda et al. (1990) Amer. Heart J. 119:801-806, Ray et al. (1992) Br. Heart J. 67:383-386). Circulating and tissue endothelin immunoreactivity is increased more than twofold in patients with advanced atherosclerosis (Lerman et al. (1991) New Engl. J. Med. 325:997-1001). Increased endothelin immunoreactivity has also been associated with Buerger's disease (Kanno et al. (1990) J. Amer. Med. Assoc. 264:2868) and Raynaud's phenomenon (Zamora et al. (1990) Lancet 336 1144-1147). Increased circulating endothelin levels were observed in patients who underwent percutaneous transluminal coronary angioplasty (PTCA) (Tahara et al. (1991) Metab. Clin. Exp. 40:1235-1237; Sanjay et al. (1991) Circulation 84(Suppl. 4):726), and in individuals (Miyauchi et al. (1992) Jpn. J. Pharmacol.58:279P; Stewart et al. (1991) Ann.Internal Medicine 114:464-469) with pulmonary hypertension. Thus, there is clinical human data supporting the correlation between increased endothelin levels and numerous disease states.

Endothelin agonists and antagonists

Because endothelin is associated with certain disease states and is implicated in numerous physiological effects, compounds that can interfere with or potentiate endothelin-associated activities, such as endothelin-receptor interaction and vasoconstrictor activity, are of interest. Compounds that exhibit endothelin antagonistic activity have been identified. For example, a fermentation product of Streptomyces misakiensis, designated BE-18257B, has been identified as an ET_A receptor antagonist. BE-18257B is a cyclic pentapeptide, cyclo(D-Glu-L-Ala-allo-D-Ile-L-Leu-D-Trp), which inhibits ^{125}I-labelled endothelin-1 binding in cardiovascular tissues in a concentration-dependent manner (IC_{50} 1.4 μM in aortic smooth muscle, 0.8 μM in ventricle membranes and 0.5 μM

in cultured aortic smooth muscle cells), but fails to inhibit binding to receptors in tissues in which ET_B receptors predominate at concentrations up to 100 μM. Cyclic pentapeptides related to BE-18257B, such as cyclo(D-Asp-Pro-D-Val-Leu-D-Trp) (BQ-123), have been synthesized and shown to exhibit activity as ET_A receptor antagonists (see, U.S. Patent No. 5,114,918 to Ishikawa et al.; see, also, EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD (October 7, 1991)). Studies that measure the inhibition by these cyclic peptides of endothelin-1 binding to endothelin-specific receptors indicate that these cyclic peptides bind preferentially to ET_A receptors. Other peptide and non-peptidic ET_A antagonists have been identified (see, e.g., 5,352,800, 5,334,598, 5,352,659, 5,248,807, 5,240,910, 5,198,548, 5,187,195, 5,082,838). These include other cyclic pentapeptides, acyltripeptides, hexapeptide analogs, certain anthraquinone derivatives, indanecarboxylic acids, certain N-pyriminylbenzenesulfonamides, certain benzenesulfonamides, and certain naphthalenesulfonamides (Nakajima et al. (1991) J. Antibiot. 44:1348-1356; Miyata et al. (1992) J. Antibiot. 45:74-8; Ishikawa et al. (1992) J.Med. Chem. 35:2139-2142; U.S. Patent No. 5,114,918 to Ishikawa et al.; EP A1 0 569 193; EP A1 0 558 258; EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD (October 7, 1991); Canadian Patent Application 2,067,288; Canadian Patent Application 2,071,193; U.S. Patent No. 5,208,243; U.S. Patent No. 5,270,313; U.S. Patent No. 5,612,359, U.S. Patent No. 5,514,696, U.S. Patent No. 5,378,715; Cody et al. (1993) Med. Chem. Res. 3:154-162; Miyata et al. (1992) J. Antibiot 45:1041-1046; Miyata et al. (1992) J. Antibiot 45:1029-1040, Fujimoto et al. (1992) FEBS Lett. 305:41-44; Oshashi et al. (1002) J. Antibiot 45:1684-1685; EP A1 0 496 452; Clozel et al. (1993) Nature 365:759-761; International Patent Application WO93/08799; Nishikibe et al. (1993) Life Sci. 52:717-724; and Benigni et al. (1993) Kidney Int.

44:440-444). Numerous sulfonamides that are endothelin peptide antagonists are also described in U.S. Patent Nos. 5,464,853, 5,594,021, 5,591,761, 5,571,821, 5,514,691, ~~5,464,853,~~ International PCT application No.96/31492 and International PCT application No. WO 97/27979. ← In general, the identified compounds have activities in in vitro assays as ET_A antagonists at concentrations on the order of about 50-100 μM or less. A number of such compounds have also been shown to possess activity in in vivo animal models.

Endothelin antagonists and agonists as therapeutic agents

It has been recognized that compounds that exhibit activity at IC_{50} or EC_{50} concentrations on the order of 10^{-4} or lower in standard in vitro assays that assess endothelin antagonist or agonist activity have pharmacological utility (see, e.g., U.S. Patent Nos. 5,352,800, 5,334,598, 5,352,659, 5,248,807, 5,240,910, 5,198,548, 5,187,195 and 5,082,838). By virtue of this activity, such compounds are considered to be useful for the treatment of hypertension such as peripheral circulatory failure, heart disease such as angina pectoris, cardiomyopathy, arteriosclerosis, myocardial infarction, pulmonary hypertension, vasospasm, vascular restenosis, Raynaud's disease, cerebral stroke such as cerebral arterial spasm, cerebral ischemia, late phase cerebral spasm after subarachnoid hemorrhage, asthma, bronchoconstriction, renal failure, particularly post-ischemic renal failure, cyclosporine nephrotoxicity such as acute renal failure, colitis, as well as other inflammatory diseases, endotoxic shock caused by or associated with endothelin, and other diseases in which endothelin has been implicated.

In view of the numerous physiological effects of endothelin and its association with certain diseases, endothelin is believed to play a critical role in these pathophysiological conditions (see, e.g., Saito et al. (1990)

Hypertension 15: 734-738; Tomita et al. (1989) N. Engl. J. Med. 321: 1127; Kurihara et al. (1989) J. Cardiovasc. Pharmacol. 13(Suppl. 5): S13-S17; Doherty (1992) J. Med. Chem. 35: 1493-1508; Morel et al. (1989) Eur. J. Pharmacol. 167: 427-428). More detailed knowledge of the function and structure of the endothelin peptide family should provide insight in the progression and treatment of such conditions.

To aid in gaining further understanding of and to develop treatments for endothelin-mediated or related disorders, there is a need to identify compounds that modulate or alter endothelin activity. Identification of compounds that modulate endothelin activity, such as those that act as specific antagonists or agonists, may not only aid in elucidating the function of endothelin, but may yield in therapeutically useful compounds. In particular, compounds that specifically interfere with the interaction of endothelin peptides with the ET_A or ET_B receptors should be useful in identifying essential characteristics of endothelin peptides, should aid in the design of therapeutic agents, and may be useful as disease specific therapeutic agents. As noted above, many of the compounds, particularly the sulfonamide compounds, are potent endothelin antagonists, and, thus, are ideal clinical candidates. For clinical use, potent compounds optimized for in vivo activity as well as stable formulations and suitable formulations for various routes of administration are needed.

Therefore, it is an object herein to provide compounds that have the ability to modulate the biological activity of one or more of the endothelin isopeptides and that exhibit in vivo activity. It is another object to provide compounds that have use as specific endothelin antagonists in vivo. It is also an object to use compounds that specifically interact with or inhibit the interaction of endothelin peptides with ET_A receptors. It is also an object herein to provide formulations of

such compounds useful for treatment of endothelin-mediated diseases. These compounds should be useful as therapeutic agents for the treatment of endothelin-mediated diseases and disorders.

SUMMARY OF THE INVENTION

Sulfonamides, formulations of sulfonamides and methods for modulating the interaction of an endothelin peptide with ET_A and/or ET_B receptors are provided. In particular, sulfonamides, formulations of sulfonamides and methods for inhibiting the binding of an endothelin peptide to ET_A or ET_B receptors are provided. The sulfonamides are substituted or unsubstituted thienyl, furyl, pyrrolyl and phenyl sulfonamides.

Particularly preferred sulfonamides are N-isoxazolyl thienyl, furyl, pyrrolyl and phenyl sulfonamides where the thiophene, furan, pyrrole or benzene ring is substituted with an aryl group, preferably a phenyl group, which has only one or two hydrogen substituents. These compounds exhibit superior potency, selectivity, efficacy, bioavailability, in vivo half-life and/or stability compared with compounds where the aryl group has more than two hydrogen substituents, while avoiding toxicological effects associated with hydrophobicity. In addition, these compounds exhibit good profiles in standard in vitro and in vivo toxicity tests.

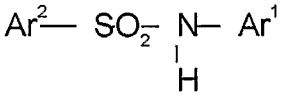
It shown herein that for in vivo administration, it is desirable to achieve the proper degree of hydrophilicity of the sulfonamide provided herein in order to reduce potential hemolytic properties of the compounds. This is achieved, for example, in ~~compunds~~ compounds in which the aryl group substituting the thiophene, furan, pyrrole or benzene ring is tetra-, penta- or hexasubstituted, preferably tetra- or penta-substituted. Where the aryl group is tetrasubstituted, it is preferably substituted at the 1, 2, 4 and 6 positions. The substituent at the 1-position is the linkage to the thiophene, furan, pyrrole or benzene ring. One of the substituents at the 2, 4 or 6 positions is preferably a polar group, such as hydroxyl,

acetoxy, carboxyl, sulfonyl, acyl, heteroaryl, oxime, halide, pseudohalide and carboxamide. Such substitution enhances the endothelin antagonist activity and the hydrophilicity of the compounds.

If the aryl group is substituted with three nonpolar groups, such as alkyl groups, more specifically methyl groups, then the aryl group is preferably penta- or hexasubstituted. In such pentasubstituted aryl groups, the fourth substituent is the linkage to the thiophene, furan, pyrrole or benzene ring, and the fifth substituent is preferably a polar group, such as hydroxyl, acetoxy, carboxyl, sulfonyl, acyl, heteroaryl, oxime, halide, pseudohalide and carboxamide. Such substitution is preferred to achieve highest levels of activity for therapeutic use.

The above substitution patterns provide compounds with good bioavailability, long in vivo half-life, and/or good in vivo efficacy. In view of the disclosure herein, other such optimal substituent patterns and substituents can be determined empirically using suitable animal models.

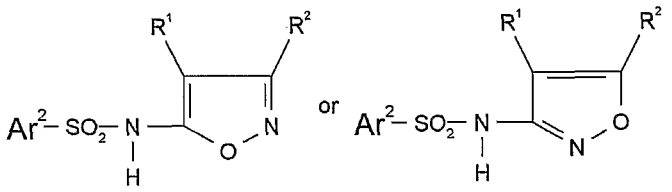
Compounds for use in the formulations and methods provided herein are sulfonamides having the formula I:



and pharmaceutically acceptable derivatives thereof, in which Ar^1 is an aryl or heteroaryl group that is unsubstituted or substituted with one or more substituents, including an alkyl group, an aryl group, a substituted aryl group, a nitro group, an amino group or a halide; or is an alkyl group. In particular, Ar^1 is alkyl or is a five or six membered substituted or unsubstituted aromatic or heteroaromatic ring, particularly 3- or 5-isoxazolyl, pyridazinyl, pyrazinyl, including 2-pyrazinyl, thiazolyl, including 2-thiazolyl, benzothiadiazolyl, including 2,1,3-benzothiadiazol-5-yl, benzoxadiazolyl, including 2,1,3-benzoxadiazol-5-yl, pyrimidinyl, including 2-pyrimidinyl, or substituted benzene groups, including aryloxy

substituted benzene groups, or is a bicyclic or tricyclic carbon or heterocyclic ring.

More preferred groups for Ar^1 are 3- or 5-isoxazolyl. In these embodiments, the compounds have the formula II:



in which R^1 and R^2 are either (i), (ii) or (iii) as follows:

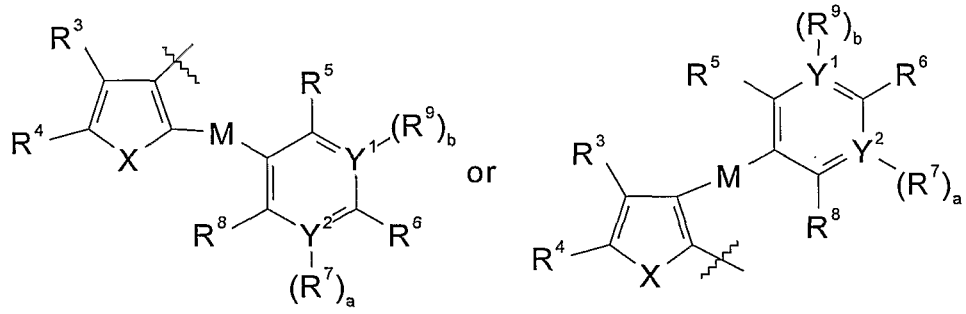
(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-).

In preferred embodiments herein, R^1 and R^2 are each selected independently from among alkyl, lower alkenyl, lower alkynyl, lower haloalkyl, halide, pseudohalide or H, except that R^2 is not halide.

In the compounds for use in the compositions and methods provided herein, Ar^2 is a thiophene, furan, pyrrole or phenyl group that has the formula:



in which M is -C(Y)-W-, $(CH_2)_mC(Y)(CH_2)_r$, $(CH_2)_mC(Y)NH(CH_2)_r$, $(CH_2)_m(CH=CH)(CH_2)_r$, $(CH_2)_mC(Y)(CH_2)_sNH(CH_2)_r$, $C=N(OH)(CH_2)_r$, $(CH_2)_mC(Y)(CH=CH)_sNH(CH_2)_r$, $CH(OH)(CH_2)_r$, $CH(CH_3)C(Y)(CH_2)_r$, $CH(CH_3)C(Y)(CH_2)_m(CH=CH)(CH_2)_r$, $(CH_2)_r$, $(CH_2)_rO$, or $(CH_2)S(O)_n$; where n is 0-2; m, s and r are each independently 0 to 6, preferably 0 to 3; W is O, NH or $(CH_2)_z$ where z is 0 to 6, preferably 0 to 3, more preferably 1; and Y is O, S, or, together with R^8 and the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring, preferably a 5 or 6 membered unsubstituted or substituted cyclic or heterocyclic ring, more preferably a 6 membered unsubstituted or substituted heterocyclic ring; M is preferably -C(Y)-W- or $(CH_2)_z$;

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, a sulfonyl chloride, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl;~~ lower haloalkyl x and y are each independently 0 to 14; and R^{50} is a ~~subsitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy (i.e. $-O\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}S-$, where n is 1 to 4, preferably 1 or 2) which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or

halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i); and

X is $-C(R^3)=C(R^4)-$, S, O or NR^{11}, where R^{11} is hydrogen or contains up to about 30 carbon atoms, preferably 1 to 10, more preferably 1 to 6 and is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{15}$ and $S(O)_nR^{15}$ in which n is 0-2; R^{15} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{11} and R^{15} are unsubstituted or are substituted with one or more substituents each selected independently from Z, which as defined herein includes hydrogen, halide, pseudohalide, alkyl, alkoxy, alkenyl, alkynyl, aryl, amino acids, primary and secondary amides, O-glycosides, hexoses, riboses, alkylaryl, alkylheteroaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, OH, CN, $C(O)R^{16}$, $OC(O)R^{16}$, CO_2R^{16}, OCO_2R^{16}, SH, $S(O)_nR^{16}$ in which n is 0-2, NHOH, $NR^{12}R^{16}$, NO_2, N_3, OR^{16}, $R^{12}NCOR^{16}$ and $CONR^{12}R^{16}$; R^{16} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, chloride, NHR^{50}, alkylaryl, alkylheteroaryl or $-(CH_2)_xOH$; R^{50} is a substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; x is 0 to 14; R^{12}, which is selected independently from R^{11} and Z, is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{17}$ and $S(O)_nR^{17}$ in which n is 0-2; R^{17} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{12} and R^{16} may together form alkylene; each of R^{11}, R^{12}, R^{15} and R^{16} may be further substituted with the any of the appropriate groups of those set forth for Z.

In all embodiments herein, X is preferably S or -CH=CH-, more preferably S.

In certain embodiments, the compounds are selected with the proviso that at most two of R^5, R^6, R^7, R^8 and R^9 are hydrogen. In other embodiments, the compounds are selected with the proviso that at most one of R^5, R^6, R^7, R^8 and R^9 are hydrogen.

In other embodiments, the compounds are of formula I or II, with the proviso that the compound is not specifically disclosed in International Patent application Publication Nos. WO 94/27979, WO 96/31492, WO 98/13366 and WO 98/49162, the disclosures of which are incorporated herein by reference.

In other embodiments, the compounds are selected with the proviso that R^8 is not COOH, $CONH_2$ or phenyl.

Of the compounds described herein, those that inhibit or increase an endothelin-mediated activity by about 50% at concentrations of less than about 10 μM are preferred. More preferred are those that inhibit or increase an endothelin-mediated activity by about 50% at concentrations of less than about 1 μM, more preferably less than about 0.1 μM, even more preferably less than about 0.01 μM, and most preferably less than about 0.001 μM. It is noted that, as described below, the IC_{50} concentration determined in the in vitro assays is a non-linear function of incubation temperature. The preferred values recited herein refer to the assays that are performed at 4° C. When the assays are performed at 24° C, somewhat higher (see, Table 1) IC_{50} concentrations are observed. Accordingly, the preferred IC_{50} concentrations are about 10-fold higher. Furthermore, among these compounds, those that exhibit the greatest bioavailability and stability, as determined using standard animal models are more preferred.

Also among the most preferred compounds for use in methods provided herein, are those that are ET_A selective, i.e., they interact with ET_A receptors at substantially lower concentrations (at an IC_{50} at least about 10-fold lower, preferably 100-fold lower) than they interact with ET_B receptors. In particular, compounds that interact with ET_A with an IC_{50} of less than about 10 μM, preferably less than 1 μM, more preferably less than 0.1 μM, but with ET_B with an IC_{50} of greater than about ~~about~~ 10 μM or compounds that interact with ET_B with an IC_{50} of less than about 10 μM, preferably less than 1 μM, more preferably less than 0.1 μM, but with ET_A with an IC_{50} of greater than about 10 μM are preferred.

Also of interest are any pharmaceutically-acceptable derivatives, including salts, esters, acids and bases, solvates, hydrates and prodrugs of the sulfonamides. Preferred are pharmaceutically-acceptable salts, including, but not limited to, amine salts, such as but not limited to N,N'-dibenzylethylenediamine, chloroprocaine, choline, ammonia, diethanolamine and other hydroxyalkylamines, ethylenediamine, N-methylglucamine, procaine, N-benzylphenethylamine, 1-para-chlorobenzyl-2-pyrrolidin-1'-ylmethylbenzimidazole, diethylamine and other alkylamines, piperazine, tris(hydroxymethyl)aminomethane, alkali metal salts, such as but not limited to lithium, potassium and sodium, alkali earth metal salts, such as but not limited to barium, calcium and magnesium, transition metal salts, such as but not limited to zinc and other metal salts, such as but not limited to sodium hydrogen phosphate and disodium phosphate, preferably sodium salts, more preferably the sodium salt, and also including, but not limited to, salts of mineral acids, such as but not limited to hydrochlorides and sulfates, salts of organic acids, such as but not limited to acetates, lactates, malates, tartrates, citrates, ascorbates, succinates, butyrates, valerates and fumarates. Alkali metal salts,

particularly sodium salts, are preferred herein. Most preferred salts are sodium salts.

Pharmaceutical formulations for administration by an appropriate route and means containing effective concentrations of one or more of the compounds provided herein or pharmaceutically acceptable derivatives, such as salts, esters, acids and bases, solvates, hydrates and prodrugs, of the sulfonamides, preferably salts, more preferably sodium salts, including but not limited to sodium salts and sodium hydrogen phosphate salts, most preferably the sodium salt, thereof that deliver amounts effective for the treatment of hypertension, stroke, cardiovascular diseases, cardiac diseases including myocardial infarction, pulmonary hypertension, neonatal pulmonary hypertension, erythropoietin-mediated hypertension, respiratory diseases, inflammatory diseases including asthma, bronchoconstriction, ophthalmologic diseases including glaucoma and inadequate retinal perfusion, gastroenteric diseases, renal failure, endotoxin shock, menstrual disorders, obstetric conditions, wounds, laminitis, erectile dysfunction, menopause, osteoporosis and metabolic bone disorders, climacteric disorders including hot flushes, abnormal clotting patterns, urogenital discomfort and increased incidence of cardiovascular disease, and other disorders associated with the reduction in ovarian function in middle-aged women, pre-eclampsia, control and management of labor during pregnancy, anaphylactic shock, hemorrhagic shock, nitric oxide attenuated disorders, and other diseases in which endothelin mediated physiological responses are implicated or that involve vasoconstriction or whose symptoms can be ameliorated by administration of an endothelin antagonist or agonist, are also provided.

The formulations are compositions suitable for administration by any desired route and include solutions, suspensions, emulsions, tablets,

dispersible tablets, pills, capsules, powders, dry powders for inhalation, sustained release formulations, aerosols for nasal and respiratory delivery, patches for transdermal delivery and ~~and~~ any other suitable route. The compositions should be suitable for oral administration, parenteral administration by injection, including subcutaneously, intramuscularly or intravenously as an injectable aqueous or oily solution or emulsion, transdermal administration and other selected routes.

Lyophilized powders of the sulfonamide derivatives, methods for preparation thereof, and formulations containing reconstituted forms of the lyophilized powders are also provided. Vials and ampules and syringes and other suitable vessels containing the powders are also provided.

Preferred formulations include a sterile lyophilized powder containing pharmaceutically-acceptable salts, preferably sodium salts, more preferably a sodium salt, of a sulfonamide, and also include capsules and tablets. The effective amounts and concentrations are effective for ameliorating any of the symptoms of any of the disorders.

In one embodiment, the formulations are lyophilized solids containing one or more salts, preferably sodium hydrogen phosphate or sodium salts, more preferably sodium salts, of one or more sulfonamide compounds of formula I and also contain one or more of the following: a buffer, such as sodium or potassium phosphate, or citrate; a solubilizing agent, such as LABRASOL (polyethylene glycol-8 caprylic capric glycerides sold by Gattefosse SA, France), DMSO, bis(trimethylsilyl)acetamide, ethanol, propyleneglycol (PG), or polyvinylpyrrolidine (PVP); and a sugar or other carbohydrate, such as sorbitol or dextrose.

In other embodiments, the formulations are solid dosage forms, preferably capsules or tablets. In a preferred embodiment, the

formulations are solid dosage forms, preferably capsules or tablets, containing 10-100%, preferably 50-95%, more preferably 75-85%, most preferably 80-85%, by weight, of one or more salts, preferably sodium hydrogen phosphate or sodium salts, more preferably the sodium salts, of one or more sulfonamide compounds of formula I; about 0-25%, preferably 8-15%, of an excipient or a binder, such as lactose or microcrystalline cellulose; about 0 to 10%, preferably about 3-7%, of a disintegrant, such as a modified starch or cellulose polymer, particularly a cross-linked sodium carboxymethyl cellulose, such as crosscarmellose sodium (Crosscarmellose sodium NF is available commercially under the name AC-DI-SOL, FMC Corporation, Philadelphia, PA) or sodium starch glycolate; and 0-2% of a lubricant, such a magnesium stearate, talc and calcium stearate. The disintegrant, such as crosscarmellose sodium or sodium starch glycolate, provides for rapid break-up of the cellulosic matrix for immediate release of active agent following dissolution of coating polymer. In all embodiments, the precise amount of active ingredient and ~~auxilliary~~ Auxiliary ingredients can be determined empirically and is a function of the route of administration and the ~~d~~disorder that is treated.

Solid forms for administration as tablets are also contemplated herein. It is understood that precise amounts and composition thereof can be empirically determined by the skilled artisan.

Methods using such compounds and formulations for modulating the interaction of an endothelin peptide with ET_A and/or ET_B receptors are provided. The methods are effected by contacting the receptors with one or more of the sulfonamides, or pharmaceutically acceptable derivatives thereof, particularly salts thereof, prior to, simultaneously with, or subsequent to contacting the receptors with an endothelin peptide.

Methods for inhibiting binding of an endothelin peptide to an endothelin receptor are provided. These methods are practiced by

contacting the receptor with one or more of the compounds, or pharmaceutically acceptable derivatives thereof, particularly salts thereof, simultaneously, prior to, or subsequent to contacting the receptor with an endothelin peptide.

Methods for treatment of endothelin-mediated disorders, including, but not limited to, hypertension, asthma, shock, ocular hypertension, glaucoma, inadequate retinal perfusion and other conditions that are in some manner mediated by an endothelin peptide, or for treatment of disorder that involve vasoconstriction or that are ameliorated by administration of an endothelin antagonist or agonist are provided.

In particular, methods of treating endothelin-mediated disorders by administering effective amounts of the sulfonamides, or pharmaceutically acceptable derivatives of the sulfonamides are provided. In particular, methods for treating endothelin-mediated disorders, including hypertension, cardiovascular diseases, cardiac diseases including myocardial infarction, pulmonary hypertension, neonatal pulmonary hypertension, erythropoietin-mediated hypertension, respiratory diseases and inflammatory diseases, including asthma, bronchoconstriction, ophthalmologic diseases including glaucoma and inadequate retinal perfusion, gastroenteric diseases, renal failure, endotoxin shock, menstrual disorders, obstetric conditions, wounds, laminitis, erectile dysfunction, menopause, osteoporosis and metabolic bone disorders, climacteric disorders including hot flushes, abnormal clotting patterns, urogenital discomfort and increased incidence of cardiovascular disease, and other disorders associated with the reduction in ovarian function in middle-aged women, pre-eclampsia, control and management of labor during pregnancy, nitric oxide attenuated disorders, anaphylactic shock, hemorrhagic shock, and other diseases in which endothelin mediated physiological responses are implicated, by administering effective

amounts of one or more of the compounds provided herein in pharmaceutically acceptable carriers are provided. Preferred methods of treatment are methods for treatment of hypertension and renal failure.

More preferred methods of treatment are those which use at least one compound that inhibits the interaction of endothelin-1 with ET_A receptors at an IC_{50} of less than about 10 μM, and preferably less than about 5 μM, more preferably less than about 1 μM, even more preferably less than 0.1 μM, and most preferably less than 0.05 μM. Other preferred methods are those which use formulations containing pharmaceutically-acceptable salts of one or more compounds that is (are) ET_A selective or pharmaceutically-acceptable salts of one or more compounds that is (are) ET_B selective. Methods in which the compounds are ET_A selective are for treatment of disorders, such as hypertension, that require vasodilation; and methods in which the compounds are ET_B selective are for treatment of disorders, such as asthma, that require bronchodilation.

In practicing the methods, effective amounts of formulations containing therapeutically effective concentrations of the compounds formulated for oral, intravenous, local and topical application for the treatment of hypertension, cardiovascular diseases, cardiac diseases, including myocardial infarction, respiratory diseases, including asthma, inflammatory diseases, ophthalmologic diseases including glaucoma and inadequate retinal perfusion, gastroenteric diseases, renal failure, immunosuppressant-mediated renal vasoconstriction, erythropoietin-mediated vasoconstriction, endotoxin shock, anaphylactic shock, hemorrhagic shock, pulmonary hypertension, neonatal pulmonary hypertension, laminitis, erectile dysfunction, nitric oxide attenuated disorders, menopause, osteoporosis and metabolic bone disorders, climacteric disorders including hot flushes, abnormal clotting patterns,

urogenital discomfort and increased incidence of cardiovascular disease, and other disorders associated with the reduction in ovarian function in middle-aged women, pre-eclampsia, control and management of labor during pregnancy, and other diseases in which endothelin mediated physiological responses are implicated are administered to an individual exhibiting the symptoms of one or more of these disorders. The amounts are effective to ameliorate or eliminate one or more symptoms of the disorders.

Methods for the identification and isolation of endothelin receptor subtypes are also provided. In particular, methods for detecting, distinguishing and isolating endothelin receptors using the disclosed compounds are provided. In particular, methods are provided for detecting, distinguishing and isolating endothelin receptors using the compounds provided herein.

In addition, methods for identifying compounds that are suitable for use in treating particular diseases based on their preferential affinity for a particular endothelin receptor subtype are also provided.

Articles of manufacture containing packaging material, a compound provided herein, or a pharmaceutically acceptable derivative thereof, which is effective for ameliorating the symptoms of an endothelin-mediated disorder, antagonizing the effects of endothelin or inhibiting binding of an endothelin peptide to an ET receptor with an IC_{50} of less than about 10 μM, within the packaging material, and a label that indicates that the compound, or pharmaceutically acceptable derivative thereof, is used for ameliorating the symptoms of an endothelin-mediated disorder, antagonizing the effects of endothelin, or inhibiting the binding of an endothelin peptide to an ET receptor are provided.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Definitions

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of skill in the art to which this invention belongs. All patents and publications referred to herein are incorporated by reference.

As used herein, endothelin (ET) peptides include peptides that have substantially the amino acid sequence of endothelin-1, endothelin-2 or endothelin-3 and that act as potent endogenous vasoconstrictor peptides.

As used herein, an endothelin-mediated condition is a condition that is caused by abnormal endothelin activity or one in which compounds that inhibit endothelin activity have therapeutic use. Such diseases include, but are not limited to hypertension, cardiovascular disease, asthma, inflammatory diseases, ophthalmologic disease, menstrual disorders, obstetric conditions, gastroenteric disease, renal failure, pulmonary hypertension, endotoxin shock, anaphylactic shock, or hemorrhagic shock. Endothelin-mediated conditions also include conditions that result from therapy with agents, such as erythropoietin and immunosuppressants, that elevate endothelin levels.

As used herein an effective amount of a compound for treating a particular disease is an amount that is sufficient to ameliorate, or in some manner reduce the symptoms associated with the disease. Such amount may be administered as a single dosage or may be administered according to a regimen, whereby it is effective. The amount may cure the disease but, typically, is administered in order to ameliorate the symptoms of the disease. Typically, repeated administration is required to achieve the desired amelioration of symptoms.

As used herein, an endothelin agonist is a compound that potentiates or exhibits a biological activity associated with or possessed by an endothelin peptide.

As used herein, an endothelin antagonist is a compound, such as a drug or an antibody, that inhibits endothelin-stimulated vasoconstriction and contraction and other endothelin-mediated physiological responses. The antagonist may act by interfering with the interaction of the endothelin with an endothelin-specific receptor or by interfering with the physiological response to or bioactivity of an endothelin isopeptide, such as vasoconstriction. Thus, as used herein, an endothelin antagonist interferes with endothelin-stimulated vasoconstriction or other response or interferes with the interaction of an endothelin with an endothelin-specific receptor, such as ET_A receptors, as assessed by assays known to those of skill in the art.

The effectiveness of potential agonists and antagonists can be assessed using methods known to those of skill in the art. For example, endothelin agonist activity can be identified by its ability to stimulate vasoconstriction of isolated rat thoracic aorta or portal vein ring segments (Borges et al. (1989) "Tissue selectivity of endothelin" Eur. J. Pharmacol. 165: 223-230). Endothelin antagonist activity can be assessed by the ability to interfere with endothelin-induced vasoconstriction. Exemplary assays are set forth in the EXAMPLES. As noted above, the preferred IC_{50} concentration ranges are set forth with reference to assays in which the test compound is incubated with the ET receptor-bearing cells at 4° C. Data presented for assays in which the incubation step is performed at the less preferred 24° C are identified. It is understood that for purposes of comparison, these concentrations are somewhat higher than the concentrations determined at 4° C.

As used herein, bioavailability or oral availability refers to the rate and extent of absorption. Methods for determining bioavailability or oral availability are well known to those of skill in the art. For example, bioavailability or oral availability of any of the compounds described herein can be determined empirically by administration of the compound to an animal, followed by taking blood samples over time and measuring the blood concentration of the compound. In vivo half life ($t_{1/2}$) is defined as the time it takes for the concentration of the compound in the blood to be reduced by one-half. Estimations of the area under the curve for intravenous administration can be used to estimate the area under the curve for oral administration, yielding bioavailability data. See, e.g., Milo Gibal (1991) Biopharmaceutics and Pharmacology, 4th edition (Lea and Sediger).

As used herein, efficacy refers to the maximal effect that can be produced by a compound. Efficacy can be determined by methods known to those of skill in the art. For example, it can be determined by the properties of the compound and its receptor-effector system and is reflected in the plateau of the concentration-effect curve. In vivo efficacy refers to efficacy which is determined in an animal model. For example, in vivo efficacy of the compounds described herein can be determined by hypoxia-induced pulmonary hypertension in rat. See, e.g., DiCarlo et al. (1995) Am. J. Physiol. 269:L690-L697.

As used herein, recitation that a compound that exhibits a good profile in standard in vitro or in vivo toxicity tests means that the compound demonstrates improved tolerability relative to known endothelin antagonists. In particular, as described herein, compounds that show higher IC_{50} values for inhibition of P450 enzymes, in particular, CP4502C9, 2C19 and 3A4 enzymes, exhibit good profiles in standard in vitro toxicity tests. Compounds for which a lower dose is required to

achieve 50% inhibition of mean pulmonary arterial pressure (MPAP) increase in a standard in vivo acute hypoxia model exhibit good profiles in vivo.

As used herein, the biological activity or bioactivity of endothelin includes any activity induced, potentiated or influenced by endothelin in vivo. It also includes the ability to bind to particular receptors and to induce a functional response, such as vasoconstriction. It may be assessed by in vivo assays or by in vitro assays, such as those exemplified herein. The relevant activities include, but are not limited to, vasoconstriction, vasorelaxation and bronchodilation. For example, ET_B receptors appear to be expressed in vascular endothelial cells and may mediate vasodilation and other such responses; whereas ET_A receptors, which are endothelin-1-specific, occur on smooth muscle and are linked to vasoconstriction Any assay known to those of skill in the art to measure or detect such activity may be used to assess such activity (see, e.g., Spokes et al. (1989) J. Cardiovasc. Pharmacol. 13(Suppl. 5):S191-S192; Spinella et al. (1991) Proc. Natl. Acad. Sci. USA 88: 7443-7446; Cardell et al. (1991) Neurochem. Int. 18:571-574); and the Examples herein).

As used herein, the IC_{50} refers to an amount, concentration or dosage of a particular test compound that achieves a 50% inhibition of a maximal response, such as binding of endothelin to tissue receptors, in an assay that measures such response.

As used herein, EC_{50} refers to a dosage, concentration or amount of a particular test compound that elicits a dose-dependent response at 50% of maximal expression of a particular response that is induced, provoked or potentiated by the particular test compound.

As used herein a sulfonamide that is ET_A selective refers to sulfonamides that exhibit an IC_{50} that is at least about 10-fold lower with respect to ET_A receptors than ET_B receptors.

As used herein, a sulfonamide that is ET_B selective refers to sulfonamides that exhibit an IC_{50} that is at least about 10-fold lower with respect to ET_B receptors than ET_A receptors.

As used herein, pharmaceutically acceptable salts, esters, hydrates, solvates or other derivatives of the compounds include any such salts, esters and other derivatives that may be prepared by those of skill in this art using known methods for such derivatization and that produce compounds that may be administered to animals or humans without substantial toxic effects and that either are pharmaceutically active or are prodrugs. Pharmaceutically-acceptable salts include, but are not limited to, salts of alkali metals and alkaline earth metals, including but not limited to sodium salts, potassium salts, lithium salts, calcium salts and magnesium salts; transition metal salts, such as zinc salts, copper salts and aluminum salts; polycationic counter ion salts, such as but not ~~limited~~ limited to ammonium and substituted ammonium salts and organic amine salts, such as hydroxyalkylamines and alkylamines; salts of mineral acids, such as but not limited to hydrochlorides and sulfates, salts of organic acids, such as but not limited to acetates, lactates, malates, tartrates, citrates, ascorbates, succinates, butyrate, valerate and fumarates. Also contemplated herein are the corresponding esters.

As used herein, reference to "sodium salts" refers to salts of any sodium compounds in which the counter ion includes Na^+ and can include other ions, such as HPO_4^{2-}; reference to a "sodium salt" (rather than sodium salts) refers specifically to a salt in which Na^+ is the counter ion.

As used herein, treatment means any manner in which the symptoms of a conditions, disorder or disease are ameliorated or

otherwise beneficially altered. Treatment also encompasses any pharmaceutical use of the compositions herein, such as use as contraceptive agents.

As used herein, amelioration of the symptoms of a particular disorder by administration of a particular pharmaceutical composition refers to any lessening, whether permanent or temporary, lasting or transient that can be attributed to or associated with administration of the composition.

As used herein, substantially pure means sufficiently homogeneous to appear free of readily detectable impurities as determined by standard methods of analysis, such as thin layer chromatography (TLC), gel electrophoresis and high performance liquid chromatography (HPLC), used by those of skill in the art to assess such purity, or sufficiently pure such that further purification would not detectably alter the physical and chemical properties, such as enzymatic and biological activities, of the substance. Methods for purification of the compounds to produce substantially chemically pure compounds are known to those of skill in the art. A substantially chemically pure compound may, however, be a mixture of stereoisomers. In such instances, further purification might increase the specific activity of the compound.

As used herein, biological activity refers to the in vivo activities of a compound or physiological responses that result upon in vivo administration of a compound, composition or other mixture. Biological activity, thus, encompasses therapeutic effects and pharmaceutical activity of such compounds, compositions and mixtures.

As used herein, increased stability of a formulation means that the percent of active component present in the formulation, as determined by assays known to those of skill in the art, such as high performance liquid chromatography, gas chromatography, and the like, at a given period of

time following preparation of the formulation is significantly higher than the percent of active component present in another formulation at the same period of time following preparation of the formulation. In this case, the former formulation is said to possess increased stability relative to the latter formulation.

As used herein, a prodrug is a compound that, upon in vivo administration, is metabolized or otherwise converted to the biologically, pharmaceutically or therapeutically active form of the compound. To produce a prodrug, the pharmaceutically active compound is modified such that the active compound will be regenerated by metabolic processes. The prodrug may be designed to alter the metabolic stability or the transport characteristics of a drug, to mask side effects or toxicity, to improve the flavor of a drug or to alter other characteristics or properties of a drug. By virtue of knowledge of pharmacodynamic processes and drug metabolism in vivo, those of skill in this art, once a pharmaceutically active compound is known, can design prodrugs of the compound (see, e.g., Nogrady (1985) Medicinal Chemistry A Biochemical Approach, Oxford University Press, New York, pages 388-392). For example, succinyl-sulfathiazole is a prodrug of 4-amino-N-(2-thiazoyl)benzenesulfonamide (sulfathiazole) that exhibits altered transport characteristics.

As used herein, acid isostere means a group that is significantly ionized at physiological pH. Examples of suitable acid isosteres include sulfo, phosphono, alkylsulfonylcarbamoyl, tetrazolyl, arylsulfonylcarbamoyl or heteroarylsulfonylcarbamoyl.

As used herein, halo or halide refers to the halogen atoms; F, Cl, Br and I.

As used herein, pseudohalides are compounds that behave substantially similar to halides. Such compounds can be used in the same manner and treated in the same manner as halides (X^-, in which X is

a halogen, such as Cl or Br). Pseudohalides include, but are not limited to cyanide, cyanate, thiocyanate, selenocyanate and azide.

As used herein, haloalkyl refers to a lower alkyl radical in which one or more of the hydrogen atoms are replaced by halogen including, but not limited to, chloromethyl, trifluoromethyl, 1-chloro-2-fluoroethyl and the like.

As used herein, alkyl means an aliphatic hydrocarbon group that is a straight or branched chain preferably having about 1 to 12 carbon atoms in the chain. Preferred alkyl groups are lower alkyl groups which are alkyls containing 1 to about 6 carbon atoms in the chain. Branched means that one or more lower alkyl groups such as methyl, ethyl or propyl are attached to a linear alkyl chain. The alkyl group may be unsubstituted or independently substituted by one or more groups, such as, but not limited to: halo, carboxy, formyl, sulfo, sulfino, carbamoyl, amino and imino. Exemplary alkyl groups include methyl, ethyl, propyl, methanoic acid, ethanoic acid, propanoic acid, ethanesulfinic acid and ethane sulfonic acid.

As used herein the term lower describes alkyl, alkenyl and alkynyl groups containing about 6 carbon atoms or fewer. It is also used to describe aryl groups or heteroaryl groups that contain 6 or fewer atoms in the ring. Lower alkyl, lower alkenyl, and lower alkynyl refer to carbon chains having less than about 6 carbons. In preferred embodiments of the compounds provided herein that include alkyl, alkenyl, or alkynyl portions include lower alkyl, lower alkenyl, and lower alkynyl portions.

As used herein, alkenyl means an aliphatic hydrocarbon group containing a carbon-carbon double bond and which may be straight or branched chained having from about 2 to about 10 carbon atoms in the chain. Preferred alkenyl groups have 2 to about 4 carbon atoms in the chain. Branched means that one or more lower alkyl or lower alkenyl

groups are attached to a linear alkenyl chain. The alkenyl group may be unsubstituted or independently substituted by one or more groups, such as halo, carboxy, formyl, sulfo, sulfino, carbamoyl, amino and imino. Exemplary alkenyl groups include ethenyl, propenyl, carboxyethenyl, carboxypropenyl, sulfinoethenyl and sulfonoethenyl.

As used herein, alkynyl means an aliphatic hydrocarbon group containing a carbon-carbon triple bond and which may be straight or branched having about 2 to 10 carbon atoms in the chain. Branched means that one or more lower alkyl, alkenyl or alkynyl groups are attached to a linear alkynyl chain. An exemplary alkynyl group is ethynyl.

As used herein, aryl means an aromatic monocyclic or multicyclic hydrocarbon ring system containing from 3 to 15 or 16 carbon atoms, preferably from 5 to 10. Aryl groups include, but are not limited to groups, such as phenyl, substituted phenyl, ~~napthyl~~ naphthyl, substituted naphthyl, in which the ~~substituent~~ substituent is lower alkyl, halogen, or lower alkoxy. Preferred aryl groups are lower aryl groups that contain less than 7 carbons in the ring structure.

As used herein, the nomenclature alkyl, alkoxy, carbonyl, etc. are used as is generally understood by those of skill in this art. For example, as used herein alkyl refers to saturated carbon chains that contain one or more carbons; the chains may be straight or branched or include cyclic portions or be cyclic. As used herein, alicyclic refers to aryl groups that are cyclic.

As used herein, cycloalkyl refers to saturated cyclic carbon chains; cycloalkyenyl and cycloalkynyl refer to cyclic carbon chains that include at least one unsaturated double or triple bond, respectively. The cyclic portions of the carbon chains may include one ring or two or more fused rings.

As used herein, cycloalkenyl means a non-aromatic monocyclic or multicyclic ring system containing a carbon-carbon double bond and having about 3 to about 10 carbon atoms. Exemplary monocyclic cycloalkenyl rings include cyclopentenyl or cyclohexenyl; preferred is cyclohexenyl. An exemplary multicyclic cycloalkenyl ring is norbornylenyl. The cycloalkenyl group may be independently substituted by one or more halo or alkyl.

As used herein, "haloalkyl" refers to a lower alkyl radical in which one or more of the hydrogen atoms are replaced by halogen including, but not limited to, chloromethyl, trifluoromethyl, 1-chloro-2-fluoroethyl and the like.

As used herein, "haloalkoxy" refers to RO- in which R is a haloalkyl group.

As used herein, "carboxamide" refers to groups of formula R_pCONH_2 in which R is selected from alkyl or aryl, preferably lower alkyl or lower aryl and p is 0 or 1.

As used herein, "alkylaminocarbonyl" refers to -C(O)NHR in which R is hydrogen, alkyl, preferably lower alkyl or aryl, preferably lower aryl.

As used herein "dialkylaminocarbonyl" as used herein refers to -C(O)NR'R in which R' and R are independently selected from alkyl or aryl, preferably lower alkyl or ~~loweraryl~~ lower aryl; "carboxamide" refers to groups of formula NR'COR.

As used herein, "alkoxycarbonyl" as used herein refers to -C(O)OR in which R is alkyl, preferably lower alkyl or aryl, preferably lower aryl.

As used herein, "alkoxy" and "thioalkoxy" refer to RO- and RS-, in which R is alkyl, preferably lower alkyl or aryl, preferably lower aryl.

As used herein, "haloalkoxy" refers to RO- in which R is a haloalkyl group.

As used herein, "aminocarbonyl" refers to $-C(O)NH_2$.

As used herein, "alkylaminocarbonyl" refers to -C(O)NHR in which R is alkyl, preferably lower alkyl or aryl, preferably lower aryl.

As used herein, "alkoxycarbonyl" refers to -C(O)OR in which R is alkyl, preferably lower alkyl.

As used herein, cycloalkyl refers to ~~saturated~~ saturated cyclic carbon chains; cycloalkyenyl and cycloalkynyl refer to cyclic carbon chains that include at least one unsaturated triple bond. The cyclic portions of the carbon chains may include one ring or two or more fused rings.

As used herein, alkylenedioxy means an -O-alkyl-O- group in which the alkyl group is as previously described. A replacement analog of alkylenedioxy means an alkylenedioxy in which one or both of the oxygen atoms is replaced by a similar behaving atom or group of atoms such as, S, N, NH, Se. An exemplary replacement alkylenedioxy group is ethylene-bis(sulfandiyl). Alkylenethioxyoxy is —S-alkyl-O— , —O-alkyl-S— and alkylenedithioxy is —S-alkyl-S—.

As used herein, heteroaryl means an aromatic monocyclic or fused ring system in which one or more of the carbon atoms in the ring system is(are) replaced by an element(s) other than carbon, for example nitrogen, oxygen or sulfur. Preferred cyclic groups contain one or two fused rings and include from about 3 to about 7 members in each ring. Similar to "aryl groups", the heteroaryl groups may be unsubstituted or substituted by one or more substituents. Exemplary heteroaryl groups include pyrazinyl, pyrazolyl, tetrazolyl, furanyl, (2- or 3-)thienyl, (2-,3- or 4-)pyridyl, imidazoyl, pyrimidinyl, isoxazolyl, thiazolyl, isothiazolyl, quinolinyl, indolyl, isoquinolinyl, oxazolyl and 1,2,4-oxadiazolyl. Preferred heteroaryl groups include 5 to 6-membered nitrogen-containing rings, such as pyrmidinyl.

As used herein, alkoxycarbonyl means an alkyl-O-CO- group. Exemplary alkoxycarbonyl groups include methoxy- and ethoxycarbonyl.

As used herein, carbamoyl means -$CONH_2$. As with all groups described herein, these groups may be unsubstituted or substituted. Substituted carbamoyl includes groups such as -$CONY^2Y^3$ in which Y^2 and Y^3 are independently hydrogen, alkyl, cyano(lower alkyl), ~~aryalkyl,~~ aralkyl heteroaralkyl, carboxy(lower alkyl), carboxy(aryl substituted lower alkyl), carboxy(carboxy substituted lower alkyl), carboxy(hydroxy substituted lower alkyl), carboxy(heteroaryl substituted lower alkyl), carbamoyl(lower alkyl), alkoxycarbonyl(lower alkyl) or alkoxycarbonyl(aryl substituted lower alkyl), provided that only one of Y^2 and Y^3 may be hydrogen and when one of Y^2 and Y^3 is carboxy(lower alkyl), carboxy(aryl substituted lower alkyl), carbamoyl(lower alkyl), alkoxycarbonyl(lower alkyl) or alkoxycarbonyl(aryl substituted lower alkyl) then the other of Y^2 and Y^3 is hydrogen or alkyl. Preferred for Y^2 and Y^3 are independently hydrogen, alkyl, cyano(lower alkyl), ~~aryalkyl,~~ aralkyl heteroaralkyl, carboxy(lower alkyl), carboxy(aryl substituted lower alkyl) and carbamoyl(lower alkyl).

As used herein, any corresponding N-(4-halo-3-methyl-5-isoxazolyl), N-(4-halo-5-methyl-3-isoxazolyl), N-(3,4-dimethyl-5-isoxazolyl), N-(4-halo-5-methyl-3-isoxazolyl), N-(4-halo-3-methyl-5-isoxazolyl), N-(4,5-dimethyl-3-isoxazolyl) derivative thereof refers to compounds in which Ar^2 is the same as the compound ~~specifically~~ specifically set forth, but Ar^1 is N-(4-halo-3-methyl-5-isoxazolyl), N-(4-halo-5-methyl-3-isoxazolyl), N-(3,4-dimethyl-5-isoxazolyl), N-(4-halo-5-methyl-3-isoxazolyl), N-(4-halo-3-methyl-5-isoxazolyl), or N-(4,5-dimethyl-3-isoxazolyl) in which halo is any halide, ~~peferably~~ preferably Cl or Br.

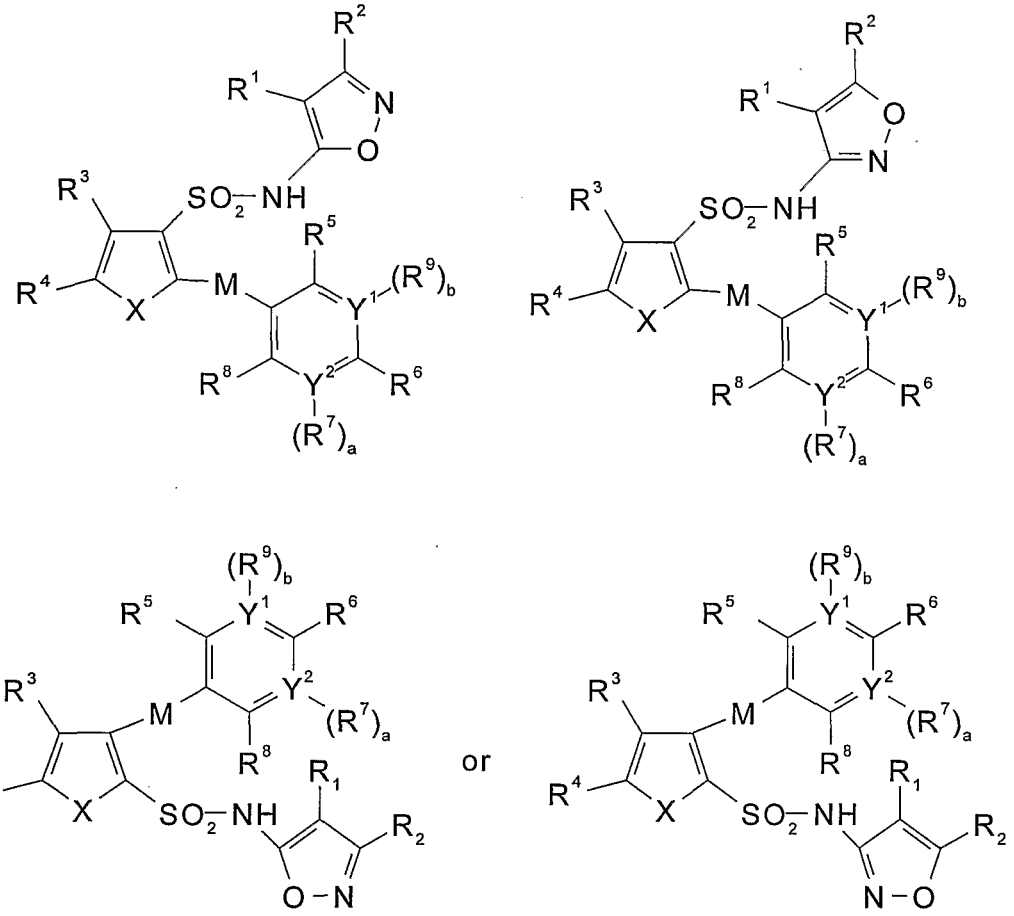
As used herein, the abbreviations for any protective groups, amino acids and other compounds, are, unless indicated otherwise, in accord with their common usage, recognized abbreviations, or the IUPAC-IUB Commission on Biochemical Nomenclature (see, (1972) Biochem. 11:942-944).

A. Compounds for use in treating endothelin-mediated diseases

Compounds, compositions and methods for treating endothelin-mediated diseases using the compounds of formula I are provided. In particular, the compounds provided herein are aryl-substituted thienyl, furanyl, pyrrolyl or phenyl sulfonamides, where the aryl group is tetra-, penta- or hexasubstituted, preferably tetra- or pentasubstituted. Particularly preferred sulfonamides are N-isoxazolyl thiophene sulfonamides wherein the thiophene is substituted with an aryl group which has only one or two hydrogen substituents. If the aryl group is tetrasubstituted, it preferably is substituted at the 1, 2, 4 and 6 positions and one of these substituents will be a polar group, such as hydroxyl, acetoxy, carboxyl, sulfonyl, acyl, heteroaryl, oxime, halide pseudohalide and carboxamide. If the aryl group is substituted at the 2, 4 and 6 positions with nonpolar groups, such as alkyl groups, more specifically methyl groups, then the aryl group is preferably penta- or hexasubstituted. In pentasubstituted aryl groups, the fourth substituent is the linkage to the thiophene, furan, pyrrole or benzene ring, and the fifth substituent is ~~preferrably~~ a polar group, such as hydroxyl, acetoxy, carboxyl, ~~sulfnyl,~~ acyl, heteroaryl, oxime, halide, pseudohalide and carboxamide.

The compounds described herein exhibit good bioavailability, relatively long in vivo half-life, good ~~tolerability~~ and good efficacy in in vivo animal models and other suitable models.

In embodiments described in detail herein, Ar^1 is a 3- or 5-isoxazolyl and the sulfonamides have formula III:



or pharmaceutically acceptable derivatives thereof, in which R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

M is -C(Y)-W-, $(CH_2)_mC(Y)(CH_2)_r$, $(CH_2)_mC(Y)NH(CH_2)_r$, $(CH_2)_m(CH=CH)(CH_2)_r$, $(CH_2)_mC(Y)(CH_2)_sNH(CH_2)_r$, $C=N(OH)(CH_2)_r$, $(CH_2)_mC(Y)(CH=CH)_sNH(CH_2)_r$, $CH(OH)(CH_2)_r$, $CH(CH_3)C(Y)(CH_2)_r$, $CH(CH_3)C(Y)(CH_2)_m(CH=CH)(CH_2)_r$, $(CH_2)_r$, $(CH_2)_rO$, $(CH_2)S(O)_n$ where n is 0-2, in which m, s and r are each independently 0 to 6, preferably 0 to 3, where W is O, NH or $(CH_2)_z$ wherein z is 0 to 6, preferably 0 to 3, more preferably 1; and Y is O, S, or, together with R^8 and the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring, preferably a 5 or 6 membered unsubstituted or substituted cyclic or heterocyclic ring, more preferably a 6 membered unsubstituted or substituted heterocyclic ring; M is preferably -C(Y)-W- or $(CH_2)_z$;

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl,

alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_x$NH-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl~~ lower haloalkyl, x and y are each independently 0 to 14; and R^{50} is a ~~subsitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

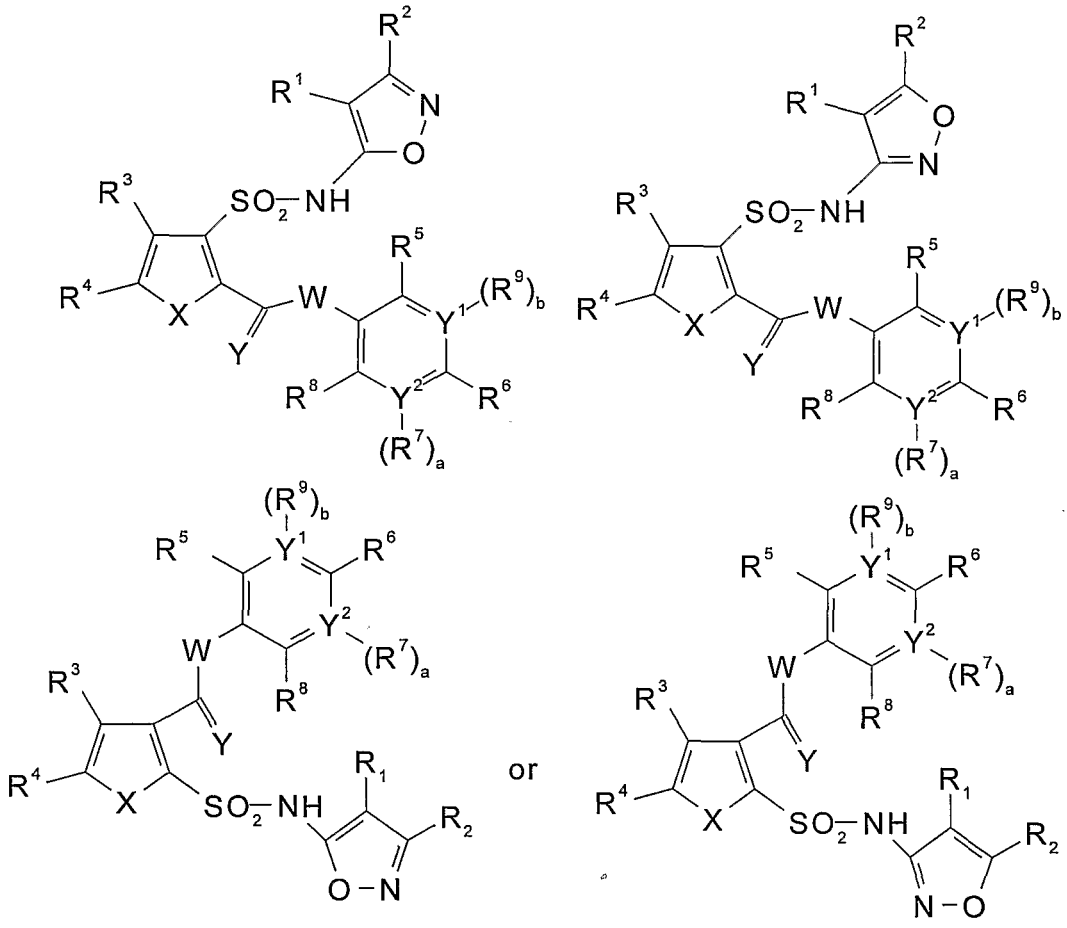
(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy (i.e. $-O\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}S-$, where n is 1 to 4, preferably 1 or 2) which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i); and

X is $-C(R^3)=C(R^4)-$, S, O or NR^{11}, where R^{11} is hydrogen or contains up to about 30 carbon atoms, preferably 1 to 10, more preferably 1 to 6 and is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl,

heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{15}$ and $S(O)_nR^{15}$ in which n is 0-2; R^{15} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{11} and R^{15} are unsubstituted or are substituted with one or more substituents each selected independently from Z, which as defined herein includes hydrogen, halide, pseudohalide, alkyl, alkoxy, alkenyl, alkynyl, aryl, amino acids, primary and secondary amides, O-glycosides, hexoses, riboses, alkylaryl, alkylheteroaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, OH, CN, $C(O)R^{16}$, $OC(O)R^{16}$, CO_2R^{16}, OCO_2R^{16}, SH, $S(O)_nR^{16}$ in which n is 0-2, NHOH, $NR^{12}R^{16}$, NO_2, N_3, OR^{16}, $R^{12}NCOR^{16}$ and $CONR^{12}R^{16}$; R^{16} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, chloride, NHR^{50}, alkylaryl, alkylheteroaryl or $-(CH_2)_xOH$; R^{50} is a substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; x is 0 to 14; R^{12}, which is selected independently from R^{11} and Z, is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{17}$ and $S(O)_nR^{17}$ in which n is 0-2; R^{17} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{12} and R^{16} may together form alkylene; each of R^{11}, R^{12}, R^{15} and R^{16} may be further substituted with the any of the appropriate groups of those set forth for Z.

In all embodiments herein, X is preferably S or $-C(R^3)=C(R^4)-$, more preferably S or -CH=CH-, most preferably S.

In one embodiment, M is preferably -C(Y)-W- and the compounds for use in the compositions and methods provided herein have formula IV:



or pharmaceutically acceptable derivatives thereof, where R^1-R^9, X, Y, W, Y^1, Y^2, a and b are as defined above.

In these embodiments, the compounds preferably are of formula IV, where X is S or -CH=CH-, preferably S; R^1 is halo or lower alkyl; R^2 is lower alkyl; R^3 and R^4 are each hydrogen; R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$; R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl; R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and

are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl~~ lower haloalkyl; x and y are each independently 0 to 14; and R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

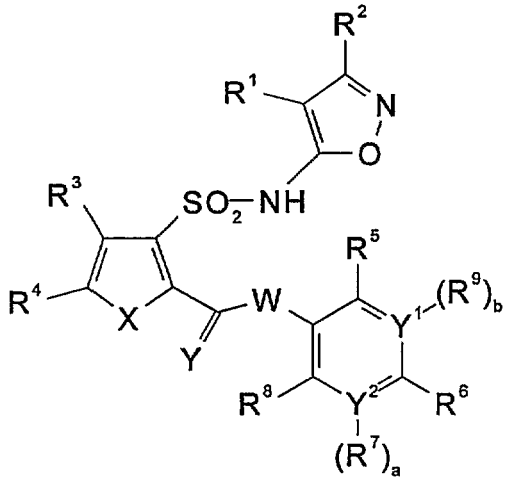
Y and R^8 are selected from (i) or (ii) as follows:

(i) Y is O; and R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$; or

(ii) Y and R^8 together with the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring, preferably a 5 or 6 membered unsubstituted or substituted cyclic or heterocyclic ring, more preferably a 6 membered unsubstituted or substituted heterocyclic ring, preferably Y and R^8 together form -CO-N= or -CO-C(CN)=;

R^9 is H; Y^1 and Y^2 are each independently carbon or nitrogen; a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen; b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and W is NH.

In particularly preferred embodiments, the compounds of formula IV are 2-substituted-3-sulfonamides that have formula V:



and pharmaceutically acceptable derivatives thereof, where X is S or -CH=CH-, preferably S; R^1 is halo or lower alkyl; R^2 is lower alkyl; R^3 and

R^4 are each hydrogen; R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$; R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl; R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl~~ lower haloalkyl; x and y are each independently 0 to 14; and R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

Y and R^8 are selected from (i) or (ii) as follows:

(i) Y is O; and R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$; or

(ii) Y and R^8 together with the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring, preferably a 5 or 6 membered unsubstituted or substituted cyclic or heterocyclic ring, more preferably a 6 membered unsubstituted or substituted heterocyclic ring, preferably Y and R^8 together form -CO-N= or -CO-C(CN)=;

R^9 is H; Y^1 and Y^2 are each independently carbon or nitrogen; a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen; b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and W is NH.

In more preferred embodiments, the compounds are of formula V, where R^1 is halide or lower alkyl; preferably Cl or Me; more preferably Me. In these embodiments, R^2 is lower alkyl, preferably Me; and R^3 and R^4 are each H.

In embodiments described in detail herein, the compounds are of formula V, where R^5 is Me or acetyl, preferably Me; R^6 is Me, acetyl or 2-

oxazolyl, preferably Me; R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl), preferably H;

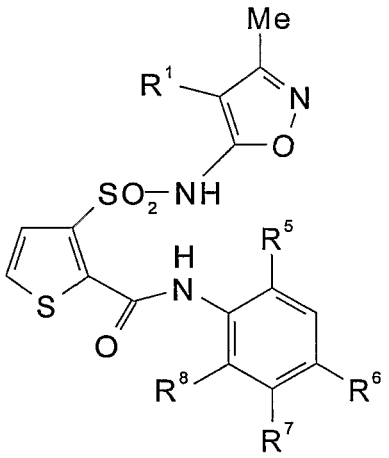
Y and R^8 are selected from (i) or (ii), preferably from (i), as follows:

(i) Y is O; and R^8 is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, $C(O)N(Me)(CH_2$-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, C(=N-OMe)Me, Me, C(O)Et, Cl, n-propyl or ethyl; or

(ii) Y and R^8 together form -CO-N= or -CO-C(CN)=;

R^9 is H; Y^1 and Y^2 are each independently carbon or nitrogen, preferably carbon; a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen; b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and W is NH.

Thus, in preferred embodiments, the compounds are of formula V, where X is S; R^1 is Cl or Me, preferably Me; R^2 is Me; R^3, R^4 and R^9 are H; Y is O; W is NH; and Y^1 and Y^2 are each carbon. In these embodiments, the compounds are thiophene sulfonamides that have the formula VI:



or pharmaceutically acceptable derivatives thereof, where R^1 is Cl or Me, preferably Me; R^5 is Me or acetyl, preferably Me; R^6 is Me, acetyl or 2-oxazolyl, preferably Me; R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl), preferably H; and R^8

is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, C(O)N(Me)(CH_2-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, C(=N-OMe)Me, Me, C(O)Et, Cl, n-propyl or ethyl.

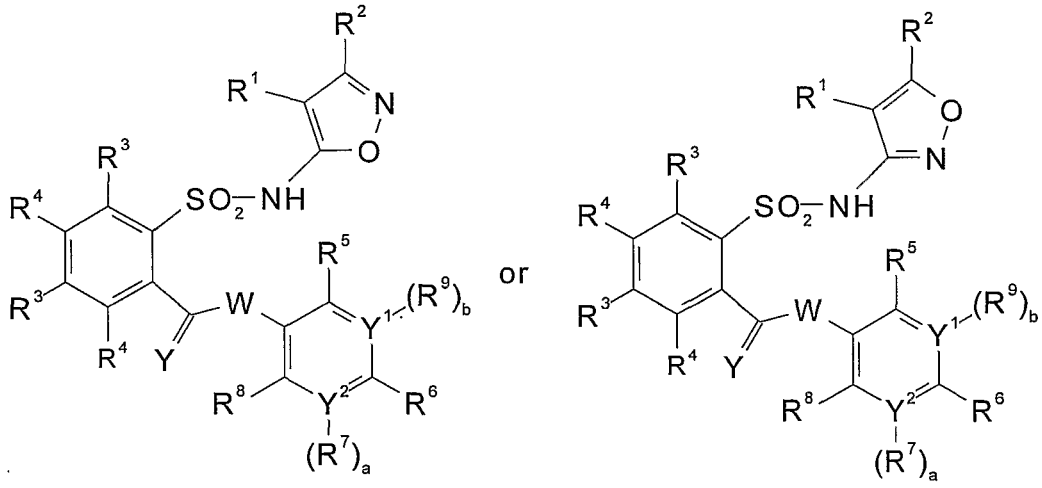
In most preferred embodiments herein, R^1, R^5 and R^6 are Me; R^7 is hydrogen; and R^8 is C(O)Me.

In another embodiment, the compounds have formula I where Y^1 and Y^2 are each nitrogen. In this embodiment, a and b are each preferably 0; and the other variables are as described above. In preferred embodiments, R^5, R^6 and R^8 are alkyl, preferably lower alkyl, more preferably Me; Y is O; and W is NH. In more preferred embodiments, R^3 and R^4 are each H; and X is S. Thus, the compounds of this embodiment are N-(5-isoxazolyl) 2- or 3-(5-pyrimidinylaminocarbonyl)thiophene sulfonamides.

Preferred compounds of the above embodiments include N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-(3,4,6-trimethyl-2-propanoylphenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2-(1-hydroxyethyl)-4,6-dimethylphenyl]-2-thiophene carboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2-[(dimethylamino)carbonyl]-4,6-dimethylphenyl)-2-thiophene carboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2,4-dimethyl-6-[(methyloxy)ethanimidoyl]phenyl}-2-thiophene carboxamide, 3-{[(3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenyl)-carbonyl]amino}-2,4,6-trimethylphenyl-N,N-dimethylsulfamate, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-[(cyclopropylmethyl)-oxy]-2,4,6-trimethylphenyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethyl-5-pyrimidinyl)-2-

thiophenecarboxamide, N-(2-acetyl-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-cyano-3,4,6-trimethylphenyl)-2-thiophenecarboxamide, N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(4,6-diacetyl-3-hydroxy-2-propylphenyl-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-[2-(methylsulfonyl)acetyl]-phenyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)-amino]sulfonyl}-N-(2,4-dimethyl-6-{[methyl(2,2-dimethylpropyl)amino]-carbonyl}phenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(methylsulfonyl)phenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]-sulfonyl}-N-[2,4-dimethyl-6-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-5-isoxazolyl)amino]sulfonyl}-N-[2-(2-propylsulfonyl)-4,6-dimethylphenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(propylsulfonyl)phenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]-sulfonyl}-N-(2-ethyl-4,6-dimethylphenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,6-dimethyl-4-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide, N-(4-chloro-3-methyl-5-isoxazolyl)-2-(6,8-dimethyl-4-hydroxy-2-benzopyrimidinyl)thiophene-3-sulfonamide and N-(4-chloro-3-methyl-5-isoxazolyl)-2-(3-cyano-4-hydroxy-6,8-dimethylbenzo[b]pyridin-2-yl)thiophene-3-sulfonamide.

In other embodiments, X is $-C(R^3)=C(R^4)-$ and the compounds are benzenesulfonamides of formula VII:



and pharmaceutically acceptable derivatives thereof, where R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

W is O, NH or $(CH_2)_z$ wherein z is 0 to 6, preferably 0 to 3, more preferably 1; and Y is O, S, or, together with R^8 and the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring, preferably a 5 or 6 membered unsubstituted or substituted cyclic or heterocyclic ring, more preferably a 6 membered

unsubstituted or substituted heterocyclic ring; M is preferably -C(Y)-W- or $(CH_2)_z$;

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$,

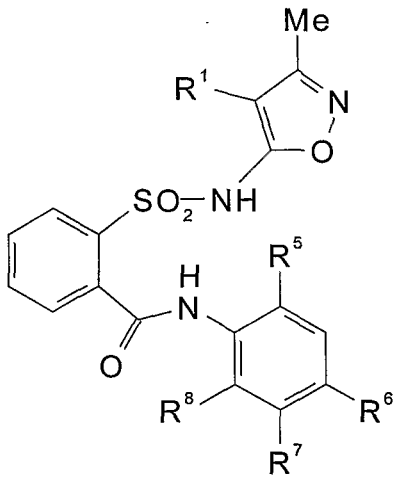
$-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl~~ lower haloalkyl; x and y are each independently 0 to 14; and R^{50} is a ~~subsitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy (i.e. $-O-(CH_2)_n-O-$, $-S-(CH_2)_n-O-$, $-S-(CH_2)_n-S-$, where n is 1 to 4, preferably 1 or 2) which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i).

In certain embodiments, the compounds have formula VII where R^3, R^4 and R^9 are H; Y is O; and W is NH. R^1 and R^2 are, in preferred embodiments, each selected independently from among alkyl, lower alkenyl, lower alkynyl, lower haloalkyl, halide, pseudohalide or H, except that R^2 is not halide. R^1 is preferably lower alkyl or halide, more preferably Me or Cl. R^2 is preferably lower alkyl, more preferably Me.

In more preferred embodiments, the compounds have the formula VIII:

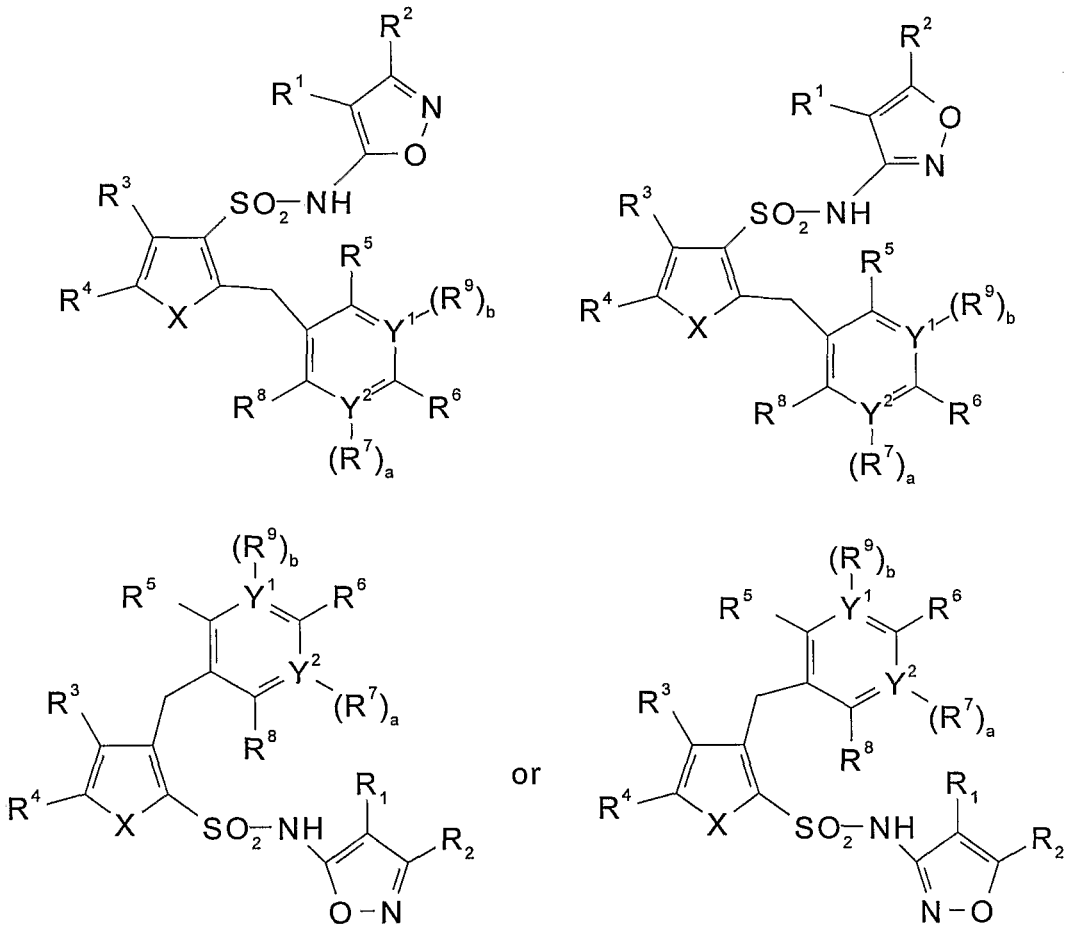


or pharmaceutically acceptable derivatives thereof, in which R^1 is lower alkyl or halide, preferably Me or Cl; R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$; R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl; R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ or $OS(O)_2NR^{38}R^{39}$; and R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$.

In more preferred embodiments, the compounds are of formula VIII where R^5 is Me or acetyl, preferably Me; R^6 is Me, acetyl or 2-oxazolyl, preferably Me; R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl), preferably H; and R^8 is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, C(O)N(Me)(CH_2-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, $C(=N\text{-}OMe)Me$, Me, C(O)Et, Cl, n-propyl or ethyl. Thus, in preferred embodiments, the compounds are of formula VIII in which R^5 and R^6 are Me; and R^7 is H. In these embodiments, R^8 is most preferably C(O)Me.

Preferred compounds of formula VIII herein include N-(4-chloro-3-methyl-5-isoxazolyl)-2-(2-acetyl-4,6-dimethylphenylaminocarbonyl)benzenesulfonamide.

In other embodiments, the compounds are of formula I where M is $(CH_2)_z$, where z is 0 to 6, preferably 0 to 3, more preferably 1. Thus, in more preferred embodiments, the compounds of formula I have the formula IX:



or pharmaceutically acceptable derivatives thereof, in which R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted

or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$,

hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

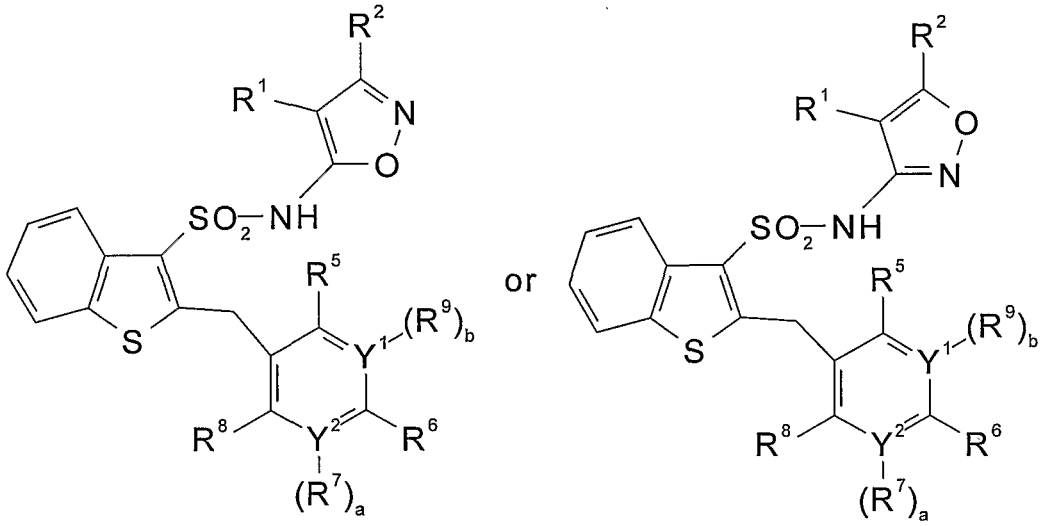
where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl;~~ lower haloalkyl x and y are each independently 0 to 14; and R^{50} is a ~~subsitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy (i.e. $-O\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}S-$, where n is 1 to 4, preferably 1 or 2) which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i); and

X is $-C(R^3)=C(R^4)-$, S, O or NR^{11}, where R^{11} is hydrogen or contains up to about 30 carbon atoms, preferably 1 to 10, more preferably 1 to 6 and is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{15}$ and $S(O)_nR^{15}$ in which n is 0-2; R^{15} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{11} and R^{15} are unsubstituted or are substituted with one or more substituents each selected independently from Z, which as defined herein includes hydrogen, halide, pseudohalide, alkyl, alkoxy, alkenyl, alkynyl, aryl, amino acids, primary and secondary amides, O-glycosides, hexoses, riboses, alkylaryl, alkylheteroaryl,

heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, OH, CN, $C(O)R^{16}$, $OC(O)R^{16}$, CO_2R^{16}, OCO_2R^{16}, SH, $S(O)_nR^{16}$ in which n is 0-2, NHOH, $NR^{12}R^{16}$, NO_2, N_3, OR^{16}, $R^{12}NCOR^{16}$ and $CONR^{12}R^{16}$; R^{16} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, chloride, NHR^{50}, alkylaryl, alkylheteroaryl or $-(CH_2)_xOH$; R^{50} is a substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; x is 0 to 14; R^{12}, which is selected independently from R^{11} and Z, is selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl, cycloalkynyl, $C(O)R^{17}$ and $S(O)_nR^{17}$ in which n is 0-2; R^{17} is hydrogen, alkyl, alkenyl, alkynyl, aryl, alkylaryl, heterocyclyl, aralkyl, aralkoxy, cycloalkyl, cycloalkenyl or cycloalkynyl; R^{12} and R^{16} may together form alkylene; each of R^{11}, R^{12}, R^{15} and R^{16} may be further substituted with the any of the appropriate groups of those set forth for Z.

In these embodiments, R^3 and R^4 preferably form -CH=CH-CH=CH- and X is preferably S. In more preferred embodiments, the compounds of formula IX are benzothiophene-3-sulfonamides substituted at the 2 position with a benzyl group. Thus, in more preferred embodiments, the compounds of formula IX have the formula X:



or pharmaceutically acceptable derivatives thereof, where R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl~~ lower haloalkyl; x and y are each independently 0 to 14; and R^{50} is a ~~subsitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy (i.e. $-O\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}O-$, $-S\text{-}(CH_2)_n\text{-}S-$, where n is 1 to 4, preferably 1 or 2) which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or

halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i).

In more preferred embodiments, the compounds are of formula X in which R^1 is halo or lower alkyl; R^2 is lower alkyl; R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$; R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl; R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl, and are each preferably selected from hydrogen, lower alkyl, lower alkoxy and ~~lowerhaloalkyl;~~ lower haloalkyl x and y are each independently 0 to 14; and R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$;

R^9 is H; Y^1 and Y^2 are each independently carbon or nitrogen; a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen; b is 1 if Y^1 is carbon; and b is 0 if Y^1 is nitrogen.

In these embodiments, Y^1 and Y^2 are preferably carbon; a and b are each 1; R^5, R^6 and R^8 are preferably lower alkyl, more preferably Me; and R^7 is preferably H or SO_2NHR^{50}, where R^{50} is heteroaryl, more preferably isoxazolyl, most preferably 4-chloro-3-methyl-5-isoxazolyl.

Preferred compounds of this embodiment include N-(4-chloro-3-methyl-5-isoxazolyl)-2-(2,4,6-trimethylbenzyl)benzo[b]thiophene-3-sulfonamide and N-(4-chloro-3-methyl-5-isoxazolyl)-2-(3-(4-chloro-3-methyl-5-isoxazolyl)aminosulfonyl-2,4,6-trimethylbenzyl)benzo[b]thiophene-3-sulfonamide.

Also of interest are any pharmaceutically-acceptable derivatives, including salts, esters, acids and bases, solvates, hydrates and prodrugs of the sulfonamides. Preferred are pharmaceutically-acceptable salts, particularly alkali metal salts, most preferably sodium salts.

Particularly preferred derivatives are salts of compounds described herein where W is alkylene, more particularly CH_2. Of these derivatives, the preferred salts are sodium salts.

In all embodiments, preferred substituents also can be determined by reference to Table 1, which sets forth exemplary compounds. Preferred compounds are those of Table 1 that have the highest activities, and preferred substituents are those on the compounds with the highest activities (activity at the lowest concentration).

TABLE 1

COMPOUND	ET_A ACTIVITY*
N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide	1.0
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide	18.1
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	38.0
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide	18.6
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-(3,4,6-trimethyl-2-propanoylphenyl)-2-thiophenecarboxamide	23.9
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2-(1-hydroxyethyl)-4,6-dimethylphenyl]-2-thiophene carboxamide	26.4
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-{2-[(dimethylamino)carbonyl]-4,6-dimethylphenyl)-2-thiophene carboxamide	14.4

COMPOUND	ET_A ACTIVITY*
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2,4-dimethyl-6-[(methyloxy)ethanimidoyl]phenyl}-2-thiophene carboxamide	23.6
3-{[(3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thienyl)carbonyl]amino}-2,4,6-trimethylphenyl-N,N-dimethylsulfamate	0.3
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-[(cyclopropylmethyl)oxy]-2,4,6-trimethylphenyl}-2-thiophenecarboxamide	9.4
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethyl-5-pyrimidinyl)-2-thiophenecarboxamide	2.0
N-(2-acetyl-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide	103.8
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-cyano-3,4,6-trimethylphenyl)-2-thiophenecarboxamide	55.7
N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide	20.7
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(4,6-diacetyl-3-hydroxy-2-propylphenyl-2-thiophenecarboxamide	0.1
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-[2-(methylsulfonyl)acetyl]phenyl}-2-thiophenecarboxamide	13.7
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-{[methyl(2,2-dimethylpropyl)amino]carbonyl}phenyl)-2-thiophenecarboxamide	2.7
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(methylsulfonyl)phenyl]-2-thiophenecarboxamide	64.1
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,4-dimethyl-6-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide	17.9

COMPOUND	ET_A ACTIVITY*
3-{[(4-chloro-5-isoxazolyl)amino]sulfonyl}-N-[2-(2-propylsulfonyl)-4,6-dimethylphenyl]-2-thiophenecarboxamide	--
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(propylsulfonyl)phenyl]-2-thiophenecarboxamide	--
3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-N-(2-acetyl-4,5-methylenedioxyphenyl)-2-thiophenecarboxamide	0.05
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethylphenyl)-2-thiophenecarboxamide	2.4
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-(2,4,6-trimethylphenylacetyl)thiophene	6.4
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(3-methoxycarbonyl-2,4,6-trimethylphenyl)-2-thiophenecarboxamide	4.7
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-acetyl-4,5-methylenedioxyphenyl)-2-thiophenecarboxamide	0.15
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-carbamoyl-4,6-dimethylphenyl)-2-thiophenecarboxamide	1.04
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-carboxyl-4,6-dimethylphenyl)-2-thiophenecarboxamide	0.05
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-ethyl-4,6-dimethylphenyl)-2-thiophenecarboxamide	3.8
3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,6-dimethyl-4-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide	1.1

* ET_A antagonist activity relative to N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide

-- data not available or measured as % inhibition @ 100 μM

The compounds provided herein also exhibit improved pharmacokinetic properties as compared to known endothelin antagonists (see, Table 2, below). As shown in Table 2, the compounds provided

herein possess increased oral availability and selectivity as compared to known endothelin antagonists. For example, N-(2-acetyl-4,6-dimethyl-phenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophene-carboxamide shows an oral availability of 148.1%, while N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide possesses an oral availability of 43.6%. Furthermore, N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide shows a selectivity for antagonism of ET_A receptors over ET_B receptors of 441,000, while N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methyl-phenyl)acetyl]-thiophene-3-sulfonamide possesses a selectivity of 20,950 in the same assay.

Table 2 also provides data demonstrating the improved tolerability, both in vitro and in vivo, of the compounds provided herein, as compared to known endothelin receptor antagonists. See, EXAMPLE 24. For example, N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide has IC_{50} values of 7.6, 126.3 and 28.0 in in vitro assays that measure inhibition of the CP4502C9, 2C19 and 3A4 enzymes, respectively, while N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide possesses IC_{50} values of 0.03, 0.2 and 0.09, respectively in the same assays. Furthermore, N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide exhibits 50% inhibition of mean pulmonary arterial pressure (MPAP) increase in vivo at approximately 1 mg/kg in an acute hypoxia model, while N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide shows 50% inhibition of MPAP increase at 2.5 mg/kg in the same assay. Additional data is provided in Table 2.

Thus, the compounds provided herein possess improved pharmacokinetic properties and improved tolerability, as demonstrated by both in vitro and in vivo assays, as compared to known endothelin receptor antagonists.

TABLE 2

COMPOUND	Oral Availability[$]	Selectivity[+]	$t_{1/2}$ elim. (h)
N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methyl-phenyl)acetyl]-thiophene-3-sulfonamide	43.6	20,950	4.5
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	25.1	442,000	4.0
N-(2-methanesulfonylacetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	16.7	66,500	12.2
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]-sulfonyl}-2-thiophenecarboxamide	148.1	441,000	6.0
N-(2-methanesulfonyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	456,000	1.5
N-(2-(2-oxazolyl)-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	119,000	5.3
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	549,800	5.1
N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	166,000	2.6

COMPOUND	Oral Availability[$]	Selectivity[+]	$t_{½}$ elim. (h)
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	330,000	5.3

[$] %

[+] IC_{50} for ET_B / $IC_{50}$for ET_A

TABLE 2 (cont.)

COMPOUND	CP450 2C9*	CP450 2C19*	CP450 3A4*
N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methyl-phenyl)acetyl]-thiophene-3-sulfonamide	0.03	0.2	0.09
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	1.67	48.8	3.3
N-(2-methanesulfonylacetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	5.1	50.6	4.0
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]-sulfonyl}-2-thiophenecarboxamide	7.6	126.3	28.0
N-(2-methanesulfonyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	5.3	6.2	13.7
N-(2-(2-oxazolyl)-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	--	--	--
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	0.77	13.53	1.44

COMPOUND	CP450 2C9*	CP450 2C19*	CP450 3A4*
N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	0.56	4.60	3.86
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	2.38	14.36	3.30

* IC_{50} values in μM.

TABLE 2 (cont.)

COMPOUND	C_{max} (μg)	Acute Hypoxia#
N-(4-chloro-3-methyl-5-isoxazolyl)-2-{[3,4-(methylenedioxy)-6-methylphenyl)acetyl]-thiophene-3-sulfonamide	133.2	2.5
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	58.8	1
N-(2-methanesulfonylacetyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	37.3	>5
N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide	157.2	1
N-(2-methanesulfonyl-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	10.3	--
N-(2-(2-oxazolyl)-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	66	--

COMPOUND	C_{max} (μg)	Acute Hypoxia#
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	45.7	1 to 5
N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	49.5	--
N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenesulfonamide	85.8	1 to 5

In vivo model, dose to achieve 50% inhibition of mean pulmonary artery pressure increase (mg/kg)

B. Preparation of the compounds

The preparation of some of the above and other compounds that possess the requisite activities are set forth in the Examples. Compounds whose synthesis is not explicitly exemplified can be synthesized by routine modification of one or more methods described in detail in the Examples by substituting appropriate readily available reagents.

Many of the compounds described herein are 3-sulfamoyl-2-arylaminocarbonylthiophene derivatives. In general, these compounds may be prepared by coupling of the appropriate 3-sulfamoylthienylcarboxylic acid with a substituted or unsubstituted aniline.

The 3-sulfamoylthienylcarboxylic acids may be prepared by a variety of methods known the those of skill in the art. In general, most of the syntheses involve the condensation of a carboalkoxythienylsulfonyl chloride with an aminoisoxazole in dry pryidine or in tetrahydrofuran (THF) and sodium hydride. Subsequent hydrolysis of the carboalkoxy group provides the desired acids. The sulfonyl ~~cherides~~ chlorides and

aminoisoxazoles either can be obtained commercially or synthesized according to methods described in the Examples or using other methods available to those of skill in this art (see, e.g., U.S. Patent Nos. 4,659,369, 4,861,366 and 4,753,672).

For example, the thienylsulfonyl chlorides may be prepared by the following methods. A 3-sulfamoylthiophene precursor may be brominated at the 2-position by reaction with, for example, bromine or N-bromosuccinimide. Subsequent metal-halogen exchange with an alkyllithium, e.g., n-butyllithium, and reaction with carbon dioxide provides the desired acid. Alternatively, a 2-thienylcarboxylic acid derivative may be sulfonated at the 3-position by reaction with, e.g., sulfur trioxide in sulfuric acid. Conversion of the resulting sulfonic acid to a sulfonyl chloride (by reaction with phosphorous pentachloride, phosphorous ~~trichoride~~ trichloride, phosphorous oxychloride, thionyl ~~choride~~ chloride, or oxalyl ~~choride~~ chloride) followed by reaction with the appropriate amine provides the desired sulfamoylthienylcarboxylic acid derivative. The intermediate sulfonyl chloride may also be prepared directly by reaction of the thienylcarboxylic acid derivative with chlorosulfonic acid.

The N-(alkylisoxazolyl)sulfonamides can be prepared by condensing an aminoisoxazole with a sulfonyl chloride in dry pyridine with or without the catalyst 4-(dimethylamino)pyridine. The N-(3,4-dimethyl-5-isoxazolyl)sulfonamides and N-(4,5-dimethyl-3-isoxazolyl)sulfonamides can be prepared from the corresponding aminodimethylisoxazole, such as 5-amino-3,4-dimethylisoxazole. For example, N-(3,4-dimethyl-5-isoxazolyl)-2-(carbomethoxy)thiophene-3-sulfonamide was prepared from 2-methoxycarbonylthiophene-3-sulfonyl chloride and 5-amino-3,4-dimethylisoxazole in dry pyridine.

The N-(4-haloisoxazolyl)sulfonamides can be prepared by condensation of amino-4-haloisoxazole with a sulfonyl chloride in THF with sodium

hydride as a base. For example, N-(4-bromo-3-methyl-5-isoxazolyl)thiophene-2-sulfonamide was prepared from 5-amino-4-bromo-3-methylisoxazole and thiophene-2-sulfonyl chloride in THF and sodium hydride.

These sulfonamides also can be prepared from the corresponding sulfonyl chloride and the aminoisoxazole in pyridine with or without a catalytic amount of 4-dimethylaminopyridine (DMAP). In some cases, the bis-sulfonyl compound is obtained as the major or exclusive product. The bis-sulfonated products can be readily hydrolyzed to the sulfonamide using aqueous sodium hydroxide and a suitable co-solvent, such as methanol or tetrahydrofuran, generally at room temperature.

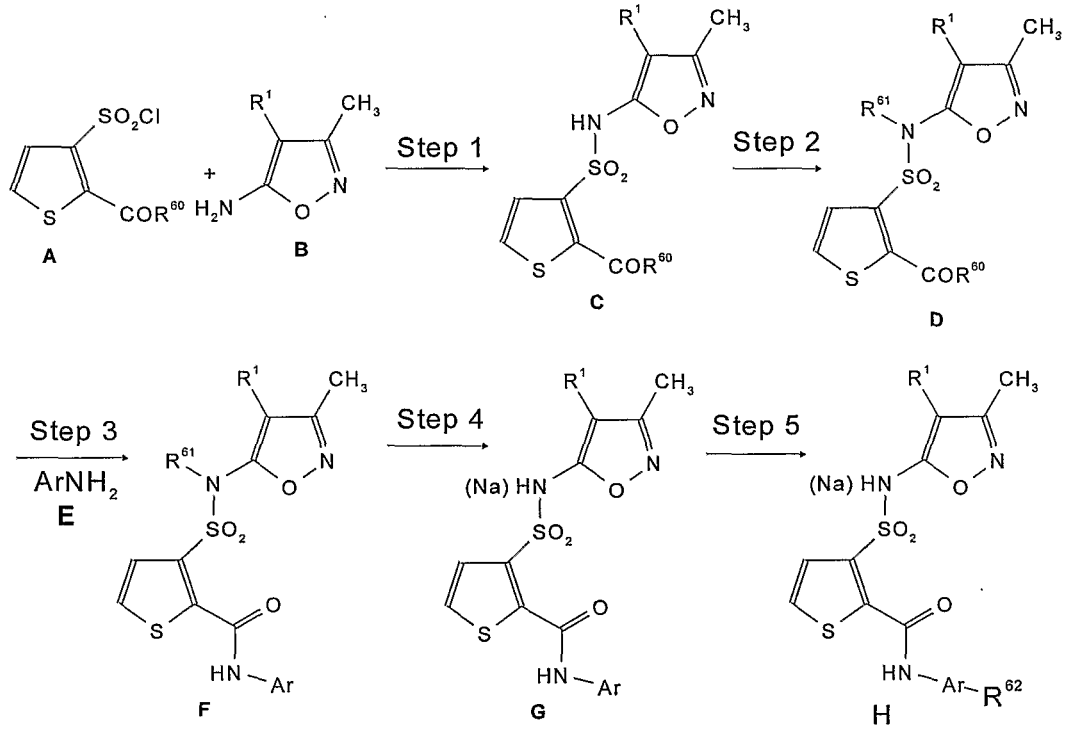
The substituted anilines may be synthesized by nitration of the appropriate precursor substituted benzene with, e.g., a mixture of nitric and sulfuric acid, or nitronium tetrafluoroborate. Reduction of the resulting aromatic nitro compound with, e.g., zinc powder, catalytic hydrogenation, stannous chloride, or any other method known to those of skill in the art, affords the desired aniline.

Coupling of the thienylcarboxylic acid with the aniline may be accomplished by conversion of the acid to the corresponding acyl imidazole (by reaction with, e.g., carbonyldiimidazole) or acyl chloride (by reaction with, e.g., oxalyl ~~chloride~~ chloride or thionyl chloride), followed by reaction with the aniline to give the desired arylaminocarbonylthiophene compounds.

Some of the compounds described herein are 3-sulfamoyl-2-benzylaminocarbonylthiophene derivatives. In preparing these compounds, the aniline in the above preparation is replaced with a benzylamine. Appropriate benzylamines may be synthesized by reaction of the corresponding benzyl halide with azide, followed by reduction of the resulting benzyl azide by, e.g., catalytic hydrogenation or treatment with a trialkyl- or triarylphosphine.

Other compounds described herein are 3-sulfamoyl-2-arylacetylthiophene derivatives. These compounds may be generated by addition of an appropriate benzylmagnesium halide to a 3-sulfamoyl-2-thienylcarboxylic acid derivative, such as an N-methyl-N-methoxyamide. This amide may be prepared by reaction of the acid with carbonyldiimidazole, followed by reaction with N-methyl-N-methoxyamine.

Certain of the compounds described herein may be prepared by the method outlined in Scheme I:



where R^1 is halogen or lower alkyl with chlorine and methyl being preferred.

For compounds of formula **A**, R^{60} is taken with CO form a carboxylic acid or derivative. In this instance R^{60} is preferably OR^4 where R^4 is lower alkyl or alkoxyalkyl, with methyl or methoxymethyl being preferred, or any other group consistent with the intended chemistry.

For compounds of formulas **C** or **D**, R^{60} is OR^4, OH, halogen, or other carboxylic acid activating group consistent with the intended chemical transformations with chlorine being especially preferred.

For compounds of formulas **D** and **F**, R^{61} is any sulfonamide protecting group consistent with the intended chemistry, for example methoxymethyl.

For compounds of formula **E**, Ar can be any aromatic or hetercyclic ring with benzene and pyrimidine being preferred.

Prodrugs and other derivatives of the compounds suitable for administration to humans may also be designed and prepared by methods known to those of skill in the art (see, e.g., Nogrady (1985) Medicinal Chemistry A Biochemical Approach, Oxford University Press, New York, pages 388-392).

Compounds described herein have been synthesized and tested for activity in in vitro assays and, in some cases, in in vivo animal models. Nuclear magnetic resonance spectroscopic (NMR), mass spectrometric, infrared spectroscopic and high performance liquid chromatographic analyses indicated that the synthesized compounds have structures consistent with those expected for such compounds and are generally greater than 95% pure. All of the compounds exemplified or described herein exhibited activity as endothelin antagonists.

C. Evaluation of the bioactivity of the compounds

Standard physiological, pharmacological and biochemical procedures are available for testing the compounds to identify those that possess any biological activities of an endothelin peptide or the ability to interfere with or inhibit endothelin peptides. Compounds that exhibit in vitro activities, such as the ability to bind to endothelin receptors or to compete with one or more of the endothelin peptides for binding to endothelin receptors can be used in the methods for isolation of endothelin

receptors and the methods for distinguishing the specificities of endothelin receptors, and are candidates for use in the methods of treating endothelin-mediated disorders.

Thus, other preferred compounds of formulas I and II, in addition to those specifically identified herein, that are endothelin antagonists or agonists may be identified using such screening assays.

1. Identifying compounds that modulate the activity of an endothelin peptide

The compounds are tested for the ability to modulate the activity of endothelin-1. Numerous assays are known to those of skill in the art for evaluating the ability of compounds to modulate the activity of endothelin (see, e.g., U.S. Patent No. 5,114,918 to Ishikawa et al.; EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD. (October 7, 1991); Borges et al. (1989) Eur. J. Pharm. 165: 223-230; Filep et al. (1991) Biochem. Biophys. Res. Commun. 177: 171-176). In vitro studies may be corroborated with in vivo studies (see, e.g., U.S. Patent No. 5,114,918 to Ishikawa et al.; EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD. (October 7, 1991)) and pharmaceutical activity thereby evaluated. Such assays are described in the Examples herein and include the ability to compete for binding to ET_A and ET_B receptors present on membranes isolated from cell lines that have been genetically engineered to express either ET_A or ET_B receptors on their cell surfaces.

The properties of a potential antagonist may be assessed as a function of its ability to inhibit an endothelin induced activity in vitro using a particular tissue, such as rat portal vein and aorta as well as rat uterus, trachea and vas deferens (see e.g., Borges, R., Von Grafenstein, H. and Knight, D.E., "Tissue selectivity of endothelin," Eur. J. Pharmacol 165:223-230, (1989)). The ability to act as an endothelin antagonist in vivo can be tested in hypertensive rats, ddy mice or other recognized animal models (see, Kaltenbronn et al. (1990) J. Med. Chem. 33:838-

845, see, also, U.S. Patent No. 5,114,918 to Ishikawa et al.; and EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD (October 7, 1991); see, also Bolger et al. (1983) J. Pharmacol. Exp. Ther. 225291-309). Using the results of such animal studies, pharmaceutical effectiveness may be evaluated and pharmaceutically effective dosages determined. A potential agonist may also be evaluated using in vitro and in vivo assays known to those of skill in the art.

Endothelin activity can be identified by the ability of a test compound to stimulate constriction of isolated rat thoracic aorta (Borges et al. (1989) "Tissue selectivity of endothelin" Eur. J. Pharmacol. 165: 223-230). To perform the assay, the endothelium is abraded and ring segments mounted under tension in a tissue bath and treated with endothelin in the presence of the test compound. Changes in endothelin induced tension are recorded. Dose response curves may be generated and used to provide information regarding the relative inhibitory potency of the test compound. Other tissues, including heart, skeletal muscle, kidney, uterus, trachea and vas deferens, may be used for evaluating the effects of a particular test compound on tissue contraction.

Endothelin isotype specific antagonists may be identified by the ability of a test compound to interfere with endothelin binding to different tissues or cells expressing different endothelin-receptor subtypes, or to interfere with the biological effects of endothelin or an endothelin isotype (Takayanagi et al. (1991) Reg. Pep. 32: 23-37, Panek et al. (1992) Biochem. Biophys. Res. Commun. 183: 566-571). For example, ET_B receptors are expressed in vascular endothelial cells, possibly mediating the release of prostacyclin and endothelium-derived relaxing factor (De Nucci et al. (1988) Proc. Natl. Acad. Sci. USA 85:9797). ET_A receptors are not detected in cultured endothelial cells, which express ET_B receptors.

The binding of compounds or inhibition of binding of endothelin to ET_B receptors can be assessed by measuring the inhibition of endothelin-1-mediated release of prostacyclin, as measured by its major stable metabolite, 6-keto $PGF_{1\alpha}$, from cultured bovine aortic endothelial cells (see, e.g., Filep et al. (1991) Biochem. and Biophys Res. Commun. 177: 171-176). Thus, the relative affinity of the compounds for different endothelin receptors may be evaluated by determining the inhibitory dose response curves using tissues that differ in receptor subtype.

Using such assays, the relative affinities of the compounds for ET_A receptors and ET_B receptors have been and can be assessed. Those that possess the desired properties, such as specific inhibition of binding of endothelin-1, are selected. The selected compounds that exhibit desirable activities may be therapeutically useful and are tested for such uses using the above-described assays from which in vivo effectiveness may be evaluated (see, e.g., U.S. Patent No. 5,248,807; U.S. Patent No. 5,240,910; U.S. Patent No. 5,198,548; U.S. Patent No. 5,187,195; U.S. Patent No. 5,082,838; U.S. Patent No. 5,230,999; published Canadian Application Nos. 2,067,288 and 2071193; published Great Britain Application No. 2,259,450; Published International PCT Application No. WO 93/08799; Benigi et al. (1993) Kidney International 44:440-444; and Nirei et al. (1993) Life Sciences 52:1869-1874). Compounds that exhibit in vitro activities that correlate with in vivo effectiveness will then be formulated in suitable pharmaceutical compositions and used as therapeutics.

The compounds also may be used in methods for identifying and isolating endothelin-specific receptors and aiding in the design of compounds that are more potent endothelin antagonists or agonists or that are more specific for a particular endothelin receptor.

2. Isolation of endothelin receptors

A method for identifying endothelin receptors is provided. In practicing this method, one or more of the compounds is linked to a support and used in methods of affinity purification of receptors. By selecting compounds with particular specificities, distinct subclasses of ET receptors may be identified.

One or more of the compounds may be linked to an appropriate resin, such as Affi-gel, covalently or by other linkage, by methods known to those of skill in the art for linking endothelin to such resins (see, Schvartz et al. (1990) Endocrinology 126: 3218-3222). The linked compounds can be those that are specific for ET_A or ET_B receptors or other subclass of receptors.

The resin is pre-equilibrated with a suitable buffer generally at a physiological pH (7 to 8). A composition containing solubilized receptors from a selected tissue are mixed with the resin to which the compound is linked and the receptors are selectively eluted. The receptors can be identified by testing them for binding to an endothelin isopeptide or analog or by other methods by which proteins are identified and characterized. Preparation of the receptors, the resin and the elution method may be performed by modification of standard protocols known to those of skill in the art (see, e.g., Schvartz et al. (1990) Endocrinology 126: 3218-3222).

Other methods for distinguishing receptor type based on differential affinity to any of the compounds herein are provided. Any of the assays described herein for measuring the affinity of selected compounds for endothelin receptors may also be used to distinguish receptor subtypes based on affinity for particular compounds provided herein. In particular, an unknown receptor may be identified as an ET_A or ET_B receptor by measuring the binding affinity of the unknown receptor for a compound

provided herein that has a known affinity for one receptor over the other. Such preferential interaction is useful for determining the particular disease that may be treated with a compound prepared as described herein. For example, compounds with high affinity for ET_A receptors and little or no affinity for ET_B receptors are candidates for use as hypertensive agents; whereas, compounds that preferentially interact with ET_B receptors are candidates for use as anti-asthma agents.

D. Formulation and administration of the compositions

Formulations of the sulfonamides are provided herein. The formulations are compositions designed for administration of the pharmaceutically acceptable derivatives, particularly salts of the sulfonamide compounds provided herein. Because of the observed superior stability characteristics of the salts, compared to the neutral forms, such salts, particularly the sodium salts, are particularly suitable for oral and parenteral administration. Such compositions include solutions, suspensions, tablets, dispersible tablets, pills, capsules, powders, sustained release formulations and any other suitable formulation. Preferably the compositions will take the form of a pill or tablet. Methods for manufacture of tablets, capsules and other such formulations are known to those of skill in the art (see, e.g., Ansel, H.C (1985) Introduction to Pharmaceutical Dosage Forms, 4th Edition, pp. 126-163).

In the formulations, effective concentrations of one or more pharmaceutically acceptable derivatives is (are) mixed with a suitable pharmaceutical carrier or vehicle. Preferably, the sulfonamide compounds are derivatized as the corresponding salts, preferably sodium salts, prior to formulation, as described above. The concentrations of the salts of the compounds in the formulations are effective for delivery of an amount, upon administration, that ameliorates the symptoms of the endothelin-mediated disease. Typically, the compositions are formulated

for single dosage administration. To formulate a composition, the weight fraction of compound is dissolved, suspended, dispersed or otherwise mixed in a selected vehicle at an effective concentration such that the treated condition is relieved or ameliorated. Pharmaceutical carriers or vehicles suitable for administration of the compounds provided herein include any such carriers known to those skilled in the art to be suitable for the particular mode of administration.

In addition, the compounds may be formulated as the sole pharmaceutically active ingredient in the composition or may be combined with other active ingredients. Liposomal suspensions, including tissue-targeted liposomes, may also be suitable as pharmaceutically acceptable carriers. These may be prepared according to methods known to those skilled in the art. For example, liposome formulations may be prepared as described in U.S. Patent No. 4,522,811.

The active compound as salt, preferably as a sodium salt, is included in the pharmaceutically acceptable carrier in an amount sufficient to exert a therapeutically useful effect in the absence of undesirable side effects on the patient treated. The therapeutically effective concentration may be determined empirically by testing the compounds in known in vitro and in vivo systems (see, e.g., U.S. Patent No. 5,114,918 to Ishikawa et al.; EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD (October 7, 1991); Borges et al. (1989) Eur. J. Pharm. 165: 223-230; : Filep et al. (1991) Biochem. Biophys. Res. Commun. 177: 171-176) and then extrapolated therefrom for dosages for humans.

The concentration of active compound sodium salt in the drug composition will depend on absorption, inactivation and excretion rates of the active compound, the physicochemical characteristics of the compound, the dosage schedule, and amount administered as well as other factors known to those of skill in the art. For example, the amount

that is delivered is sufficient to treat the symptoms of hypertension. The effective amounts for treating endothelin-mediated disorders are expected to be higher than the amount of the sulfonamide compound that would be administered for treating bacterial infections.

Typically a therapeutically effective dosage should produce a serum concentration of active ingredient of from about 0.1 ng/ml to about 50-100 μg/ml. The pharmaceutical compositions typically should provide a dosage of from about 0.001 mg to about 2000 mg of compound per kilogram of body weight per day. Pharmaceutical dosage unit forms are prepared to provide from about 1 mg to about 1000 mg and preferably from about 10 to about 500 mg of the essential active ingredient or a combination of essential ingredients per dosage unit form.

The active ingredient may be administered at once, or may be divided into a number of smaller doses to be administered at intervals of time. It is understood that the precise dosage and duration of treatment is a function of the disease being treated and may be determined empirically using known testing protocols or by extrapolation from in vivo or in vitro test data. It is to be noted that concentrations and dosage values may also vary with the severity of the condition to be alleviated. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the compositions, and that the concentration ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed compositions.

Preferred pharmaceutically acceptable derivatives include acids, salts, esters, hydrates, solvates and prodrug forms. The derivative is selected to be a more stable form than the corresponding neutral compound. Preferred are pharmaceutically-acceptable salts. More

preferred salts include alkali metal salts, particularly sodium salts, such as, but not limited to, a sodium hydrogen phosphate salt and a sodium salt, most ~~preferrably~~ the sodium salt.

Thus, effective concentrations or amounts of one or more of the compounds provided herein or pharmaceutically acceptable derivatives thereof are mixed with a suitable pharmaceutical carrier or vehicle for systemic, topical or local administration to form pharmaceutical compositions. Compounds are included in an amount effective for ameliorating or treating the endothelin-mediated disorder for which treatment is contemplated. The concentration of active compound in the composition will depend on absorption, inactivation, excretion rates of the active compound, the dosage schedule, amount administered, particular formulation as well as other factors known to those of skill in the art.

The compositions are intended to be administered by an suitable route, which includes orally, parenterally, rectally and topically and locally depending upon the disorder being treated. For example, for treatment of ophthalmic disorders, such as glaucoma, formulation for intraocular and also intravitreal injection is contemplated. For oral administration, capsules and tablets are presently preferred. For parenteral administration reconstitution of a lyophilized powder, prepared as described herein, is preferred. The compounds in liquid, semi-liquid or solid form and are formulated in a manner suitable for each route of administration. Preferred modes of administration include parenteral and oral modes of administration.

Solutions or suspensions used for parenteral, intradermal, subcutaneous, or topical application can include any of the following components: a sterile diluent, such as water for injection, saline solution, fixed oil, polyethylene glycol, glycerine, propylene glycol or other

synthetic solvent; antimicrobial agents, such as benzyl alcohol and methyl parabens; antioxidants, such as ascorbic acid and sodium bisulfite; chelating agents, such as ethylenediaminetetraacetic acid (EDTA); buffers, such as acetates, citrates and phosphates; and agents for the adjustment of tonicity such as sodium chloride or dextrose. Parenteral preparations can be enclosed in ampules, disposable syringes or single or multiple dose vials made of glass, plastic or other suitable material.

In instances in which the compounds exhibit insufficient solubility, methods for solubilizing compounds may be used. Such methods are known to those of skill in this art, and include, but are not limited to, using cosolvents, such as dimethylsulfoxide (DMSO), using surfactants, such as tween, or dissolution in aqueous sodium bicarbonate. Derivatives of the compounds, such as prodrugs of the compounds may also be used in formulating effective pharmaceutical compositions.

Upon mixing or addition of the sodium salt of the sulfonamide compound(s), the resulting mixture may be a solution, suspension, emulsion or the like. The form of the resulting mixture depends upon a number of factors, including the intended mode of administration and the solubility of the compound in the selected carrier or vehicle. The effective concentration is sufficient for ameliorating the symptoms of the disease, disorder or condition treated and may be empirically determined.

The formulations are provided for administration to humans and animals in unit dosage forms, such as tablets, capsules, pills, powders, granules, sterile parenteral solutions or suspensions, and oral solutions or suspensions, and oil-water emulsions containing suitable quantities of the compounds, particularly the pharmaceutically acceptable salts, preferably the sodium salts, thereof. The pharmaceutically therapeutically active compounds and derivatives thereof are typically formulated and administered in unit-dosage forms or multiple-dosage forms. Unit-dose

forms as used herein refers to physically discrete units suitable for human and animal subjects and packaged individually as is known in the art. Each unit-dose contains a predetermined quantity of the therapeutically active compound sufficient to produce the desired therapeutic effect, in association with the required pharmaceutical carrier, vehicle or diluent. Examples of unit-dose forms include ampoules and syringes individually packaged tablet or capsule. Unit-dose forms may be administered in fractions or multiples thereof. A multiple-dose form is a plurality of identical unit-dosage forms packaged in a single container to be administered in segregated unit-dose form. Examples of multiple-dose forms include vials, bottles of tablets or capsules or bottles of pint or gallons. Hence, multiple dose form is a multiple of unit-doses which are not segregated in packaging.

The composition can contain along with the active ingredient: a diluent such as lactose, sucrose, dicalcium phosphate, or carboxymethylcellulose; a lubricant, such as magnesium stearate, calcium stearate and talc; and a binder such as starch, natural gums, such as gum acaciagelatin, glucose, molasses, polvinylpyrrolidine, celluloses and derivatives thereof, povidone, crospovidones and other such binders known to those of skill in the art. Liquid pharmaceutically administrable compositions can, for example, be prepared by dissolving, dispersing, or otherwise mixing an active compound as defined above and optional pharmaceutical adjuvants in a carrier, such as, for example, water, saline, aqueous dextrose, glycerol, glycols, ethanol, and the like, to thereby form a solution or suspension. If desired, the pharmaceutical composition to be administered may also contain minor amounts of nontoxic auxiliary substances such as wetting agents, emulsifying agents, or solubilizing agents, pH buffering agents and the like, for example, acetate, sodium citrate, cyclodextrine derivatives, sorbitan monolaurate, triethanolamine

sodium acetate, triethanolamine oleate, and other such agents. Actual methods of preparing such dosage forms are known, or will be apparent, to those skilled in this art; for example, see Remington's Pharmaceutical Sciences, Mack Publishing Company, Easton, Pa., 15th Edition, 1975. The composition or formulation to be administered will, in any event, contain a quantity of the active compound in an amount sufficient to alleviate the symptoms of the treated subject.

Dosage forms or compositions containing active ingredient in the range of 0.005% to 100% with the balance made up from non-toxic carrier may be prepared. For oral administration, a pharmaceutically acceptable non-toxic composition is formed by the incorporation of any of the normally employed excipients, such as, for example pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, talcum, cellulose derivatives, sodium crosscarmellose, glucose, sucrose, magnesium carbonate or sodium saccharin. Such compositions include solutions, suspensions, tablets, capsules, powders and sustained release formulations, such as, but not limited to, implants and microencapsulated delivery systems, and biodegradable, biocompatible polymers, such as collagen, ethylene vinyl acetate, polyanhydrides, polyglycolic acid, polyorthoesters, polylactic acid and others. Methods for preparation of these formulations are known to those skilled in the art. he contemplated compositions may contain 0.001%-100% active ingredient, preferably 0.1-85%, typically 75-95%.

The salts, preferably sodium salts, of the active compounds may be prepared with carriers that protect the compound against rapid elimination from the body, such as time release formulations or coatings.

The formulations may be include other active compounds to obtain desired combinations of properties. The compounds of formula I, or a

pharmaceutically acceptable salts and derivatives thereof as described herein, may also be advantageously administered for therapeutic or prophylactic purposes together with another pharmacological agent known in the general art to be of value in treating one or more of the diseases or medical conditions referred to hereinabove, such as beta-adrenergic blocker (for example atenolol), a calcium channel blocker (for example nifedipine), an angiotensin converting enzyme (ACE) inhibitor (for example lisinopril), a diuretic (for example furosemide or hydrochlorothiazide), an endothelin converting enzyme (ECE) inhibitor (for example phosphoramidon), a neutral endopeptidase (NEP) inhibitor, an HMGCoA reductase inhibitor, a nitric oxide donor, an anti-oxidant, a vasodilator, a dopamine agonist, a neuroprotective agent, a steroid, a beta-agonist, an anti-coagulant, or a thrombolytic agent. It is to be understood that such combination therapy constitutes a further aspect of the compositions and methods of treatment provided herein.

1. Formulations for oral administration

Oral pharmaceutical dosage forms are either solid, gel or liquid. The solid dosage forms are tablets, capsules, granules, and bulk powders. Types of oral tablets include compressed, chewable lozenges and tablets which may be enteric-coated, sugar-coated or film-coated. Capsules may be hard or soft gelatin capsules, while granules and powders may be provided in non-effervescent or effervescent form with the combination of other ingredients known to those skilled in the art.

In certain embodiments, the formulations are solid dosage forms, preferably capsules or tablets. The tablets, pills, capsules, troches and the like can contain any of the following ingredients, or compounds of a similar nature: a binder; a diluent; a disintegrating agent; a lubricant; a glidant; a sweetening agent; and a flavoring agent.

Examples of binders include microcrystalline cellulose, gum tragacanth, glucose solution, acacia mucilage, gelatin solution, sucrose and starch paste. Lubricants include talc, starch, magnesium or calcium stearate, lycopodium and stearic acid. Diluents include, for example, lactose, sucrose, starch, kaolin, salt, mannitol and dicalcium phosphate. Glidants include, but are not limited to, colloidal silicon dioxide. Disintegrating agents include crosscarmellose sodium, sodium starch glycolate, alginic acid, corn starch, potato starch, bentonite, methylcellulose, agar and carboxymethylcellulose. Coloring agents include, for example, any of the approved certified water soluble FD and C dyes, mixtures thereof; and water insoluble FD and C dyes suspended on ~~alumia~~ hydrate. Sweetening agents include sucrose, lactose, mannitol and artificial sweetening agents such as sodium cyclamate and saccharin, and any number of spray dried flavors. Flavoring agents include natural flavors extracted from plants such as fruits and synthetic blends of compounds which produce a pleasant sensation, such as, but not limited to peppermint and methyl salicylate. Wetting agents include propylene glycol monostearate, sorbitan monooleate, diethylene glycol monolaurate and polyoxyethylene laural ether. Emetic-coatings include fatty acids, fats, waxes, shellac, ammoniated shellac and cellulose acetate phthalates. Film coatings include hydroxyethylcellulose, sodium carboxymethylcellulose, polyethylene glycol 4000 and cellulose acetate phthalate.

If oral administration is desired, the salt of the compound could be provided in a composition that protects it from the acidic environment of the stomach. For example, the composition can be formulated in an enteric coating that maintains its integrity in the stomach and releases the active compound in the intestine. The composition may also be formulated in combination with an antacid or other such ingredient.

When the dosage unit form is a capsule, it can contain, in addition to material of the above type, a liquid carrier such as a fatty oil. In addition, dosage unit forms can contain various other materials which modify the physical form of the dosage unit, for example, coatings of sugar and other enteric agents. The compounds can also be administered as a component of an elixir, suspension, syrup, wafer, sprinkle, chewing gum or the like. A syrup may contain, in addition to the active compounds, sucrose as a sweetening agent and certain preservatives, dyes and colorings and flavors.

The active materials can also be mixed with other active materials which do not impair the desired action, or with materials that supplement the desired action, such as antacids, H2 blockers, and diuretics. For example, if the compound is used for treating asthma or hypertension, it may be used with other bronchodilators and antihypertensive agents, respectively. The active ingredient is a compound or salt thereof as described herein. Higher concentrations, up to about 98% by weight of the active ingredient may be included.

Pharmaceutically acceptable carriers included in tablets are binders, lubricants, diluents, disintegrating agents, coloring agents, flavoring agents, and wetting agents. Enteric-coated tablets, because of the enteric-coating, resist the action of stomach acid and dissolve or disintegrate in the neutral or alkaline intestines. Sugar-coated tablets are compressed tablets to which different layers of pharmaceutically acceptable substances are applied. Film-coated tablets are compressed tablets which have been coated with a polymer or other suitable coating. Multiple compressed tablets are compressed tablets made by more than one compression cycle utilizing the pharmaceutically acceptable substances previously mentioned. Coloring agents may also be used in the above dosage forms. Flavoring and sweetening agents are

used in compressed tablets, sugar-coated, multiple compressed and chewable tablets. Flavoring and sweetening agents are especially useful in the formation of chewable tablets and lozenges.

Liquid oral dosage forms include aqueous solutions, emulsions, suspensions, solutions and/or suspensions reconstituted from non-effervescent granules and effervescent preparations reconstituted from effervescent granules. Aqueous solutions include, for example, elixirs and syrups. Emulsions are either oil-in-water or water-in-oil.

Elixirs are clear, sweetened, hydroalcoholic preparations. Pharmaceutically acceptable carriers used in elixirs include solvents. Syrups are concentrated aqueous solutions of a sugar, for example, sucrose, and may contain a preservative. An emulsion is a two-phase system in which one liquid is dispersed in the form of small globules throughout another liquid. Pharmaceutically acceptable carriers used in emulsions are non-aqueous liquids, emulsifying agents and preservatives. Suspensions use pharmaceutically acceptable suspending agents and preservatives. Pharmaceutically acceptable substances used in non-effervescent granules, to be reconstituted into a liquid oral dosage form, include diluents, sweeteners and wetting agents. Pharmaceutically acceptable substance used in effervescent granules, to be reconstituted into a liquid oral dosage form, include organic adds and a source of carbon dioxide. Coloring and flavoring agents are used in all of the above dosage forms.

Solvents include glycerin, sorbitol, ethyl alcohol and syrup. Examples of preservatives include glycerin, methyl and propylparaben, benzoic add, sodium benzoate and alcohol. Examples of non-aqueous liquids utilized in emulsions include mineral oil and cottonseed oil. Examples of emulsifying agents include gelatin, acacia, tragacanth, bentonite, and surfactants such as polyoxyethylene sorbitan monooleate.

Suspending agents include sodium carboxymethylcellulose, pectin, tragacanth, Veegum and acacia. Diluents include lactose and sucrose. Sweetening agents include sucrose, syrups, glycerin and artificial sweetening agents such as sodium cyclamate and saccharin. Wetting agents include propylene glycol monostearate, sorbitan monooleate, diethylene glycol monolaurate and polyoxyethylene lauryl ether. Organic adds include citric and tartaric acid. Sources of carbon dioxide include sodium bicarbonate and sodium carbonate. Coloring agents include any of the approved certified water soluble FD and C dyes, and mixtures thereof. Flavoring agents include natural flavors extracted from plants such fruits, and synthetic blends of compounds which produce a pleasant taste sensation.

For a solid dosage form, the solution or suspension, in for example propylene carbonate, vegetable oils or triglycerides, is preferably encapsulated in a gelatin capsule. Such solutions, and the preparation and encapsulation thereof, are disclosed in U.S. Patent Nos 4,328,245; 4,409,239; and 4,410,545. For a liquid dosage form, the solution, e.g., for ~~exmaple,~~ example in a polyethylene glycol, may be diluted with a sufficient quantity of a pharmaceutically acceptable liquid carrier, e.g. water, to be easily measured for administration.

Alternatively, liquid or semi-solid oral formulations may be prepared by dissolving or dispersing the active compound or salt in vegetable oils, glycols, triglycerides, propylene glycol esters (e.g. propylene carbonate) and other such carriers, and encapsulating these solutions or suspensions in hard or soft gelatin capsule shells. Other useful formulations include those set forth in U.S. Patent Nos. Re 28,819 and 4,358,603.

In one embodiment, the formulations are solid dosage forms, preferably capsules or tablets. In a preferred embodiment, the formulations are solid dosage forms, preferably capsules or tablets,

containing 10-100%, preferably 50-95%, more preferably 75-85%, most preferably 80-85%, by weight, of one or more sulfonamides or sulfonamide salts, preferably sodium hydrogen phosphate or sodium salts, more preferably the sodium salts, of one or more sulfonamide compounds of formula I; about 0-25%, preferably 8-15%, of a diluent or a binder, such as lactose or microcrystalline cellulose; about 0 to 10%, preferably about 0-7%, of a disintegrant, such as a modified starch or cellulose polymer, particularly a cross-linked sodium carboxymethyl cellulose, such as crosscarmellose sodium (Crosscarmellose sodium NF is available commercially under the name AC-DI-SOL, FMC Corporation, Philadelphia, PA) or sodium starch glycolate; and 0-2% of a lubricant, such a magnesium stearate, talc and calcium stearate. The disintegrant, such as crosscarmellose sodium or sodium starch glycolate, provides for rapid break-up of the cellulosic matrix for immediate release of active agent following dissolution of coating polymer. In all embodiments, the precise amount of active ingredient and ~~auxilliary~~ auxiliary ingredients can be determined empirically and is a function of the route of administration and the ~~dierder~~ disorder that is treated.

In an exemplary embodiment, the formulations are capsules containing about 50%-100%, preferably about 70-90%, more preferably about 80-90%, most preferably about 83% of one or more sodium salts of one or more sulfonamide compounds of formula I; about 0-15%, preferably about 11% of a diluent or a binder, such as lactose or microcrystalline cellulose; about 0-10%, preferably about 5% of a disintegrant, such as crosscarmellose sodium or sodium starch glycolate; and about 0 to 5%, preferably about 1% of a lubricant, such as

magnesium stearate. Solid forms for administration as tablets are also contemplated herein.

In an exemplary preferred embodiment, the formulations are capsules containing 83% of one or more sodium salts of one or more sulfonamide compounds; 11% of microcrystalline cellulose; 5% of a disintegrant, such as Crosscarmellose sodium or sodium starch glycolate; and 1% of magnesium stearate.

The above embodiments may also be formulated in the form of a tablet, which may optionally be coated. Tablets will contain the compositions described herein.

In all embodiments, tablets and capsules formulations may be coated as known by those of skill in the art in order to modify or sustain dissolution of the active ingredient. Thus, for example, they may be coated with a conventional enterically digestible coating, such as phenylsalicylate, waxes and cellulose acetate phthalate.

2. Injectables, solutions and emulsions

Parenteral administration, generally characterized by injection, either subcutaneously, intramuscularly or intravenously is also contemplated herein. Injectables can be prepared in conventional forms, either as liquid solutions or suspensions, solid forms suitable for solution or suspension in liquid prior to injection, or as emulsions. Suitable excipients are, for example, water, saline, dextrose, glycerol or ethanol. In addition, if desired, the pharmaceutical compositions to be administered may also contain minor amounts of non-toxic auxiliary substances such as wetting or emulsifying agents, pH buffering agents, stabilizers, solubility enhancers, and other such agents, such as for example, sodium acetate, sorbitan monolaurate, triethanolamine oleate and cyclodextrins. Implantation of a slow-release or sustained-release system, such that a constant level of dosage is maintained (see, e.g.,

U.S. Patent No. 3,710,795) is also contemplated herein. The percentage of active compound contained in such parenteral compositions is highly dependent on the specific nature thereof, as well as the activity of the compound and the needs of the subject.

Parenteral administration of the formulations includes intravenous, subcutaneous and intramuscular administrations. Preparations for parenteral administration include sterile solutions ready for injection, sterile dry soluble products, such as the lyophilized powders described herein, ready to be combined with a solvent just prior to use, including hypodermic tablets, sterile suspensions ready for injection, sterile dry insoluble products ready to be combined with a vehicle just prior to use and sterile emulsions. The solutions may be either aqueous or nonaqueous.

If administered intravenously, suitable carriers include physiological saline or phosphate buffered saline (PBS), and solutions containing thickening and solubilizing agents, such as glucose, polyethylene glycol, and polypropylene glycol and mixtures thereof.

Pharmaceutically acceptable carriers used in parenteral preparations include aqueous vehicles, nonaqueous vehicles, antimicrobial agents, isotonic agents, buffers, antioxidants, local anesthetics, suspending and dispersing agents, emulsifying agents, sequestering or chelating agents and other pharmaceutically acceptable substances.

Examples of aqueous vehicles include Sodium Chloride Injection, Ringers Injection, Isotonic Dextrose Injection, Sterile Water Injection, Dextrose and Lactated Ringers Injection. Nonaqueous parenteral vehicles include fixed oils of vegetable origin, cottonseed oil, corn oil, sesame oil and peanut oil. Antimicrobial agents in bacteriostatic or fungistatic concentrations must be added to parenteral preparations packaged in multiple-dose containers which include phenols or cresols, mercurials,

benzyl alcohol, chlorobutanol, methyl and propyl p-hydroxybenzoic acid esters, thimerosal, benzalkonium chloride and benzethonium chloride. Isotonic agents include sodium chloride and dextrose. Buffers include phosphate and citrate. Antioxidants include sodium bisulfate. Local anesthetics include procaine hydrochloride. Suspending and dispersing agents include sodium carboxymethylcelluose, hydroxypropyl methylcellulose and polyvinylpyrrolidone. Emulsifying agents include Polysorbate 80 (Tween 80). A sequestering or chelating agent of metal ions include EDTA. Pharmaceutical carriers also include ethyl alcohol, polyethylene glycol and propylene glycol for water miscible vehicles and sodium hydroxide, hydrochloric acid, citric acid or lactic acid for pH adjustment.

The concentration of the pharmaceutically active compound is adjusted so that an injection provides an effective amount to produce the desired pharmacological effect. The exact dose depends on the age, weight and condition of the patient or animal as is known in the art.

The unit-dose parenteral preparations are packaged in an ampoule, a vial or a syringe with a needle. All preparations for parenteral administration must be sterile, as is know and practiced in the art.

Illustratively, intravenous or intraarterial infusion of a sterile aqueous solution containing an active compound is an effective mode of administration. Another embodiment is a sterile aqueous or oily solution or suspension containing an active material injected as necessary to produce the desired pharmacological effect.

Injectables are designed for local and systemic administration. Typically a therapeutically effective dosage is formulated to contain a concentration of at least about 0.1% w/w up to about 90% w/w or more, preferably more than 1% w/w of the active compound to the treated tissue(s). The active ingredient may be administered at once, or

may be divided into a number of smaller doses to be administered at intervals of time. It is understood that the precise dosage and duration of treatment is a function of the tissue being treated and may be determined empirically using known testing protocols or by extrapolation from in vivo or in vitro test data. It is to be noted that concentrations and dosage values may also vary with the age of the individual treated. It is to be further understood that for any particular subject, specific dosage regimens should be adjusted over time according to the individual need and the professional judgment of the person administering or supervising the administration of the formulations, and that the concentration ranges set forth herein are exemplary only and are not intended to limit the scope or practice of the claimed formulations.

The compound may be suspended in micronized or other suitable form or may be derivatized to produce a more soluble active product or to produce a prodrug. The form of the resulting mixture depends upon a number of factors, including the intended mode of administration and the solubility of the compound in the selected carrier or vehicle. The effective concentration is sufficient for ameliorating the symptoms of the condition and may be empirically determined.

In many instances, the solutions of sodium salts, including the sodium salt and sodium hydrogen phosphate salts exhibit compared to the neutral compound. These salts also exhibit improved solubility over the neutral compound in aqueous media. The sodium salt was found, in certain aqueous formulations, to be as stable as the sodium hydrogen phosphate salt.

3. Lyophilized powders

Of particular interest herein are lyophilized powders, which can be reconstituted for administration as solutions, emulsions and other

mixtures. They may also be ~~reconsititude~~ reconstituted and formulated as solids or gels.

In particular embodiments, formulations of sodium hydrogen phosphate or sodium, preferably sodium, salts of the sulfonamide compounds, which possess increased stability relative to formulations of the neutral sulfonamides are provided. Specifically, formulation of sulfonamide sodium salts as a sterile, lyophilized powder are provided. These powders were found to have increased stability relative to formulations of the neutral sulfonamides.

The sterile, lyophilized powder is prepared by dissolving the sodium salt in a sodium phosphate buffer solution containing dextrose or other suitable excipient. Subsequent sterile filtration of the solution followed by lyophilization under standard conditions known to those of skill in the art provides the desired formulation. Briefly, the lyophilized powder is prepared by dissolving dextrose, sorbital, fructose, corn syrup, xylitol, glycerin, glucose, sucrose or other suitable agent, about 1-20%, preferably about 5 to 15%, in a suitable buffer, such as citrate, sodium or potassium phosphate or other such buffer known to those of skill in the art at, typically, about neutral pH. Then, a selected salt, preferably the sodium salt of the sulfonamide (about 1 gm of the salt per 10-100 gms of the buffer solution, typically about 1 gm/30 gms), is added to the resulting mixture, preferably above room temperature, more preferably at about 30-35° C, and stirred until it dissolves. The resulting mixture is diluted by adding more buffer (so that the resulting concentration of the salt decreases by about 10-50%, typically about 15-25%). The resulting mixture is sterile filtered or treated to remove particulates and to insure sterility, and apportioned into vials for lyophilization. Each vial will contain a single dosage (100-500 mg, preferably 250 mg) or multiple dosages of the sulfonamide salt. The lyophilized powder can be stored

under appropriate conditions, such as at about 4° C to room temperature. Details of an exemplary procedure are set forth in the Examples.

Reconstitution of this lyophilized powder with water for injection provides a formulation for use in parenteral administration of sodium salts of the sulfonamides. For reconstitution about 1-50 mg, preferably 5-35, more preferably about 9-30 is added per ml of sterile water or other suitable carrier. The precise amount depends upon the indication treated and selected compound. Such amount can be empirically determined.

In one embodiment, the formulations contain lyophilized solids containing one or more sodium hydrogen phosphate or sodium, preferably sodium, salts of one or more sulfonamide compounds of formula I, and also contain one or more of the following:

a buffer, such as sodium or potassium phosphate, or citrate;

a solubilizing agent, such as LABRASOL, DMSO, bis(trimethylsilyl)acetamide, ethanol, propyleneglycol (PG), or polyvinylpyrrolidine (PVP); and

a sugar, such as sorbitol or dextrose.

In more preferred embodiments, the formulations contain one or more sodium hydrogen phosphate or sodium, preferably sodium, salts of one or more sulfonamide compounds of formula I; a buffer, such as sodium or potassium phosphate, or citrate; and a sugar, such as sorbitol or dextrose.

In the most preferred embodiments, the formulations contain one or more sodium salts of one or more sulfonamide compounds of formula I; a sodium phosphate buffer; and dextrose.

4. Topical administration

Topical mixtures are prepared as described for the local and systemic administration. The resulting mixture may be a solution, suspension, emulsions or the like and are formulated as creams, gels,

ointments, emulsions, solutions, elixirs, lotions, suspensions, tinctures, pastes, foams, aerosols, irrigations, sprays, suppositories, bandages, dermal patches or any other formulations suitable for topical administration.

The sodium salts and other derivatives of the compounds may be formulated as aerosols for topical application, such as by inhalation (see, e.g., U.S. Patent Nos. 4,044,126, 4,414,209, and 4,364,923, which describe aerosols for delivery of a steroid useful for treatment inflammatory diseases, particularly asthma). These formulations for administration to the respiratory tract can be in the form of an aerosol or solution for a nebulizer, or as a microfine powder for insufflation, alone or in combination with an inert carrier such as lactose. In such a case, the particles of the formulation will typically diameters of less than 50 microns, preferably less than 10 microns.

The sodium salts of the compounds may be formulated for local or topical application, such as for topical application to the skin and mucous membranes, such as in the eye, in the form of gels, creams, and lotions and for application to the eye or for intracisternal or intraspinal application. Topical administration is contemplated for transdermal delivery and also for administration to the eyes or mucosa, or for inhalation therapies. Nasal solutions of the active compound alone or in combination with other pharmaceutically acceptable excipients can also be administered.

These solutions, particularly those intended for ophthalmic use, may be formulated as 0.01% - 10% isotonic solutions, pH about 5-7, with appropriate salts.

5. Articles of manufacture

Finally, the derivatives, particularly the salts, acids, esters and prodrugs, preferably the sodium salts, of the compounds may be

packaged as articles of manufacture containing packaging material, a salt, acid, ester or prodrug, preferably a sodium salt, of a compound provided herein, which is effective for antagonizing the effects of endothelin, ameliorating the symptoms of an endothelin-mediated disorder, or inhibiting binding of an endothelin peptide to an ET receptor with an IC_{50} of less than about 10 μM, within the packaging material, and a label that indicates that the compound or salt thereof is used for antagonizing the effects of endothelin, treating endothelin-mediated disorders or inhibiting the binding of an endothelin peptide to an ET receptor.

The articles of manufacture provided herein contain packaging materials. Packaging materials for use in packaging pharmaceutical products are well known to those of skill in the art. See, e.g., U.S. Patent Nos. 5,323,907, 5,052,558 and 5,033,352. Examples of pharmaceutical packaging materials include, but are not limited to, blister packs, bottles, tubes, inhalers, pumps, bags, vials, containers, syringes, bottles, and any packaging material suitable for a selected formulation and intended mode of administration and treatment. A wide array of formulations of the compounds and compositions provided herein are contemplated as are a variety treatments for any disorder in which PAI, particularly PAI-1, is implicated as a mediator or contributor to the symptoms or cause.

6. Formulations for other routes of administration

Depending upon the condition treated other routes of administration, such as topical application, transdermal patches, an rectal administration are also contemplated herein.

For example, pharmaceutical dosage forms for rectal administration are rectal suppositories, capsules and tablets for systemic effect. Rectal suppositories are used herein mean solid bodies for insertion into the

rectum which melt or soften at body temperature releasing one or more pharmacologically or therapeutically active ingredients. Pharmaceutically acceptable substances utilized in rectal suppositories are bases or vehicles and agents to raise the melting point. Examples of bases include cocoa butter (theobroma oil), glycerin-gelatin, carbowax, (polyoxyethylene glycol) and appropriate mixtures of mono-, di- and triglycerides of fatty acids. Combinations of the various bases may be used. Agents to raise the melting point of suppositories include spermaceti and wax. Rectal suppositories may be prepared either by the compressed method or by molding. The typical weight of a rectal suppository is about 2 to 3 gm.

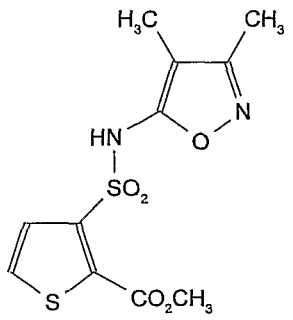
Tablets and capsules for rectal administration are manufactured using the same pharmaceutically acceptable substance and by the same methods as for formulations for oral administration.

The following examples are included for illustrative purposes only and are not intended to limit the scope of the invention.

EXAMPLE 1

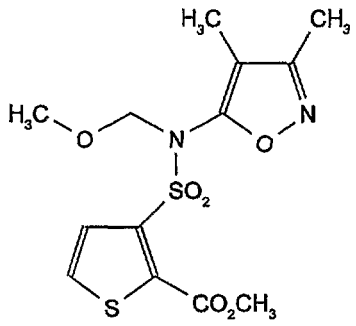
Preparation of compound 7: N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide

Step 1: Preparation of compound **1**:



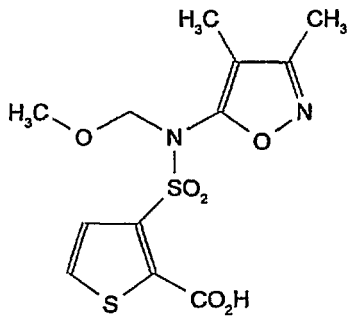
To a 250 mL round-bottom flask equipped with a magnetic stir bar was added 20.0 gm of 5-amino-3,4-dimethylisoxazole, 50 mL of pyridine, and 2.0 gm (catalytic amount) of dimethylaminopyridine. The mixture was cooled in an ice bath as 21.5 gm of 2-carboxymethyl-3-thiophenesulfonyl chloride was added in portions. The flask was sealed, the ice bath removed, and the reaction stirred at room temperature overnight. The majority of the pyridine was removed by rotary evaporation and the residual materials partitioned between ethyl acetate and 2N HCl. The layers were separated and the aqueous layer extracted with ethyl acetate (2X). The combined extracts were washed with dilute HCL (2X), brine (2X), and then dried over magnesium sulfate. Filtration and condensation by rotary evaporation yielded 23.2 gm of compound **1** as an oil.

Step 2A: Preparation of compound **2**.



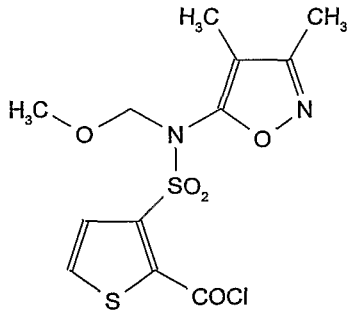
To a 1L round-bottom flask equipped with a magnetic stir bar and dropping funnel was added 23.1 gm of compound 1, 500 mL of methylene chloride, and 28.4 gm of diisopropylamine. The reaction was cooled in an ice bath and 6.0 mL of ~~bromomethylmethyl ether~~ bromomethyl methyl was added dropwise. The ice bath was removed and the reaction stirred at room temperature overnight. At this point, 200 mL of water was added and the reaction stirred for 30 min. The layers were separated and the aqueous layer extracted (2X) with methylene chloride. The combined organic layers were then washed with 0.5 N HCl, water, saturated sodium bicarbonate, brine, and finally dried over magnesium sulfate. Filtration and rotary evaporation yielded an oil which was further purified by silica gel chromatography using 25 - 30% ethyl acetate/hexane as the eluant to afford 21.5 gm of compound **2** as an oil.

Step 2B: Preparation of compound **3**.



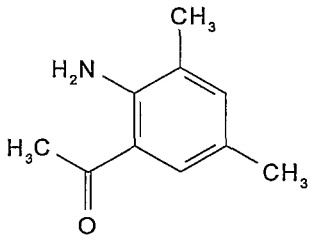
To a 500 mL round bottom flask equipped with a magnetic stir bar was added 21.4 gm of compound **2**, 120 mL of tetrahydrofuran, and 120 mL of 1N sodium hydroxide. The reaction was rapidly stirred until complete reaction (approximately 3 - 4 hr). The majority of the tetrahydrofuran was removed by rotary evaporation and the residual materials mixed with 50 mL of water. This mixture was then acidified by the addition of 130 mL of 1N HCl and then extracted with 200 mL (2X) of ethyl acetate. The combined extracts were washed with water (50 mL), then brine (50mL), and finally dried with magnesium sulfate. Filtration and condensation by rotary evaporation yielded 20.1 gm of compound **3** as a yellow oil which solidified upon standing.

Step 2C: Preparation of compound **4**.

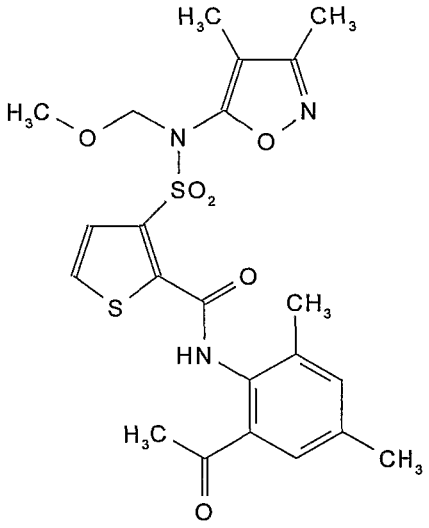


To a 1 L round bottom flask equipped with a magnetic stir bar and dropping funnel was added 19.7 gm of compound 3,200 mL of methylene chloride, and 5 drops of pyridine. A solution of 128 mL of oxalyl chloride in 100 mL of methylene chloride was added dropwise. The dropping funnel was then replaced with a reflux condenser and the reaction heated to gentle reflux for 3 hr. after which it was condensed by rotary evaporation to yield 20.9 gm of compound **4** as a brown solid. This material was used directly in Step 3 without further purification.

Step 3: Preparation of compound **6**.



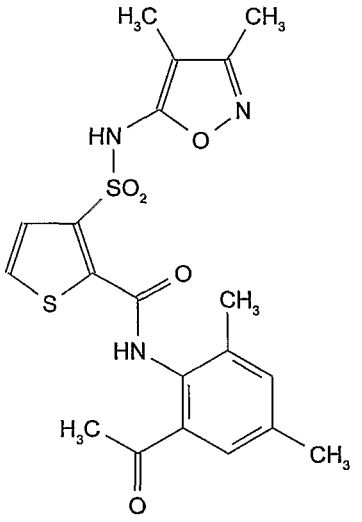
5



6

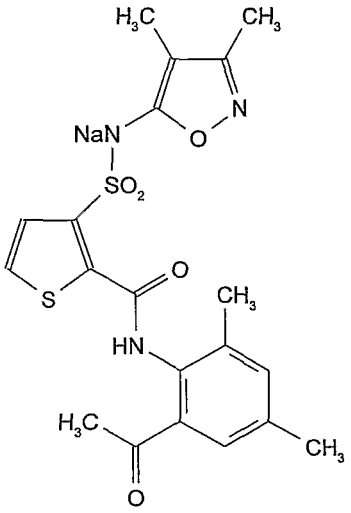
To a 1-L round bottom flask equipped with a magnetic stir bar and dropping funnel was added 18.5 gm of 2-acetyl-4,6-dimethylaniline (**5**) and 150 mL of methylene chloride. To this was added dropwise a solution of 20.7 gm of compound **4** dissolved in 350 mL of methylene chloride. The reaction was stirred at room temperature for 3 hr. and then condensed by rotary evaporation. To the residual materials was added 200 mL of ether and the mixture was filtered. The filter cake was washed with 3X 100 mL of ether. The combined filtrates were washed with 3X 100mL of 1N HCl followed by 100 mL each with water, sat. sodium bicarbonate, and brine. The solution was then dried with magnesium sulfate, filtered, and condensed by rotary evaporation to yield a semi-crystalline material. This material was triturated with 200 mL of ether to yield 23.7 gm of compound **6** as a white solid.

Step 4A: Preparation of compound **7**.



To a 500 mL round-bottom flask equipped with a magnetic stir bar and reflux condenser was added 23.7 gm of compound **6**, 180 mL of methanol, and 90 mL of conc. HCl. The mixture was heated to reflux for 4 hr. Heating was discontinued and the mixture stirred and cooled with an ice bath. After approximately 30 min. the mixture was filtered and the filter cake washed with a mixture of water and methanol to yield 18.3 gm of compound **7**. This material was recrystallized from ethyl acetate/hexane to give 16.8 gm of material as a white solid: mp 158 - 160 °C.

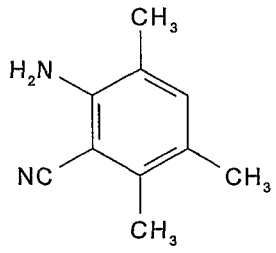
Step 4B: Preparation of compound **7** sodium salt.



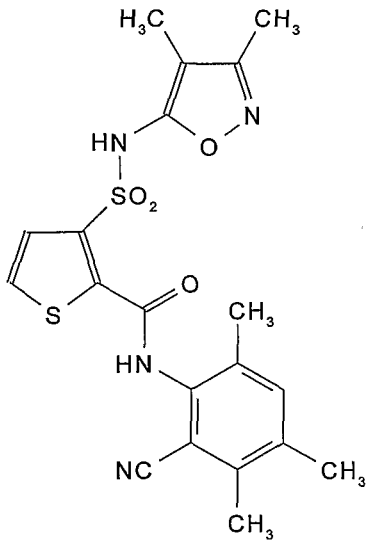
To 16.8 gm of compound **7** solubilized in 800 mL of ethyl acetate and 200 mL of tetrahydrofuran was added 100 mL of saturated sodium bicarbonate. The layers were separated and the organic layer washed with an additional 2X 100 mL of sat. sodium bicarbonate. The combined bicarbonate washes were back extracted with ethyl acetate and the combined organic solutions dried over magnesium sulfate, filtered, and condensed by rotary evaporation to yield a foam. This material was solubilized in 300 mL of water and the resulting solution filtered and lyophilized to yield 15.5 gm of compound **7** sodium salt as a white solid.

EXAMPLE 2

Preparation of compound 9: N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide



8



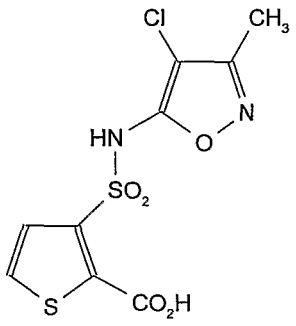
9

N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, was prepared by the procedure of Example 1 except that 2-cyano-3,4,6-trimethylaniline (**8**) was substituted for 2-acetyl-4,6-dimethylaniline in Step 3.

EXAMPLE 3

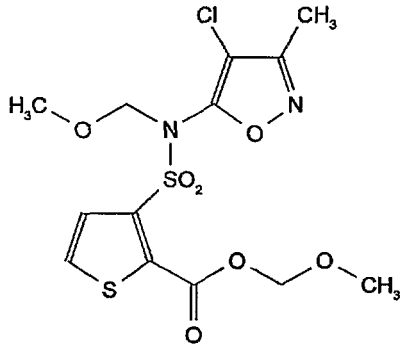
Preparation of compound 16: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-(3,4,6-trimethyl-2-propanoylphenyl)-2-thiophenecarboxamide

Step 1: Preparation of compound **10: 3{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxylic acid**



To a 500 mL round bottom flask containing 46.5 g of 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxylic acid methyl ester was added 250 mL of 1 N sodium hydroxide. The mixture was stirred until no starting material remained. The reaction solution was acidified with 2 N hydrochloric acid, ethyl acetate extracted (3 x 100 mL). The combined extracts were dried ($MgSO_4$), ~~filtered~~ filtered and condensed by rotary evaporation to yield 42.5 g of compound **10** as a solid.

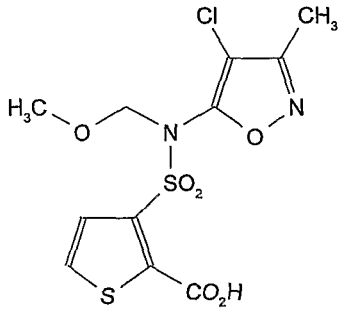
Step 2A: Preparation of compound **11: 3{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-methoxymethyl-2-thiophenecarboxylic acid methoxymethyl ester.**



To a 2-L round bottom flask equipped with a magnetic stir bar and dropping funnel was added 42.5 gm of compound **10**, 500 mL of methylene chloride, and 40.1 gm of diisopropylethylamine. The reaction mixture was cooled with an ice bath and 21.5 mL of ~~bromomethylmethyl~~ bromomethyl methyl ether was added dropwise. The ice bath was removed and the reaction stirred at room temperature overnight. 200 mL of water was added and the reaction mixture stirred for 30 min. The layers were separated and the aqueous layer washed with 100 mL of methylene chloride. The combined organic layers were washed with 50 mL each of 0.5 N HCl, water, sat. sodium bicarbonate, brine and then finally dried with magnesium sulfate. The mixture was filtered and the filtrate condensed by rotary evaporation to yield an oil that was further purified by silica gel

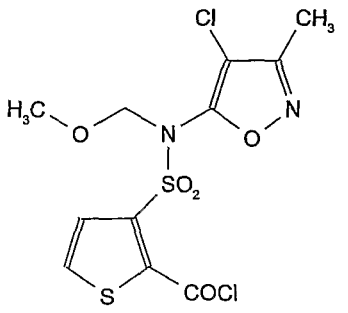
chromatography using 25 - 30% ethyl acetate/hexane as the eluant to yield 38.1 gm of compound **11** as an oil.

Step 2B: Preparation of compound **12.**



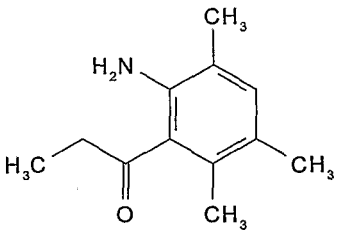
To a 1-L round bottom flask equipped with a magnetic stir bar was added 38 gm of compound **11**, 250 mL of tetrahydrofuran, and 250 mL of 1N sodium hydroxide. The reaction was rapidly stirred until complete reaction (approximately 4 hr). The majority of the tetrahydrofuran was removed by rotary evaporation and the residual materials were mixed with 50 mL of water. This solution was then acidified by the addition of 260 mL of 1N HCl. This mixture was then twice extracted with 200 mL of ethyl acetate. The combined extracts were washed with 50 mL each of water and brine and then dried with magnesium sulfate. Filtration and condensation by rotary evaporation yielded 30.8 gm of compound **12** as a yellow oil which solidified upon standing.

Step 2C: Preparation of compound **13.**

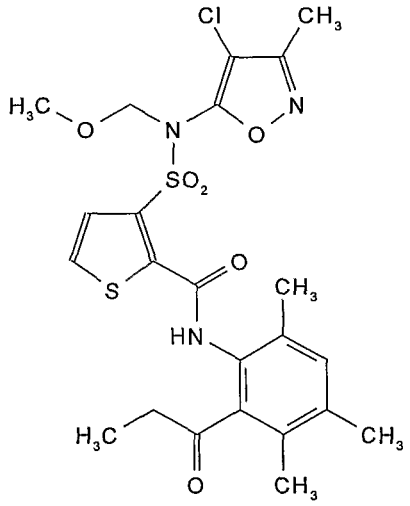


To a 1-L round bottom flask equipped with a magnetic stir bar and dropping funnel was added 30 gm of compound **12**, 200 mL of methylene chloride, and 5 drops of pyridine. A solution of 29.2 gm of thionyl chloride in 200 mL of methylene chloride was added dropwise. The dropping funnel was then replaced with a reflux condenser and the reaction heated to gentle reflux for 4 hr. The reaction was then condensed by rotary evaporation to yield 31.4 gm of compound **13** as a brown solid. This material was used directly in Step 3 without additional purification.

Step 3: Preparation of compound **15**.



14

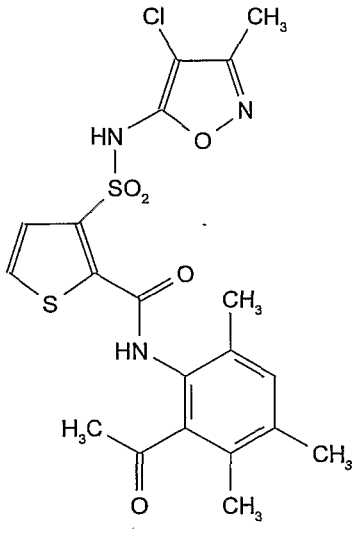


15

To a 1-L round bottom flask equipped with a magnetic stir bar and dropping funnel was added 19.8 gm of compound (**14**) and 150 mL of methylene chloride. To this was added dropwise a solution of 20.0 gm of compound **13** dissolved in 350 mL of methylene chloride. The reaction was stirred at room temperature for 3 hr and then condensed by rotary evaporation. To the residual materials was added 200 mL of ether and the mixture was filtered. The filter cake was washed with 100 mL of ether followed by 2X 200 mL of hot ethyl acetate. The combined

washings were washed with 3X 100mL of 1N HCl followed by 100 mL each with water, sat. sodium bicarbonate, and brine. The solution was then dried with magnesium sulfate, filtered, and condensed by rotary evaporation to yield a semi-crystalline material. This material was triturated with 100 mL of ether to yield 20.1 gm of compound **15** as a white solid.

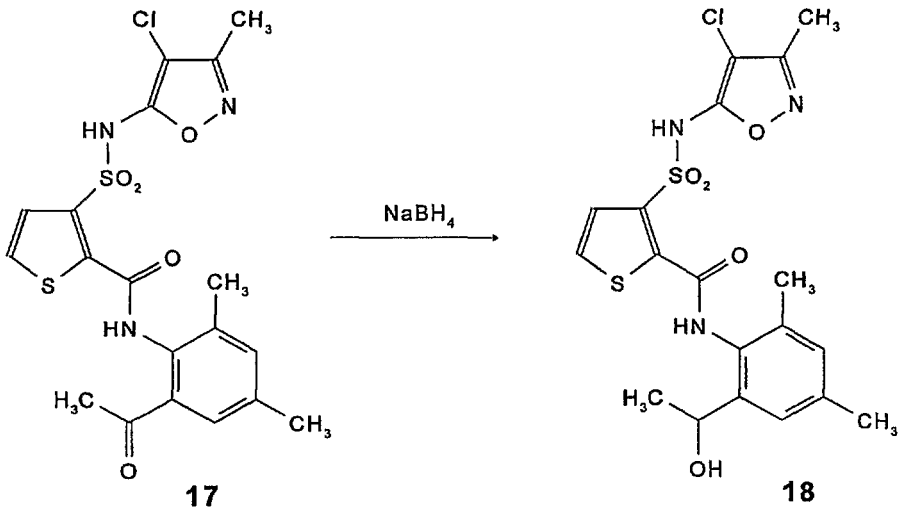
Step 4: Preparation of compound **16**.



By the procedure of Example 1, Step 4A, compound **15** was converted to compound **16**, a solid, mp 166-170 °C.

EXAMPLE 4

Preparation of compound 18: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2-(1-hydroxyethyl)-4,6-dimethylphenyl]-2-thiophene carboxamide

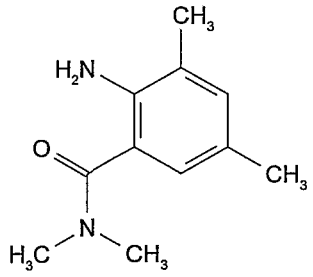


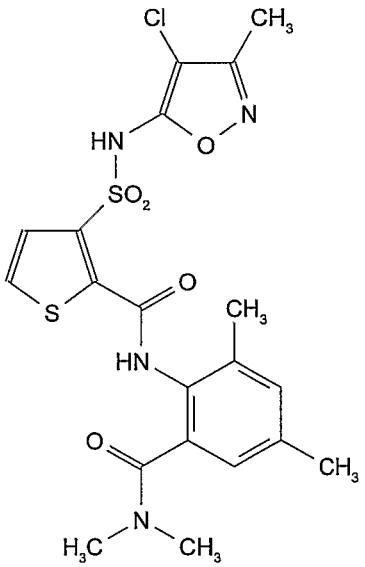
17 18

To a solution of 100 mg of compound **17** (sodium salt) in water was added 100 mg of sodium borohydride. After 3 h, an additional 100 mg of sodium ~~borohydrode~~ boronamide was added and the solution stirred at room temperature overnight. The reaction was mixed with excess saturated ammonium chloride solution, extracted with ethyl acetate (3 x 50 mL). The extracts were washed with saturated sodium bicarbonate solution and evaporated to give compound **18** (Na salt) as a solid, mp 147-154 °C.

EXAMPLE 5

Preparation of compound 20: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-{2-[(dimethylamino)carbonyl]-4,6-dimethylphenyl)-2-thiophene carboxamide

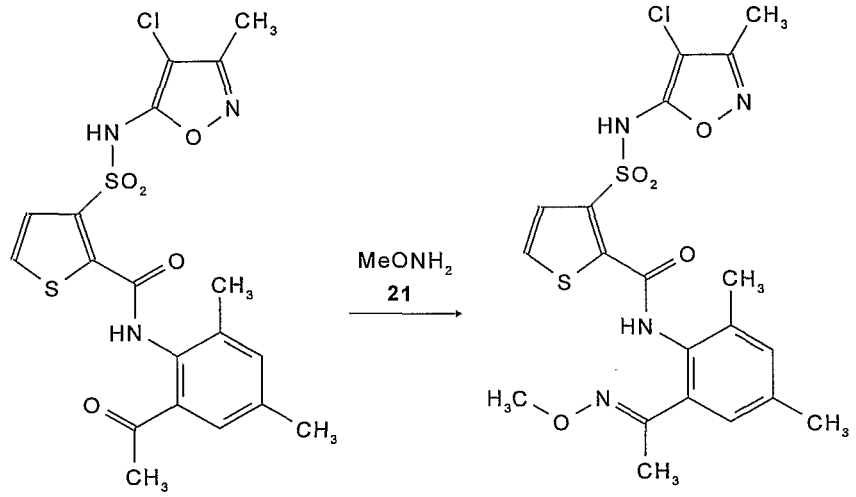




Compound **20** was prepared according to the procedure of Example 3 except that 2-[(dimethylamino)carbonyl]-4,6-dimethylaniline (19) was used in step 3 in the place of compound **12**. Compound **20** was obtained as a white solid.

EXAMPLE 6

Preparation of compound 22: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2,4-dimethyl-6-[(methyloxy)ethanimidoyl]phenyl}-2-thiophene carboxamide

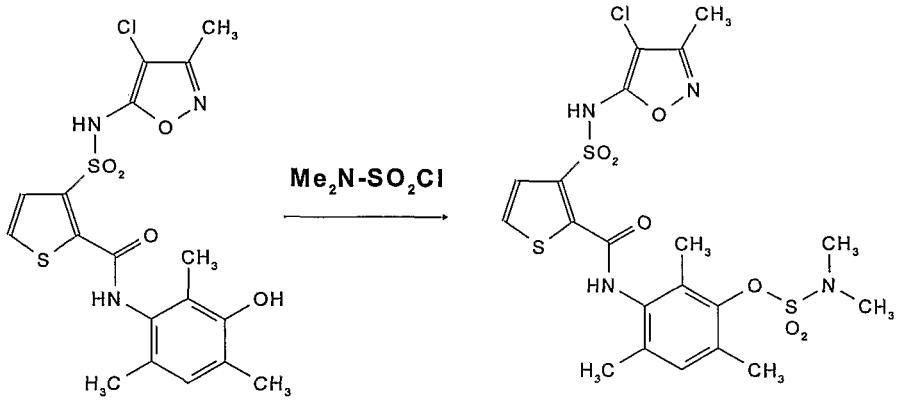


17 22

Compound **17** was reacted with methoxyamine (**21**) in ethanol solution to yield compound **22** as a white solid; mp 140-145 °C.

EXAMPLE 7

Preparation of compound 24: 3-{[(3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenyl)carbonyl]amino}-2,4,6-trimethylphenyl-N,N-dimethylsulfamate

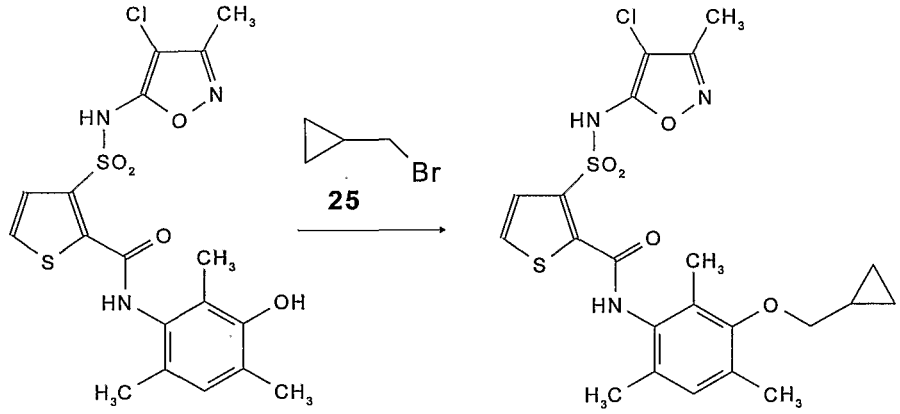


23 24

To an ice-cold solution of 700 mg of 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-hydroxy-2,4,6-trimethylphenyl}-2-thiophenecarboxamide (**23**) in 15 mL of dimethylformamide was added 247 mg of potassium t-butoxide. After a short period, 317 mg of dimethylaminosulfonyl chloride was added. When the reaction was judged complete, it was diluted with water, acidified with 1 N hydrochloric acid. This mixture was extracted with ethyl acetate (3 x 30 mL) and the combined extracts were dried ($MgSO_4$), filtered, and evaporated to yield compound **24** as a white solid; mp 169-174 °C.

EXAMPLE 8

Preparation of compound 26: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-[(cyclopropylmethyl)oxy]-2,4,6-trimethylphenyl}-2-thiophenecarboxamide

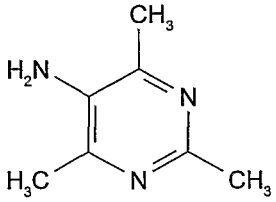


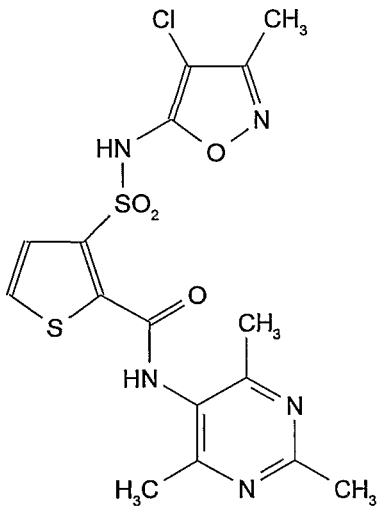
To an ice-cold solution of 700 mg of 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-hydroxy-2,4,6-trimethylphenyl}-2-thiophenecarboxamide (**23**) in 15 mL of dimethylformamide was added 247 mg of potassium t-butoxide. After a short period, 135 mg of cyclopropylmethylbromide (**25**) was added. When the reaction was judged complete, it was diluted with water, acidified with 1 N hydrochloric acid. This mixture was extracted with ethyl acetate (3 x 30

mL) and the combined extracts were dried ($MgSO_4$), filtered, and evaporated to yield compound **26** as a white solid; mp 155-158 °C.

EXAMPLE 9

Preparation of compound 28: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethyl-5-pyrimidinyl)-2-thiophenecarboxamide

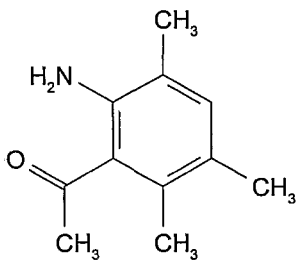


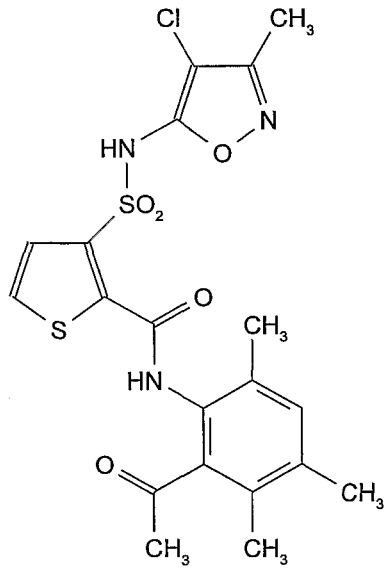


Compound **28** was prepared according to the procedure of Example 3 except that 5-amino-2,4,6-trimethylpyrimidine (**27**) was used in step 3 in the place of compound **12**. Compound **28** was obtained as a white solid; mp 170-175 °C.

EXAMPLE 10

Preparation of compound 30: N-(2-acetyl-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide

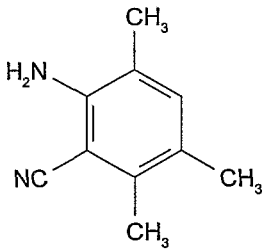


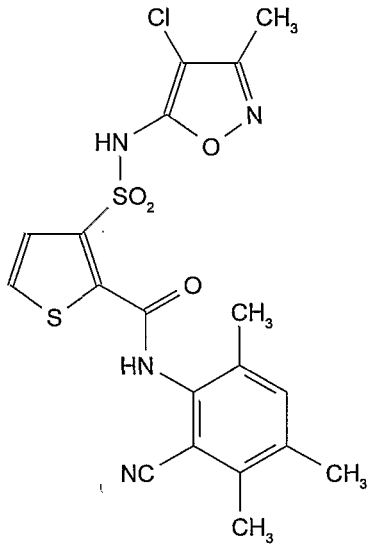


Compound **30** was prepared according to the procedure of Example 3 except that 2-acetyl-3,4,6-trimethylaniline (**29**) was used in step 3 in the place of compound **12**. Compound **30** was obtained as a white solid; mp 223-225 °C.

EXAMPLE 11

Preparation of compound 32: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-cyano-3,4,6-trimethylphenyl)-2-thiophenecarboxamide

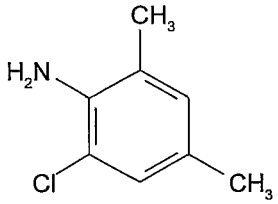


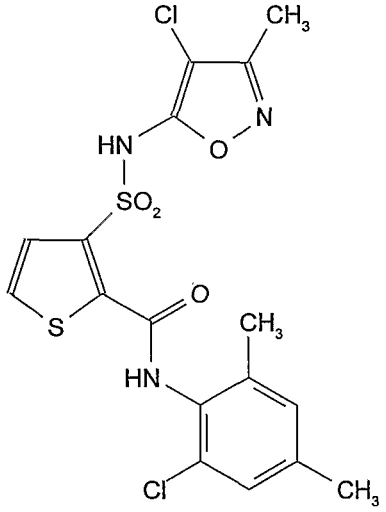


Compound **32** was prepared according to the procedure of Example 3 except that 2-cyano-3,4,6-trimethylaniline (**31**) was used in step 3 in the place of compound **12**. Compound **32** was obtained as a white solid; mp 218-220 °C.

EXAMPLE 12

Preparation of compound 34: N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide

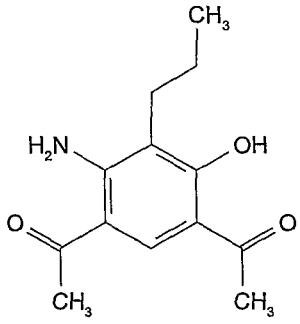


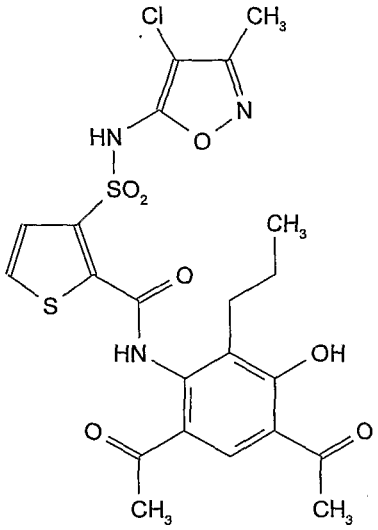


Compound **34** was prepared according to the procedure of Example 3 except that 2-chloro-4,6-dimethylaniline (**33**) was used in step 3 in the place of compound **12**. Compound **34** was obtained as a white solid; mp 174-176 °C.

EXAMPLE 13

Preparation of compound 36: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(4,6-diacetyl-3-hydroxy-2-propylphenyl-2-thiophenecarboxamide

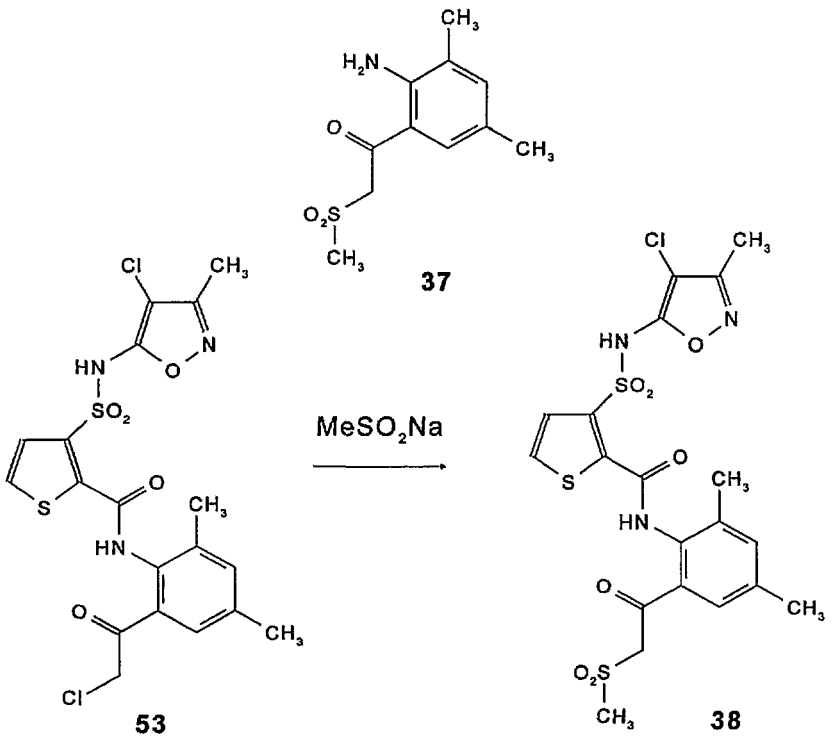




Compound **36** was prepared according to the procedure of Example 3 except that 4,6-diacetyl-3-hydroxy-2-propylaniline (**35**) was used in step 3 in the place of compound **12**. Compound **36** was obtained as a white solid; mp 163-167 °C.

EXAMPLE 14

Preparation of compound 38: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-[2-(methylsulfonyl)acetyl]phenyl}-2-thiophenecarboxamide

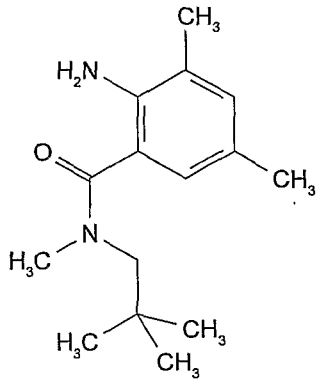


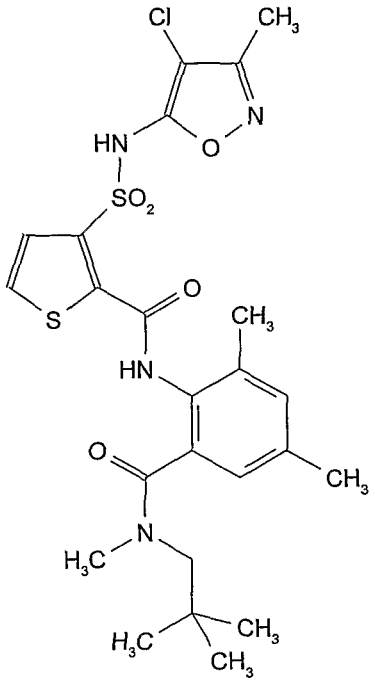
Intermediate compound **53** was prepared according to the procedure of Example 3 except that 2,4-dimethyl-6-(2-chloroacetyl)aniline (**37**) was used in step 3 in the place of compound **12**.

A solution of 400 mg of compound **53** and 1.2 g of sodium methanesulfonate in 10 mL of dimethylformamide was stirred at room temperature. When the ~~reation~~ reaction was judged complete, the reaction was diluted with water, acidified with 2 N hydrochloric acid and extracted with ethyl acetate (3 x 30 mL). The combined extracts were dried ($MgSO_4$), filtered, and condensed by rotary evaporation to yield compound **38** as a solid; mp 172-175 °C.

EXAMPLE 15

Preparation of compound 40: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-{[methyl(2,2-dimethylpropyl)amino]carbonyl}phenyl)-2-thiophenecarboxamide

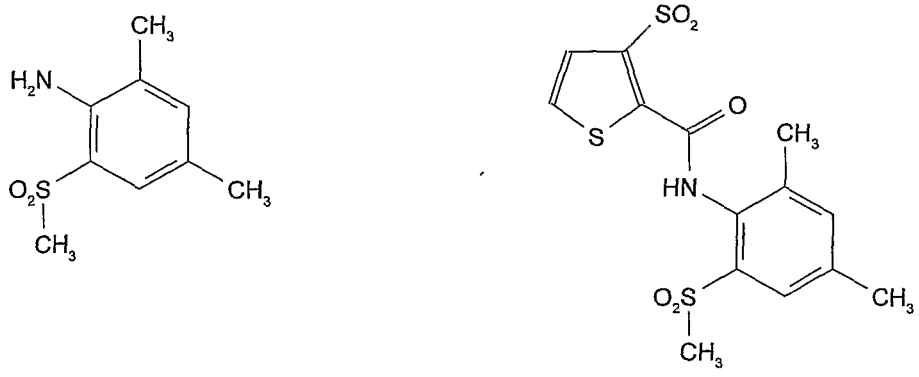




Compound **40** was prepared according to the procedure of Example 3 except that 2-{[methyl-(2,2-dimethylpropyl)amino]carbonyl}-4,6-dimethylaniline (39) was used in step 3 in the place of compound **12**. Compound **40** was obtained as a white solid; mp 174-176 °C.

EXAMPLE 16

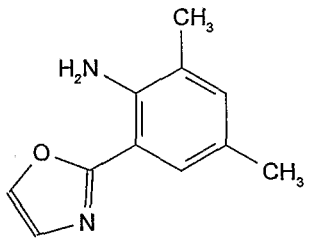
Preparation of compound 42: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(methylsulfonyl)phenyl]-2-thiophenecarboxamide

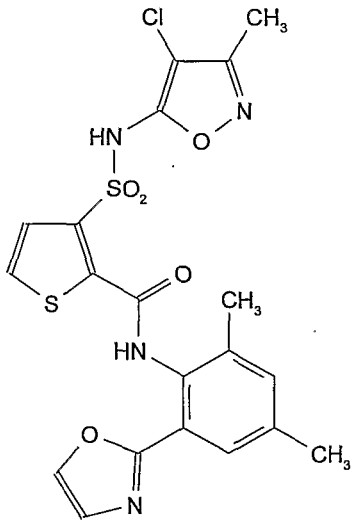


Compound **42** was prepared according to the procedure of Example 3 except that 2,4-dimethyl-6-(methylsulfonyl)aniline (41) was used in step 3 in the place of compound **12**. Compound **42** was obtained as a white solid; mp 208-210 °C.

EXAMPLE 17

Preparation of compound 44: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,4-dimethyl-6-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide

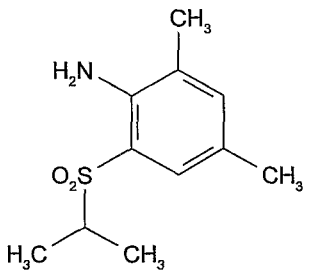


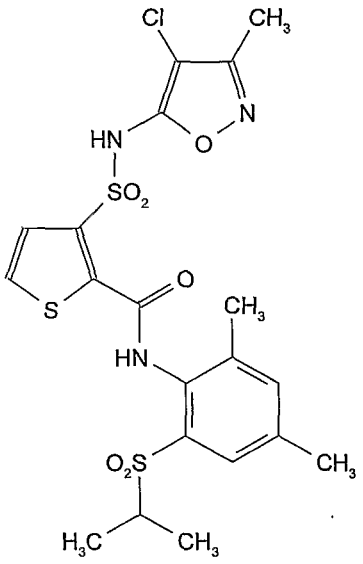


Compound **44** was prepared according to the procedure of Example 3 except that 2,4-dimethyl-6-(1,3-oxazol-2-yl)aniline (43) was used in step 3 in the place of compound **12**. Compound **44** was obtained as a white solid; mp 176-178 °C.

EXAMPLE 18

Preparation of compound 46: 3-{[(4-chloro-5-isoxazolyl)amino]sulfonyl}-N-[2-(2-propylsulfonyl)-4,6-dimethylphenyl]-2-thiophenecarboxamide

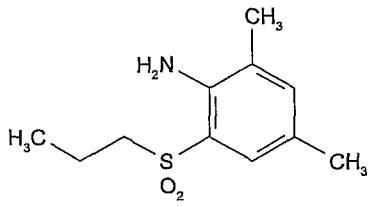


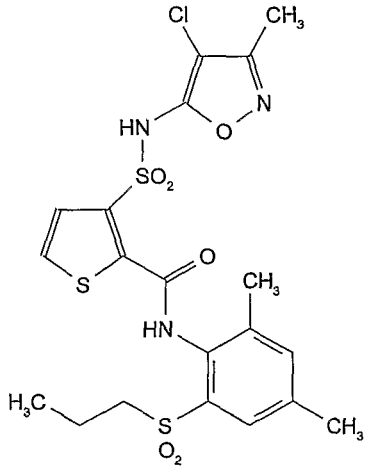


Compound **46** was prepared according to the procedure of Example 3 except that 2-(2-propylsulfonyl)-4,6-dimethylaniline (**45**) was used in step 3 in the place of compound **12**. Compound **46** was obtained as a white solid; mp 190-192 °C.

EXAMPLE 19

Preparation of compound 48: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(propylsulfonyl)phenyl]-2-thiophenecarboxamide

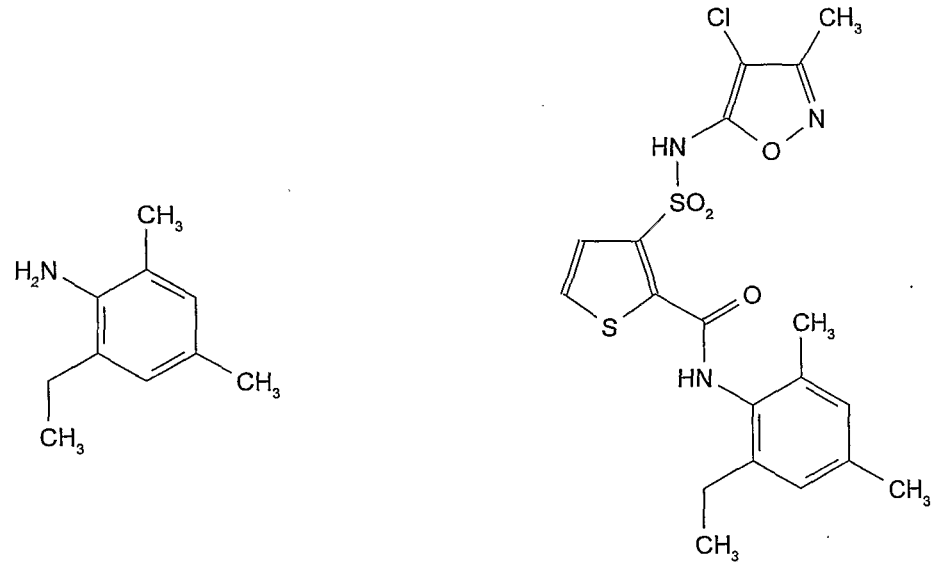




Compound **48** was prepared according to the procedure of Example 3 except that 2,4-dimethyl-6-(propylsulfonyl)aniline (**47**) was used in step 3 in the place of compound **12**. Compound **48** was obtained as a white solid; mp 152-155 °C.

EXAMPLE 20

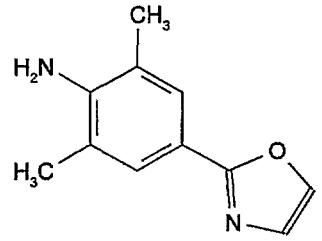
Preparation of compound 50: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-ethyl-4,6-dimethylphenyl)-2-thiophenecarboxamide

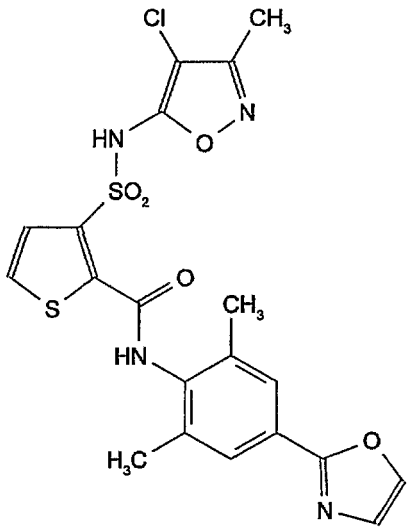


Compound **50** was prepared according to the procedure of Example 3 except that 2-ethyl-4,6-dimethylaniline (**49**) was used in step 3 in the place of compound **12**. Compound **50** was obtained as a white solid; mp 152-154 °C.

EXAMPLE 21

Preparation of compound 52: 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,6-dimethyl-4-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide





Compound **52** was prepared according to the procedure of Example 3 except that 2,6-dimethyl-4-(1,3-oxazol-2-yl)aniline (**51**) was used in step 3 in the place of compound **12**. Compound **52** was obtained as a white solid; mp 205-207 °C.

EXAMPLE 22

Formulations of sulfonamide sodium salts

A. Formulation of sulfonamide sodium salts for ~~intraveneous~~ intravenous administration

Phosphate buffer is prepared by adding 3200 mL of sterile water for injection, USP, to a 4 L graduated cylinder. Sodium phosphate dibasic heptahydrate, USP (21.44 g) is added to the sterile water and the mixture is stirred for 5 minutes or until the solid had dissolved. Sodium phosphate monobasic, USP (11.04 g) is added and the mixture was stirred until the solids had dissolved. The solution was diluted to 4.0 L and stirred. 3000 g of the sodium phosphate buffer is added to an eight

liter beaker. Dextrose, USP (200.0 g) is added, and the mixture is heated to 30-35 °C in a water bath and stirred until a complete solution formed. A sulfonamide sodium salt (100.0 g) is added with efficient mixing. This mixture is stirred for a minimum of ten minutes or until a solution formed. The solution was removed from the water bath after the sodium salt dissolved. The solution was diluted to 4000 g with sodium phosphate buffer and stirred for five minutes. This solution is sterile filtered using a sterile 0.22 micron pre-size Durapore Millipak 200 filter. The filtered solution is filled into sterile vials and lyophilized under standard conditions. The vials are stoppered. The lyophilized product was then reconstituted with either 9.4 mL or 19.4 mL of water for injection, to give a final concentration of 25 mg/mL or 12.5 mg/mL, respectively.

B. Formulation of sulfonamide sodium salts for oral administration

These formulations may be prepared by methods known to those of skill in the art (see, e.g., Ansel Introduction to Pharmaceutical Dosage Forms (4th Edition) **1985** (Lea & Febiger)). In general, the tablets may be prepared by wet or dry granulation of the ingredients, followed by compression. Alternatively, the combined ingredients may be formed into tablets by direct compression. In the preparation of capsules, the combined sulfonamide sodium salt, excipient (diluent), binder, disintegrating agent and lubricant are filled directly into the capsule shell. The optimal amount of active and inert ingredients in these formulations may be determined empirically by methods known to those of skill in the art. In general, the amount of active ingredient (i.e., sulfonamide sodium salt) will be sufficient to provide a therapeutically-effective dose of the active ingredient. The therapeutically effective dose may be determined empirically by testing the compounds in known in vitro and in vivo systems (see, e.g., U.S. Patent No. 5,114,918 to Ishikawa et al.; EP A1 0 436 189 to BANYU PHARMACEUTICAL CO., LTD (October 7, 1991);

Borges et al. (1989) Eur. J. Pharm. 165: 223-230; : Filep et al. (1991) Biochem. Biophys. Res. Commun. 177: 171-176) and then extrapolated therefrom for dosages for humans.

EXAMPLE 23

Assays for identifying compounds that exhibit endothelin antagonistic and/or agonist activity

Compounds that are potential endothelin antagonists are identified by testing their ability to compete with ^{125}I-labeled ET-1 for binding to human ET_A receptors or ET_B receptors present on isolated cell membranes. The effectiveness of the test compound as an antagonist or agonist of the biological tissue response of endothelin can also be assessed by measuring the effect on endothelin induced contraction of isolated rat thoracic aortic rings. The ability of the compounds to act as antagonists or agonists for ET_B receptors can be assess by testing the ability of the compounds are to inhibit endothelin-1 induced prostacyclin release from cultured bovine aortic endothelial cells.

A. Endothelin binding inhibition - Binding Test #1: Inhibition of binding to ET_A receptors

TE 671 cells (ATCC Accession No. HTB 139) express ET_A receptors. These cells were grown to confluence in T-175 flasks. Cells from multiple flasks were collected by scraping, pooled and centrifuged for 10 min at 190 X g. The cells were resuspended in phosphate buffered saline (PBS) containing 10 mM EDTA using a Tenbroeck homogenizer. The suspension was centrifuged at 4° C at 57,800 X g for 15 min, the pellet was resuspended in 5 ml of buffer A (5mM HEPES buffer, pH 7.4 containing aprotinin (100 KIU/ml)) and then frozen and thawed once. 5 ml of Buffer B (5 mM HEPES Buffer, pH 7.4 containing 10 mM $MnCl_2$ and 0.001% deoxyribonuclease Type 1) was added, the suspension mixed by inversion and then incubated at 37° C for 30 minutes. The mixture was centrifuged at 57,800 X g as described above, the pellet washed twice

with buffer A and then resuspended in buffer C (30 mM HEPES buffer, pH 7.4 containing aprotinin (100 KIU/ml) to give a final protein concentration of 2 mg/ml and stored at -70° C until use.

The membrane suspension was diluted with binding buffer (30 mM HEPES buffer, pH 7.4 containing 150 mM NaCl, 5mM $MgCl_2$, 0.5% Bacitracin) to a concentration of 8 μg/50 μl. ^{125}I-endothelin-1 (3,000 cpm, 50 mL) was added to 50 μL of either: (A) endothelin-1 (for non specific binding) to give a final concentration 80 nM); (B) binding buffer (for total binding); or (C) a test compound (final concentration 1 nM to 100 μM). The membrane suspension (50 μL), containing up to 8 μg of membrane protein, was added to each of (A), (B), or (C). Mixtures were shaken, and incubated at 4° C for 16-18 hours, and then centrifuged at 4° C for 25 min at 2,500 X g. Alternatively, the incubation was conducted at 24° C. When incubated at 24° C, the IC_{50} concentrations are 2- to 10-fold higher than when the incubation is conducted at 4° C. This, must be kept in mind when comparing IC_{50} concentrations among compounds provided herein.

The supernatant, containing unbound radioactivity, was decanted and the pellet counted on a Genesys multiwell gamma counter. The degree of inhibition of binding (D) was calculated according to the following equation:

$$\% D = 100 - \frac{(C) - (A)}{(B) - (A)} X\ 100$$

Each test was generally performed in triplicate.

B. Endothelin binding inhibition - Binding Test #2: Inhibition of binding to ET_B receptors

COS7 cells were transfected with DNA encoding the ET_B receptor, The resulting cells, which express the human ET_B receptor, were grown to confluence in T-150 flasks. Membrane was prepared as described

above. The binding assay was performed as described above using the membrane preparation diluted with binding buffer to a concentration of 1 μg/50 μl.

Briefly, the COS7 cells, described above, that had been transfected with DNA encoding the ET_B receptor and express the human ET_B receptor on their surfaces were grown to confluence in T-175 flasks. Cells from multiple flasks were collected by scraping, pooled and centrifuged for 10 min at 190 X g. The cells were resuspended in phosphate buffered saline (PBS) containing 10 mM EDTA using a Tenbroeck homogenizer. The suspension was centrifuged at 4° C 57,800 X g for 15 min, the pellet was resuspended in 5 ml of buffer A (5mM HEPES buffer, pH 7.4 containing aprotinin (100 KIU/ml)) and then frozen and thawed once. Five ml of Buffer B (5 mM HEPES Buffer, pH 7.4 containing 10 mM $MnCl_2$ and 0.001% deoxyribonuclease Type 1) was added, the suspension mixed by inversion and then incubated at 37° C for 30 minutes. The mixture was centrifuged at 57,800 X g as described above, the pellet washed twice with buffer A and then resuspended in buffer C (30 mM HEPES buffer, pH 7.4 containing aprotinin (100 KIU/ml) to give a final protein concentration of 2 mg/ml.

The binding assay was performed as described above using the membrane preparation diluted to give 1 μg/50 μl of binding buffer.

C. *Test for activity against endothelin-induced* contraction of isolated rat thoracic aortic rings

The effectiveness of the test compound as an antagonist or agonist of the biological tissue response of endothelin also is assessed by measuring the effect on endothelin induced contraction of isolated rat thoracic aortic rings (see, e.g., Borges et al. (1989) Eur. J. Pharmacol. 165:223-230) or by measuring the ability to contract the tissue when added alone.

Compounds to be tested are prepared as 100 μM stocks. If necessary to effect dissolution, the compounds are first dissolved in a minimum amount of DMSO and diluted with 150 mM NaCl. Because DMSO can cause relaxation of the aortic ring, control solutions containing varying concentrations of DMSO were tested.

The thoracic portion of the adult rat aorta is excised, the endothelium abraded by gentle rubbing and then cut into 3 mm ring segments. Segments are suspended under a 2 g preload in a 10 ml organ bath filled with Krebs'- Henseleit solution saturated with a gas mixture of 95% O_2 and 5% CO_2 (118 mM NaCl, 4.7 mM KCl, 1.2 mM $MgSO_4$, 1.2 mM KH_2PO_4, 25 mM $NaHCO_3$, 2.5 mM $CaCl_2$, 10 mM D-glucose).

There is a correlation between activity as an antagonist of endothelin-induced thoracic aortic ring contraction and activity as an inhibitor of binding of endothelin to endothelin receptors. The pA_2 is a linear function of the log of the IC_{50}.

D. Assay for identifying compounds that have agonist and/or antagonistic activity against ET_B receptors

1. Stimulation of prostacyclin release

Since endothelin-1 stimulates the release of prostacyclin from cultured bovine aortic endothelial cells, the compounds that have agonist or ~~antagnoist~~ antagonist activity are identified by their ability to inhibit endothelin-1 induced prostacyclin release from such endothelial cells by measuring 6-keto $PGF_{1\alpha}$ substantially as described by (Filep et al. (1991) Biochem. Biophys. Res. Commun. 177 171-176. Bovine aortic cells are obtained from collagenase-treated bovine aorta, seeded into culture plates, grown in Medium 199 supplemented with heat inactivated 15% fetal calf serum, and L-glutamine (2 mM), penicillin, streptomycin and fungizone, and subcultured at least four times. The cells are then seeded in six-well plates in the same medium. Eight hours before the assay, after the cells reach confluence, the medium is replaced. The cells are then incubated

with a) medium alone, b) medium containing endothelin-1 (10 nM), c) test compound alone, and d) test compound + endothelin-1 (10 nM).

After a 15 min incubation, the medium is removed from each well and the concentrations of 6-keto $PGF_{1\alpha}$ are measured by a direct immunoassay. Prostacyclin production is calculated as the difference between the amount of 6-keto $PGF_{1\alpha}$ released by the cells challenged with the endothelin-1 minus the amount released by identically treated unchallenged cells. Compounds that stimulate 6-keto $PGF_{1\alpha}$ release possess agonist activity and those which inhibit endothelin-1 6-keto $PGF_{1\alpha}$ release possess antagonist activity.

2. Inhibition of sarafotoxin 6c induced contraction

Sarafotoxin 6c is a specific ET_B antagonist that contracts rat fundal stomach strips. The effectiveness of tests compounds to inhibit this sarafotoxin 6c-induced contraction of rat fundal stomach strips is used as a measure ET_B antagonist activity. Two isolated rat fundal stomach strips are suspended under a 1 g load in a 10 ml organ bath filled with Krebs'-Henseleit solution containing 10 μM cyclo(D-Asp-Pro-D-Val-Leu-D-Trp) (BQ-123; see, U.S. Patent No. 5,114,918 to Ishikawa et al.), 5 μM indomethacin, and saturated with a gas mixture of 95% O_2/5% CO_2. Changes in tension are measured isometrically and recorded using a Grass Polygraph coupled to a force transducer. Sarafotoxin 6c is added cumulatively to one strip while the second strip is preincubated for 15 min with a test compound prior to addition of cumulative doses of sarafotoxin 6c. The effects of the test compounds on the concentration-response curve for sarafotoxin 6c are examined.

E. Deoxycorticosterone acetate (DOCA)-salt hypertensive rat model for assessing in vivo activity of selected compounds

Selected compounds disclosed herein have been tested for activity in the deoxycorticosterone acetate (DOCA)-salt hypertensive rat model. To perform these tests, silastic MDX4-4210 elastomer implants containing 47 mg (DOCA) were prepared according to the method of Ornmsbee et al. ((1973) the J. Pharm. Sci. 62:255-257). Briefly, DOCA is incorporated into silicon rubber implants for sustained release. To prepare the implants the DOCA is incorporated into unpolymerized silicone rubber, catalyst is added and the mixture is cast in a hemicylindrical shape.

Sprague Dawley rats (7-8 weeks old) were unilaterally nephrectomized under ketamine anesthesia and a DOCA-implant was placed on the left lateral dorsal abdomen of the animal. The rats were allowed to recover for three weeks. During recovery they were permitted free access to normal rat chow and 0.9% NaCl drinking solution in place of drinking water. The rats develop hypertension within 3 weeks.

All animals were used in the tests between 21 and 30 days post surgery. The mean arterial blood ~~presure~~ pressure in these animals ranged from 165-200 mm Hg.

On the day of experimentation, catheters were inserted under brevital anesthesia into the right femoral artery for measurement of blood pressure, and into the right femoral vein for administration of a selected compound. The animals were placed in a restrainer and allowed to recover for a minimum of 60 min or until a steady mean arterial blood pressure was recorded. At that time, the selected compound or control vehicle was administered either intravenously, as a 60 minute infusion, or orally by oral gavage. Blood pressure was recorded continuously for a ~~fruther~~ further 10 hrs.

F. Effect of Intravenous administration on ET-1-induced pressor responses in conscious, autonomically blocked rats; a model for assessing in vivo activity of selected compounds

Male Sprague Dawley rats (250-450 g) were anesthetized (Brevital 50 mg/kg, IP) and cannulae were placed in the femoral artery to measure mean arterial pressure (MAP) and in the femoral vein for intravenous drug administration. Animals were placed in a restrainer and allowed to regain consciousness. Thirty minutes later autonomic blockade was administered (atropine methyl nitrate, 3 mg/kg, IV, followed by ~~propranalol,~~ Propranolol 2 mg/kg, IV). An hour later animals received a bolus injection of vehicle (0.5 ml) followed thirty minutes later by intravenous bolus administration of ET-1 (Control, 1 μg/kg). Following recovery from this challenge, test -compounds were administered by intravenous bolus administration (0.5 ml) and then re-challenged with ET-1 thirty minutes later. Results are expressed as the percent inhibition of the ET-1-induced pressor response after administration of the test compound compared to the pressor response induced by the control ET-1 challenge. In some cases a third ET-1 challenge was administered ninety minutes after administration of the test compound.

G. Results

1. In vitro

The IC_{50} for each of the compounds of the preceding Examples for ET_A and ET_B receptors has been measured. Almost all of the compounds have an IC_{50} of less than 10 μM for either or both of the ET_A and ET_B receptors. Many of the compounds have an IC_{50} less than about 10 μM, others have an IC_{50} less than about 1 μM and some of the compounds have an IC_{50} less than about 0.1 μM. A number of the compounds have an IC_{50} for ET_A receptors that is substantially less (10 to 100-fold or

more) than for ET_B receptors, and, thus are selective for ET_A receptors. Others of the compounds are ET_B selective.

2. In vivo

Selected compounds, such as N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, have been tested in the hypertensive rat model, and were effective in decreasing blood pressure.

EXAMPLE 24

Assays for assessing toxicological properties of compounds

A. Cytochrome P450 enzyme assays

In vitro assays to determine the concentration of the compounds provided herein required for 50% inhibition of substrate metabolism (IC_{50}) by different human cytochrome P450 enzymes (2C9, 2C19, 3A4) were conducted using human recombinant cytochrome P450 enzyme assays, developed by Gentest Corporation. These assays contain Gentest Supersomes™ (specific human cytochrome P450 enzyme, co-expressed with P450 reductase and cytochrome b_5), a NADPH regenerating system, substrate and a concentration range of the compounds provided herein. The fluorescent product was the measured end point for these assays. IC_{50}s were calculated using a four-parameter logistic equation with the bottom fixed at 0% inhibition and the top fixed at 100% inhibition. (Values are the mean IC_{50} ± SD when n is greater than I.)

i. General Assay Conditions

Assays were conducted in 96-well microtiter plates using fluorometric assays developed by Gentest Corporation. The 12 wells in each row were used for one inhibition curve. Wells 1 to 8 contained serial 1:3 dilutions of the test compound. Wells 9 to 12 contained no inhibitor and wells 11 and 12 were blanks for background fluorescence (stop solution was added before the enzyme). All concentration curves

were performed in duplicate. Incubations were initiated by the addition of enzyme and substrate to the pre-warmed reaction mixture. After a specific incubation period, the reaction was stopped by the addition of stop solution. Metabolite production per well was determined by measuring fluorescence using a fluorescent plate reader. Detailed experimental procedures for each enzyme are listed below. See, generally, Methodology of a high throughput method for measuring cytochrome P450 inhibition (Gentest Corporation, Technical Bulletin); Crespi, C.L.; Miller, V.P.; and Penman, B.W. (1997) Anal. Biochem. 248:188-190; and Geungerich, F.P. (1997) Adv. Pharm. 43:7-35.

ii. CYP2C9 Assay

A 0.2 ml/well reaction mixture containing 2 pmol CYP2C9 (P258), 1.3 mM $NADP^+$, 3.3 mM glucose-6-phosphate, 3.3 mM magnesium chloride, 0.4 U/ml glucose-6-phosphate dehydrogenase and 75 μM 7-methoxy-4-trifluoromethylcoumarin in 25 mM potassium phosphate (pH 7.4), was incubated at 37 °C for 45 minutes. Sulfaphenazole, a standard inhibitor of CYP2C9, was serially diluted from the highest concentration of 10 μM and acted as a positive control. The test compound was serially diluted from the highest concentration of 100 μM. After incubation, the reaction was stopped by the addition of 75 μl stop solution (80% acetonitrile/20% 0.5 M Tris base) and fluorescence/well was measured using a Spectra Fluor (Tecan) or Cytoflour 2350 (Millipore) fluorescent plate reader. An excitation wavelength of 409 nm (30 nm bandwidth) and emission wavelength of 535 nm (25 nm bandwidth), or an excitation wavelength of 400 nm (30 nm bandwidth) and emission wavelength of 460 nm (40 nm bandwidth) were used, respectively.

iii. **CYP2C19 Assay**

A 0.2 ml/well reaction mixture containing 1 pmol CYP2C19 (P259), 1.3 mM $NADP^+$, 3.3 mM glucose-6-phosphate, 3.3 mM magnesium chloride, 0.4 U/ml glucose-6-phosphate dehydrogenase and 25 μM 3-cyano-7-ethoxycoumarin in 50 mM potassium phosphate (pH 7.4), was incubated at 37°C for 45 minutes. Tranylcypromine, a standard inhibitor of CYP2C19, was serially diluted from the highest concentration of 500 μM and acted as a positive control. The test compound was serially diluted from the highest concentration of 100 μM. After incubation, the reaction was stopped by the addition of 75 μl stop solution (80% acetonitrile/20% 0.5 M Tris base) and fluorescence/well was read within 1 hour using a Spectra Fluor (Tecan) fluorescent plate reader. An excitation wavelength of 409 nm (30 nm bandwidth) and emission wavelength of 465 nm (25 nm bandwidth) were used.

iv. **CYP3A4 Assay**

A 0.2 ml/well reaction mixture containing 4 pmol CYP3A4 (P202), 1.3 mM $NADP^+$, 3.3 mM glucose-6-phosphate, 3.3 mM magnesium chloride 0.4 U/ml glucose-6-phosphate dehydrogenase, 0.01% pluronic F68, and 50 μM resorufin benzyl ether in 200 mM potassium phosphate (pH 7.4), was incubated at 37°C for 30 minutes. Ketoconazole, a standard inhibitor of 3A4, was serially diluted from the highest concentration of 5 μM and acted as a positive control. The test compound was serially diluted from the highest concentration of 100 μM. After incubation, the reaction was stopped by the addition of 75 μl stop solution (80% acetonitrile/20% 0.5 M Tris base) and fluorescence/well was measured within 1 hour using a Spectra Fluor (Tecan) fluorescent plate reader. An excitation wavelength of 530 nm (30 nm bandwidth) and emission wavelength of 580 nm (4nm bandwidth) were used.

v. Analysis

The fluorescence values from duplicate wells for each individual concentration, the four wells where no test compound was added (this is 0% inhibition), and the four wells of "stop-blank" (these wells represent "background" since the reaction was stopped before the addition of enzyme) were averaged for each compound.

The "% inhibition" was calculated as follows:

$$100 - \frac{\text{(mean of individual fluorescence value - background)} \times 100}{\text{(0\% inhibition - background)}}$$

Concentration versus % inhibition curves were constructed in Prism (GraphPad, Inc.). The data was analyzed using "Top & Bottom Fixed" routine. The equation used was:

$Y\text{-}0 + 100/(1 + 10__((\text{Log } IC_{50}\text{-}X)*\text{HillSlope}))$

Where:

X is the logarithm of concentration.

Y is the response (% inhibition) and starts at 0% and goes to 100% with a sigmoid shape.

This equation is identical to the "four parameter logistic equation".

vi. Results

The mean IC_{50} of the test compounds on different CYP enzyme-mediated metabolite formations are presented in Table 2. Assay values were validated using a known inhibitor for each CYP analyzed (positive control). Experiments were considered valid for inclusion in Table 2 if the IC_{50} value of the positive control was within one standard deviation of the historical mean for the positive controls for that CYP. Experiments where the positive control IC_{50} falls outside one standard deviation were excluded.

B. Hypoxia Protocols

Hypoxic exposure (10.0 ± 0.5% O_2) was achieved by placing rats in a 3301 Plexiglas glove box (Manostat, Brooklyn, New York, USA). The chamber was gassed by adding N_2 to the chamber intermittently from a liquid N_2 reservoir. A baralyme (Allied Health Care Products, St. Louis, Missouri, USA) CO_2 scrubber kept the CO_2 concentration <0.2%. Relative humidity within the chamber was kept <70% with anhydrous $CaSO_4$. Boric acid was used to keep NH_3 levels within the chamber at a minimum. See, Tilton et al. (2000) Pulm. Pharm. Ther. 13:87-97.

i. Acute Hypoxia Protocol

In the initial experiment, effects of a test compound were assessed on mean pulmonary arterial pressure (MPAP) of rats subsequently exposed to acute hypoxia 90 min in duration. Under pentobarbital sodium anesthesia (50mg/kg ip), a femoral artery and vein were cannulated and the pulmonary artery was cannulated via the right jugular vein with a closed-chest technique. All catheters were connected to polyethylene (PE 20) tubing, and were exteriorized at the back of the neck by a stainless steel wire (0.018 in. diam) tunneled subcutaneously. Two days later, MPAP was recorded through the femoral and pulmonary arterial cannulas via transducers coupled to a polygraph recorder. Once stable tracings were obtained, conscious unrestrained rats were exposed to hypoxia (10% O_2, 1 atm) and the effects of hypoxia on this parameter was recorded over a 90-min period. A test compound prevention protocol (5mg/kg infused iv over a 10-min period terminating 10 min before onset of hypoxia) and a test compound intervention protocol (5mg/kg infused iv over a 10-min period starting 50 min after onset of hypoxia) were incorporated into the experimental design.

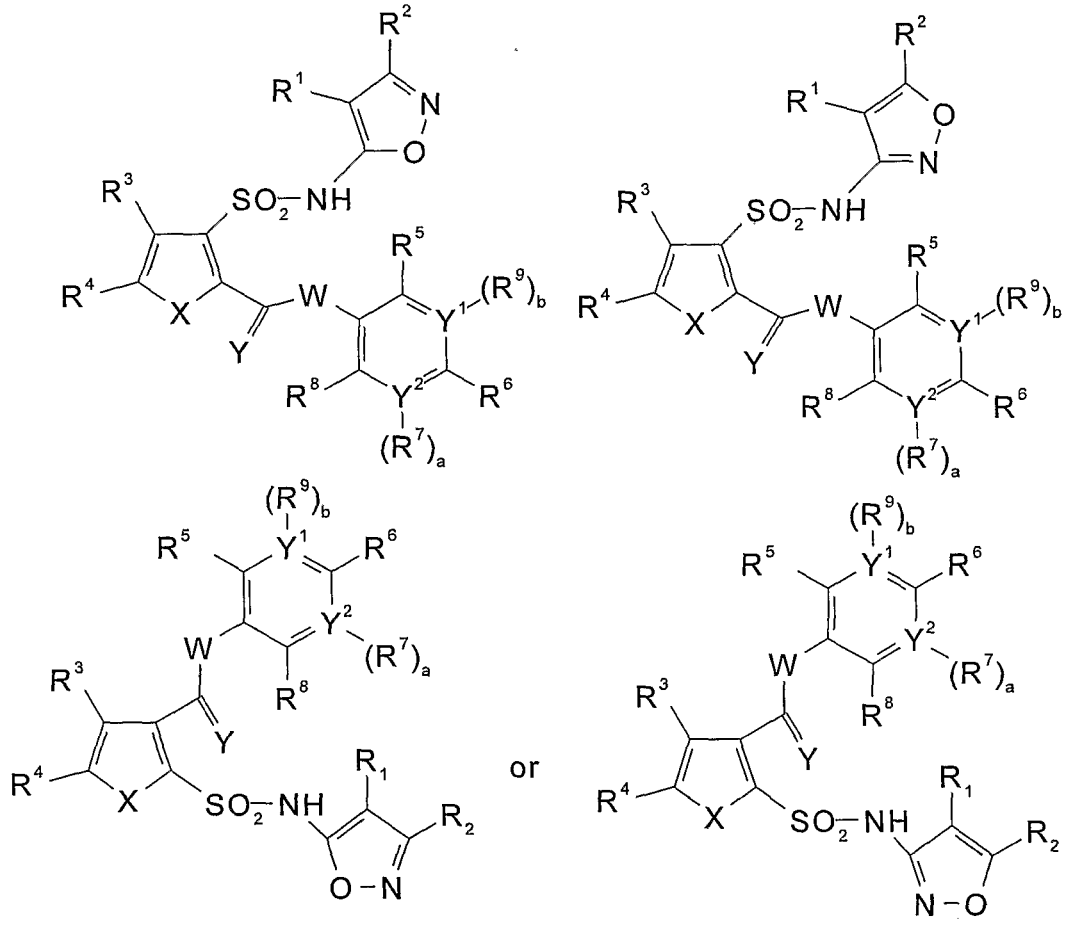
ii. Results

Acute exposure to normobaric hypoxia was associated with a biphasic increase in MPAP from baseline level of 19 mm Hg to 24.5mm Hg within 5 min, followed by a decrease to 21 mm Hg during the next 10 mins then a return to peak levels of ~ 25 mm Hg during the remainder of hypoxic exposure. Pulmonary pressure rapidly returned toward baseline values when this group was returned to room air at the end of the experiment. As shown in Table 2, the compounds provided herein were effective in inhibiting hypoxia-induced vasoconstriction at dosages lower than dosages required for known endothelin antagonists.

Since modifications will be apparent to those of skill in this art, it is intended that this invention be limited only by the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A compound that has formula IV:



or pharmaceutically acceptable derivatives thereof, wherein:

X is S or $-C(R^3)=C(R^4)-$;

R^1 is halo or lower alkyl;

R^2 is lower alkyl;

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$;

R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl;

R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl;

x and y are each independently 0 to 14;

R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

Y and R^8 are selected from (i) or (ii) as follows:

(i) Y is O; and R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$; or

(ii) Y and R^8 together with the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring;

R^9 is H;

Y^1 and Y^2 are each independently carbon or nitrogen;

a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen;

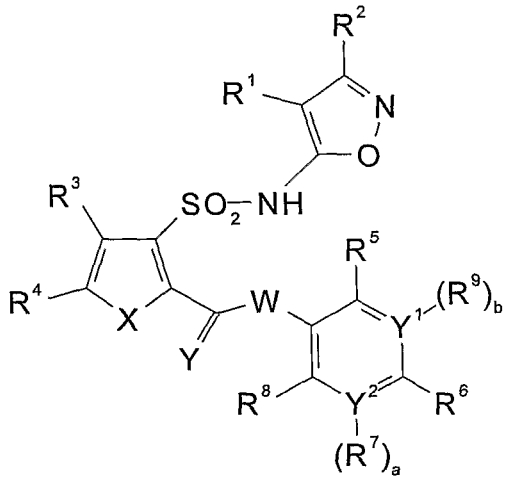
b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and

W is NH.

2. The compound of claim 1, wherein:

X is S; R^3 and R^4 are each H; Y^1 and Y^2 are each carbon; and a and b are each 1.

3. The compound of claim 1, wherein the compound has formula V:



and pharmaceutically acceptable derivatives thereof, wherein:

X is S or -CH=CH-;

R^1 is halo or lower alkyl;

R^2 is lower alkyl;

R^3 and R^4 are each hydrogen;

R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$; R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl;

R^7 is selected from the group consisting of hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl;

x and y are each independently 0 to 14;

R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

Y and R^8 are selected from (i) or (ii) as follows:

(i) Y is O; and R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$; or

(ii) Y and R^8 together with the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring;

R^9 is H;

Y^1 and Y^2 are each independently carbon or nitrogen;

a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen;

b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and

W is NH.

4. The compound of claim 3, wherein R^1 is Cl or Me; and R^2 is Me.

5. The compound of claim 3, wherein:

R^5 is Me or acetyl;

R^6 is Me, acetyl or 2-oxazolyl;

R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl);

Y and R^8 are selected from (i) or (ii), as follows:

(i) Y is O; and R^8 is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, $C(O)N(Me)(CH_2$-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, C(=N-OMe)Me, Me, C(O)Et, Cl, n-propyl or ethyl; or

(ii) Y and R^8 together form -CO-N= or -CO-C(CN)=;

R^9 is H;

Y^1 and Y^2 are each independently carbon or nitrogen;

a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen;

b is 1 if Y^1 is carbon; b is 0 if Y^1 is nitrogen; and

W is NH.

6. The compound of claim 3, wherein:

X is S;

R^1 is Cl or Me;

R^2 is Me;

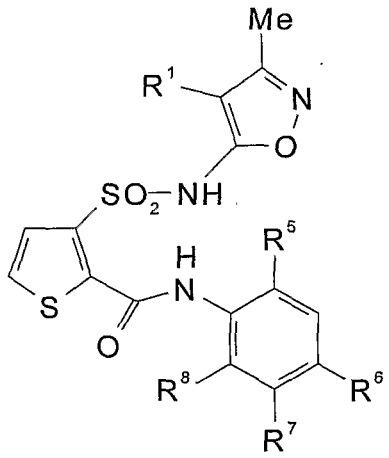
R^3, R^4 and R^9 are H;

Y is O;

W is NH; and

Y^1 and Y^2 are each carbon.

7. The compound of claim 6, wherein the compound has the formula VI:



or pharmaceutically acceptable derivatives thereof, wherein:

R^1 is Cl or Me;

R^5 is Me or acetyl;

R^6 is Me, acetyl or 2-oxazolyl;

R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl); and

R^8 is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, C(O)N(Me)(CH_2-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, C(=N-OMe)Me, Me, C(O)Et, Cl, n-propyl or ethyl.

8. The compound of claim 7, wherein R^1, R^5 and R^6 are Me; and R^7 is hydrogen.

9. The compound of claim 1 that is selected from the group consisting of N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-

isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, N-(2-cyano-3,4,6-trimethylphenyl)-3-{[(3,4-dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino] sulfonyl}-N-(3,4,6-trimethyl-2-propanoylphenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2-(1-hydroxyethyl)-4,6-dimethylphenyl]-2-thiophene carboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2-[(dimethylamino)carbonyl]-4,6-dimethylphenyl)-2-thiophene carboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{2,4-dimethyl-6-[(methyloxy)ethanimidoyl]phenyl}-2-thiophene carboxamide, 3-{[(3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenyl)-carbonyl]amino}-2,4,6-trimethylphenyl-N,N-dimethylsulfamate, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-{3-[(cyclopropylmethyl)-oxy]-2,4,6-trimethylphenyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethyl-5-pyrimidinyl)-2-thiophenecarboxamide, N-(2-acetyl-3,4,6-trimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2-cyano-3,4,6-trimethyl-phenyl)-2-thiophenecarboxamide, N-(2-chloro-4,6-dimethylphenyl)-3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(4,6-diacetyl-3-hydroxy-2-propylphenyl-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4-dimethyl-6-[2-(methylsulfonyl)acetyl]-phenyl}-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)-amino]sulfonyl}-N-(2,4-dimethyl-6-{[methyl(2,2-dimethylpropyl)amino]-carbonyl}phenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(methylsulfonyl)phenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]-sulfonyl}-N-[2,4-dimethyl-6-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarbox-

amide, 3-{[(4-chloro-5-isoxazolyl)amino]sulfonyl}-N-[2-(2-propylsulfonyl)-4,6-dimethylphenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl)-N-[2,4-dimethyl-6-(propylsulfonyl)phenyl]-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]-sulfonyl}-N-(2-ethyl-4,6-dimethylphenyl)-2-thiophenecarboxamide, 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-[2,6-dimethyl-4-(1,3-oxazol-2-yl)phenyl]-2-thiophenecarboxamide, N-(4-chloro-3-methyl-5-isoxazolyl)-2-(6,8-dimethyl-4-hydroxy-2-benzopyrimidinyl)thiophene-3-sulfonamide and N-(4-chloro-3-methyl-5-isoxazolyl)-2-(3-cyano-4-hydroxy-6,8-dimethylbenzo[b]pyridin-2-yl)thiophene-3-sulfonamide, or a pharmaceutically acceptable derivative thereof.

10. The compound of claim 1 that is N-(2-acetyl-4,6-dimethylphenyl)-3-{[(3,4 dimethyl-5-isoxazolyl)amino]sulfonyl}-2-thiophenecarboxamide, or a pharmaceutically acceptable derivative thereof.

11. A pharmaceutically acceptable salt comprising the compound of claim 10.

12. The salt of claim 11 that is a sodium salt.

13. The compound of claim 1, wherein Y^1 and Y^2 are each nitrogen.

14. The compound of claim 13, wherein a and b are each 0.

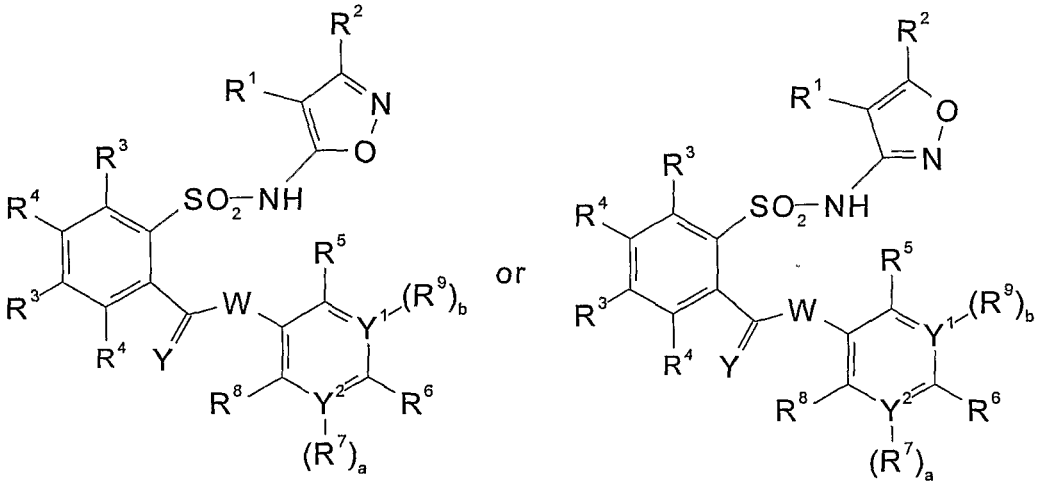
15. The compound of claim 13, wherein R^5, R^6 and R^8 are alkyl; Y is O; and W is NH.

16. The compound of claim 13, wherein R^3 and R^4 are each H; and X is S.

17. The compound of claim 13 that is 3-{[(4-chloro-3-methyl-5-isoxazolyl)amino]sulfonyl}-N-(2,4,6-trimethyl-5-pyrimidinyl)-2-thiophenecarboxamide, or a pharmaceutically acceptable derivative thereof.

18. The compound of claim 1, wherein X is -C(R^3)=C(R^4)-.

19. The compound of claim 18 that has formula VII:



and pharmaceutically acceptable derivatives thereof, where R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form -$(CH_2)_n$-, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

W is O, NH or $(CH_2)_z$ wherein z is 0 to 6; and Y is O, S, or, together with R^8 and the atoms to which they are attached, form a 3 to 16 membered unsubstituted or substituted cyclic or heterocyclic ring;

R^3 and R^4 are independently selected from among hydrogen, halo, cyano, cyanoalkyl, $C(O)R^{41}$, alkyl, alkenyl, cycloalkyl and aryl, or together form alkylene or alkenylene, where R^{41} is alkyl, aryl, heteroaryl, aralkyl, heteroaralkyl, cycloalkyl, alkylamino, dialkylamino, arylamino, diarylamino, alkylsulfonylamino, arylsulfonylamino, alkylsulfonylalkylamino, alkylsulfonylarylamino, arylsulfonylalkylamino or arylsulfonylarylamino;

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl;

x and y are each independently 0 to 14;

R^{50} is a ~~substitutent~~ substituent such as hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

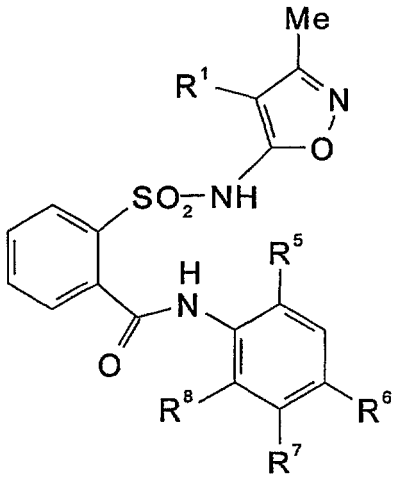
(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or halo lower alkyl, *and the others of* R^5, R^6, R^7, R^8 *and* R^9 *are selected as in (i).*

20. The compound of claim 19, wherein R^3, R^4 and R^9 are H; Y is O; and W is NH.

21. The compound of claim 19, wherein R^1 and R^2 are each selected independently from among alkyl, lower alkenyl, lower alkynyl, lower haloalkyl, halide, pseudohalide or H, except that R^2 is not halide.

22. The compound of claim 19, wherein R^1 is lower alkyl or halide; and R^2 is lower alkyl.

23. The compound of claim 19, wherein the compound has formula VIII:



or pharmaceutically acceptable derivatives thereof, wherein:

R^1 is lower alkyl or halide;

R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$;

R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl;

R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ or $OS(O)_2NR^{38}R^{39}$; and

R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$.

24. The compound of claim 23, wherein:

R^5 is Me or acetyl;

R^6 is Me, acetyl or 2-oxazolyl;

R^7 is H, Me, OSO_2NMe_2, OCH_2-cyclopropyl, hydroxy or SO_2NH-(4-chloro-3-methyl-5-isoxazolyl); and

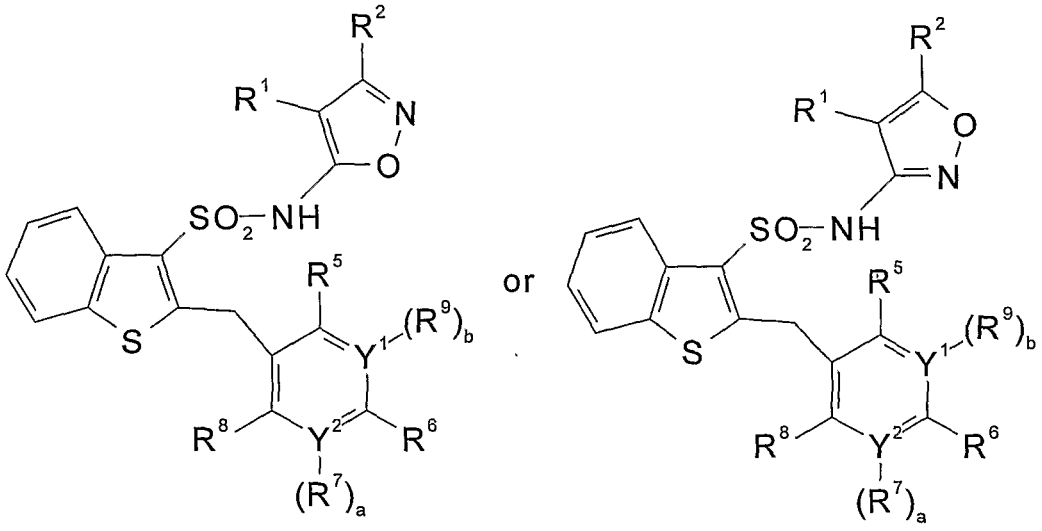
R^8 is $C(O)CH_2SO_2CH_3$, C(O)Me, CN, C(O)N(Me)(CH_2-t-Bu), SO_2Me, 2-oxazolyl, SO_2-isopropyl, SO_2-n-propyl, CH(OH)Me, $C(O)NMe_2$, C(=N-OMe)Me, Me, C(O)Et, Cl, n-propyl or ethyl.

25. The compound of claim 23, wherein R^5 and R^6 are Me; R^7 is H; and R^8 is C(O)Me.

26. The compound of claim 23 that is N-(4-chloro-3-methyl-5-isoxazolyl)-2-(2-acetyl-4,6-dimethylphenylaminocarbonyl)benzene-sulfonamide.

27. The compound of claim 1, wherein M is $(CH_2)_z$, where z is 0 to 6.

28. The compound of claim 27, wherein the compound has formula X:



or pharmaceutically acceptable derivatives thereof, where R^1 and R^2 are either (i), (ii) or (iii) as follows:

(i) R^1 and R^2 are each independently selected from H, NH_2, NO_2, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, alkyloxy, haloalkyl, alkylsulfinyl, alkylsulfonyl, aryloxy, arylamino, arylthio, arylsulfinyl, arylsulfonyl, haloalkyl, haloaryl, alkoxycarbonyl, alkylcarbonyl, aminocarbonyl, arylcarbonyl, formyl, substituted or unsubstituted amido, and substituted or unsubstituted ureido, in which the alkyl, alkenyl and alkynyl portions contain from 1 up to about 14 carbon atoms and are either straight or branched chains or cyclic, and the aryl portions contain from about 4 to about 16 carbons, except that R^2 is not halide or pseudohalide; or,

(ii) R^1 and R^2 together form $-(CH_2)_n-$, where n is 3 to 6; or,

(iii) R^1 and R^2 together form 1,3-butadienyl (-CH=CH-CH=CH-);

Y^1 and Y^2 are each independently carbon or nitrogen; a and b are each independently 0 or 1;

R^5, R^6, R^7, R^8 and R^9 are each independently selected from (i) or (ii) as follows:

(i) R^5, R^6, R^7, R^8 and R^9 are each independently selected from among H, OH, NHR^{38}, $CONR^{38}R^{39}$, NO_2, cyano, halide, pseudohalide, alkyl, alkenyl, alkynyl, aryl, arylalkyl, heteroaryl, alkoxy, alkylamino, alkylthio, haloalkyl, alkylsulfinyl, alkylsulfonyl, alkoxycarbonyl, alkylcarbonyl, alkenylthio, alkenylamino, alkenyloxy, alkenylsulfinyl, alkenylsulfonyl, alkoxycarbonyl, arylaminocarbonyl, alkylaminocarbonyl, aminocarbonyl, (alkyl-aminocarbonyl)alkyl, acetoxy, hydroxyl, carboxyl, carboxyalkyl, carboxyalkenyl, alkylsulfonylaminoalkyl, cyanoalkyl, acetyl, acetoxyalkyl, hydroxyalkyl, alkoxyalkoxy, hydroxyalkyl, (acetoxy)alkoxy, (hydroxy)alkoxy, formyl, sulfonyl chlorides, amino acids, hexoses, O-glycosides, riboses, lower alkyl, CN, $-(CH_2)_xC(O)(CH_2)_yCH_3$, $-(CH_2)_xCH_3$, $(CH_2)_xNH$-lower alkyl, $-(CH_2)_xC(O)NH_2$, a D-, L- or racemic amino acid, a primary or secondary amide, O-glycoside, a hexose or ribose, $-S(O)_2NH_2$, hydroxy, alkoxy, alkoxycarbonyl, acetoxyalkyl, $-(CH_2)_xCOOH$, $-(CH_2)_xCH(COOH)(CH_2)_yCH_3$, CO_2-lower alkyl, CN, heteroaryl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$, $C(=N\text{-}OR^{38})(CH_2)_yCH_3$, $-C(O)C(O)(CH_2)_yCH_3$, $-(CH_2)_xN(CH_3)_2$, $S(O)_2NHR^{50}$, $OS(O)_2NR^{38}R^{39}$, alkylaryl, alkylheteroaryl, $C(O)NHR^{50}$, $-(CH_2)_xOH$, and $-C(O)N(H)N(H)R^{50}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl; x and y are each independently 0 to 14; and R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl; or

(ii) at least two of R^5, R^6, R^7, R^8 and R^9, which substitute adjacent carbons on the ring, together form alkylenedioxy, alkylenethioxyoxy or alkylenedithioxy which is unsubstituted or substituted by replacing one or more hydrogens with halide, lower alkyl, lower alkoxy or halo lower alkyl, and the others of R^5, R^6, R^7, R^8 and R^9 are selected as in (i).

29. The compound of claim 28, wherein:

R^1 is halo or lower alkyl;

R^2 is lower alkyl;

R^5 is lower alkyl or $-(CH_2)_xC(O)(CH_2)_yCH_3$;

R^6 is lower alkyl, $-(CH_2)_xC(O)(CH_2)_yCH_3$, or heteroaryl;

R^7 is hydrogen, hydroxy, alkoxy, lower alkyl, $S(O)_2NHR^{50}$ and $OS(O)_2NR^{38}R^{39}$;

where R^{38} and R^{39} are each independently selected from hydrogen, alkyl, alkenyl, alkynyl, aryl, haloalkyl, alkylaryl, heterocyclyl, arylalkyl, arylalkoxy, alkoxy, aryloxy, cycloalkyl, cycloalkenyl and cycloalkynyl; x and y are each independently 0 to 14; and R^{50} is hydrogen, lower alkyl, lower alkoxy or heteroaryl;

R^8 is $CONR^{38}R^{39}$, CN, heteroaryl, alkylsulfonyl, $(CH_2)_xC(O)(CH_2)_yCH_3$, alkyl, halide, pseudohalide, hydroxyalkyl, $C(O)(CH_2)_xS(O)_2(CH_2)_yCH_3$ or $C(=N\text{-}OR^{38})(CH_2)_yCH_3$;

R^9 is H; Y^1 and Y^2 are each independently carbon or nitrogen; a is 1 if Y^2 is carbon; a is 0 if Y^2 is nitrogen; b is 1 if Y^1 is carbon; and b is 0 if Y^1 is nitrogen.

30. The compound of claim 29, wherein Y^1 and Y^2 are carbon; a and b are each 1; R^5, R^6 and R^8 are lower alkyl; and R^7 is H or SO_2NHR^{50}, where R^{50} is heteroaryl.

31. The compound of claim 28 selected from the group consisting of N-(4-chloro-3-methyl-5-isoxazolyl)-2-(2,4,6-trimethylbenzyl)benzo[b]thiophene-3-sulfonamide and N-(4-chloro-3-methyl-5-isoxazolyl)-2-(3-(4-chloro-3-methyl-5-isoxazolyl)aminosulfonyl-2,4,6-trimethylbenzyl)benzo[b]thiophene-3-sulfonamide.

32. A pharmaceutically acceptable salt of the compound of claim 1.

33. The salt of claim 32 that is a sodium salt.

34. A pharmaceutical composition, comprising an effective amount of a compound of claim 1 or a pharmaceutically acceptable derivative thereof in a pharmaceutically acceptable carrier, wherein the amount is effective for ameliorating the symptoms of an endothelin-mediated disease.

35. A pharmaceutical composition, comprising an effective amount of a compound of claim 10 or a pharmaceutically acceptable derivative thereof in a pharmaceutically acceptable carrier, wherein the amount is effective for ameliorating the symptoms of an endothelin-mediated disease.

36. The composition of claim 34 that is formulated for single or multiple dosage administration.

37. The composition of claim 35 that is formulated for single or multiple dosage administration.

38. An article of manufacture, comprising packaging material and a compound or a pharmaceutically acceptable derivative thereof of claim 1 contained within the packaging material, wherein the compound is effective for antagonizing the effects of endothelin, ameliorating the symptoms of an endothelin-mediated disorder, or inhibiting the binding of an endothelin peptide to an ET receptor with an IC_{50} of less than about 10 μM, and the packaging material includes a label that indicates that the sulfonamide or derivative thereof is used for antagonizing the effects of endothelin, inhibiting the binding of endothelin to an endothelin receptor or treating an endothelin-mediated disorder.

39. An article of manufacture, comprising packaging material and a compound or a pharmaceutically acceptable derivative thereof of claim 10 contained within the packaging material, wherein the compound is effective for antagonizing the effects of endothelin, ameliorating the symptoms of an endothelin-mediated disorder, or inhibiting the binding of

an endothelin peptide to an ET receptor with an IC_{50} of less than about 10 μM, and the packaging material includes a label that indicates that the sulfonamide or derivative thereof is used for antagonizing the effects of endothelin, inhibiting the binding of endothelin to an endothelin receptor or treating an endothelin-mediated disorder.

40. A method for the treatment of endothelin-mediated diseases, comprising administering to a subject an effective amount of a compound of claim 1, or a pharmaceutically acceptable derivative thereof, wherein the effective amount is sufficient to ameliorate one or more of the symptoms of the disease.

41. A method for the treatment of endothelin-mediated diseases, comprising administering to a subject an effective amount of a compound of claim 10, or a pharmaceutically acceptable derivative thereof, wherein the effective amount is sufficient to ameliorate one or more of the symptoms of the disease.

42. The method of claim 40, wherein the disease is selected from the group consisting of hypertension, cardiovascular diseases, cardiac diseases including myocardial infarction, pulmonary hypertension, neonatal pulmonary hypertension, erythropoietin-mediated hypertension, respiratory diseases and inflammatory diseases, including asthma, bronchoconstriction, ophthalmologic diseases including glaucoma and inadequate retinal perfusion, gastroenteric diseases, renal failure, endotoxin shock, menstrual disorders, obstetric conditions, wounds, laminitis, erectile dysfunction, menopause, osteoporosis and metabolic bone disorders, climacteric disorders including hot flushes, abnormal clotting patterns, urogenital discomfort and increased incidence of cardiovascular disease, and other disorders associated with the reduction in ovarian function in middle-aged women, pre-eclampsia, control and management of labor during pregnancy, nitric oxide attenuated disorders,

anaphylactic shock, hemorrhagic shock and immunosuppressant-mediated renal vasoconstriction.

43. The method of claim 41, wherein the disease is selected from the group consisting of hypertension, cardiovascular diseases, cardiac diseases including myocardial infarction, pulmonary hypertension, neonatal pulmonary hypertension, erythropoietin-mediated hypertension, respiratory diseases and inflammatory diseases, including asthma, bronchoconstriction, ophthalmologic diseases including glaucoma and inadequate retinal perfusion, gastroenteric diseases, renal failure, endotoxin shock, menstrual disorders, obstetric conditions, wounds, laminitis, erectile dysfunction, menopause, osteoporosis and metabolic bone disorders, climacteric disorders including hot flushes, abnormal clotting patterns, urogenital discomfort and increased incidence of cardiovascular disease, and other disorders associated with the reduction in ovarian function in middle-aged women, pre-eclampsia, control and management of labor during pregnancy, nitric oxide attenuated disorders, anaphylactic shock, hemorrhagic shock and immunosuppressant-mediated renal vasoconstriction.

44. The method of claim 42, wherein the disease is selected from the group consisting of asthma and inflammatory diseases.

45. The method of claim 42, wherein the disease is glaucoma.

46. The method of claim 43, wherein the disease is selected from the group consisting of asthma and inflammatory diseases.

47. The method of claim 43, wherein the disease is glaucoma.

48. A method for inhibiting the binding of an endothelin peptide to an endothelin$_A$ (ET_A) or endothelin$_B$ (ET_B) receptor, comprising contacting the receptor with a compound of claim 1, or a ~~pharmaceutially~~ pharmaceutically acceptable derivative thereof, wherein:

the contacting is effected prior to, simultaneously with or subsequent to contacting the receptor with the endothelin peptide.

49. A method for inhibiting the binding of an endothelin peptide to an endothelin$_A$ (ET_A) or endothelin$_B$ (ET_B) receptor, comprising contacting the receptor with a compound of claim 10, or a ~~pharmaceutially~~ pharmaceutically acceptable derivative thereof, wherein:

the contacting is effected prior to, simultaneously with or subsequent to contacting the receptor with the endothelin peptide.

50. A method for altering endothelin receptor-mediated activity, comprising contacting an endothelin receptor with a compound of claim 1, or a ~~pharmaceutially~~ pharmaceutically acceptable derivative thereof.

51. A method for altering endothelin receptor-mediated activity, comprising contacting an endothelin receptor with a compound of claim 10, or a ~~pharmaceutially~~ pharmaceutically acceptable derivative thereof.

52. The pharmaceutical composition of claim 34, wherein the pharmaceutically acceptable carrier comprises a sodium phosphate buffer solution containing a sugar.

53. The pharmaceutical formulation of claim 52, wherein the compound is a pharmaceutically-acceptable alkali metal salt.

54. A lyophilized powder, comprising a salt of the compound of claim 1.

55. The lyophilized powder of claim 54 produced by a process, comprising:

(a) dissolving a pharmaceutically-acceptable salt of the sulfonamide compound in a sodium phosphate buffer solution containing a sugar or carbohydrate;

(b) sterile-filtering the resulting solution; and

(c) lyophilizing the filtered solution under standard conditions to produce a sterile powder.

56. The powder of claim 55, wherein the sugar or ~~carobohydrate~~ carbohydrate contains dextrose.

57. An article of manufacture, comprising packaging material and a the powder of claim 54, contained within the packaging material, wherein the compound is effective for antagonizing the effects of endothelin, ameliorating the symptoms of an endothelin-mediated disorder, or inhibiting the binding of an endothelin peptide to an ET receptor with an IC_{50} of less than about 1 μM, and the packaging material includes a label that indicates that the sulfonamide or salt thereof is used for antagonizing the effects of endothelin, inhibiting the binding of endothelin to an endothelin receptor or treating an endothelin-mediated disorder.

58. A combination comprising:

a sterile vial containing the pharmaceutical formulation of claim 54.

59. The combination of claim 58, wherein the sterile vial contains an amount of the powder that is for single dose administration.

60. The combination of claim 58, wherein the sterile vial also contains an amount of sterile water for injection; and the final concentration of the sulfonamide sodium salt is between about 1 and 250 mg/mL.

61. The pharmaceutical composition of claim 34 that is formulated as a tablet or capsule.

62. The composition of claim 61, further comprising an enteric coating.

63. The composition of claim 61, wherein the coating is selected from cellulose acetate phthalate, polyethylene glycol, polyoxyethylene sorbitan, castor oil, ethyl cellulose pseudolatex, phenyl salicylate, n-butyl stearate, stearic acid and carnuba wax.

64. The pharmaceutical composition of claim 35, wherein the pharmaceutically acceptable carrier comprises a sodium phosphate buffer solution containing a sugar.

65. The pharmaceutical formulation of claim 64, wherein the compound is a pharmaceutically-acceptable alkali metal salt.

66. A lyophilized powder, comprising a salt of the compound of claim 10.

67. The lyophilized powder of claim 66 produced by a process, comprising:

(a) dissolving a pharmaceutically-acceptable salt of the sulfonamide compound in a sodium phosphate buffer solution containing a sugar or carbohydrate;

(b) sterile-filtering the resulting solution; and

(c) lyophilizing the filtered solution under standard conditions to produce a sterile powder.

68. The powder of claim 67, wherein the sugar or ~~carobohydrate~~ carbohydrate contains dextrose.

69. An article of manufacture, comprising packaging material and a the powder of claim 66, contained within the packaging material, wherein the compound is effective for antagonizing the effects of endothelin, ameliorating the symptoms of an endothelin-mediated disorder, or inhibiting the binding of an endothelin peptide to an ET receptor with an IC_{50} of less than about 1 μM, and the packaging material includes a label that indicates that the sulfonamide or salt thereof is used for antagonizing the effects of endothelin, inhibiting the binding of endothelin to an endothelin receptor or treating an endothelin-mediated disorder.

70. A combination comprising:

a sterile vial containing the pharmaceutical formulation of claim 66.

71. The combination of claim 70, wherein the sterile vial contains an amount of the powder that is for single dose administration.

72. The combination of claim 70, wherein the sterile vial also contains an amount of sterile water for injection; and the final concentration of the sulfonamide sodium salt is between about 1 and 250 mg/mL.

73. The pharmaceutical composition of claim 35 that is formulated as a tablet or capsule.

74. The composition of claim 73, further comprising an enteric coating.

75. The composition of claim 73, wherein the coating is selected from cellulose acetate phthalate, polyethylene glycol, polyoxyethylene sorbitan, castor oil, ethyl cellulose pseudolatex, phenyl salicylate, n-butyl stearate, stearic acid and carnuba wax.