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(71) Applicant (for all designated States except US): **NI-TROMED, INC.** [US/US]; 125 Spring Street, Lexington, MA 02421-7801 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **ELLIS, James, L.** [GB/US]; 21 Pearl Road, Boxford, MA 01921 (US). **GARVEY, David, S.** [US/US]; 10 Grand Hill Drive, Dover, MA 02030 (US). **LIN, Chia-En** [US/US]; 98 Prescott Road, Concord, MA 01742 (US).

(74) Agents: **LEW, Belinda** et al.; Wilmer Cutler Pickering Hale And Dorr LLP, The Willard Office Building, 1455 Pennsylvania Avenue, Nw, Washington, DC 20004 (US).

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(54) Title: ORGANIC NITRIC OXIDE DONOR SALTS OF ANTIMICROBIAL COMPOUNDS, COMPOSITIONS AND METHODS OF USE

(57) Abstract: The invention describes novel organic nitric oxide donor salts of a antimicrobial . compounds, and novel compositions and kits comprising at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound and/or at least one therapeutic agent. The invention also provides methods for (a) treating bacterial infections; (b) treating viral infections; (c) treating fungal infections; and (d) treating lesions. In one embodiment the antimicrobial compounds of the invention are aztreonam, ciprofloxacin, doripenam, duramycin and tobramycin. The organic nitric oxide donors that form salts are preferably organic nitrates, organic nitrites, nitrosothiols, thionitrites and heterocyclic nitric oxide donors. The heterocyclic nitric oxide donors are preferably furoxans, sydnonimines, oxatriazole-5-ones and/or oxatriazole-5-imines. The methods of the invention are preferably for the treatment of bacterial infections associated with pulmonary diseases such as cystic fibrosis and for treating *Bacillus anthracis* infections.



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ORGANIC NITRIC OXIDE DONOR SALTS OF ANTIMICROBIAL COMPOUNDS, COMPOSITIONS AND METHODS OF USE

RELATED APPLICATIONS

5 This application claims priority under 35 USC § 119 to U.S. Application No. 60/653,120 filed February 16, 2005 and U.S. Application No. 60/741,454 filed December 2, 2005.

FIELD OF THE INVENTION

10 The invention describes novel organic nitric oxide donor salts of antimicrobial compounds, and novel compositions and kits comprising at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound and/or at least one therapeutic agent. The invention also provides methods for (a) treating bacterial infections; (b) treating viral infections; (c) treating fungal infections; and (d) treating lesions. In one embodiment the antimicrobial compounds of the invention are
15 aztreonam, ciprofloxacin, doripenam, duramycin and tobramycin. The organic nitric oxide donors that form salts are preferably organic nitrates, organic nitrites, nitrosothiols, thionitrites and heterocyclic nitric oxide donors. The heterocyclic nitric oxide donors are preferably furoxans, sydnonimines, oxatriazole-5-ones and/or oxatriazole-5-imines. The methods of the invention are preferably for the treatment of bacterial infections associated
20 with pulmonary diseases such as cystic fibrosis and for treating *Bacillus anthracis* infections.

BACKGROUND OF THE INVENTION

Antimicrobial compounds are used to control infections, to treat life-threatening diseases and to reduce death and illness. However, many antimicrobial compounds and antiviral compounds are potent anti-infective agents and also cause toxic side-effects such as
25 skin rashes, shock and other allergic responses, toxic effects on the stomach, liver and kidney. In addition the wide use of antimicrobial compounds and antiviral compounds in the treatment of infections has caused the development of strains resistant to these drugs.

Hence there is a need in the art for antimicrobial compounds that can be administered to treat infections and that have improved efficacy, lower toxicity, can be used at low dosages and reduce microbial resistance. The invention is directed to these, as well as other,
30 important ends.

SUMMARY OF THE INVENTION

The invention provides novel organic nitric oxide donor salts of antimicrobial compounds. The antimicrobial compounds must contain one or more of the following

functionalities: a carboxylic acid group (-COOH), a hydroxyl group (-OH), a thiol group (-SH) and/or a primary or secondary amine group (-NH). The invention also provides compositions comprising the novel compounds described herein in a pharmaceutically acceptable carrier.

5 The invention is also based on the discovery that administering at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound improves the properties of the cardiovascular compound. Nitric oxide enhancing compounds include, for example, S-nitrosothiols, nitrites, nitrates, N-oxo-N-nitrosamines, furoxans, sydnonimines, SPM 3672, SPM 4757, SPM 5185, SPM 5186 and
10 analogues thereof, substrates of the various isozymes of nitric oxide synthase, and nitroxides. Thus, another embodiment of the invention provides compositions comprising at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound.

 Another embodiment of the invention provides compositions comprising at least one
15 organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound and/or at least one therapeutic agent, including, but not limited to, aldosterone antagonists, α -adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors,
20 antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors,
5 selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof. In one embodiment the at least one therapeutic agent is selected from the group consisting of a β -adrenergic agonist, an anti-allergic compound, an antitussive compound, an antioxidant, a bronchodilator, an expectorant, a H_2 receptor antagonist, a nonsteroidal antiinflammatory compound (NSAIDs), a phosphodiesterase inhibitor, a proton pump
0 inhibitor, a selective cyclooxygenase-2 (COX-2) inhibitor and a steroid. The invention also provides for such compositions in a pharmaceutically acceptable carrier.

 Yet another embodiment of the invention provides methods for (a) treating bacterial infections; (b) treating viral infections; (c) treating fungal infections; and (d) treating lesions in a patient in need thereof comprising administering to the patient a therapeutically effective

amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound. The methods can optionally further comprise the administration of at least one therapeutic agent, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof. In this embodiment of the invention, the methods can involve (i) administering the organic nitric oxide donor salt of the antimicrobial compound, (ii) administering the organic nitric oxide donor salt of the antimicrobial compound, and nitric oxide enhancing compounds, (iii) administering the organic nitric oxide donor salt of the antimicrobial compound, and therapeutic agents, or (iv) administering the organic nitric oxide donor salt of the antimicrobial compound, nitric oxide enhancing compounds and therapeutic agents. The organic nitric oxide donor salt of the antimicrobial compound, nitric oxide enhancing compounds, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

Another embodiment of the invention provides kits comprising at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally, at least one nitric oxide enhancing compound. The kit can further comprise at least one therapeutic agent, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof. The organic nitric oxide donor salt of the antimicrobial compound, the nitric oxide

enhancing compound and/or therapeutic agent, can be separate components in the kit or can be in the form of a composition in one or more pharmaceutically acceptable carriers.

These and other aspects of the invention are described in detail herein.

DETAILED DESCRIPTION OF THE INVENTION

As used throughout the disclosure, the following terms, unless otherwise indicated, shall be understood to have the following meanings.

“Antimicrobial compound” refers to any compound that alters the growth of bacterial, fungi or virus cells whereby growth is prevented, modified, impaired, stabilized, inhibited or terminated. Antimicrobial compounds can be microbiocidal or microbiostatic and include, but are not limited to antibiotics, chemotherapeutic agents, semisynthetic antibiotics, synthetic antibiotics, antifungal compounds, antiviral compounds, and the like.

“Antifungal compound” refers to any compound that alters the growth of fungi whereby growth is prevented, modified, impaired, stabilized, inhibited or terminated.

“Antiviral compound” refers to any compound that alters the growth of viral cells whereby growth is prevented, modified, impaired, stabilized, inhibited or terminated.

“Bacterial infection” refers to any infection resulting from a bacteria or pathogen, including but not limited to infections resulting from *Acinetobacter*, *Actinomyces israelii*, *Alcaligenes xylosoxidans*, *Bacillus anthracis*, *Borrelia burgdorferi*, *Borrelia recurrentis*, *Brucella*, *Burkholderia cepacia*, *Campylobacter jejuni*, *Campylobacter fetus*, *Calymmatobacterium granulomatis*, *Chlamydia psittaci*, *Chlamydia pneumoniae*, *Chlamydia trachomatis*, *Clostridium perfringens*, *Clostridium tetani*, *Clostridium difficile*, *Corynebacterium diphtheriae*, *Corynebacterium species*, *Enterobacter species*, *Erysipelothrix rhusiopathiae*, *Escherichia coli*, *Flavobacterium meningosepticum*, *Francisella tularensis*, *Fusobacterium nucleatum*, *Haemophilus ducreyi*, *Haemophilus influenzae*, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Legionella pneumophila*, *Leptospira*, *Listeria monocytogenes*, *Moraxella catarrhalis*, *Mycobacterium avium-intracellulare*, *Mycobacterium tuberculosis*, *Mycobacterium leprae*, *Mycoplasma pneumoniae*, *Neisseria gonorrhoeae*, *Neisseria meningitidis*, *Nitrobacter species*, *Nocardia asteroides*, *Pasteurella multocida*, *Pneumocystis carinii*, *Proteus mirabilis*, *Proteus*, *Pseudomonas aeruginosa*, *Pseudomonas mallei*, *Pseudomonas pseudomallei*, *Rickettsia*, *Salmonella*, *Shigella*, *Serratia*, *Streptococcus aureus*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, *Streptococcus*, *Streptococcus agalactiae*, *Streptococcus bovis*, *Streptobacillus moniliformis*, *Serratia marcescens*, *Stenotrophomonas maltophilia*, *Treponema pallidum*, *Treponema pertenue*, *Ureaplasma urealyticum*, *Vibria cholerae*, *Yersinia pestis*, *Yersinia enterocolitica*, and the

like; pulmonary infections in patients with disease including, but not limited to, endobronchial infections, cystic fibrosis, bronchiectasis, pneumonia, tuberculosis, emphysema, AIDS, pneumococcal meningitis, bacteremia, otitis media, chronic obstructive pulmonary disease, sinus congestion, common cold, septicemia and the like; gastrointestinal infections, including, but not limited to, chronic gastritis, gastric ulcer, duodenal ulcer, *Helicobacter pylori*, gastric malignant lymphoma, gastroenteritis, diarrhea, dysentery, inflammatory bowel disease, Crohn's disease, ulcerative colitis, infections resulting from *E. Coli*, and the like; and infections of the eyes, ear or nose.

"Fungal infection" refers to and includes any infection resulting from a fungi, including but not limited to, infections resulting from *Aspergillus species*, agents of mucormycosis, *Blastomyces dermatitidis*, *Candida species*, *Coccidioides immitis*, *Cryptococcus neoformans*, *Histoplasma capsulatum*, *Mucoramyces pseudallescheriasis*, *Paracoccidioides brasiliensis*, *Sporothrix schenckii*, and the like.

"Viral infection" refers to and includes any infection resulting from a virus, including but not limited to infections resulting from adenovirus, anaerobic bacilli, cytomegalovirus, corona virus, cellulites, Epstein barr virus, Herpes simplex virus, human immunodeficiency virus (HIV), human papilloma virus, influenza virus, mycobacteria, parainfluenza virus, picornavirus, papilloma virus, respiratory syncytial virus, staphylococci, streptococci, syncytial virus, varicella zoster virus, severe acute respiratory syndrome (SARS) and the like. Microbial infection includes dental diseases such as gingival inflammations, periodontal inflammations, dental caries, and the like.

"Lesion" refers to and includes any lesion such as those caused by antineoplastic therapy such as radiation, chemotherapy; surgical intervention such as hemorrhoidectomy, biopsy procedure, resection; herpes virus; lesions of the distal bowel such as proctitis, enteritis, Crohn's disease, ulcerative colitis, those resulting from microbial infections, and the like.

"Therapeutic agent" includes any therapeutic agent that can be used to treat or prevent the diseases described herein. "Therapeutic agents" include, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal

antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and the like. Therapeutic agent includes the pro-drugs and pharmaceutical derivatives thereof including, but not limited to, the
5 corresponding nitrosated and/or nitrosylated derivatives. Although nitric oxide donors have therapeutic activity, the term "therapeutic agent" does not include the nitric oxide donors described herein, since nitric oxide donors are separately defined.

"Prodrug" refers to a compound that is made more active *in vivo*.

"Antioxidant" refers to and includes any compound that can react and quench a free
10 radical.

"Angiotensin converting enzyme (ACE) inhibitor" refers to compounds that inhibit an enzyme which catalyzes the conversion of angiotensin I to angiotensin II. ACE inhibitors include, but are not limited to, amino acids and derivatives thereof, peptides, including di- and tri-peptides, and antibodies to ACE which intervene in the renin-angiotensin system by
5 inhibiting the activity of ACE thereby reducing or eliminating the formation of the pressor substance angiotensin II.

"Angiotensin II antagonists" refers to compounds which interfere with the function, synthesis or catabolism of angiotensin II. Angiotensin II antagonists include peptide compounds and non-peptide compounds, including, but not limited to, angiotensin II
10 antagonists, angiotensin II receptor antagonists, agents that activate the catabolism of angiotensin II, and agents that prevent the synthesis of angiotensin I from angiotensin II. The renin-angiotensin system is involved in the regulation of hemodynamics and water and electrolyte balance. Factors that lower blood volume, renal perfusion pressure, or the concentration of sodium in plasma tend to activate the system, while factors that increase
15 these parameters tend to suppress its function.

"Anti-hyperlipidemic compounds" refers to any compound or agent that has the effect of beneficially modifying serum cholesterol levels such as, for example, lowering serum low density lipoprotein (LDL) cholesterol levels, or inhibiting oxidation of LDL cholesterol, whereas high density lipoprotein (HDL) serum cholesterol levels may be lowered, remain the same, or be increased. Preferably, the anti-hyperlipidemic compound brings the serum levels of LDL cholesterol and HDL cholesterol (and, more preferably, triglyceride levels) to normal or nearly normal levels.

"Diuretic compound" refers to and includes any compound or agent that increases the amount of urine excreted by a patient.

"Neutral endopeptidase inhibitors" refers to and includes compounds that are antagonists of the renin angiotensin aldosterone system including compounds that are dual inhibitors of neutral endopeptidases and angiotensin converting (ACE) enzymes.

"Renin inhibitors" refers to compounds which interfere with the activity of renin.

5 "Phosphodiesterase inhibitor" or "PDE inhibitor" refers to any compound that inhibits the enzyme phosphodiesterase. The term refers to selective or non-selective inhibitors of cyclic guanosine 3',5'-monophosphate phosphodiesterases (cGMP-PDE) and cyclic adenosine 3',5'-monophosphate phosphodiesterases (cAMP-PDE).

10 "Platelet reducing agents" refers to compounds that prevent the formation of a blood thrombus via any number of potential mechanisms. Platelet reducing agents include, but are not limited to, fibrinolytic agents, anti-coagulant agents and any inhibitors of platelet function. Inhibitors of platelet function include agents that impair the ability of mature platelets to perform their normal physiological roles (i.e., their normal function, such as, for example, adhesion to cellular and non-cellular entities, aggregation, release of factors such as growth factors) and the like.

15 "Proton pump inhibitor" refers to any compound that reversibly or irreversibly blocks gastric acid secretion by inhibiting the H^+/K^+ -ATP ase enzyme system at the secretory surface of the gastric parietal cell.

20 "NSAID" refers to a nonsteroidal anti-inflammatory compound or a nonsteroidal anti-inflammatory drug. NSAIDs inhibit cyclooxygenase, the enzyme responsible for the biosyntheses of the prostaglandins and certain autocoid inhibitors, including inhibitors of the various isozymes of cyclooxygenase (including but not limited to cyclooxygenase-1 and -2), and as inhibitors of both cyclooxygenase and lipoxigenase.

5 "Cyclooxygenase-2 (COX-2) selective inhibitor" refers to a compound that selectively inhibits the cyclooxygenase-2 enzyme over the cyclooxygenase-1 enzyme. In one embodiment, the compound has a cyclooxygenase-2 IC_{50} of less than about 2 μM and a cyclooxygenase-1 IC_{50} of greater than about 5 μM , in the human whole blood COX-2 assay (as described in Brideau et al., *Inflamm Res.*, 45: 68-74 (1996)) and also has a selectivity ratio of cyclooxygenase-2 inhibition over cyclooxygenase-1 inhibition of at least 10, and preferably of at least 40. In another embodiment, the compound has a cyclooxygenase-1 IC_{50} of greater than about 1 μM , and preferably of greater than 20 μM . The compound can also inhibit the enzyme, lipoxigenase. Such selectivity may indicate an ability to reduce the incidence of common NSAID-induced side effects.

"Patient" refers to animals, preferably mammals, most preferably humans, and

includes males and females, and children and adults.

"Transdermal" refers to the delivery of a compound by passage through the skin and into the blood stream.

"Transmucosal" refers to delivery of a compound by passage of the compound through the mucosal tissue and into the blood stream.

"Penetration enhancement" or "permeation enhancement" refers to an increase in the permeability of the skin or mucosal tissue to a selected pharmacologically active compound such that the rate at which the compound permeates through the skin or mucosal tissue is increased.

"Inhaled" or "inhalation" refers to the delivery of a compound where a maximum amount of compound is delivered to the patient's airways, respiratory tract and/or lungs.

"Penetration enhancement" or "permeation enhancement" refers to an increase in the permeability of the skin or mucosal tissue to a selected pharmacologically active compound such that the rate at which the compound permeates through the skin or mucosal tissue is increased.

"Carriers" or "vehicles" refers to carrier materials suitable for compound administration and include any such material known in the art such as, for example, any liquid, gel, solvent, liquid diluent, solubilizer, or the like, which is non-toxic and which does not interact with any components of the composition in a deleterious manner.

"Sustained release" refers to the release of a therapeutically active compound and/or composition such that the blood levels of the therapeutically active compound are maintained within a desirable therapeutic range over a period of time. The sustained release formulation can be prepared using any conventional method known to one skilled in the art to obtain the desired release characteristics.

"Nitric oxide enhancing" refers to compounds and functional groups which, under physiological conditions can increase endogenous nitric oxide. Nitric oxide enhancing compounds include, but are not limited to, nitric oxide releasing compounds, nitric oxide donating compounds, nitric oxide donors, radical scavenging compounds and/or reactive oxygen species scavenger compounds. In one embodiment the radical scavenging compound contains a nitroxide group.

"Nitroxide group" refers to compounds that have the ability to mimic superoxide dimutase and catalase and act as radical scavengers, or react with superoxide or other reactive oxygen species via a stable aminoxyl radical i.e. N-oxide.

"Nitric oxide adduct" or "NO adduct" refers to compounds and functional groups

which, under physiological conditions, can donate, release and/or directly or indirectly transfer any of the three redox forms of nitrogen monoxide (NO^+ , NO^- , $\text{NO}\bullet$), such that the biological activity of the nitrogen monoxide species is expressed at the intended site of action.

"Nitric oxide releasing" or "nitric oxide donating" refers to methods of donating, releasing and/or directly or indirectly transferring any of the three redox forms of nitrogen monoxide (NO^+ , NO^- , $\text{NO}\bullet$), such that the biological activity of the nitrogen monoxide species is expressed at the intended site of action.

"Nitric oxide donor" or "NO donor" refers to compounds that donate, release and/or directly or indirectly transfer a nitrogen monoxide species, and/or stimulate the endogenous production of nitric oxide or endothelium-derived relaxing factor (EDRF) *in vivo* and/or elevate endogenous levels of nitric oxide or EDRF *in vivo* and/or are oxidized to produce nitric oxide and/or are substrates for nitric oxide synthase and/or cytochrome P450. "NO donor" also includes compounds that are precursors of L-arginine, inhibitors of the enzyme arginase and nitric oxide mediators.

"Heterocyclic nitric oxide donor" refers to a trisubstituted 5-membered ring comprising two or three nitrogen atoms and at least one oxygen atom. The heterocyclic nitric oxide donor is capable of donating and/or releasing a nitrogen monoxide species upon decomposition of the heterocyclic ring. Exemplary heterocyclic nitric oxide donors include oxatriazol-5-ones, oxatriazol-5-imines, sydnonimines, furoxans, and the like.

"Organic nitric oxide donor salt" refers to any organic compound that contains a nitric oxide donor group and is capable of donating or transferring a biologically active form of nitrogen monoxide (i.e., nitric oxide) or is capable of increasing the levels of endogeneous nitric oxide and also capable of ionically associating with a compound through at least one acidic group or basic group. Exemplary organic nitric oxide donor salts include N-[4-(hydroxymethyl)-1,2,5-oxadiazol-3-yl]carbonylglycine N-oxide (ACS registry number 158590-81-9), 3-[[5-oxido-4-(phenylsulfonyl)-1,2,5-oxadiazol-3-yl]oxy]methylpyridine (ACS registry number 174187-57-6), N,N-dimethyl-2-[[5-oxido-4-(phenylsulfonyl)-1,2,5-oxadiazol-3-yl]oxy]-ethanamine ((ACS registry number 186408-97-9), 2,2',2''-nitrilotriethanol trinitrate (ACS registry number 7077-34-1), N,N-bis(2-hydroxyethyl)-nicotinamide dinitrate (ACS registry number 1157-74-0), [1-hydroxy-4-[[4-[(nitrooxy)methyl]benzoyl]amino] butylidene]bis- phosphonic acid (ACS registry number 636585-86-9), 4-(nitrooxy)-, (S)-(2-sulfoethyl) butanethioate (ACS registry number 586351-09-9), 3-(Nitryloxy)-2,2-bis[(nitryloxy) methyl] propionic acid (ACS registry number 67406-79-5), (S)-[2-[4-(2-hydroxyethyl)-1-piperidinyl]-1,1-dimethylethyl] thionitrite (ACS registry

number 364590-39-6), (S)-[1,1-dimethyl-2-[(3-pyridinylcarbonyl)amino]ethyl] thionitrite (ACS registry number 307492-58-6), 2-(acetylamino)-2-carboxy-1,1-dimethylethyl thionitrite (ACS registry number 67776-06-1), and the like.

"Alkyl" refers to a lower alkyl group, a substituted lower alkyl group, a haloalkyl group, a hydroxyalkyl group, an alkenyl group, a substituted alkenyl group, an alkynyl group, a bridged cycloalkyl group, a cycloalkyl group or a heterocyclic ring, as defined herein. An alkyl group may also comprise one or more radical species, such as, for example a cycloalkylalkyl group or a heterocyclicalkyl group.

"Lower alkyl" refers to branched or straight chain acyclic alkyl group comprising one to about ten carbon atoms (preferably one to about eight carbon atoms, more preferably one to about six carbon atoms). Exemplary lower alkyl groups include methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, pentyl, neopentyl, iso-amyl, hexyl, octyl, and the like.

"Substituted lower alkyl" refers to a lower alkyl group, as defined herein, wherein one or more of the hydrogen atoms have been replaced with one or more R^{100} groups, wherein each R^{100} is independently a hydroxy, an ester, an amidyl, an oxo, a carboxyl, a carboxamido, a halo, a cyano, a nitrate, a nitrite, a thionitrate, a thionitrite or an amino group, as defined herein.

"Haloalkyl" refers to a lower alkyl group, an alkenyl group, an alkynyl group, a bridged cycloalkyl group, a cycloalkyl group or a heterocyclic ring, as defined herein, to which is appended one or more halogens, as defined herein. Exemplary haloalkyl groups include trifluoromethyl, chloromethyl, 2-bromobutyl, 1-bromo-2-chloro-pentyl, and the like.

"Alkenyl" refers to a branched or straight chain C_2 - C_{10} hydrocarbon (preferably a C_2 - C_8 hydrocarbon, more preferably a C_2 - C_6 hydrocarbon) that can comprise one or more carbon-carbon double bonds. Exemplary alkenyl groups include propylenyl, buten-1-yl, isobutenyl, penten-1-yl, 2,2-methylbuten-1-yl, 3-methylbuten-1-yl, hexan-1-yl, hepten-1-yl, octen-1-yl, and the like.

"Lower alkenyl" refers to a branched or straight chain C_2 - C_4 hydrocarbon that can comprise one or two carbon-carbon double bonds.

"Substituted alkenyl" refers to a branched or straight chain C_2 - C_{10} hydrocarbon (preferably a C_2 - C_8 hydrocarbon, more preferably a C_2 - C_6 hydrocarbon) which can comprise one or more carbon-carbon double bonds, wherein one or more of the hydrogen atoms have been replaced with one or more R^{100} groups, wherein each R^{100} is independently a hydroxy, an oxo, a carboxyl, a carboxamido, a halo, a cyano or an amino group, as defined herein.

"Alkynyl" refers to an unsaturated acyclic C₂-C₁₀ hydrocarbon (preferably a C₂-C₈ hydrocarbon, more preferably a C₂-C₆ hydrocarbon) that can comprise one or more carbon-carbon triple bonds. Exemplary alkynyl groups include ethynyl, propynyl, butyn-1-yl, butyn-2-yl, pentyl-1-yl, pentyl-2-yl, 3-methylbutyn-1-yl, hexyl-1-yl, hexyl-2-yl, hexyl-3-yl, 3,3-dimethyl-butyn-1-yl, and the like.

"Bridged cycloalkyl" refers to two or more cycloalkyl groups, heterocyclic groups, or a combination thereof fused via adjacent or non-adjacent atoms. Bridged cycloalkyl groups can be unsubstituted or substituted with one, two or three substituents independently selected from alkyl, alkoxy, amino, alkylamino, dialkylamino, hydroxy, halo, carboxyl, alkylcarboxylic acid, aryl, amidyl, ester, alkylcarboxylic ester, carboxamido, alkylcarboxamido, oxo and nitro. Exemplary bridged cycloalkyl groups include adamantyl, decahydronaphthyl, quinuclidyl, 2,6-dioxabicyclo(3.3.0)octane, 7-oxabicyclo(2.2.1)heptyl, 8-azabicyclo(3,2,1)oct-2-enyl and the like.

"Cycloalkyl" refers to a saturated or unsaturated cyclic hydrocarbon comprising from about 3 to about 10 carbon atoms. Cycloalkyl groups can be unsubstituted or substituted with one, two or three substituents independently selected from alkyl, alkoxy, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino, aryl, amidyl, ester, hydroxy, halo, carboxyl, alkylcarboxylic acid, alkylcarboxylic ester, carboxamido, alkylcarboxamido, oxo, alkylsulfinyl, and nitro. Exemplary cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclohexenyl, cyclohepta-1,3-dienyl, and the like.

"Heterocyclic ring or group" refers to a saturated or unsaturated cyclic hydrocarbon group having about 2 to about 10 carbon atoms (preferably about 4 to about 6 carbon atoms) where 1 to about 4 carbon atoms are replaced by one or more nitrogen, oxygen and/or sulfur atoms. Sulfur maybe in the thio, sulfinyl or sulfonyl oxidation state. The heterocyclic ring or group can be fused to an aromatic hydrocarbon group. Heterocyclic groups can be unsubstituted or substituted with one, two or three substituents independently selected from alkyl, alkoxy, amino, alkylthio, aryloxy, arylthio, arylalkyl, hydroxy, oxo, thial, halo, carboxyl, carboxylic ester, alkylcarboxylic acid, alkylcarboxylic ester, aryl, arylcarboxylic acid, arylcarboxylic ester, amidyl, ester, alkylcarbonyl, arylcarbonyl, alkylsulfinyl, carboxamido, alkylcarboxamido, arylcarboxamido, sulfonic acid, sulfonic ester, sulfonamide nitrate and nitro. Exemplary heterocyclic groups include pyrrolyl, furyl, thienyl, 3-pyrrolinyl, 4,5,6-trihydro-2H-pyranyl, pyridinyl, 1,4-dihydropyridinyl, pyrazolyl, triazolyl, pyrimidinyl, pyridazinyl, oxazolyl, thiazolyl, imidazolyl, indolyl, thiophenyl, furanyl, tetrahydrofuranlyl, tetrazolyl, pyrrolinyl, pyrrolindinyl, oxazolindinyl, 1,3-dioxolanyl,

imidazolinyl, imidazolindinyl, pyrazolinyl, pyrazolidinyl, isoxazolyl, isothiazolyl, 1,2,3-oxadiazolyl, 1,2,3-triazolyl, 1,3,4-thiadiazolyl, 2H-pyranyl, 4H-pyranyl, piperidinyl, 1,4-dioxanyl, morpholinyl, 1,4-dithianyl, thiomorpholinyl, pyrazinyl, piperazinyl, 1,3,5-triazinyl, 1,3,5-trithianyl, benzo(b)thiophenyl, benzimidazolyl, benzothiazolinyl, quinolinyl, 2,6-dioxabicyclo(3.3.0)octane, and the like.

"Heterocyclic compounds" refer to mono- and polycyclic compounds comprising at least one aryl or heterocyclic ring.

"Aryl" refers to a monocyclic, bicyclic, carbocyclic or heterocyclic ring system comprising one or two aromatic rings. Exemplary aryl groups include phenyl, pyridyl, naphthyl, quinoyl, tetrahydronaphthyl, furanyl, indanyl, indenyl, indoyl, and the like. Aryl groups (including bicyclic aryl groups) can be unsubstituted or substituted with one, two or three substituents independently selected from alkyl, alkoxy, alkylthio, amino, alkylamino, dialkylamino, arylamino, diarylamino, alkylarylamino, halo, cyano, alkylsulfinyl, hydroxy, carboxyl, carboxylic ester, alkylcarboxylic acid, alkylcarboxylic ester, aryl, arylcarboxylic acid, arylcarboxylic ester, alkylcarbonyl, arylcarbonyl, amidyl, ester, carboxamido, alkylcarboxamido, carbomyl, sulfonic acid, sulfonic ester, sulfonamido and nitro. Exemplary substituted aryl groups include tetrafluorophenyl, pentafluorophenyl, sulfonamide, alkylsulfonyl, arylsulfonyl, and the like.

"Cycloalkenyl" refers to an unsaturated cyclic C₂-C₁₀ hydrocarbon (preferably a C₂-C₈ hydrocarbon, more preferably a C₂-C₆ hydrocarbon) which can comprise one or more carbon-carbon double bonds.

"Alkylaryl" refers to an alkyl group, as defined herein, to which is appended an aryl group, as defined herein. Exemplary alkylaryl groups include benzyl, phenylethyl, hydroxybenzyl, fluorobenzyl, fluorophenylethyl, and the like.

"Arylalkyl" refers to an aryl radical, as defined herein, attached to an alkyl radical, as defined herein. Exemplary arylalkyl groups include benzyl, phenylethyl, 4-hydroxybenzyl, 3-fluorobenzyl, 2-fluorophenylethyl, and the like.

"Arylalkenyl" refers to an aryl radical, as defined herein, attached to an alkenyl radical, as defined herein. Exemplary arylalkenyl groups include styryl, propenylphenyl, and the like.

"Cycloalkylalkyl" refers to a cycloalkyl radical, as defined herein, attached to an alkyl radical, as defined herein.

"Cycloalkylalkoxy" refers to a cycloalkyl radical, as defined herein, attached to an alkoxy radical, as defined herein.

"Cycloalkylalkylthio" refers to a cycloalkyl radical, as defined herein, attached to an alkylthio radical, as defined herein.

"Heterocyclicalkyl" refers to a heterocyclic ring radical, as defined herein, attached to an alkyl radical, as defined herein.

5 "Arylheterocyclic ring" refers to a bi- or tricyclic ring comprised of an aryl ring, as defined herein, appended via two adjacent carbon atoms of the aryl ring to a heterocyclic ring, as defined herein. Exemplary arylheterocyclic rings include dihydroindole, 1,2,3,4-tetrahydroquinoline, and the like.

10 "Alkylheterocyclic ring" refers to a heterocyclic ring radical, as defined herein, attached to an alkyl radical, as defined herein. Exemplary alkylheterocyclic rings include 2-pyridylmethyl, 1-methylpiperidin-2-one-3-methyl, and the like.

"Alkoxy" refers to $R_{50}O-$, wherein R_{50} is an alkyl group, as defined herein (preferably a lower alkyl group or a haloalkyl group, as defined herein). Exemplary alkoxy groups include methoxy, ethoxy, t-butoxy, cyclopentyloxy, trifluoromethoxy, and the like.

5 "Aryloxy" refers to $R_{55}O-$, wherein R_{55} is an aryl group, as defined herein. Exemplary arylkoxy groups include naphthyloxy, quinolyloxy, isoquinolizinyloxy, and the like.

"Alkylthio" refers to $R_{50}S-$, wherein R_{50} is an alkyl group, as defined herein.

"Lower alkylthio" refers to a lower alkyl group, as defined herein, appended to a thio group, as defined herein.

0 "Arylalkoxy" or "alkoxyaryl" refers to an alkoxy group, as defined herein, to which is appended an aryl group, as defined herein. Exemplary arylalkoxy groups include benzyloxy, phenylethoxy, chlorophenylethoxy, and the like.

5 "Arylalklythio" refers to an alkylthio group, as defined herein, to which is appended an aryl group, as defined herein. Exemplary arylalklythio groups include benzylthio, phenylethylthio, chlorophenylethylthio, and the like.

"Arylalklythioalkyl" refers to an arylalkylthio group, as defined herein, to which is appended an alkyl group, as defined herein. Exemplary arylalklythioalkyl groups include benzylthiomethyl, phenylethylthiomethyl, chlorophenylethylthioethyl, and the like.

10 "Alkylthioalkyl" refers to an alkylthio group, as defined herein, to which is appended an alkyl group, as defined herein. Exemplary alkylthioalkyl groups include allylthiomethyl, ethylthiomethyl, trifluoroethylthiomethyl, and the like.

"Alkoxyalkyl" refers to an alkoxy group, as defined herein, appended to an alkyl group, as defined herein. Exemplary alkoxyalkyl groups include methoxymethyl, methoxyethyl, isopropoxymethyl, and the like.

"Alkoxyhaloalkyl" refers to an alkoxy group, as defined herein, appended to a haloalkyl group, as defined herein. Exemplary alkoxyhaloalkyl groups include 4-methoxy-2-chlorobutyl and the like.

"Cycloalkoxy" refers to $R_{54}O-$, wherein R_{54} is a cycloalkyl group or a bridged cycloalkyl group, as defined herein. Exemplary cycloalkoxy groups include cyclopropyloxy, cyclopentyloxy, cyclohexyloxy, and the like.

"Cycloalkylthio" refers to $R_{54}S-$, wherein R_{54} is a cycloalkyl group or a bridged cycloalkyl group, as defined herein. Exemplary cycloalkylthio groups include cyclopropylthio, cyclopentylthio, cyclohexylthio, and the like.

"Haloalkoxy" refers to an alkoxy group, as defined herein, in which one or more of the hydrogen atoms on the alkoxy group are substituted with halogens, as defined herein. Exemplary haloalkoxy groups include 1,1,1-trichloroethoxy, 2-bromobutoxy, and the like.

"Hydroxy" refers to $-OH$.

"Oxy" refers to $-O-$

"Oxo" refers to $=O$.

"Oxylate" refers to $-O^- R_{77}^+$ wherein R_{77} is an organic or inorganic cation.

"Thiol" refers to $-SH$.

"Thio" refers to $-S-$.

"Oxime" refers to $=N-OR_{81}$ wherein R_{81} is a hydrogen, an alkyl group, an aryl group, an alkylsulfonyl group, an arylsulfonyl group, a carboxylic ester, an alkylcarbonyl group, an arylcarbonyl group, a carboxamido group, an alkoxyalkyl group or an alkoxyaryl group.

"Hydrazone" refers to $=N-N(R_{81})(R'_{81})$ wherein R'_{81} is independently selected from R_{81} , and R_{81} is as defined herein.

"Hydrazino" refers to $H_2N-N(H)-$.

"Organic cation" refers to a positively charged organic ion. Exemplary organic cations include alkyl substituted ammonium cations, and the like.

"Inorganic cation" refers to a positively charged metal ion. Exemplary inorganic cations include Group I metal cations such as for example, sodium, potassium, magnesium, calcium, and the like.

"Hydroxyalkyl" refers to a hydroxy group, as defined herein, appended to an alkyl group, as defined herein.

"Nitrate" refers to $-O-NO_2$ i.e. oxidized nitrogen.

"Nitrite" refers to $-O-NO$ i.e. oxidized nitrogen.

"Thionitrate" refers to $-S-NO_2$.

"Thionitrite" and "nitrosothiol" refer to -S-NO.

"Nitro" refers to the group -NO₂ and "nitrosated" refers to compounds that have been substituted therewith.

"Nitroso" refers to the group -NO and "nitrosylated" refers to compounds that have been substituted therewith.

"Nitrile" and "cyano" refer to -CN.

"Halogen" or "halo" refers to iodine (I), bromine (Br), chlorine (Cl), and/or fluorine (F).

"Imine" refers to -C(=N-R₅₁)- wherein R₅₁ is a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein

"Amine" refers to any organic compound that contains at least one basic nitrogen atom.

"Amino" refers to -NH₂, an alkylamino group, a dialkylamino group, an arylamino group, a diarylamino group, an alkylarylamino group or a heterocyclic ring, as defined herein.

"Alkylamino" refers to R₅₀NH-, wherein R₅₀ is an alkyl group, as defined herein. Exemplary alkylamino groups include methylamino, ethylamino, butylamino, cyclohexylamino, and the like.

"Arylamino" refers to R₅₅NH-, wherein R₅₅ is an aryl group, as defined herein.

"Dialkylamino" refers to R₅₂R₅₃N-, wherein R₅₂ and R₅₃ are each independently an alkyl group, as defined herein. Exemplary dialkylamino groups include dimethylamino, diethylamino, methyl propargylamino, and the like.

"Diarylamino" refers to R₅₅R₆₀N-, wherein R₅₅ and R₆₀ are each independently an aryl group, as defined herein.

"Alkylarylamino or arylalkylamino" refers to R₅₂R₅₅N-, wherein R₅₂ is an alkyl group, as defined herein, and R₅₅ is an aryl group, as defined herein.

"Alkylarylalkylamino" refers to R₅₂R₇₉N-, wherein R₅₂ is an alkyl group, as defined herein, and R₇₉ is an arylalkyl group, as defined herein.

"Alkylcycloalkylamino" refers to R₅₂R₈₀N-, wherein R₅₂ is an alkyl group, as defined herein, and R₈₀ is a cycloalkyl group, as defined herein.

"Aminoalkyl" refers to an amino group, an alkylamino group, a dialkylamino group, an arylamino group, a diarylamino group, an alkylarylamino group or a heterocyclic ring, as defined herein, to which is appended an alkyl group, as defined herein. Exemplary aminoalkyl groups include dimethylaminopropyl, diphenylaminocyclopentyl, methylaminomethyl, and the like.

"Aminoaryl" refers to an aryl group to which is appended an alkylamino group, an arylamino group or an arylalkylamino group. Exemplary aminoaryl groups include anilino, N-methylanilino, N-benzylanilino, and the like.

"Sulfinyl" refers to $-S(O)-$.

"Methanthial" refers to $-C(S)-$.

"Thial" refers to $=S$.

"Sulfonyl" refers to $-S(O)_2-$.

"Sulfonic acid" refers to $-S(O)_2OR_{76}$, wherein R_{76} is a hydrogen, an organic cation or an inorganic cation, as defined herein.

"Alkylsulfonic acid" refers to a sulfonic acid group, as defined herein, appended to an alkyl group, as defined herein.

"Arylsulfonic acid" refers to a sulfonic acid group, as defined herein, appended to an aryl group, as defined herein.

"Sulfonic ester" refers to $-S(O)_2OR_{58}$, wherein R_{58} is an alkyl group, an aryl group, or an aryl heterocyclic ring, as defined herein.

"Sulfonamido" refers to $-S(O)_2-N(R_{51})(R_{57})$, wherein R_{51} and R_{57} are each independently a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein, or R_{51} and R_{57} when taken together are a heterocyclic ring, a cycloalkyl group or a bridged cycloalkyl group, as defined herein.

"Alkylsulfonamido" refers to a sulfonamido group, as defined herein, appended to an alkyl group, as defined herein.

"Arylsulfonamido" refers to a sulfonamido group, as defined herein, appended to an aryl group, as defined herein.

"Alkylthio" refers to $R_{50}S-$, wherein R_{50} is an alkyl group, as defined herein (preferably a lower alkyl group, as defined herein).

"Arylthio" refers to $R_{55}S-$, wherein R_{55} is an aryl group, as defined herein.

"Arylalkylthio" refers to an aryl group, as defined herein, appended to an alkylthio group, as defined herein.

"Alkylsulfinyl" refers to $R_{50}-S(O)-$, wherein R_{50} is an alkyl group, as defined herein.

"Alkylsulfonyl" refers to $R_{50}-S(O)_2-$, wherein R_{50} is an alkyl group, as defined herein.

"Alkylsulfonyloxy" refers to $R_{50}-S(O)_2-O-$, wherein R_{50} is an alkyl group, as defined herein.

"Arylsulfinyl" refers to $R_{55}-S(O)-$, wherein R_{55} is an aryl group, as defined herein.

"Arylsulfonyl" refers to $R_{55}-S(O)_2-$, wherein R_{55} is an aryl group, as defined herein.

"Arylsulfonyloxy" refers to $R_{55}\text{-S(O)}_2\text{-O-}$, wherein R_{55} is an aryl group, as defined herein.

"Amidyl" refers to $R_{51}\text{C(O)N(R}_{57}\text{)-}$ wherein R_{51} and R_{57} are each independently a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein.

5 "Ester" refers to $R_{51}\text{C(O)R}_{82}\text{-}$ wherein R_{51} is a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein and R_{82} is oxygen or sulfur.

10 "Carbamoyl" refers to $\text{-O-C(O)N(R}_{51}\text{)(R}_{57}\text{)}$, wherein R_{51} and R_{57} are each independently a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein, or R_{51} and R_{57} taken together are a heterocyclic ring, a cycloalkyl group or a bridged cycloalkyl group, as defined herein.

"Carboxyl" refers to -C(O)OR_{76} , wherein R_{76} is a hydrogen, an organic cation or an inorganic cation, as defined herein.

"Carbonyl" refers to -C(O)- .

"Alkylcarbonyl" refers to $R_{52}\text{-C(O)-}$, wherein R_{52} is an alkyl group, as defined herein.

5 "Arylcarbonyl" refers to $R_{55}\text{-C(O)-}$, wherein R_{55} is an aryl group, as defined herein.

"Arylalkylcarbonyl" refers to $R_{55}\text{-R}_{52}\text{-C(O)-}$, wherein R_{55} is an aryl group, as defined herein, and R_{52} is an alkyl group, as defined herein.

"Alkylarylcarbonyl" refers to $R_{52}\text{-R}_{55}\text{-C(O)-}$, wherein R_{55} is an aryl group, as defined herein, and R_{52} is an alkyl group, as defined herein.

0 "Heterocyclicalkylcarbonyl" refer to $R_{78}\text{C(O)-}$ wherein R_{78} is a heterocyclicalkyl group, as defined herein.

"Carboxylic ester" refers to -C(O)OR_{58} , wherein R_{58} is an alkyl group, an aryl group or an aryl heterocyclic ring, as defined herein.

5 "Alkylcarboxylic acid" and "alkylcarboxyl" refer to an alkyl group, as defined herein, appended to a carboxyl group, as defined herein.

"Alkylcarboxylic ester" refers to an alkyl group, as defined herein, appended to a carboxylic ester group, as defined herein.

"Alkyl ester" refers to an alkyl group, as defined herein, appended to an ester group, as defined herein.

10 "Arylcarboxylic acid" refers to an aryl group, as defined herein, appended to a carboxyl group, as defined herein.

"Arylcarboxylic ester" and "arylcarboxyl" refer to an aryl group, as defined herein, appended to a carboxylic ester group, as defined herein.

"Aryl ester" refers to an aryl group, as defined herein, appended to an ester group, as defined herein.

"Carboxamido" refers to $-C(O)N(R_{51})(R_{57})$, wherein R_{51} and R_{57} are each independently a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein, or R_{51} and R_{57} when taken together are a heterocyclic ring, a cycloalkyl group or a bridged cycloalkyl group, as defined herein.

"Alkylcarboxamido" refers to an alkyl group, as defined herein, appended to a carboxamido group, as defined herein.

"Arylcarboxamido" refers to an aryl group, as defined herein, appended to a carboxamido group, as defined herein.

"Urea" refers to $-N(R_{59})-C(O)N(R_{51})(R_{57})$ wherein R_{51} , R_{57} , and R_{59} are each independently a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein, or R_{51} and R_{57} taken together are a heterocyclic ring, a cycloalkyl group or a bridged cycloalkyl group, as defined herein.

"Phosphoryl" refers to $-P(R_{70})(R_{71})(R_{72})$, wherein R_{70} is a lone pair of electrons, thial or oxo, and R_{71} and R_{72} are each independently a covalent bond, a hydrogen, a lower alkyl, an alkoxy, an alkylamino, a hydroxy, an oxy or an aryl, as defined herein.

"Phosphoric acid" refers to $-P(O)(OR_{51})OH$ wherein R_{51} is a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein.

"Phosphinic acid" refers to $-P(O)(R_{51})OH$ wherein R_{51} is a hydrogen atom, an alkyl group, an aryl group or an arylheterocyclic ring, as defined herein.

"Silyl" refers to $-Si(R_{73})(R_{74})(R_{75})$, wherein R_{73} , R_{74} and R_{75} are each independently a covalent bond, a lower alkyl, an alkoxy, an aryl or an arylalkoxy, as defined herein.

"Organic acid" refers to compound having at least one carbon atom and one or more functional groups capable of releasing a proton to a basic group. The organic acid preferably contains a carboxyl, a sulfonic acid or a phosphoric acid moiety. Exemplary organic acids include acetic acid, benzoic acid, citric acid, camphorsulfonic acid, methanesulfonic acid, taurocholic acid, chlondronic acid, glyphosphate, medronic acid, and the like.

"Inorganic acid" refers to a compound that does not contain at least one carbon atom and is capable of releasing a proton to a basic group. Exemplary inorganic acids include hydrochloric acid, sulfuric acid, nitric acid, phosphoric acid, and the like.

"Organic base" refers to a carbon containing compound having one or more functional groups capable of accepting a proton from an acid group. The organic base preferably contains an amine group. Exemplary organic bases include triethylamine,

benzyl-diethylamine, dimethylethyl amine, imidazole, pyridine, piperidine, and the like.

The compounds used in the compounds and compositions of the invention are antimicrobial compounds. Suitable antimicrobial compounds, include, but are not limited to, acediasulfone, aceturate, acetyl sulfametossipirazine, acetyl sulfamethoxypyrazine, acranil, albendazole, alexidine, amatadine, ambazone, amdinocillin, amikacin, p-aminosalicylic acid, p-aminosalicylic acid hydrazine, amoxicillin, ampicillin, anisomycin, apalcillin, apicyclin, apramycin, arbekacin, arginins, aspoxicillin, azidamfenicol, azidocillin, azithromycin, azlocillin, aztreonam, bacampicillin, benzoylpas, benzyl penicillin acid, benzyl sulfamide, bicozamycin, bipenam, brodimoprim, capreomycin, carbenicillin, carbomycin, cafazedone, carindacillin, carumonam, cefcapene pivoxil, cefaclor, cefadroxil, cefafroxil, cefamandole, cefatamet, cefatrizine, cefazedone, cefazolin, cefbuperazone, cefclidin, cefdinir, cefditoren, cefixime, cefmenoxime, cefmetazole, cefminox, cefodizime, cefonicid, cefoperazone, ceforanide, cefotaxime, cefotetan, cefotiam, cefoxitin, cefozopran, cefpimizole, cefpiramide, cefpirome, cefpodoxime proxetil, cefprozil, cefroxadine, cefsulodin, ceftazidime, cefteram, ceftezole, ceftibuten, ceftiofur, ceftizoxime, ceftriaxone, cefuroxime, cefuzonam, cephaetrile sodium, cephadrine, cephalixin, cephaloglycin, cephaloridine, cephalosporin C, cephalothin, cephapirin sodium, cephradine, chloramphenicol, chlorotetracycline, cinoxacin, ciprofloxacin, claritromycin, clavulanic acid, clinafloxacin, clindamycin, clofazimine, clofoctal, clometocillin, clomocycline, cloxacillin, cloxyquin, cyclacilline, cycloserine, danoflaxcin, dapsone, deoxycycline, deoxydihydrostreptomycin, dibekacin, dicloxacillin, difloxacin, dihydrostreptomycin, dimetridazole, diminazene, dirirtomycin, doripenam, duramycin, eflornithine, enoxacin, enrofloxacin, enviomycin, epicillin, erythromycin, etacillin, ethambutol, ethionamide, famcyclovir, fenbecillin, fleroxacin, flomoxef, floxacillin, flumequine, furonazide, fortimycin, furazolium chloride, gentamycin, glyconiazide, grepafloxacin, guamecycline, halofuginone, hetacillin, homidium, hydroxyl-stilbamidine, ibostamycin, imidocarb, imipenam, ipronidazole, isoniazide, iosamycin, inosine, lauroguadine, lenampicillin, levofloxacin, lincomycin, lomefloxacin, loracarbef, lymecyclin, mafenide, mebendazole, meclocyclin, meropenem, metampicillin, metaciclone, methacycline, methicillin sodium, metronidazole, 4'-(methylsulfamoyl) sulfanilamide, mezlocillin, meziocillin, micronomycin, midecamycin A₁, minocycline, miocamycin, miokamycin, morfazinamide, moxalactam, mupirocin, myxin, nadifloxacin, nalidixic acid, negamycin, neomycin, netlimycin, nifurfoline, nifurpirinol, nifurprazine, nimorazole, nitroxoline, norfloxacin, novobiocin, ofloxacin, oleandomycin, opiniazide, oxacillin, oxophenarsine, oxolinic acid, oxytetracycline, panipenam, paromycin, pazufloxacin, pefloxacin, penicillin G

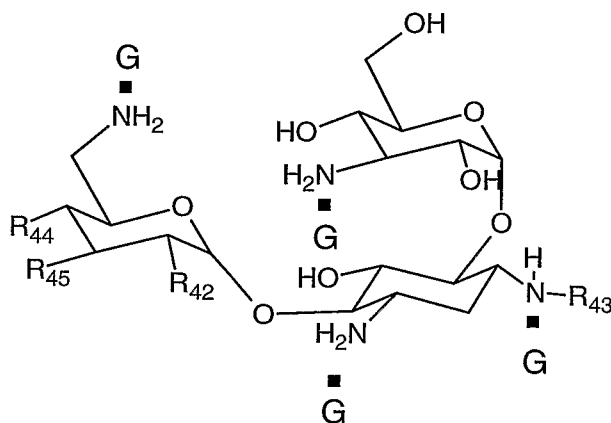
potassium salt, penicillin N, penicillin O, penicillin V, penethamate hydroiodide, pentamidine, phenamidine, phenethicillin potassium salt, phenyl aminosalicylate, pipacycline, pipemidic acid, piperacillin, pirlimycin, piromidic acid, pivampicillin, pivcefalexin, profiromycin, propamidine, propicillin, protionamide, puraltadone, puromycin, pyrazinamide, pyrimethamine, quinacillin, quinacrine, quinapyramine, quintine, ribostamycin, rifabutine, rifamide, rifampin, rifamycin, rifanpin, rifapentine, rifaxymine, ritipenem, rokitamycin, rolitetracycline, rosamycin, rufloxacin, salazosulfadimidine, salinazid, sancycline, sarafloxacin, sedacamycin, secnidazole, sisomycin, sparfloxacin, spectinomycin, spiramycin, spiramycin I, spiramycin II, spiramycin III, stilbamidine, streptomycin, streptonicizid, sulbactam, sulbenicillin, succisulfone, sulfanilamide, sulfabenzamide, sulfacetamide, sulfachloropyridazine, sulfachrysoidine, sulfacytine, sulfadiazine, sulfadicramide, sulfadimethoxine, sulfadoxine, sulfadrazine, sulfaetidol, sulfafenazol, sulfaguanidine, sulfaguanole, sulfalene, sulfamerazine, sulfameter, sulfamethazine, sulfamethizole, sulfamethomidine, sulfamethoxazole, sulfamethoxypyridazine, sulfamethylthiazol, sulfamethylthiazole, sulfametrole, sulfamidochrysoidine, sulfamoxole, sulfanilamide, 4-sulfanilamido salicylic acid, 4-4'-sulfanilylbenzylamine, p-sulfanilylbenzylamine, 2-p-sulfinylanilinoethanol, sulfanilylurea, sulfoniazide, sulfaperine, sulfaphenazole, sulfaproxyline, sulfapyrazine, sulfapyridine, sulfathiazole, sulfaethidole, sulfathiourea, sulfisomidine, sulfasomizole, sulfasymazine, sulfisoxazole, 4,4'-sulfinyldianiline, N⁴-sulfanilylsulfanilamide, N-sulfanilyl-3,4-xylamide, sultamicillin, talampicillin, tambutol, taurolidine, teicoplanin, temocillin, tetracycline, tetroxoprim, thiabendazole, thiazolsulfone, tibezoneium iodide, ticarcillin, tigemonam, tinidazole, tobramycin, tosufloxacin, trimethoprim, troleandomycin, trospectomycin, trovafloxacin, tubercidine, miokamycin, oleandomycin, troleandomycin, vancomycin, verazide, viomycin, virginiamycin and zalcitabine.

The contemplated compounds of the invention are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, (1996); Merck Index on CD-ROM, 13th Edition; STN Express, file phar and file registry, the disclosures of each of which are incorporated by reference herein in their entirety.

In one embodiment the antimicrobial compounds are amikacin, azetreonam, azithromycin, ciprofloxacin, doripenam, duramycin, gentamycin, tigecycline, tobramycin, vancomycin, PA-1806 and PA-2794. In other embodiments, the antimicrobial compounds are aztreonam, ciprofloxacin, doripenam, duramycin and tobramycin.

In one embodiment the antimicrobial compounds must contain one or more of the following functionalities: a carboxylic acid group (-COOH), a sulfonic acid group (-SO₃H), a phosphoric acid group (-P(O)(OH)(OH)), phosphinic acid group (-P(O)(R₅₁)(OH)), an amidine group (-C(=NH)-NH₂), a guanidine group (-N(H)C(O)-NH₂) and/or a primary or secondary amine group (-NH). The antimicrobial compounds form salts with at least one organic nitric oxide donor group that is ionically associated with the antimicrobial compound through one or more acid or base groups. The organic nitric oxide donors that form the salt are preferably organic nitrates, organic nitrites, nitrosothiols, thionitrites and heterocyclic nitric oxide donors. The heterocyclic nitric oxide donors are preferably furoxans, sydnones, oxatriazole-5-ones and/or oxatriazole-5-imines.

In another embodiment, the invention describes compounds of Formula (I):



I

wherein:

R₄₂ is -OH, -NH₂ or -NH₂•G;

R₄₃ is a hydrogen, (2S)-C(O)-CH(OH)-(CH₂)₂-NH₂, (2S)-C(O)-CH(OH)-(CH₂)₂-NH₂•G; (2R)-C(O)-CH(OH)-(CH₂)₂-NH₂ or (2R)-C(O)-CH(OH)-(CH₂)₂-NH₂•G;

R₄₄ and R₄₅ are each independently is a hydrogen or OH;

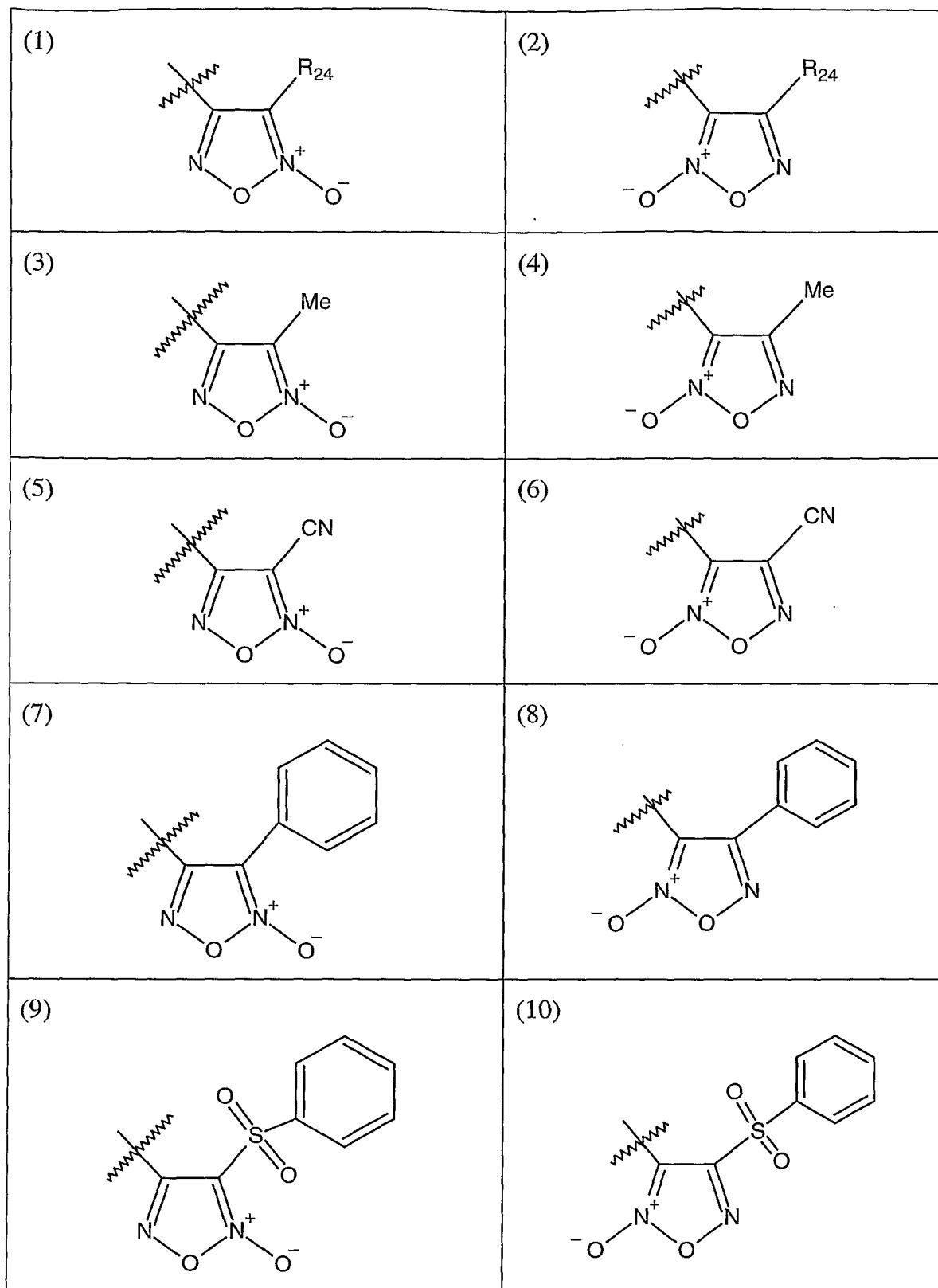
G is either not present, an organic acid, an inorganic acid, or K;

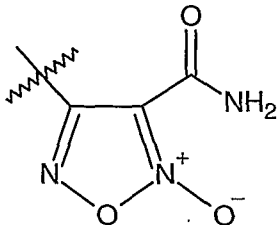
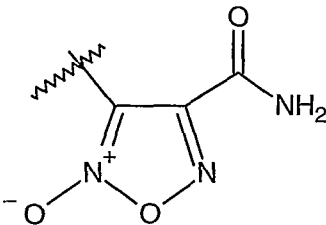
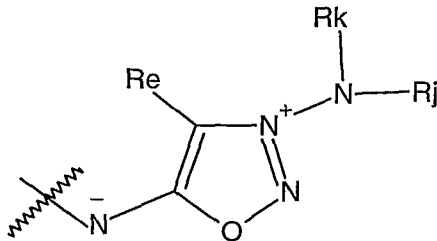
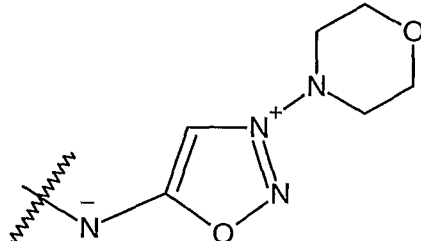
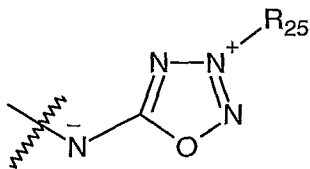
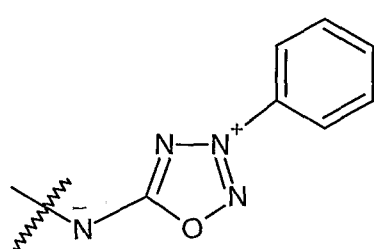
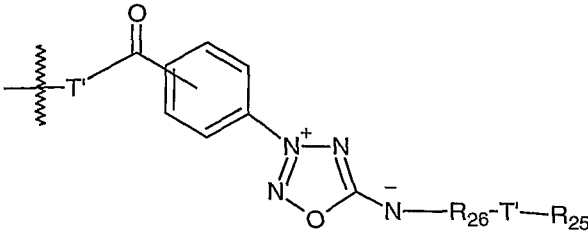
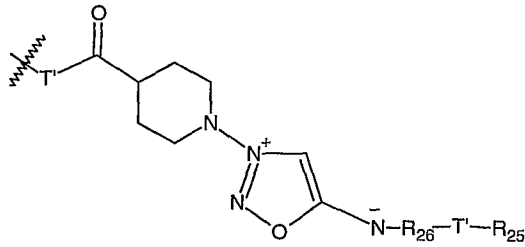
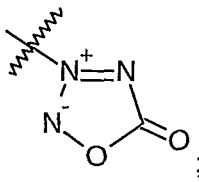
K is Z-(W₃)_a-E_b-(C(R_e)(R_f))_{p1}-E_c-(C(R_e)(R_f))_x-(W₃)_d-(C(R_e)(R_f))_y-(W₃)_i-E_j-(W₃)_g-(C(R_e)(R_f))_z-V₇;

Z is -CO₂H, -SO₃H or -P(O)OR₂₅OH;

V₇ is V₃, R_e, -U₃-V₅ or V₆;

V₃ is:



(11) 	(12) 
(13) 	(14) 
(15) 	(16) 
(17) 	(18)  or
(19) 	

R_{24} is $-C_6H_4R_{29}$, $-CN$, $-S(O)_2-C_6H_4R_{29}$, $-C(O)-N(R_a)(R_i)$, $-NO_2$, $-C(O)-OR_{25}$ or $-S(O)_2-R_{25}$;

R_{25} is an aryl group, a lower alkyl group, a haloalkyl group, a hydroxyalkyl group or an arylalkyl group;

R_{26} is $-\text{C}(\text{O})-$ or $-\text{S}(\text{O})_2-$;

R_{29} is a hydrogen, $-\text{CN}$, $-\text{S}(\text{O})_2-\text{R}_{25}$, $-\text{C}(\text{O})-\text{N}(\text{R}_a)(\text{R}_i)$, $-\text{NO}_2$ or $-\text{C}(\text{O})-\text{OR}_{25}$;

T' is oxygen, sulfur or NR_6 ;

R_6 is a hydrogen, a lower alkyl group, an aryl group;

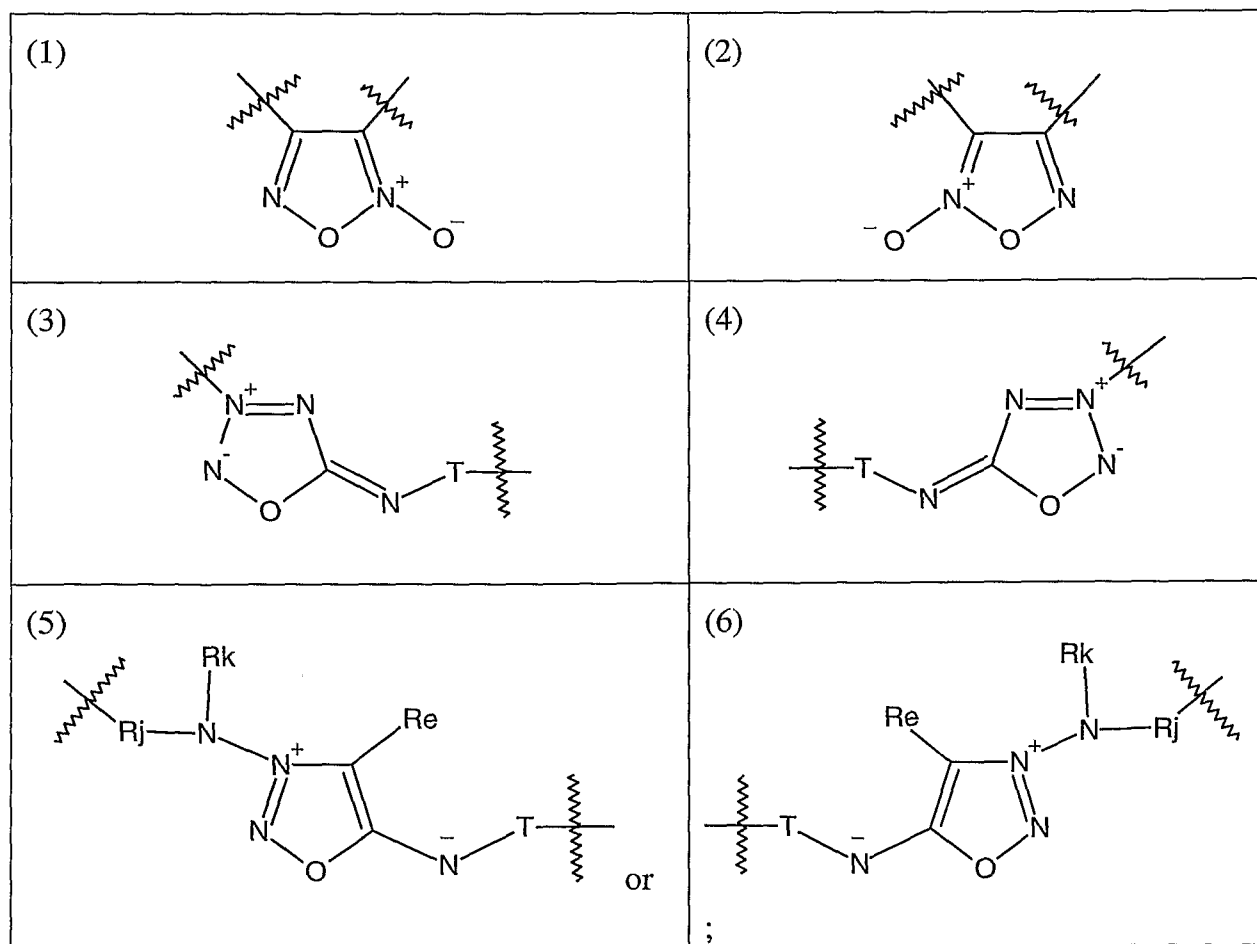
a, b, c, d, g, i and j are each independently an integer from 0 to 3;

p_1 , x, y and z are each independently an integer from 0 to 10;

W_3 at each occurrence is independently $-\text{C}(\text{O})-$, $-\text{C}(\text{S})-$, $-\text{T}_3-$, $-(\text{C}(\text{R}_e)(\text{R}_f))_h-$, $-\text{N}(\text{R}_a)\text{R}_i$, an alkyl group, an aryl group, a heterocyclic ring, an arylheterocyclic ring, $-(\text{CH}_2\text{CH}_2\text{O})_{q1}-$ or a heterocyclic nitric oxide donor;

E at each occurrence is independently $-\text{T}_3-$, an alkyl group, an aryl group, $-(\text{C}(\text{R}_e)(\text{R}_f))_h-$, a heterocyclic ring, an arylheterocyclic ring, $-(\text{CH}_2\text{CH}_2\text{O})_{q1}-$ or Y_3 ;

Y_3 is:



T is a $-\text{S}(\text{O})_o-$; a carbonyl or a covalent bond;

o is an integer from 0 to 2;

R_j and R_k are independently selected from an alkyl group, an aryl group, or R_j and R_k

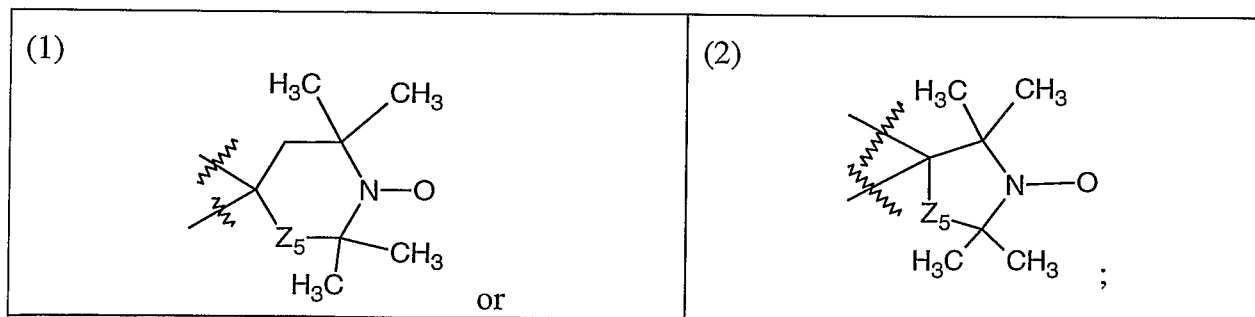
taken together with the nitrogen atom to which they are attached are a heterocyclic ring;

T_3 at each occurrence is independently a covalent bond, a carbonyl, an oxygen, -S(O)_o- or -N(R_a)R_i;

h is an integer form 1 to 10;

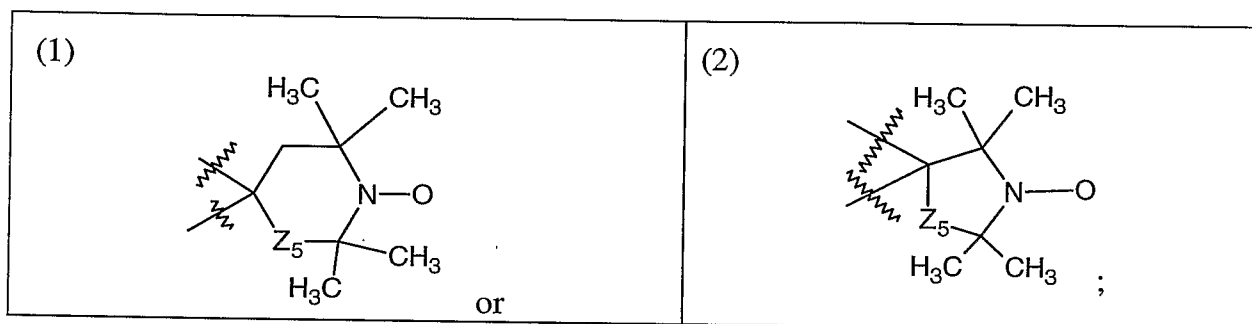
q_1 is an integer from 1 to 5;

R_e and R_f are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalklythio, an arylalklythioalkyl, an alkylthioalkyl, a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an alkylarylamino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano, an aminoalkyl, an aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, -U₃-V₅, V₆, -(C(R_o)(R_p))_{k1}-U₃-V₅, -(C(R_o)(R_p))_{k1}-U₃-V₄, -(C(R_o)(R_p))_{k1}-U₃-C(O)-V₆, or R_e and R_f taken together with the carbons to which they are attached form a carbonyl, a methanthial, a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, an imine, a hydrazone, a bridged cycloalkyl group,



R_o and R_p are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalklythio, an arylalklythioalkyl, an alkylthioalkyl a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a

haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an
 alkylarylamino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an
 arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano an aminoalkyl, an
 aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an
 5 arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an
 arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an
 alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an
 arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a
 sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, -U₃-V₅, V₆, or R₀ and
 10 R_p taken together with the carbons to which they are attached form a carbonyl, a methanthial,
 a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, an imine, a hydrazone a
 bridged cycloalkyl group,

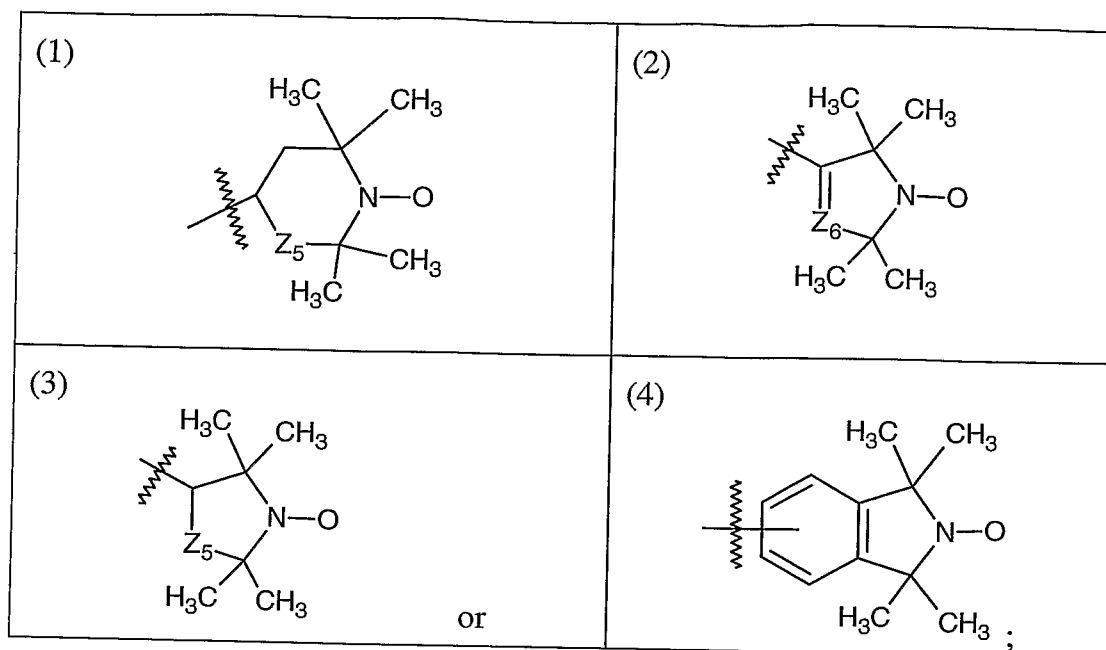


5 V₄ is V₃ or V₆;

U₃ is an oxygen, sulfur or -N(R_a)R_i;

V₅ is -NO or -NO₂ (i.e. an oxidized nitrogen);

V₆ is:



Z₅ is -CH₂ or oxygen;

Z₆ is -CH or nitrogen;

k₁ is an integer from 1 to 3;

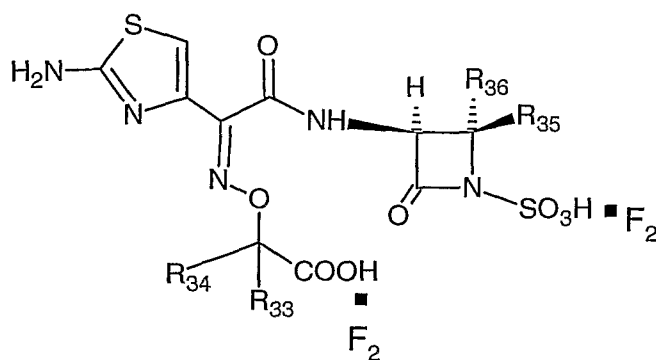
R_a is a lone pair of electrons, a hydrogen or an alkyl group;

R_i is a hydrogen, an alkyl, an aryl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarboxylic ester, an arylcarboxylic ester, an alkylcarboxamido, an arylcarboxamido, an alkylaryl, an alkylsulfinyl, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfinyl, an arylsulfonyl, an arylsulphonyloxy, a sulfonamido, a carboxamido, a carboxylic ester, an aminoalkyl, an aminoaryl, -CH₂-C-(U₃-V₅)(R_e)(R_f), a bond to an adjacent atom creating a double bond to that atom or -(N₂O₂-)•M₁⁺, wherein M₁⁺ is an organic or inorganic cation; and

with the proviso that the compound of Formula (I) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., •) to at least one amine group in the antimicrobial compound of Formula (I).

In cases where multiple designations of variables which reside in sequence are chosen as a "covalent bond" or the integer chosen is 0, the intent is to denote a single covalent bond connecting one radical to another. For example, E₀ would denote a covalent bond, while E₂ denotes (E-E) and (C(R₄)(R₄))₂ denotes -C(R₄)(R₄)-C(R₄)(R₄)-.

In another embodiment, the invention describes compounds of Formula (II):



II

wherein:

R_{33} , R_{34} and R_{36} are each independently selected from a hydrogen or CH_3 ;

R_{35} is hydrogen or $-\text{CH}_2-\text{OC}(\text{O})-\text{NH}_2$;

F_2 is not present, an organic base, or $-\text{N}(\text{R}_{37})(\text{R}_{38})(\text{R}_{39})$;

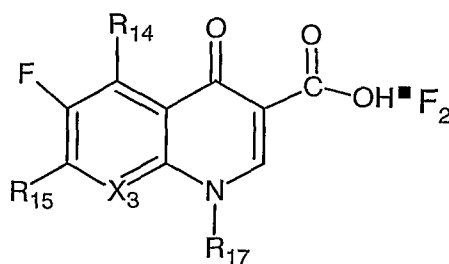
R_{37} , R_{38} and R_{39} are each independently selected from L or R_e , or R_{37} and R_{38} taken together with the nitrogen to which they are attached are a heterocyclic ring, with the proviso that when the heterocyclic ring is an aromatic ring it can be substituted at any position by L and R_{38} is not present;

L is $-(\text{W}_3)_a-\text{E}_b-(\text{C}(\text{R}_e)(\text{R}_f))_{p1}-\text{E}_c-(\text{C}(\text{R}_e)(\text{R}_f))_x-(\text{W}_3)_d-(\text{C}(\text{R}_e)(\text{R}_f))_y-(\text{W}_3)_i-\text{E}_j-(\text{W}_3)_g-(\text{C}(\text{R}_e)(\text{R}_f))_z-\text{V}_7$;

W_3 , E, R_e , R_f , V_7 , a, b, c, d, g, i, j, p₁, x, y and z are as defined herein; and

with the proviso that the compound of Formula (II) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., $\bullet$) to at least one carboxylic acid group or sulfonic group in the antimicrobial compound of Formula (II).

In another embodiment, the invention describes compounds of Formula (III):



(III)

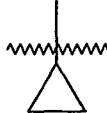
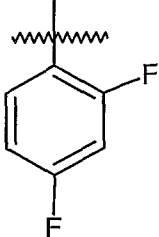
wherein:

X_3 is a C- R_{16} or a nitrogen;

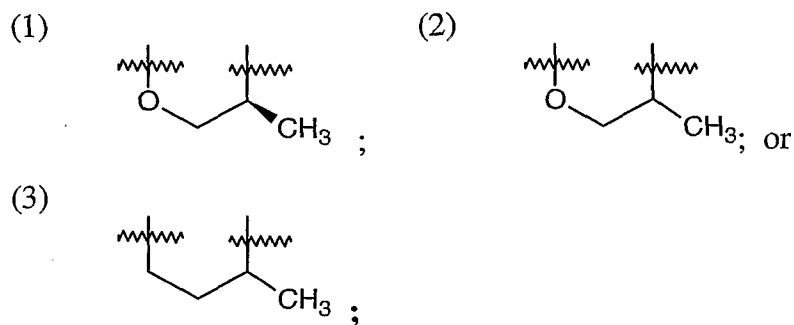
R_{14} is a hydrogen, $-\text{CH}_3$, $-\text{NH}_2$ or $\text{NH}_2\bullet\text{G}$;

R_{16} is a hydrogen, a fluorine or a chlorine;

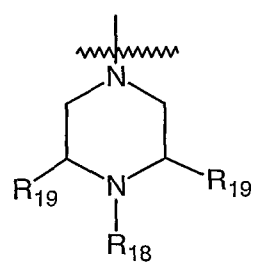
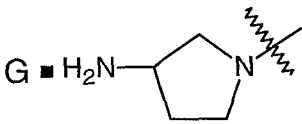
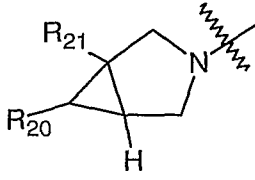
R_{17} is:

(1) $-\text{CH}_2-\text{CH}_2\text{F}$	(2) $-\text{C}_2\text{H}_5$
(3)  or	(4)  ; or

R_{16} and R_{17} together with the atoms to which they are attached are:



R_{15} is:

(1) 	(2)  or
(3) 	

R_{18} is a hydrogen, $-\text{CH}_3$ or $-\text{CH}_2-\text{CH}_3$;

R_{19} at each occurrence is independently a hydrogen or $-\text{CH}_3$;

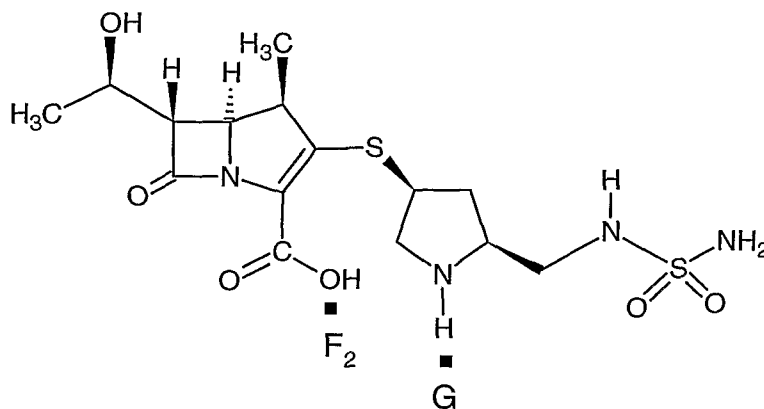
R_{20} is a hydrogen, $-NH_2$, $NH_2 \bullet G$, $-CH_2-NH_2$, $-CH_2-NH_2 \bullet G$;

R_{21} is a hydrogen, $-CH_2-NH_2$ or $-CH_2-NH_2 \bullet G$;

F_2 and G are as defined herein; and

with the proviso that the compound of Formula (III) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., $\bullet$) to at least one carboxylic acid group in the antimicrobial compound of Formula (III).

In another embodiment, the invention describes compounds of Formula (IV):



(IV)

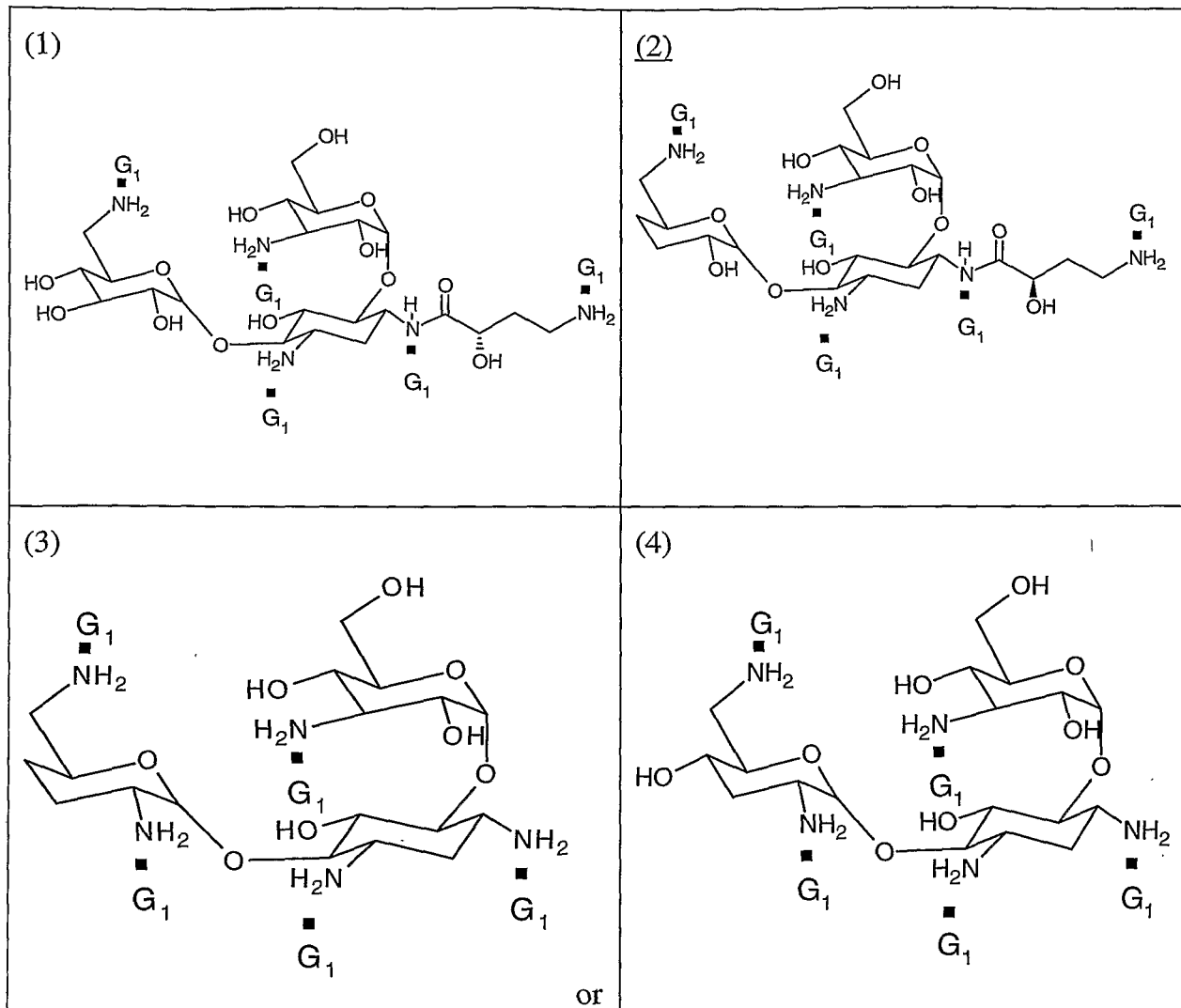
wherein F_2 and G are as defined herein; and

with the proviso that the compound of Formula (IV) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., $\bullet$) to at least one amine group or carboxylic acid group in the antimicrobial compound of Formula (IV).

In other embodiments of the invention the compound of Formula (I) is an organic nitric oxide donor salt of amikacin, an organic nitric oxide donor salt of arbekacin, an organic nitric oxide donor salt of dibekacin or an organic nitric oxide donor salt of tobramycin; the compound of Formula (II) is an organic nitric oxide donor salt of aztreonam, or an organic nitric oxide donor salt of carumonam; the compound of Formula (III) is an organic nitric oxide donor salt of ciprofloxacin, an organic nitric oxide donor salt of clinafloxacin, an organic nitric oxide donor salt of enoxacin, an organic nitric oxide donor salt of enrofloxacin, an organic nitric oxide donor salt of fleroxacin, an organic nitric oxide donor salt of flumequine, an organic nitric oxide donor salt of grepafloxin, an organic nitric oxide donor salt of lomefloxacin, an organic nitric oxide donor salt of levofloxacin, an organic nitric oxide donor salt of norfloxacin, an organic nitric oxide donor salt of ofloxacin, an organic nitric oxide donor salt of pefloxacin, an organic nitric oxide donor salt of sparfloxacin, an organic nitric oxide donor salt of tosufloxacin or an organic nitric oxide donor salt of trovafloxacin; and the

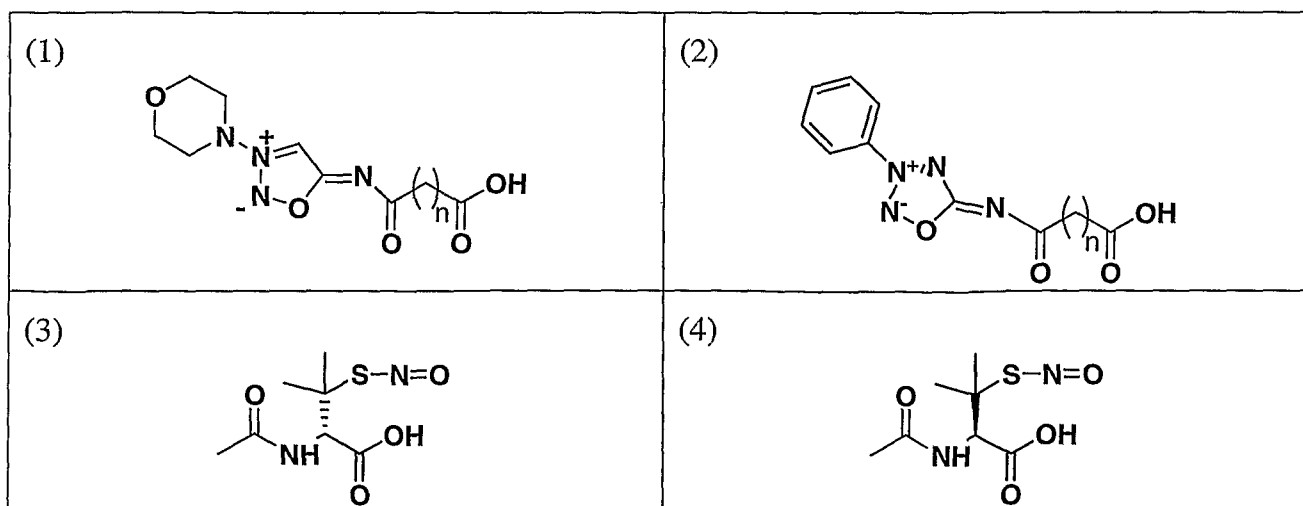
compound of Formula (IV) is an organic nitric oxide donor salt of doripenam.

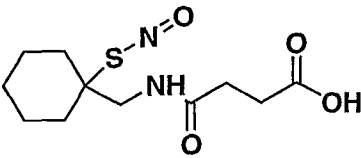
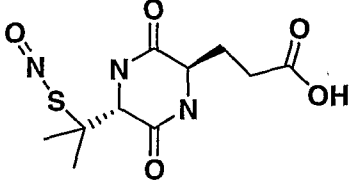
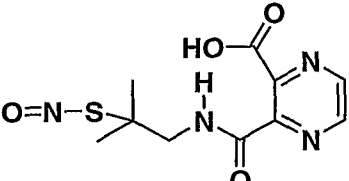
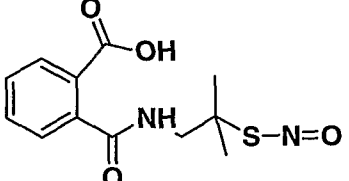
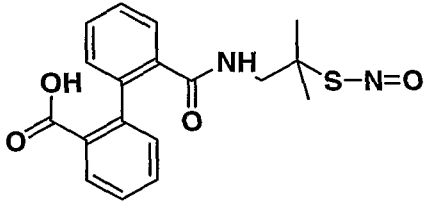
In other embodiments of the invention, the antimicrobial compound of Formula (I) is:



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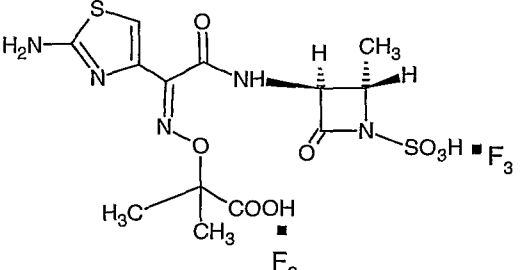
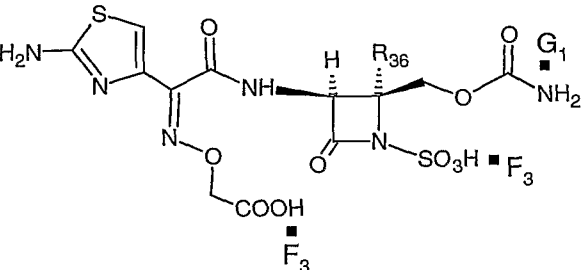
wherein G_1 is:



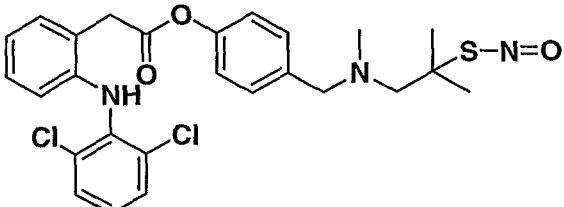
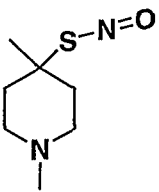
(5) 	(6) 
(7) 	(8)  or
(9) 	

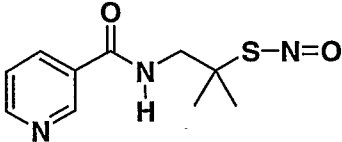
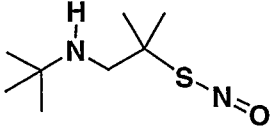
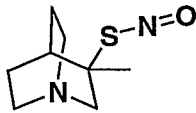
The above mentioned organic nitric oxide donor compounds are either prepared as described herein or are disclosed in U.S. Application 2003/0203915.

In other embodiments of the invention, the antimicrobial compound of Formula (II) is:

(1)  or	(2) 
--	---

5 wherein F₃ is:

(1) 	(2) 
--	--

(3) 	(4)  or
(5) 	

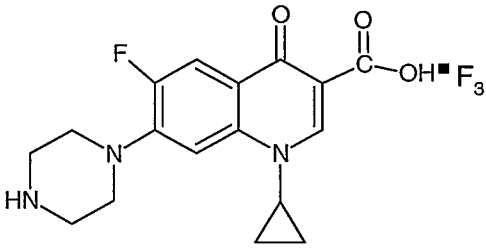
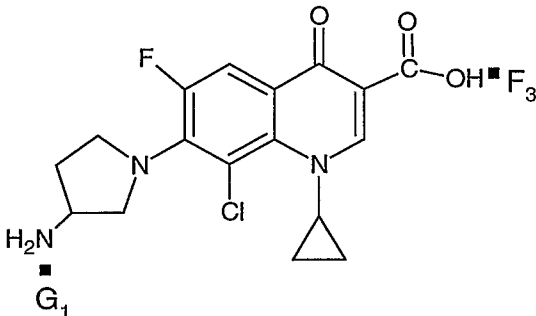
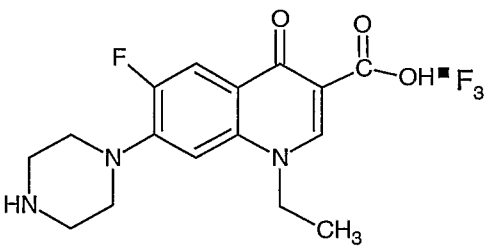
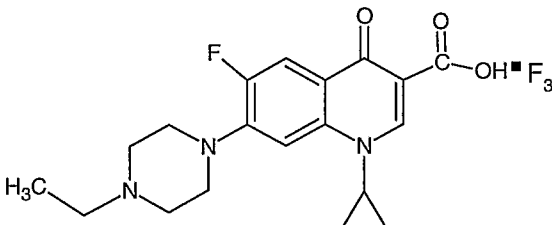
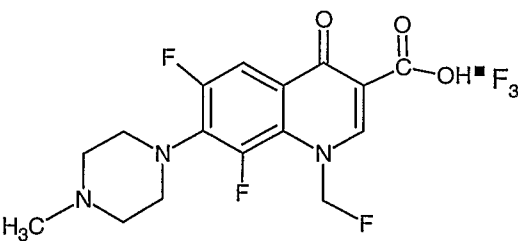
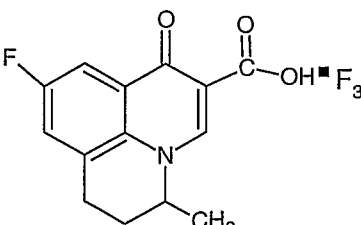
and G₁ is as defined herein.

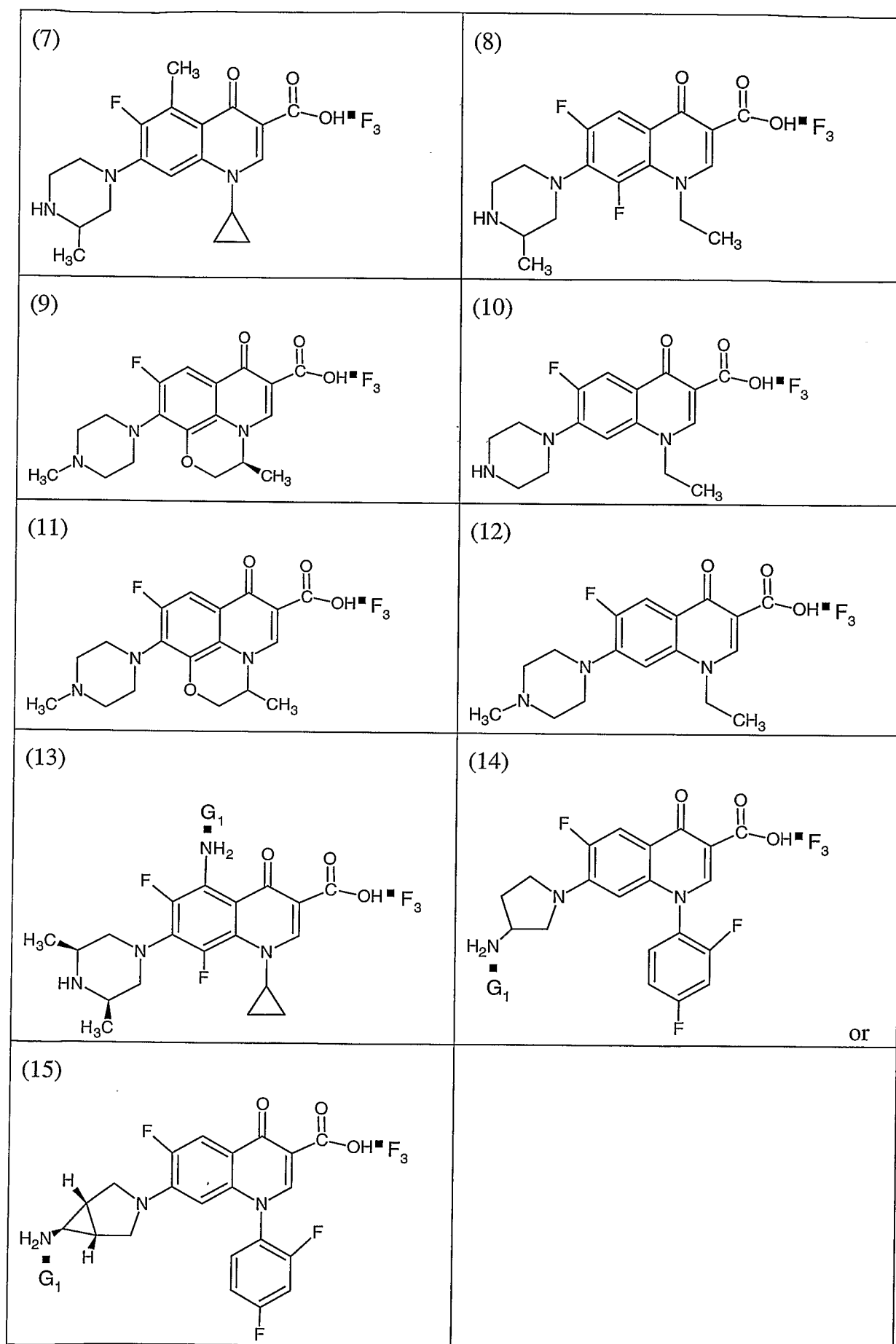
The above mentioned organic nitric oxide donor compounds are either prepared as described herein or are disclosed in U.S. Application 2003/0203915, U.S. Patent No. 6,297,260.

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In other embodiments of the invention, the antimicrobial compound of Formula (III)

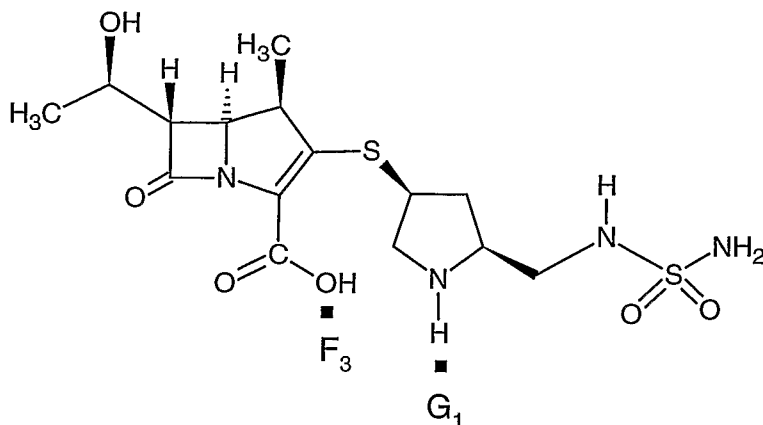
is:

(1) 	(2) 
(3) 	(4) 
(5) 	(6) 



and G₁ and F₃ are as defined herein.

In other embodiments of the invention, the antimicrobial compound of Formula (IV) is:



wherein G_1 and F_3 are as defined herein.

In other embodiments, the organic nitric oxide enhancing compounds that form salts are preferably organic nitrates, organic nitrites, nitrosothiols, thionitrites and heterocyclic nitric oxide donors.

In one embodiment, the organic nitric oxide donor salts of antimicrobial do not contain at least one nitrate ion mole per mole of the antimicrobial compound.

In another embodiment, the invention describes organic nitric oxide donor salts of antimicrobial compounds, wherein the antimicrobial compounds are acediasulfone, aceturate, acetyl sulfametossipirazine, acetyl sulfamethoxypyrazine, acranil, albendazole, alexidine, amatadine, ambazone, amdinocillin, p-aminosalicylic acid, p-aminosalicylic acid hydrazine, amoxicillin, ampicillin, anisomycin, apalcillin, apicyclin, apramycin, argininsa, aspoxicillin, azidamfenicol, azidocillin, azithromycin, azlocillin, bacampicillin, benzoylpas, benzyl penicillin acid, benzyl sulfamide, bicozamycin, biperam, brodimoprim, capreomycin, carbenicillin, carbomycin, cafazedone, carindacillin, cefcapene pivoxil, cefaclor, cefadroxil, cefafroxil, cefamandole, cefatamet, cefatrizine, cefazedone, cefazolin, cefbuperazone, cefclidin, cefdinir, cefditoren, cefixime, cefmenoxime, cefmetazole, cefminox, cefodizime, cefonicid, cefoperazone, ceforanide, cefotaxime, cefotetan, cefotiam, cefoxitin, cefozopran, cefpimizole, cefpiramide, cefpirome, cefpodoxime proxetil, cefprozil, cefroxadine, cefsulodin, ceftazidime, cefteram, ceftezole, ceftibuten, ceftiofur, ceftizoxime, ceftriaxone, cefuroxime, cefuzonam, cephradine, cephaloglycin, cephaloridine, cephalosporin C, cephalothin, cephapirin sodium, cephradine, chloramphenicol, chlorotetracycline, cinoxacin, ciprofloxacin, claritromycin, clavulanic acid, clinafloxacin, clindamycin, clofazimine, clofoctal, clometocillin, clomocycline, cloxacillin,

cloxyquin, cyclacilline, cycloserine, danoflaxcin, dapson, deoxycycline,
 deoxydihydrostreptomycin, dicloxacillin, difloxacin, dihydrostreptomycin, dimetridazole,
 diminazene, dirirtomycin, doripenam, duramycin, eflornithine, enoxacin, enrofloxacin,
 enviomycin, epicillin, erythromycin, etacillin, ethambutol, ethionamide, famcyclovir,
 5 fenbecillin, fleroxacin, flomoxef, floxacillin, flumequine, furonazide, fortimycin, furazolium
 chloride, gentamycin, glyconiazide, grepafloxacin, guamecycline, halofuginone, hetacillin,
 homidium, hydroxyl-stilbamidine, ibostamycin, imidocarb, imipenam, ipronidazole,
 isoniazide, iseganan, iosamycin, inosine, lauroguadine, lenampicillin, levofloxacin,
 lincomycin, lomefloxacin, loracarbef, lymecyclin, mafenide, mebendazole, meclocyclin,
 0 meropenem, metampicillin, metaciclone, methacycline, methicillin sodium, metronidazole, 4'-
 (methylsulfamoyl) sulfanilamide, mezlocillin, meziocillin, micronomycin, midecamycin A₁,
 minocycline, miocamycin, miokamycin, morfazinamide, moxalactam, mupirocin, myxin,
 nadifloxacin, nalidixic acid, negamycin, neomycin, netlimycin, nifurfoline, nifurpirinol,
 nifurprazine, nimorazole, nitroxoline, norfloxacin, novobiocin, ofloxacin, oleandomycin,
 5 opiniazide, oxacillin, oxophenarsine, oxolinic acid, oxytetracycline, panipenam, paromycin,
 pazufloxacin, pefloxacin, penicillin G potassium salt, penicillin N, penicillin O, penicillin V,
 penethamate hydroiodide, pentamidine, phenamidine, phenethicillin potassium salt, phenyl
 aminosalicyclate, pipacycline, pipemidic acid, piperacillin, pirlimycin, piromidic acid,
 pivampicillin, pivcefalexin, profiromycin, propamidine, propicillin, protionamide,
 0 puraltadone, puromycin, pyrazinamide, pyrimethamine, quinacillin, quinacrine,
 quinapyramine, quintine, ribostamycin, rifabutine, rifamide, rifampin, rifamycin, rifanpin,
 rifapentine, rifaxymine, ritipenem, rokitamycin, rolitetracycline, rosamycin, rifloxacin,
 salazosulfadimidine, salinazid, sancycline, sarafloxacin, sedacamycin, secnidazole,
 sisomycin, sparfloxacin, spectinomycin, spiramycin, spiramycin I, spiramycin II, spiramycin
 5 III, stilbamidine, streptomycin, streptonicizid, sulbactam, sulbenicillin, succisulfone,
 sulfanilamide, sulfabenzamide, sulfacetamide, sulfachloropyridazine, sulfachrysoidine,
 sulfacytine, sulfadiazine, sulfadicramide, sulfadimethoxine, sulfadoxine, sulfadrazine,
 sulfaetidol, sulfafenazol, sulfaguanidine, sulfaguanole, sulfalene, sulfamerazine, sulfameter,
 sulfamethazine, sulfamethizole, sulfamethomidine, sulfamethoxazole,
 0 sulfamethoxypyridazine, sulfamethylthiazol, sulfamethylthiazole, sulfametrole,
 sulfamidochrysoidine, sulfamoxole, sulfanilamide, 4-sulfanilamido salicylic acid, 4-4'-
 sulfanilylbenzylamine, p-sulfanilylbenzylamine, 2-p-sulfinylanilinoethanol, sulfanilylurea,
 sulfoniazide, sulfaperine, sulfaphenazole, sulfaproxyline, sulfapyrazine, sulfapyridine,
 sulfathiazole, sulfaethidole, sulfathiourea, sulfisomidine, sulfasomizole, sulfasymazine,

sulfisoxazole, 4,4'-sulfinyldianiline, N⁴-sulfanilylsulfanilamide, N-sulfanilyl-3,4-xylamide, sultamicillin, talampicillin, tambutol, taurolidine, teicoplanin, temocillin, tetracycline, tetroxoprim, thiabendazole, thiazolsulfone, tbezonium iodide, ticarcillin, tigemonam, tinidazole, tosuflaxacin, trimethoprim, troleandomycin, trospectomycin, trovafloxacin, tubercidine, miokamycin, oleandomycin, troleandomycin, vancomycin, verazide, viomycin, virginiamycin, zalcitabine, acyclovir, amatadine, cidofovir, cytarabine, didanosine, dideoxyadenosine, edoxudine, famciclovir, floxuridine, gancyclovir, idoxuridine, indanavir, kethoxal, lamivudine, MADU, penciclovir, podophyllotoxin, ribavirine, rimantadine, saquinavir, sorivudine, stavudine, trifluridine, valacyclovir, vidarabine, xenazoic acid, zalcitabine, zidovudine, daptomycin, duramycin, nafcillin, tigecycline, PA-1806, PA-2794.

Compounds of the invention that have one or more asymmetric carbon atoms may exist as the optically pure enantiomers, pure diastereomers, mixtures of enantiomers, mixtures of diastereomers, racemic mixtures of enantiomers, diastereomeric racemates or mixtures of diastereomeric racemates. It is to be understood that the invention anticipates and includes within its scope all such isomers and mixtures thereof.

Another embodiment of the invention describes the organic nitric oxide donor salts of the metabolites of the antimicrobials. These metabolites, include but are not limited to, degradation products, hydrolysis products, and the like, of the antimicrobial compound.

Another embodiment of the invention provides processes for making the novel salts of the invention. The reactions are performed in solvents appropriate to the reagents and materials used are suitable for the transformations being effected. It is understood by one skilled in the art of organic synthesis that the functionality present in the molecule must be consistent with the chemical transformation proposed. This will, on occasion, necessitate judgment by the routineer as to the order of synthetic steps, protecting groups required, and deprotection conditions. Substituents on the starting materials may be incompatible with some of the reaction conditions required in some of the methods described, but alternative methods and substituents compatible with the reaction conditions will be readily apparent to one skilled in the art. The use of sulfur and oxygen protecting groups is well known for protecting thiol and alcohol groups against undesirable reactions during a synthetic procedure and many such protecting groups are known and described by, for example, Greene and Wuts, *Protective Groups in Organic Synthesis*, Third Edition, John Wiley & Sons, New York (1999).

The chemical reactions described herein are generally disclosed in terms of their broadest application to the preparation of the compounds of this invention. Occasionally, the

reactions may not be applicable as described to each compound included within the disclosed scope. The compounds for which this occurs will be readily recognized by one skilled in the art. In all such cases, either the reactions can be successfully performed by conventional modifications known to one skilled in the art, *e.g.*, by appropriate protection of interfering groups, by changing to alternative conventional reagents, by routine modification of reaction conditions, and the like, or other reactions disclosed herein or otherwise conventional, will be applicable to the preparation of the corresponding compounds of this invention. In all preparative methods, all starting materials are known or readily prepared from known starting materials.

The salts of the invention are formulated according to well known techniques in the prior art, see for example, Remington's Pharmaceutical Sciences.

The antimicrobial compounds are either commercially available or can be prepared according to the methods described are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

The novel organic nitric oxide donor compounds can be synthesized by one skilled in the art using conventional methods. Known methods for linking a nitric oxide donor group to compounds, such as, for example, linking nitrates, thionitrates, nitrites, thionitrites, (i.e. nitrosated and/or nitrosylated compounds), heterocyclic nitric oxide donors, nitroxides and the like are described in the literature. For example, heterocyclic nitric oxide donor compounds are described in WO 99/64417, WO 94/01422; EP 0 574 726 A1, EP 0 683 159 A1; and in *J. Med. Chem.*, 47: 2688-2693 (2004); *J. Med. Chem.*, 47: 1840-1846 (2004); *J. Med. Chem.*, 46: 3762-3765 (2003); *J. Med. Chem.*, 46: 747-754 (2003); *Chem Rev.*, 102: 1091-1134 (2002); *J. Med. Chem.*, 42: 1941-1950 (1999); *J. Med. Chem.*, 41: 5393-5401 (1998); *J. Med. Chem.*, 38: 4944-4949 (1995); *Arzneim. Forsch. Drug Res.*, 47 (II): 847-854 (1997); the disclosures of each of which are incorporated by reference herein in their entirety. The methods of linking the heterocyclic nitric oxide donor group to compounds described in these references can be applied by one skilled in the art to produce any of the organic nitric oxide enhancing compounds described herein. Nitrosated and/or nitrosylated compound can be synthesized by the nitrosated and/or nitrosylated of a compound through one or more sites such as oxygen, sulfur and/or nitrogen using conventional methods known to one skilled in the art. Known methods for nitrosating and/or nitrosylating compounds are described in U.S. Patent Nos. 5,380,758, 5,859,053, 5,703,073 and 6,297,260; and in WO 94/03421, WO

94/04484, WO 94/12463, WO 95/09831, WO 95/19952, WO 95/30641, WO 97/27749, WO 98/09948, WO 98/19672, WO 98/21193, WO 00/51988, WO 00/61604, WO 00/72838, WO 01/00563, WO 01/04082, WO 01/10814, WO 01/12584, WO 01/45703, WO 00/61541, WO 00/61537, WO 02/11707, WO 02/30866 and in Oae et al, *Org. Prep. Proc. Int.*, 15(3):165-198 (1983), the disclosures of each of which are incorporated by reference herein in their entirety. The methods of nitrosating and/or nitrosylating the compounds described in these references can be applied by one skilled in the art to produce any of the nitrosated and/or nitrosylated compounds described herein. Known methods of linking the nitroxide group to compounds are described in U.S. Patent Nos. 6,448,267, 6,455,542, 6,759,430, and in WO 2004/050084, WO 03/088961, the disclosures of each of which are incorporated by reference herein in their entirety.

The organic nitric oxide donor salts of the antibacterial compounds are prepared by the following methods. When the antimicrobial compound to be salified is available as free base soluble in an organic solvent, which preferably does not contain hydroxyl groups, for example acetonitrile, ethyl acetate, tetrahydrofuran, and the like, the salt is prepared by dissolving the compound in the solvent at a concentration preferably equal to or higher than 10% w/v, adding the amount of organic nitric oxide enhancing compound corresponding to the moles of the ionizable groups in the antimicrobial compound. The organic nitric oxide enhancing compound is preferably diluted in the same solvent. The salt is generally recovered by filtration and washed with the solvent.

When the antimicrobial compound is not very soluble, or is available in the form of a not very soluble salt in the above mentioned solvents, a hydroxylated solvent, such as, for examples, methyl alcohol, ethyl alcohol, water, and the like, can be used.

When the starting antimicrobial compound is an inorganic salt, the corresponding base can also be prepared by treatment with a saturated solution of sodium or potassium bicarbonate or carbonate, or with a diluted solution of sodium or potassium hydroxide. The base is then extracted with a suitable organic solvent (for example halogenated solvents, esters, ethers), which is then dried. The organic solution is evaporated and the organic nitric oxide donor salt is prepared as described herein.

Compounds contemplated for use in the invention, e.g., organic nitric oxide donor salts of antimicrobial compounds, are, optionally, used in combination with nitric oxide enhancing compounds that release nitric oxide, increase endogeneous levels of nitric oxide or otherwise directly or indirectly deliver or transfer a biologically active form of nitrogen monoxide to a site of its intended activity, such as on a cell membrane *in vivo*.

Nitrogen monoxide can exist in three forms: NO⁻ (nitroxyl), NO[•] (nitric oxide) and NO⁺ (nitrosonium). NO[•] is a highly reactive short-lived species that is potentially toxic to cells. This is critical because the pharmacological efficacy of NO depends upon the form in which it is delivered. In contrast to the nitric oxide radical (NO[•]), nitrosonium (NO⁺) does not react with O₂ or O₂⁻ species, and functionalities capable of transferring and/or releasing NO⁺ and NO⁻ are also resistant to decomposition in the presence of many redox metals. Consequently, administration of charged NO equivalents (positive and/or negative) does not result in the generation of toxic by-products or the elimination of the active NO group.

The term "nitric oxide" encompasses uncharged nitric oxide (NO[•]) and charged nitrogen monoxide species, preferably charged nitrogen monoxide species, such as nitrosonium ion (NO⁺) and nitroxyl ion (NO⁻). The reactive form of nitric oxide can be provided by gaseous nitric oxide. The nitrogen monoxide releasing, delivering or transferring compounds have the structure F-NO, wherein F is a nitrogen monoxide releasing, delivering or transferring group, and include any and all such compounds which provide nitrogen monoxide to its intended site of action in a form active for its intended purpose.

The term "NO adducts" encompasses any nitrogen monoxide releasing, delivering or transferring compounds, including, for example, S-nitrosothiols, nitrites, nitrates, S-nitrothiols, sydnonimines, 2-hydroxy-2-nitrosohydrazines, (NONOates), (E)-alkyl-2-((E)-hydroxyimino)-5-nitro-3-hexeneamide (FK-409), (E)-alkyl-2-((E)-hydroxyimino)-5-nitro-3-hexeneamines, N-((2Z, 3E)-4-ethyl-2-(hydroxyimino)-6-methyl-5-nitro-3-heptenyl)-3-pyridinecarboxamide (FR 146801), N-nitrosoamines, N-hydroxyl nitrosamines, nitrosimines, diazetine dioxides, oxatriazole 5-imines, oximes, hydroxylamines, N-hydroxyguanidines, hydroxyureas, benzofuroxanes, furoxans as well as substrates for the endogenous enzymes which synthesize nitric oxide.

Suitable NONOates include, but are not limited to, (Z)-1-(N-methyl-N-(6-(N-methylammoniohexyl)amino))diazene-1,2-diolate ("MAHMA/NO"), (Z)-1-(N-(3-ammoniopropyl)-N-(n-propyl)amino)diazene-1,2-diolate ("PAPA/NO"), (Z)-1-(N-(3-aminopropyl)-N-(4-(3-aminopropylammonio)butyl)-amino) diazene-1,2-diolate (spermine NONOate or "SPER/NO") and sodium(Z)-1-(N,N-diethylamino)diazene-1,2-diolate (diethylamine NONOate or "DEA/NO") and derivatives thereof. NONOates are also described in U.S. Patent Nos. 6,232,336, 5,910,316 and 5,650,447, the disclosures of which are incorporated herein by reference in their entirety. The "NO adducts" can be mono-nitrosylated, poly-nitrosylated, mono-nitrosated and/or poly-nitrosated at a variety of naturally susceptible or artificially provided binding sites for biologically active forms of nitrogen

monoxide.

Suitable furoxanes include, but are not limited to, CAS 1609, C93-4759, C92-4678, S35b, CHF 2206, CHF 2363, and the like.

Suitable sydnonimines include, but are not limited to, molsidomine (N-ethoxycarbonyl-3-morpholinosydnonimine), SIN-1 (3-morpholinosydnonimine) CAS 936 (3-(cis-2,6-dimethylpiperidino)-N-(4-methoxybenzoyl)-sydnonimine, pirsidomine), C87-3754 (3-(cis-2,6-dimethylpiperidino)sydnonimine, linsidomine, C4144 (3-(3,3-dimethyl-1,4-thiazane-4-yl)sydnonimine hydrochloride), C89-4095 (3-(3,3-dimethyl-1,1-dioxo-1,4-thiazane-4-yl)sydnonimine hydrochloride, and the like.

Suitable oximes, include, but are not limited to, NOR-1, NOR-3, NOR-4, and the like.

One group of NO adducts is the S-nitrosothiols, which are compounds that include at least one -S-NO group. These compounds include S-nitroso-polypeptides (the term "polypeptide" includes proteins and polyamino acids that do not possess an ascertained biological function, and derivatives thereof); S-nitrosylated amino acids (including natural and synthetic amino acids and their stereoisomers and racemic mixtures and derivatives thereof); S-nitrosylated sugars; S-nitrosylated, modified and unmodified, oligonucleotides (preferably of at least 5, and more preferably 5-200 nucleotides); straight or branched, saturated or unsaturated, aliphatic or aromatic, substituted or unsubstituted S-nitrosylated hydrocarbons; and S-nitroso heterocyclic compounds. S-nitrosothiols and methods for preparing them are described in U.S. Patent Nos. 5,380,758 and 5,703,073; WO 97/27749; WO 98/19672; and Oae et al, *Org. Prep. Proc. Int.*, 15(3):165-198 (1983), the disclosures of each of which are incorporated by reference herein in their entirety.

Another embodiment of the invention is S-nitroso amino acids where the nitroso group is linked to a sulfur group of a sulfur-containing amino acid or derivative thereof. Such compounds include, for example, S-nitroso-N-acetylcysteine, S-nitroso-captopril, S-nitroso-N-acetylpenicillamine, S-nitroso-homocysteine, S-nitroso-cysteine, S-nitroso-glutathione, S-nitroso-cysteinyl-glycine, and the like.

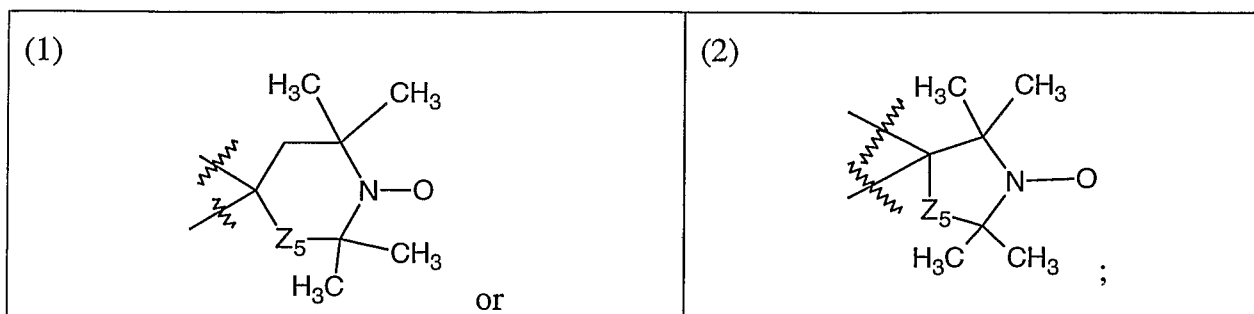
Suitable S-nitrosylated proteins include thiol-containing proteins (where the NO group is attached to one or more sulfur groups on an amino acid or amino acid derivative thereof) from various functional classes including enzymes, such as tissue-type plasminogen activator (TPA) and cathepsin B; transport proteins, such as lipoproteins; heme proteins, such as hemoglobin and serum albumin; and biologically protective proteins, such as immunoglobulins, antibodies and cytokines. Such nitrosylated proteins are described in WO 93/09806, the disclosure of which is incorporated by reference herein in its entirety.

Examples include polynitrosylated albumin where one or more thiol or other nucleophilic centers in the protein are modified.

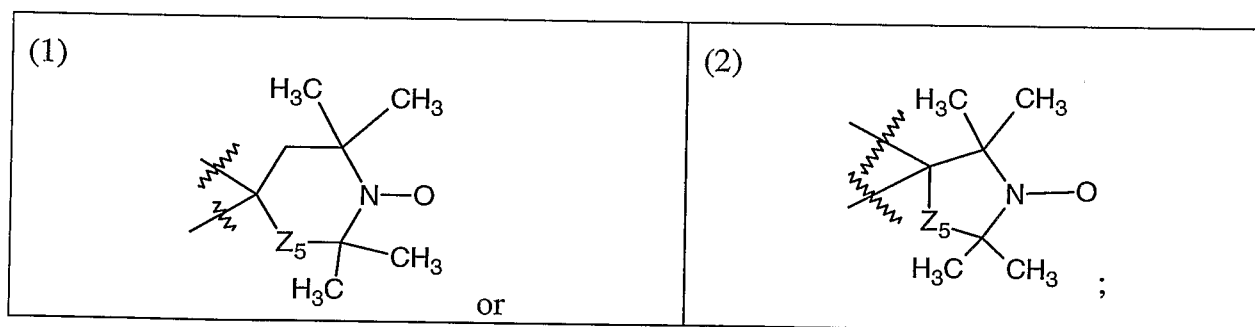
Other examples of suitable S-nitrosothiols include:

- (i) $\text{HS}(\text{C}(\text{R}_e)(\text{R}_f))_m\text{SNO}$;
 (ii) $\text{ONS}(\text{C}(\text{R}_e)(\text{R}_f))_m\text{R}_e$; or
 (iii) $\text{H}_2\text{N}-\text{CH}(\text{CO}_2\text{H})-(\text{CH}_2)_m-\text{C}(\text{O})\text{NH}-\text{CH}(\text{CH}_2\text{SNO})-\text{C}(\text{O})\text{NH}-\text{CH}_2-\text{CO}_2\text{H}$;
 wherein m is an integer from 2 to 20;

R_e and R_f are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalkylthio, an arylalkylthioalkyl, an alkylthioalkyl, a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an alkylaryl amino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano, an aminoalkyl, an aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, $-\text{U}_3-\text{V}_5$, V_6 , $-(\text{C}(\text{R}_o)(\text{R}_p))_{k1}-\text{U}_3-\text{V}_5$, $-(\text{C}(\text{R}_o)(\text{R}_p))_{k1}-\text{U}_3-\text{V}_6$, $-(\text{C}(\text{R}_o)(\text{R}_p))_{k1}-\text{U}_3-\text{C}(\text{O})-\text{V}_6$, or R_e and R_f taken together with the carbons to which they are attached form a carbonyl, a methanthial, a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, a hydrazone, a bridged cycloalkyl group,



R_o and R_p are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalklythio, an arylalklythioalkyl, an alkylthioalkyl a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an alkylaryl amino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano, an aminoalkyl, an aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, $-U_3-V_5$, V_6 , or R_o and R_p taken together with the carbons to which they are attached form a carbonyl, a methanthial, a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, an imine, a hydrazone, a bridged cycloalkyl group,



k_1 is an integer form 1 to 3;

U_3 is an oxygen, sulfur- or $-N(R_a)R_i$;

V_5 is $-NO$ or $-NO_2$ (i.e. an oxidized nitrogen);

R_a is a lone pair of electrons, a hydrogen or an alkyl group;

R_i is a hydrogen, an alkyl, an aryl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarboxylic ester, an arylcarboxylic ester, an alkylcarboxamido, an arylcarboxamido, an alkylaryl, an alkylsulfinyl, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfinyl, an arylsulfonyl, arylsulphonyloxy, a sulfonamido, a carboxamido, a carboxylic ester, an aminoalkyl, an aminoaryl, $-CH_2-C(U_3-V_5)(R_e)(R_f)$, a bond to an adjacent atom creating a double bond to that atom or $-(N_2O_2)^- \cdot M_1^+$, wherein M_1^+ is an organic or inorganic cation.

In cases where R_e and R_f are independently a heterocyclic ring or taken together R_e and R_f are a heterocyclic ring, then R_i can be a substituent on any disubstituted nitrogen contained within the radical wherein R_i is as defined herein.

Nitrosothiols can be prepared by various methods of synthesis. In general, the thiol precursor is prepared first, then converted to the S-nitrosothiol derivative by nitrosation of the thiol group with NaNO_2 under acidic conditions (pH is about 2.5) which yields the S-nitroso derivative. Acids which can be used for this purpose include aqueous sulfuric, acetic and hydrochloric acids. The thiol precursor can also be nitrosylated by reaction with an organic nitrite such as *tert*-butyl nitrite, or a nitrosonium salt such as nitrosonium tetrafluoroborate in an inert solvent.

Another group of NO adducts for use in the invention, where the NO adduct is a compound that donates, transfers or releases nitric oxide, include compounds comprising at least one ON-O- or ON-N- group. The compounds that include at least one ON-O- or ON-N- group are preferably ON-O- or ON-N-polypeptides (the term "polypeptide" includes proteins and polyamino acids that do not possess an ascertained biological function, and derivatives thereof); ON-O- or ON-N-amino acids (including natural and synthetic amino acids and their stereoisomers and racemic mixtures); ON-O- or ON-N-sugars; ON-O- or -ON-N- modified or unmodified oligonucleotides (comprising at least 5 nucleotides, preferably 5-200 nucleotides); ON-O- or ON-N- straight or branched, saturated or unsaturated, aliphatic or aromatic, substituted or unsubstituted hydrocarbons; and ON-O-, ON-N- or ON-C-heterocyclic compounds. Examples of compounds comprising at least one ON-O- or ON-N- group include butyl nitrite, isobutyl nitrite, *tert*-butyl nitrite, amyl nitrite, isoamyl nitrite, N-nitrosamines, N-nitrosamides, N-nitrosourea, N-nitrosoguanidines, N-nitrosocarbamates, N-acyl-N-nitroso compounds (such as, N-methyl-N-nitrosourea); N-hydroxy-N-nitrosamines, cupferron, alanosine, dopastin, 1,3-disubstituted nitrosiminobenzimidazoles, 1,3,4-thiadiazole-2-nitrosimines, benzothiazole-2(3H)-nitrosimines, thiazole-2-nitrosimines, oligonitroso sydnonimines, 3-alkyl-N-nitroso-sydnonimines, 2H-1,3,4-thiadiazine nitrosimines.

Another group of NO adducts for use in the invention include nitrates that donate, transfer or release nitric oxide, such as compounds comprising at least one $\text{O}_2\text{N-O-}$, $\text{O}_2\text{N-N-}$ or $\text{O}_2\text{N-S-}$ group. Among these compounds are $\text{O}_2\text{N-O-}$, $\text{O}_2\text{N-N-}$ or $\text{O}_2\text{N-S-}$ polypeptides (the term "polypeptide" includes proteins and also polyamino acids that do not possess an ascertained biological function, and derivatives thereof); $\text{O}_2\text{N-O-}$, $\text{O}_2\text{N-N-}$ or $\text{O}_2\text{N-S-}$ amino acids (including natural and synthetic amino acids and their stereoisomers and racemic mixtures); $\text{O}_2\text{N-O-}$, $\text{O}_2\text{N-N-}$ or $\text{O}_2\text{N-S-}$ sugars; $\text{O}_2\text{N-O-}$, $\text{O}_2\text{N-N-}$ or $\text{O}_2\text{N-S-}$ modified and

unmodified oligonucleotides (comprising at least 5 nucleotides, preferably 5-200 nucleotides); O₂N-O-, O₂N-N- or O₂N-S- straight or branched, saturated or unsaturated, aliphatic or aromatic, substituted or unsubstituted hydrocarbons; and O₂N-O-, O₂N-N- or O₂N-S- heterocyclic compounds. Examples of compounds comprising at least one O₂N-O-, O₂N-N- or O₂N-S- group include isosorbide dinitrate, isosorbide mononitrate, clonitrate, erythrityl tetranitrate, mannitol hexanitrate, nitroglycerin, pentaerythritoltetranitrate, pentrinitrol, propatylnitrate and organic nitrates with a sulfhydryl-containing amino acid such as, for example SPM 3672, SPM 4757, SPM 5185, SPM 5186 and those disclosed in U. S. Patent Nos. 5,284,872, 5,428,061, 5,661,129, 5,807,847 and 5,883,122 and in WO 97/46521, WO 00/54756 and in WO 03/013432, the disclosures of each of which are incorporated by reference herein in their entirety.

Another group of NO adducts are N-oxo-N-nitrosoamines that donate, transfer or release nitric oxide and are represented by the formula: R¹R²N-N(O-M⁺)-NO, where R¹ and R² are each independently a polypeptide, an amino acid, a sugar, a modified or unmodified oligonucleotide, a straight or branched, saturated or unsaturated, aliphatic or aromatic, substituted or unsubstituted hydrocarbon, or a heterocyclic group, and where M₁⁺ is an organic or inorganic cation, such, as for example, an alkyl substituted ammonium cation or a Group I metal cation.

The invention is also directed to compounds that stimulate endogenous NO or elevate levels of endogenous endothelium-derived relaxing factor (EDRF) *in vivo* or are oxidized to produce nitric oxide and/or are substrates for nitric oxide synthase and/or cytochrome P450. Such compounds include, for example, L-arginine, L-homoarginine, and N-hydroxy-L-arginine, N-hydroxy-L-homoarginine, N-hydroxydebrisoquine, N-hydroxypentamidine including their nitrosated and/or nitrosylated analogs (e.g., nitrosated L-arginine, nitrosylated L-arginine, nitrosated N-hydroxy-L-arginine, nitrosylated N-hydroxy-L-arginine, nitrosated and nitrosylated L-homoarginine), N-hydroxyguanidine compounds, amidoxime, ketoximes, aldoxime compounds, that can be oxidized *in vivo* to produce nitric oxide. Compounds that may be substrates for a cytochrome P450, include, for example, imino(benzylamino)methylhydroxyl amine, imino(((4-methylphenyl)methyl)amino)methylhydroxylamine, imino(((4-methoxyphenyl)methyl)amino)methylhydroxylamine, imino(((4-(trifluoromethyl)phenyl)methyl)amino)methylhydroxylamine, imino(((4-nitrophenyl)methyl)amino)methylhydroxylamine, (butylamino)iminomethylhydroxylamine, imino(propylamino)methylhydroxylamine, imino(pentylamino)methylhydroxylamine, imino(propylamino)methylhydroxylamine, imino

((methylethyl)amino)methylhydroxylamine, (cyclopropylamino) iminomethylhydroxylamine, imino-2-1,2,3,4-tetrahydroisoquinolyl methylhydroxylamine, imino(1-methyl(2-1,2,3,4-tetrahydroisoquinolyl))methylhydroxylamine, (1,3-dimethyl(2-1,2,3,4-tetrahydroisoquinolyl))iminomethylhydroxylamine, (((4-chlorophenyl)methyl) amino)iminomethylhydroxylamine, ((4-chlorophenyl)amino) iminomethylhydroxylamine, (4-chlorophenyl)(hydroxyimino) methylamine, and 1-(4-chlorophenyl)-1-(hydroxyimino) ethane, and the like, precursors of L-arginine and/or physiologically acceptable salts thereof, including, for example, citrulline, ornithine, glutamine, lysine, polypeptides comprising at least one of these amino acids, inhibitors of the enzyme arginase (e.g., N-hydroxy-L-arginine and 2(S)-amino-6-boronohexanoic acid), nitric oxide mediators and/or physiologically acceptable salts thereof, including, for example, pyruvate, pyruvate precursors, α -keto acids having four or more carbon atoms, precursors of α -keto acids having four or more carbon atoms (as disclosed in WO 03/017996, the disclosure of which is incorporated herein in its entirety), and the substrates for nitric oxide synthase, cytokines, adenosin, bradykinin, calreticulin, bisacodyl, and phenolphthalein. EDRF is a vascular relaxing factor secreted by the endothelium, and has been identified as nitric oxide (NO) or a closely related derivative thereof (Palmer et al, *Nature*, 327:524-526 (1987); Ignarro et al, *Proc. Natl. Acad. Sci. USA*, 84:9265-9269 (1987)).

The invention is also directed to nitric oxide enhancing compounds that can increase endogenous nitric oxide. Such compounds, include for example, nitroxide containing compounds, include, but are not limited to, substituted 2,2,6,6-tetramethyl-1-piperidinyloxy compounds, substituted 2,2,5,5-tetramethyl-3-pyrroline-1-oxyl compounds, substituted 2,2,5,5-tetramethyl-1-pyrrolidinyloxy compounds, substituted 1,1,3,3-tetramethylisoindolin-2-yloxy compounds, substituted 2,2,4,4-tetramethyl-1-oxazolidinyl-3-oxyl compounds, substituted 3-imidazolin-1-yloxy, 2,2,5,5-tetramethyl-3-imidazolin-1-yloxy compounds, OT-551, 4-hydroxy-2,2,6,6-tetramethyl-1-piperidinyloxy (tempol), and the like. Suitable substituents, include, but are not limited to, aminomethyl, benzoyl, 2-bromoacetamido, 2-(2-(2-bromoacetamido)ethoxy)ethylcarbamoyl, carbamoyl, carboxy, cyano, 5-(dimethylamino)-1-naphthalenesulfonamido, ethoxyfluorophosphinyloxy, ethyl, 5-fluoro-2, 4-dinitroanilino, hydroxy, 2-iodoacetamido, isothiocyanato, isothiocyanatomethyl, methyl, maleimido, maleimidoethyl, 2-(2-maleimidoethoxy)ethylcarbamoyl, maleimidomethyl, maleimido, oxo, phosphonooxy, and the like.

The invention is also based on the discovery that compounds and compositions of the invention may be used in conjunction with other therapeutic agents for co-therapies, partially or completely, in place of other therapeutic agents, such as, for example, including, but not

limited to, aldosterone antagonists, α -adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof. The therapeutic agent may optionally be substituted with a nitric oxide enhancing moiety.

In one embodiment of the invention, the therapeutic agents are β -adrenergic agonists, anti-allergic compounds, antitussive compounds, antioxidants, bronchodilators, expectorants, H_2 receptor antagonists, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, proton pump inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof.

Suitable aldosterone antagonists include, but are not limited to, canrenone, potassium canrenoate, drospirenone, spironolactone, eplerenone (INSPIRA®), epoxymexrenone, fadrozole, pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo, γ -lactone, methyl ester, ($7\alpha,11\alpha,17\beta$)-; pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo-dimethyl ester, ($7\alpha,11\alpha,17\beta$)-; 3'H-cyclopropa(6,7)pregna-4,6-diene-21-carboxylic acid, 9,11-epoxy-6,7-dihydro-17-hydroxy-3-oxo-, γ -lactone, ($6\beta,7\beta,11\alpha,17\beta$)-; pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo-, 7-(1-methylethyl) ester, monopotassium salt, ($7\alpha,11\alpha,17\beta$)-; pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo-, 7-methyl ester, monopotassium salt, ($7\alpha,11\alpha,17\beta$)-; 3'H-cyclopropa(6,7)pregna-1,4,6-triene-21-carboxylic acid, 9,11-epoxy-6,7-dihydro-17-hydroxy-3-oxo-, γ -lactone, ($6\beta,7\beta,11\alpha$)-; 3'H-cyclopropa(6,7)pregna-4,6-diene-21-carboxylic acid, 9,11-epoxy-6,7-dihydro-17-hydroxy-3-oxo-, methyl ester, ($6\beta,7\beta,11\alpha,17\beta$)-; 3'H-cyclopropa(6,7)pregna-4,6-diene-21-carboxylic acid, 9,11-epoxy-6,7-dihydro-17-hydroxy-3-oxo-, monopotassium salt, ($6\beta,7\beta,11\alpha,17\beta$)-; 3'H-cyclopropa(6,7)pregna-1,4,6-triene-21-carboxylic acid, 9,11-epoxy-6,7-dihydro-17-hydroxy-3-oxo-, γ -lactone, ($6\beta,7\beta,11\alpha,17\beta$)-; pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo-, γ -lactone, ethyl ester, ($7\alpha,11\alpha,17\beta$)-; pregn-4-ene-7,21-dicarboxylic acid, 9,11-epoxy-17-hydroxy-3-oxo-, γ -lactone, 1-methylethyl ester, ($7\alpha,11\alpha,17\beta$)-; RU-28318, and the like. Suitable aldosterone antagonists are described more

fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

In some embodiment the aldosterone antagonists is eplerenone or spironolactone (a potassium sparing diuretic that acts like an aldosterone antagonist). In more particular embodiments eplerenone is administered in an amount of about 25 milligrams to about 300 milligrams as a single dose or as multiple doses per day; the spironolactone is administered in an amount of about 25 milligrams to about 150 milligrams as a single dose or as multiple doses per day.

Suitable α -adrenergic receptor antagonists include, but are not limited to, phentolamine, tolazoline, idazoxan, deriglidole, RX 821002, BRL 44408, BRL 44409, BAM 1303, labetalol, ifenprodil, rauwolscine, corynathine, raubasine, tetrahydroalstonine, apoyohimbine, akuammigine, β -yohimbine, yohimbol, yohimbine, pseudoyohimbine, epi-3 α -yohimbine, 10-hydroxy-yohimbine, 11-hydroxy-yohimbine, tamsulosin, benoxathian, atipamezole, BE 2254, WB 4101, HU-723, tedisamil, mirtazipine, setiptiline, reboxitine, delequamine, naftopil, saterinone, SL 89.0591, ARC 239, urapidil, 5-methylurapidil, monatepi, haloperidol, indoramin, SB 216469, moxislyte, trazodone, dapiprozole, efaroan, Recordati 15/2739, SNAP 1069, SNAP 5089, SNAP 5272, RS 17053, SL 89.0591, KMD 3213, spiperone, AH 11110A, chloroethylclonidine, BMY 7378, niguldipine, and the like. Suitable α -adrenergic receptor antagonists are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable β -adrenergic agonists include, but are not limited to, albuterol, bambuterol, bitolterol, carbuterol, clenbuterol, dobutamine, fenoterol, formoterol, hexoprenaline, isoprotenerol, mabuterol, metaproterenol, pirbuterol, prenalterol, procaterol, protokylol, ritodrine, rimiterol, reproterol, salmeterol, soterenol, terbutaline, tretoquinol, tulobuterol, and the like. Suitable β -adrenergic agonists are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Suitable anti-allergic compounds include but are not limited to, acrivastine, allociamide, amlexanox, bromexine, cetirizine, clobenzepam, chromoglycate, chromolyn, deslortidine, emedastine, epinastine, fexofenadine, formoterol, hydroxyzine, ketotifen,

loratadine, levocabastine, lodoxamide, mabuterol, montelukast, nedocromil, repirinast, salmeterol, seratroast, suplatast tosylate, terfenadine, tiaramide, and the like. Suitable anti-allergic compounds are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Suitable antidiabetic compounds include but are not limited to, acarbose, acetohehexamide, buformin, carbutamide, chlorpropamide, glibornuride, gliclazide, glimepiride, glipizide, gliquidone, glisoxepid, glyburide, glybutthiazol(e), glybuzole, glyhexamide, glymidine, glypinamide, insulin, metformin, miglitol, nateglinide, phenbutamide, phenformin, pioglitazone, repaglinide, rosiglitazone, tolazamide, tolbutamide, tolcyclamide, troglitazone, voglibose, and the like. Suitable antidiabetic compounds are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable anti-hyperlipidemic compounds include, but are not limited to, statins or HMG-CoA reductase inhibitors, such as, for example, atorvastatin (LIPITOR®), bervastatin, cerivastatin (BAYCOL®), dalvastatin, fluindostatin (Sandoz XU-62-320), fluvastatin, glenvastatin, lovastatin (MEVACOR®), mevastatin, pravastatin (PRAVACHOL®), rosuvastatin (CRESTRO®), simvastatin (ZOCOR®), velostatin (also known as synvinolin), VYTORINTM (ezetimibe/simvastatin), GR-95030, SQ 33,600, BMY 22089, BMY 22,566, CI 980, and the like; gemfibrozil, cholestyramine, colestipol, niacin, nicotinic acid, bile acid sequestrants, such as, for example, cholestyramine, colesevelam, colestipol, poly(methyl-(3-trimethylaminopropyl) imino-trimethylene dihalide) and the like; probucol; fibric acid agents or fibrates, such as, for example, bezafibrate (BezalipTM), beclobrate, binifibrate, ciprofibrate, clinofibrate, clofibrate, etofibrate, fenofibrate (LipidilTM, Lipidil MicroTM), gemfibrozil (LopidTM), nicofibrate, pirifibrate, ronifibrate, simfibrate, theofibrate and the like; cholesterol ester transfer protein (CETP) inhibitors, such as for example, CGS 25159, CP-529414 (torcetrapid), JTT-705, substituted N-[3-(1,1,2,2-tetrafluoroethoxy)benzyl]-N-(3-phenoxyphenyl)-trifluoro-3-amino-2-propanols, N,N-disubstituted trifluoro-3-amino-2-propanols, PD 140195 (4-phenyl-5-tridecyl-4H-1,2,4-triazole-3-thiol), SC-794, SC-795, SCH 58149, and the like.

In some embodiments the anti-hyperlipidemic compounds are atorvastatin, fluvastatin, lovastatin, pravastatin, rosuvastatin or simvastatin. In more particular embodiments the atorvastatin is administered in an amount of about 10 milligrams to about 80 milligrams as a

single dose or as multiple doses per day; the fluvastatin is administered in an amount of about 20 milligrams to about 80 milligrams as a single dose or as multiple doses per day; the lovastatin is administered in an amount of about 10 milligrams to about 80 milligrams as a single dose or as multiple doses per day; the pravastatin is administered in an amount of about 10 milligrams to about 80 milligrams as a single dose or as multiple doses per day; the rosuvastatin is administered in an amount of about 5 milligrams to about 40 milligrams as a single dose or as multiple doses per day; the simvastatin is administered in an amount of about 5 milligrams to about 80 milligrams as a single dose or as multiple doses per day.

Suitable antitussive compounds, include, but are not limited to, dextromethorphan, carbetapentane, caramiphen, diphenylhydramine, hydrocodone, codeine and the like. Suitable antitussive compounds are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Suitable angiotensin II antagonists include, but are not limited to, angiotensin, abitesartan, candesartan, candesartan cilexetil, elisartan, embusartan, enoltasartan, eprosartan, fonsartan, forasartan, glycylosartan, irbesartan, losartan, olmesartan, milfasartan, medoxomil, ripisartan, pomisartan, prazosartan, saprisartan, saralasin, sarmesin, tasosartan, telmisartan, valsartan, zolasartan, 3-(2'-(tetrazole-5-yl)-1,1'-biphen-4-yl)methyl-5,7-dimethyl-2-ethyl-3H-imidazo(4,5-b)pyridine, antibodies to angiotensin II, A-81282, A-81988, BAY 106734, BIBR-363, BIBS-39, BIBS-222, BMS-180560, BMS-184698, BMS-346567, CGP-38560A, CGP-42112A, CGP-48369, CGP-49870, CGP-63170, CI-996, CP-148130, CL-329167, CV-11194, DA-2079, DE-3489, DMP-811, DuP-167, DuP-532, DuP-753, E-1477, E-4177, E-4188, EMD-66397, EMD-666R4, EMD-73495, EMD-66684, EXP-063, EXP-929, EXP-3174, EXP-6155, EXP-6803, EXP-7711, EXP-9270, EXP-9954, FK-739, FRI 153332, GA-0050, GA-0056, HN-65021, HOE-720, HR-720, ICI-D6888, ICI-D7155, ICI-D8731, KRI-1177, KT3-671, KT-3579, KW-3433, L-158809, L-158978, , L-159282, L-159689, L-159874, L-161177, L-162154, L-162234, L-162441, L-163007, L-163017, LF-70156, LRB-057, LRB-081, LRB-087, LY-235656, LY-266099, LY-285434, LY-301875, LY-302289, LY-315995, ME-3221, MK-954, PD-123177, PD-123319, PD-126055, PD-150304, RG-13647, RWJ-38970, RWJ-46458, S-8307, S-8308, SC-51757, SC-54629, SC-52458, SC-52459, SK 1080, SL-910102, SR-47436, TAK-536, UP-2696, U-96849, U-97018, UK-77778, UP-275-22, WAY-126227, WK-1260, WK-1360, WK-1492, WY 126227, YH-1498, YM-358, YM-31472, X-6803, XH-148, XR-510, ZD-6888, ZD-7155, ZD-8731, ZD 8131, the compounds of ACS registry numbers 124750-92-1, 133240-46-7, 135070-05-2, 139958-

16-0, 145160-84-5, 147403-03-0, 153806-29-2, 439904-54-8P, 439904-55-9P, 439904-56-0P, 439904-57-1P, 439904-58-2P, 155918-60-8P, 155918-61-9P, 272438-16-1P, 272446-75-0P, 223926-77-0P, 169281-89-4, 439904-65-1P, 165113-01-9P, 165113-02-0P, 165113-03-1P, 165113-03-2P, 165113-05-3P, 165113-06-4P, 165113-07-5P, 165113-08-6P, 165113-09-7P, 165113-10-0P, 165113-11-1P, 165113-12-2P, 165113-17-7P, 165113-18-8P, 165113-19-9P, 165113-20-2P, 165113-13-3P, 165113-14-4P, 165113-15-5P, 165113-16-6P, 165113-21-3P, 165113-22-4P, 165113-23-5P, 165113-24-6P, 165113-25-7P, 165113-26-8P, 165113-27-9P, 165113-28-0P, 165113-29-1P, 165113-30-4P, 165113-31-5P, 165113-32-6P, 165113-33-7P, 165113-34-8P, 165113-35-9P, 165113-36-0P, 165113-37-1P, 165113-38-2P, 165113-39-3P, 165113-40-6P, 165113-41-7P, 165113-42-8P, 165113-43-9P, 165113-44-0P, 165113-45-1P, 165113-46-2P, 165113-47-3P, 165113-48-4P, 165113-49-5P, 165113-50-8P, 165113-51-9P, 165113-52-0P, 165113-53-1P, 165113-54-2P, 165113-55-3P, 165113-56-4P, 165113-57-5P, 165113-58-6P, 165113-59-7P, 165113-60-0P, 165113-61-1P, 165113-62-2P, 165113-63-3P, 165113-64-4P, 165113-65-5P, 165113-66-6P, 165113-67-7P, 165113-68-8P, 165113-69-9P, 165113-70-2P, 165113-71-3P, 165113-72-4P, 165113-73-5P, 165113-74-6P, 114798-27-5, 114798-28-6, 114798-29-7, 124749-82-2, 114798-28-6, 124749-84-4, 124750-88-5, 124750-91-0, 124750-93-2, 161946-65-2P, 161947-47-3P, 161947-48-4P, 161947-51-9P, 161947-52-0P, 161947-55-3P, 161947-56-4P, 161947-60-0P, 161947-61-1P, 161947-68-8P, 161947-69-9P, 161947-70-2P, 161947-71-3P, 161947-72-4P, 161947-74-6P, 161947-75-7P, 161947-81-5P, 161947-82-6P, 161947-83-7P, 161947-84-8P, 161947-85-9P, 161947-86-0P, 161947-87-1P, 161947-88-2P, 161947-89-3P, 161947-90-6P, 161947-91-7P, 161947-92-8P, 161947-93-9P, 161947-94-0P, 161947-95-1P, 161947-96-2P, 161947-97-3P, 161947-98-4P, 161947-99-5P, 161948-00-1P, 161948-01-2P, 161948-02-3P, 168686-32-6P, 167301-42-0P, 166813-82-7P, 166961-56-4P, 166961-58-6P, 158872-96-9P, 158872-97-0P, 158807-14-8P, 158807-15-9P, 158807-16-0P, 158807-17-1P, 158807-18-2P, 158807-19-3P, 158807-20-6P, 155884-08-5P, 154749-99-2, 167371-59-7P, 244126-99-6P, 177848-35-0P and 141309-82-2P, and the like. Suitable angiotensin II antagonists are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

In some embodiments the angiotensin II antagonists are candesartan, eprosartan, irbesartan, losartan, omlesartan, telmisartan or valsartan. In more particular embodiments the candesartan is administered as candesartan cilexetil in an amount of about 15 milligrams to about 100 milligrams as a single dose or as multiple doses per day; the eprosartan, is

administered as eprosartan mesylate in an amount of about 400 milligrams to about 1600 milligrams as a single dose or as multiple doses per day; the irbesartan is administered in an amount of about 75 milligrams to about 1200 milligrams as a single dose or as multiple doses per day; the losartan is administered as losartan potassium in an amount of about 25
5 milligrams to about 100 milligrams as a single dose or as multiple doses per day; the omlesartan is administered as omlesartan medoxomil in an amount of about 5 milligrams to about 40 milligrams as a single dose or as multiple doses per day; the telmisartan is administered in an amount of about 20 milligrams to about 80 milligrams as a single dose or as multiple doses per day; the valsartan is administered in an amount of about 80 milligrams
10 to about 320 milligrams as a single dose or as multiple doses per day.

Suitable angiotensin-converting enzyme inhibitors (ACE inhibitors) include, but are not limited to, alacepril, benazepril (LOTENSIN®, CIBACEN®), benazeprilat, captopril, ceronapril, cilazapril, delapril, duinapril, enalapril, enalaprilat, fasidotril, fosinopril, fosinoprilat, gemopatrilat, glycopril, idrapril, imidapril, lisinopril, moexipril, moveltipril,
15 naphthopidil, omapatrilat, pentopril, perindopril, perindoprilat, quinapril, quinaprilat, ramipril, ramiprilat, rentipril, saralasin acetate, spirapril, temocapril, trandolapril, trandolaprilat, urapidil, zofenopril, acylmercapto and mercaptoalkanoyl pralines, carboxyalkyl dipeptides, carboxyalkyl dipeptide, phosphinylalkanoyl pralines, registry no.796406, AVE 7688, BP1.137, CHF 1514, E 4030, ER 3295, FPL-66564, MDL 100240, RL 6134, RL 6207,
20 RL 6893, SA 760, S-5590, Z 13752A, and the like. Suitable angiotensin-converting enzyme inhibitors are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Twelfth Edition, Version 12:1, 1996; and on STN Express, file phar and file registry.

15 In some embodiments the angiotensin-converting enzyme inhibitors are benazepril, captopril, enalapril, fosinopril, lisinopril, moexipril, quinapril, ramipril, trandolapril or trandolaprilat. In more particular embodiments the benazepril is administered as benazepril hydrochloride in an amount of about 5 milligrams to about 80 milligrams as a single dose or as multiple doses per day; the captopril is administered in an amount of about 12.5 milligrams
0 to about 450 milligrams as a single dose or as multiple doses per day; the enalapril is administered as enalapril maleate in an amount of about 2.5 milligrams to about 40 milligrams as a single dose or as multiple doses per day; the fosinopril is administered as fosinopril sodium in an amount of about 5 milligrams to about 60 milligrams as a single dose or as multiple doses per day; the lisinopril is administered in an amount of about 2.5

milligrams to about 75 milligrams as a single dose or as multiple doses per day; the moexipril is administered as moexipril hydrochloride in an amount of about 7.5 milligrams to about 45 milligrams as a single dose or as multiple doses per day; the quinapril is administered as quinapril hydrochloride in an amount of about 5 milligrams to about 40 milligrams as single or multiple doses per day; the ramipril hydrochloride in an amount of about 1.25 milligrams to about 40 milligrams as single or multiple doses per day; thetrandolapril is administered as in an amount of about 0.5 milligrams to about 4 milligrams as single or multiple doses per day; thetrandolaprilat is administered as in an amount of about 0.5 milligrams to about 4 milligrams as single or multiple doses per day.

Suitable antioxidants include, but are not limited to, small-molecule antioxidants and antioxidant enzymes. Suitable small-molecule antioxidants include, but are not limited to, hydralazine compounds, glutathione, vitamin C, vitamin E, cysteine, N-acetyl-cysteine, β -carotene, ubiquinone, ubiquinol-10, tocopherols, coenzyme Q, superoxide dismutase mimetics, such as, for example, 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO), DOXYL, PROXYL nitroxide compounds; 4-hydroxy-2,2,6,6-tetramethyl-1-piperidinyloxy (Tempol), M-40401, M-40403, M-40407, M-40419, M-40484, M-40587, M-40588, and the like. Suitable antioxidant enzymes include, but are not limited to, superoxide dismutase, catalase, glutathione peroxidase, NADPH oxidase inhibitors, such as, for example, apocynin, aminoguanidine, ONO 1714, S17834 (benzo(b)pyran-4-one derivative), and the like; xanthine oxidase inhibitors, such as, for example, allopurinol, oxypurinol, amflutizole, diethyldithiocarbamate, 2-styrylchromones, chrysin, luteolin, kaempferol, quercetin, myricetin, isorhamnetin, benzophenones such as 2,2',4,4'-tetrahydroxybenzophenone, 3,4,5,2',3',4'-hexahydroxybenzophenone and 4,4'-dihydroxybenzophenone; benzothiazinone analogues such as 2-amino-4H-1,3-benzothiazine-4-one, 2-guanidino-4H-1,3-benzothiazin-4-one and rhodanine; N-hydroxyguanidine derivative such as, PR5 (1-(3, 4-dimethoxy-2-chlorobenzylideneamino)-3-hydroxyguanidine); 6-formylpterin, and the like. The antioxidant enzymes can be delivered by gene therapy as a viral vector and/or a non-viral vector. Suitable antioxidants are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

In some embodiments the antioxidants are apocynin, hydralazine compounds and superoxide dismutase mimetics.

Suitable antithrombotic and vasodilator compounds include, but are not limited to, abciximab, acetorphan, acetylsalicylic acid, argatroban, bamethan, benfurodil, benziodarone,

betahistine, bisaramil, brovincamine, bufeniode, citicoline, clobenfurol, clopidogrel, cyclandelate, dalteparin, dipyridamol, droprenilamine, enoxaparin, fendiline, ifenprodil, iloprost, indobufen, isobogrel, isoxsuprine, heparin, lamifiban, midrodine, nadroparin, nicotinoyl alcohol, nylidrin, ozagrel, perhexiline, phenylpropanolamine, prenylamine, papaveroline, reviparin sodium salt, ridogrel, suloctidil, tinofedrine, tinzaparin, trifusal, vintoperoxol, xanthinal niacinate, and the like. Suitable antithrombotic and vasodilator compounds are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable β -adrenergic antagonists include, but are not limited to, acebutolol, alprenolol, amosulalol, arotinolol, atenolol, befunolol, betaxolol, bevantolol, bisoprolol, bopindolol, bucindolol, bucumolol, bufetolol, bufuralol, bunitrolol, bupranolol, butofilolol, carazolol, capsinolol, carteolol, carvedilol (COREG®), celiprolol, cetamolol, cindolol, cloranolol, dilevalol, diprafenone, epanolol, ersentilide, esmolol, esprolol, hedroxalol, indenolol, labetalol, landiolol, laniolol, levobunolol, mepindolol, methylpranol, metindol, metipranolol, metrizoranolol, metoprolol, moprolol, nadolol, nadoxolol, nebivolol, nifenalol, nipradilol, oxprenolol, penbutolol, pindolol, practolol, pronethalol, propranolol, sotalol, sotalolnadolol, sulfinalol, taliprolol, talinolol, tertatolol, tilisolol, timolol, toliprolol, tomalolol, trimepranol, xamoterol, xibenolol, 2-(3-(1,1-dimethylethyl)-amino-2-hydroxypropoxy)-3-pyridenecarbonitrilHCl, 1-butylamino-3-(2,5-dichlorophenoxy)-2-propanol, 1-isopropylamino-3-(4-(2-cyclopropylmethoxyethyl) phenoxy)-2-propanol, 3-isopropylamino-1-(7-methylindan-4-yloxy)-2-butanol, 2-(3-t-butylamino-2-hydroxypropylthio)-4-(5-carbamoyl-2-thienyl)thiazol, 7-(2-hydroxy-3-t-butylaminopropoxy)phthalide, Acc 9369, AMO-140, BIB-16S, CP-331684, Fr-172516, ISV-208, L-653328, LM-2616, SB-226552, SR-58894A, SR-59230A, TZC-5665, UK-1745, YM-430, and the like. Suitable β -adrenergic antagonists are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

In some embodiments the β -adrenergic antagonists are atenolol, bisoprolol, carvedilol, metoprolol, nebivolol, propranolol or timolol. In more particular embodiments the atenolol is administered in an amount of about 50 milligrams to about 200 milligrams as a single dose or as multiple doses per day; the bisoprolol is administered as bisoprolol fumarate in an amount of about 2.5 milligrams to about 30 milligrams as a single dose or as multiple doses per day; the carvedilol is administered in an amount of about 3.125 milligrams to about 200

milligrams as a single dose or as multiple doses per day; the metoprolol is administered as metoprolol tartarate or metoprolol succinate in an amount of about 25 milligrams to about 300 milligrams as a single dose or as multiple doses per day; the nebivolol is administered as nebivolol hydrochloride in an amount of about 2.5 milligrams to about 20 milligrams as a single dose or as multiple doses per day; the propranolol is administered as propranolol hydrochloride in an amount of about 40 milligrams to about 240 milligrams as a single dose or as multiple doses per day; the timolol is administered as timolol maleate in an amount of about 10 milligrams to about 30 milligrams as a single dose or as multiple doses per day.

Suitable bronchodilators include but are not limited to, ambroxol, atropine, bevonium methyl sulfate, bethanechol, chlorprenaline, cyclodrine, daiphenacine, N-desethyl-oxybutynin, dicyclomine, emepronium, ephedrine, epinephrine, etafredine, ethylnorepinephrine, flavoxate, flutoprium bromide, hexoprenaline, 2-hydroxy-2,2-diphenyl-N-(1,2,3,6-tetra hydro-pyridin-4-ylmethyl)acetamide, ipratropium bromide, isoetharine, NS 21, oxybutynin, oxitropium bromide, propanthelin, propiverine, rispenzepine, terbutaline, 1-teobromine actetic acid, terodiline, tiotropium bromide, tolterodine, trospium, vamicamide, zamiphenacine, and the like. Suitable bronchodilators are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Suitable calcium channel blockers include, but are not limited to, amlodipine (NORVASC®), anipamil, aranidipine, amrinone, azelnidipine, barnidipine, bencyclane, benidipine, bepridil, cilnidipine, cinnarizine, clentiazem, diltiazem, dotarizine, efonidipine, elgodipine, fantofarone, felodipine, fendiline, flunarizine, fluspirilene, furnidipine, gallopamil, ipenoxazone, isradipine, lacidipine, lemildipine, lercanidipine, lomerizine, manidipine, mibefradil, monatepil, nicardipine, nifedipine, niguldipine, niludipine, nilvadipine, nimodipine, nisoldipine, nitrendipine, nivaldipine, oxodipine, perhexilene, phenytoin, phenytprenylamine, pranidipine, ranolazine, ryosidine, semotiadil, tamolarizine, temiverine hydrochloride, terodiline, tiapamil, vatanidipine hydrochloride, verapamil, ziconotide, AE-0047, CAI, JTV-519, CHF-1521, L-651582, NS-7, NW-1015, RO-2933, SB-237376, SL-34.0829-08, S-312d, SD-3212, TA-993, YM-430, and the like. Suitable calcium channel blockers are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

In some embodiments the calcium channel blockers are amlodipine, diltiazem,

isradipine, nicardipine, nifedipine, nimodipine, nisoldipine, nitrendipine, verapamil.

Suitable diuretics include but are not limited to, thiazides (such as, for example, althiazide, bendroflumethiazide, benzclortriazide, benzhydrochlorothiazide, benzthiazide, buthiazide, chlorothiazide, cyclophenethiazide, cyclothiazide, epithiazide, ethiazide, hydrobenzthiazide, hydrochlorothiazide, hydroflumethiazide, methylclothiazide, methylcyclothiazide, penflutazide, polythiazide, teclothiazide, trichlormethiazide, triflumethazide, and the like); alilusem, ambuside, amiloride, aminometradine, azosemide, bemetizide, bumetanide, butazolamide, butizide, canrenone, carperitide, chloraminophenamide, chlorazaniol, chlormerodrin, chlorthalidone, cicletanide, clofenamide, clopamide, clorexolone, conivaptan, daglutril, dichlorophenamide, disulfamide, ethacrynic acid, ethoxzolamide, etozolon, fenoldopam, fenquizone, furosemide, indapamide, mebutizide, mefruside, meralluride, mercaptomerin sodium, mercumallylic acid, mersalyl, methazolamide, metican, metolazone, mozavaptan, muzolimine, N-(5-1,3,4-thiadiazol-2-yl)acetamide, nesiritide, pamabrom, paraflutizide, piretanide, protheobromine, quinethazone, scoparius, spironolactone, theobromine, ticrynafen, torsemide, torvaptan, triamterene, tripamide, ularitide, xipamide or potassium, AT 189000, AY 31906, BG 9928, BG 9791, C 2921, DTI 0017, JDL 961, KW 3902, MCC 134, SLV 306, SR 121463, WAY 140288, ZP 120, and the like. Suitable diuretics are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Depending on the diuretic employed, potassium may also be administered to the patient in order to optimize the fluid balance while avoiding hypokalemic alkalosis. The administration of potassium can be in the form of potassium chloride or by the daily ingestion of foods with high potassium content such as, for example, bananas or orange juice. The method of administration of these compounds is described in further detail in U.S. Patent No. 4,868,179, the disclosure of which is incorporated by reference herein in its entirety.

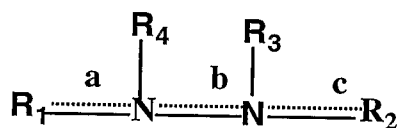
In some embodiments the diuretics are amiloride, furosemide, chlorthalidone, hydrochlorothiazide or triamterene. In more particular embodiments the amiloride is administered as amiloride hydrochloride in an amount of about 5 milligrams to about 15 milligrams as a single dose or as multiple doses per day; the furosemide is administered in an amount of about 10 milligrams to about 600 milligrams as a single dose or as multiple doses per day; the chlorthalidone is administered in an amount of about 15 milligrams to about 150 milligrams as a single dose or as multiple doses per day; the hydrochlorothiazide is

administered in an amount of about 12.5 milligrams to about 300 milligrams as a single dose or as multiple doses per day; the triamterene is administered in an amount of about 35 milligrams to about 225 milligrams as a single dose or as multiple doses per day.

Suitable endothelin antagonists include, but are not limited to, atrasentan, bosentan, darusentan, endothelin, enrasentan, sitaxsentan, sulfonamide endothelin antagonists, tezosentan, BMS 193884, BQ-123, SQ 28608, and the like. Suitable endothelin antagonists are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable expectorants include, but are not limited to, ambroxol, domiodol, erdosteine, guaiaicol, guaifenesin, iodinated glycerol, letosteine, mensa, sobrerol, strepronine, terpin, tiopronin, and the like. Suitable expectorants are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, 13th Edition; and on STN Express, file phar and file registry.

Suitable hydralazine compounds include, but are not limited to, compounds having the formula:



wherein a, b and c are independently a single or double bond; R₁ and R₂ are each independently a hydrogen, an alkyl, an ester or a heterocyclic ring, wherein alkyl, ester and heterocyclic ring are as defined herein; R₃ and R₄ are each independently a lone pair of electrons or a hydrogen, with the proviso that at least one of R₁, R₂, R₃ and R₄ is not a hydrogen. Exemplary hydralazine compounds include budralazine, cadralazine, dihydralazine, endralazine, hydralazine, pildralazine, todralazine, and the like. Suitable hydralazine compounds are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

In some embodiments the hydralazine compound is hydralazine or a pharmaceutically acceptable salt thereof such as hydralazine hydrochloride. In more particular embodiments the hydralazine is administered as hydralazine hydrochloride in an amount of about 10 milligrams to about 300 milligrams as a single dose or as multiple doses per day.

Suitable H₂ receptor antagonists include, but are not limited to, burimamide, cimetidine, ebrotidin, famotidine, nizatidine, roxatidine, rantidine, tiotidine, and the like. Suitable H₂ receptor antagonists are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995, Pgs. 901-915; the Merck Index on CD-ROM, 13th Edition; and in WO 00/28988 assigned to NitroMed Inc., the disclosures of which are incorporated herein by reference in their entirety.

Suitable neutral endopeptidase inhibitors include, but are not limited to, atrial natriuretic peptides, diazapins, azepinones, ecadotril, fasidotril, fasidotrilat, omapatrilat, sampatrilat, BMS 189,921, Z 13752 A, and the like. Neutral endopeptidase inhibitors are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable NSAIDs include, but are not limited to, acetaminophen, acemetacin, aceclofenac, alminoprofen, amfenac, bendazac, benoxaprofen, bromfenac, bucloxic acid, butibufen, carprofen, cinmetacin, clopirac, diclofenac, etodolac, felbinac, fenclozic acid, fenbufen, fenoprofen, fentiazac, flunoxaprofen, flurbiprofen, ibufenac, ibuprofen, indomethacin, isofezolac, isoxepac, indoprofen, ketoprofen, lonazolac, loxoprofen, metiazinic acid, mofezolac, miroprofen, naproxen, oxaprozin, pirozolac, pirprofen, pranoprofen, protizinic acid, salicylamide, sulindac, suprofen, suxibuzone, tiaprofenic acid, tolmetin, xenbucin, ximoprofen, zaltoprofen, zomepirac, aspirin, acemetcin, bumadizon, carprofenac, clidanac, diflunisal, enfenamic acid, fendosal, flufenamic acid, flunixin, gentisic acid, ketorolac, meclofenamic acid, mefenamic acid, mesalamine, prodrugs thereof, and the like. Suitable NSAIDs are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995, Pgs. 617-657; the Merck Index on CD-ROM, 13th Edition; and in U.S. Patent Nos. 6,057,347 and 6,297,260 assigned to NitroMed Inc., the disclosures of which are incorporated herein by reference in their entirety.

In some embodiments the NSAIDs are acetaminophen, diclofenac, flurbiprofen, ibuprofen, indomethacin, ketoprofen, naproxen or aspirin. In more particular embodiments the acetaminophen is administered in an amount of about 325 milligrams to about 4 grams as a single dose or as multiple doses per day; the diclofenac is administered in an amount of about 50 milligrams to about 250 milligrams as a single dose or as multiple doses per day; the flurbiprofen is administered in an amount of about 100 milligrams to about 300 milligrams as

a single dose or as multiple doses per day; the ibuprofen is administered in an amount of about 400 milligrams to about 3.2 grams as a single dose or as multiple doses per day; the indomethacin is administered in an amount of about 25 milligrams to about 200 milligrams as a single dose or as multiple doses per day; the ketoprofen is administered in an amount of about 50 milligrams to about 300 milligrams as a single dose or as multiple doses per day; the naproxen is administered in an amount of about 250 milligrams to about 1.5 grams as a single dose or as multiple doses per day; the aspirin is administered in an amount of about 10 milligrams to about 2 grams as a single dose or as multiple doses per day.

Suitable phosphodiesterase inhibitors, include but are not limited to, fluminast, piclamilast, rolipram, Org 20241, MCI-154, roflumilast, toborinone, posicar, lixazinone, zaprinast, sildenafil, pyrazolopyrimidinones, motapizone, pimobendan, zardaverine, siguazodan, CI 930, EMD 53998, imazodan, saterinone, loprinone hydrochloride, 3-pyridinecarbonitrile derivatives, acefylline, albifylline, bamifylline, denbufyllene, diphylline, doxofylline, etofylline, torbafylline, theophylline, nanterinone, pentoxifylline, proxiphylline, cilostazol, cilostamide, MS 857, piroximone, milrinone, amrinone, tolafentrine, dipyridamole, papaveroline, E4021, thienopyrimidine derivatives, triflusal, ICOS-351, tetrahydropiperazino(1,2-b)beta-carboline-1,4-dione derivatives, carboline derivatives, 2-pyrazolin-5-one derivatives, fused pyridazine derivatives, quinazoline derivatives, anthranilic acid derivatives, imidazoquinazoline derivatives, tadalafil, vardenafil, and in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Ed.), McGraw-Hill, Inc. (1995), The Physician's Desk Reference (49th Ed.), Medical Economics (1995), Drug Facts and Comparisons (1993 Ed), Facts and Comparisons (1993), and the Merck Index on CD-ROM, 13th Edition; and the like. Phosphodiesterase inhibitors and their nitrosated and/or nitrosylated derivatives are also disclosed in U. S. Patent Nos. 5,932,538, 5,994,294, 5,874,437, 5,958,926 reissued as U.S. Patent No. RE 03772346, 1,72,060, 6,197,778, 6,177,428, 6,172,068, 6,221,881, 6,232,321, 6,197,782, 6,133,272, 6,211,179, 6,316,457 and 6,331,542, the disclosures of each of which are incorporated herein by reference in their entirety.

Suitable potassium channel blockers include but are not limited to, nicorandil, pinacidil, cromakalim (BRL 34915), aprikalim, bimakalim, emakalim, lemakalim, minoxidil, diazoxide, 9-chloro-7-(2-chlorophenyl)-5H-pyrimido(5,4,-d)(2)-benzazepine, Ribl, CPG-11952, CGS-9896, ZD 6169, diazoxide, Bay X 9227, P1075, Bay X 9228, SDZ PCO 400, WAY-120,491, WAY-120,129, Ro 31-6930, SR 44869, BRL 38226, S 0121, SR 46142A, CGP 42500, SR 44994, artilide fumarate, lorazepam, temazepam, rilmafazone, nimetazepam, midazolam, lormetazepam, lopraxolam, ibutilide fumarate, haloxazolam, flunitrazepam,

estazolam, doxefazepam, clonazepam, cinolazepam, brotizolam, and the like. Suitable potassium channel blockers are described more fully in the literature, such as in Goodman and Gilman, *The Pharmacological Basis of Therapeutics* (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable platelet reducing agents include but are not limited to, fibrinolytic agents such as for example, ancrod, anistreplase, bisobrin lactate, brinolase, Hageman factor (i.e. factor XII) fragments, plasminogen activators such as, for example, streptokinase, tissue plasminogen activators (TPA), urokinase, pro-Urokinase, recombinant TPA, plasmin, plasminogen, and the like; anti-coagulant agents including but are not limited to, inhibitors of factor Xa, factor TFPI, factor VIIa, factor IXc, factor Va, factor VIIIa, inhibitors of other coagulation factors, and the like; vitamin K antagonists, such as, for example, coumarin, coumarin derivatives (e.g., warfarin sodium); glycosaminoglycans such as, for example, heparins both in unfractionated form and in low molecular weight form; ardeparin sodium, bivalirudin, bromindione, coumarin, dalteparin sodium, danaparoid sodium; dazoxiben hydrochloride, desirudin, dicumarol, efegatran sulfate, enoxaparin sodium, ifetroban, ifetroban sodium, lyapolate sodium, nafamostat mesylate, phenprocoumon, sulfatide, tinzaparin sodium, retaplase; trifenagrel, warfarin, dextrans and the like; abciximab, acadesine, anipamil, argatroban, aspirin, clopidogrel, diadenosine 5',5'''-P₁,P₄-tetrphosphate (Ap₄A) analogs, difibrotide, dilazep dihydrochloride, dipyridamole, dopamine, 3-methoxytyramine, glucagon, glycoprotein IIb/IIIa antagonists, such as, for example, Ro-43-8857, L-700,462, iloprost, isocarbacyclin methyl ester, itazigrel, ketanserin, BM-13.177, lamifiban, lifarizine, molsidomine, nifedipine, oxagrelate, prostaglandins, platelet activating factor antagonists such as, for example, lexipafant, prostacyclins, pyrazines, pyridinol carbamate, ReoPro (i.e., abciximab), sulfinpyrazone, synthetic compounds BN-50727, BN-52021, CV-4151, E-5510, FK-409, GU-7, KB-2796, KBT-3022, KC-404, KF-4939, OP-41483, TRK-100, TA-3090, TFC-612, ZK-36374, 2,4,5,7-tetrathiaoctane, 2,4,5,7-tetrathiaoctane 2,2-dioxide, 2,4,5-trithiahexane, theophyllin pentoxifyllin, thromboxane and thromboxane synthetase inhibitors such as, for example, picotamide, sulotroban, ticlopidine, tirofiban, trapidil, ticlopidine, trifenagrel, trilinolein, 3-substituted 5,6-bis(4-methoxyphenyl)-1,2,4-triazines; antibodies to glycoprotein IIb/IIIa; anti-serotonin drugs, such as, for example, clopidogrel; sulfinpyrazone and the like; aspirin; dipyridamole; clofibrate; pyridinol carbamate; glucagon, caffeine; theophyllin pentoxifyllin; ticlopidine, and the like.

Suitable proton pump inhibitors include, but are not limited to, disulprazole,

esomeprazole, lansoprazole, leminoprazole, omeprazole, pantoprazole, rabeprazole, timoprazole, tenatoprazole, 2-(2-benzimidazolyl)-pyridine, tricyclic imidazole, thienopyridine benzimidazole, fluoroalkoxy substituted benzimidazole, dialkoxy benzimidazole, N-substituted 2-(pyridylalkenesulfinyl) benzimidazole, cycloheptenepyrindine, 5-pyrrolyl-2-pyridylmethylsulfinyl benzimidazole, alkylsulfinyl benzimidazole, fluoro-pyridylmethylsulfinyl benzimidazole, imidazo(4,5-b)pyridine, RO 18-5362, IY 81149, 4-amino-3-carbonyl quinoline, 4-amino-3-acylnaphthyridine, 4-aminoquinoline, 4-amino-3-acylquinoline, 3-butyryl-4-(2-methylphenylamino)-8-(2-hydroxyethoxy)quinoline, quinazoline, tetrahydroisoquinolin-2-yl pyrimidine, YH 1885, 3-substituted 1,2,4-thiadiazolo(4,5-a) benzimidazole, 3-substituted imidazo(1,2-d)-thiadiazole, 2-sulfinylnicotinamide, pyridylsulfinylbenzimidazole, pyridylsulfinyl thienoimidazole, theinoimidazole-toluidine, 4,5-dihydrooxazole, thienoimidazole-toluidine, Hoe-731, imidazo(1,2-a)pyridine, pyrrolo(2,3-b)pyridine, and the like. Suitable proton pump inhibitors are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; the Merck Index on CD-ROM, 13th Edition; and in WO 00/50037 assigned to NitroMed Inc., the disclosures of which are incorporated herein by reference in their entirety.

Suitable renin inhibitors include, but are not limited to, aldosterone, aliskiren (SPP-100), ditekiren, enalkrein (A-64662), medullipin, terliren, tonin, zankiren, RO 42-5892 (remikiren), A 62198, A 64662, A 65317, A 69729, A 72517 (zankiren), A 74273, CP 80794, CGP 29287, CGP-38560A, EMD 47942, ES 305, ES 1005, ES 8891, FK 906, FK 744, H 113, H-142, KRI 1314, pepstatin A, RO 44-9375 (ciprokiren), RO 42-5892, RO 66-1132, RO 66-1168, SP 500, SP 800, SR-43845, SQ 34017, U 71038, YM-21095, YM-26365, urea derivatives of peptides, amino acids connected by nonpeptide bonds, di- and tri-peptide derivatives (e.g., Act-A, Act-B, Act-C, ACT-D, and the like), amino acids and derivatives thereof, diol sulfonamides and sulfinyls, modified peptides, peptidyl beta-aminoacyl aminodiols, carbamates, monoclonal antibodies to renin. Suitable renin inhibitors are described more fully in U.S. Patent Nos. 5,116,835, 5,114,937, 5,106,835, 5,104,869, 5,095,119, 5,098,924, 5,095,006, 5,089,471, 5,075,451, 5,066,643, 5,063,208, 4,845,079, 5,055,466, 4,980,283, 4,885,292, 4,780,401, 5,071,837, 5,064,965, 5,063,207, 5,036,054, 5,036,053, 5,034,512, and 4,894,437, the disclosures of each of which are incorporated herein by reference in their entirety; and in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

Suitable COX-2 inhibitors include, but are not limited to, nimesulide, celecoxib (CELEBREX®), etoricoxib (ARCOXIA®), flosulide, lumiracoxib (PREXIG®, COX-189), parecoxib (DYNSTAT®), rofecoxib (VIOXX®), tiracoxib (JTE-522), valdecoxib (BEXTRA®), ABT 963, BMS 347070, CS 502, DuP 697, GW-406381, NS-386, SC-57666, SC-58125, SC-58635, and the like, and mixtures of two or more thereof. Suitable COX-2 inhibitors are in U.S. Patent Nos. 5,344,991, 5,380,738, 5,393,790, 5,409,944, 5,434,178, 5,436,265, 5,466,823, 5,474,995, 5,510,368, 5,536,752, 5,550,142, 5,552,422, 5,604,253, 5,604,260, 5,639,780, 5,932,598 and 6,633,272, and in WO 94/03387, WO 94/15723, WO 94/20480, WO 94/26731, WO 94/27980, WO 95/00501, WO 95/15316, WO 96/03387, WO 96/03388, WO 96/06840, WO 96/21667, WO 96/31509, WO 96/36623, WO 97/14691, WO 97/16435, WO 01/45703 and WO 01/87343, the disclosures of each of which are incorporated herein by reference in their entirety; and in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995; and the Merck Index on CD-ROM, Thirteenth Edition; and on STN Express, file phar and file registry.

In some embodiments the COX-2 inhibitors are celecoxib, etoracoxib, lumiracoxib, paracoxib, rofecoxib or valdecoxib. In more particular embodiments the celecoxib is administered in an amount of about 100 milligrams to about 800 milligrams as a single dose or as multiple doses per day; the etoricoxib is administered in an amount of about 50 milligrams to about 200 milligrams as a single dose or as multiple doses per day; the lumiracoxib is administered in an amount of about 40 milligrams to about 1200 milligrams as a single dose or as multiple doses per day; the paracoxib is administered in an amount of about 20 milligrams to about 100 milligrams as a single dose or as multiple doses per day; the rofecoxib is administered in an amount of about 12.5 milligrams to about 50 milligrams as a single dose or as multiple doses per day; the valdecoxib is administered in an amount of about 10 milligrams to about 40 milligrams as a single dose or as multiple doses per day.

Suitable steroids include, but are not limited to, 21-acetoxypregnenolone, alcolometasone, algestone, amcinonide, beclomethasone, betamethasone, budesonide, chlorprednisone, clobetasol, clobetasone, clocortolone, cloprednol, corticosterone, cortisone, corticazol (cortivatoI), deflazacort, desonide, desoximetasone, dexamethasone, diflorasone, diflucortolone, difluprednate, enoxolone, fluzacort, fluccloronide, flumethasone, flunisolide, flucinolone acetonide, fluocininide, fluocortin butyl, fluocortolone, fluorometholone, fluperolone acetate, fluprednidene acetate, fluprednisolone, flurandrenolide, fluticasone propionate, fluticasone propionate, formocortal, halcinonide, halobetasol propionate,

halometasone, haloprednone acetate, hydrocortamate, hydrocortisone and its derivatives (such as phosphate, 21-sodium succinate and the like), hydrocortisone terbutate, isoflupredone, loteprednol etabonate, mazipredone, medrysone, meprednisone, methylprednisolone, mometasone furoate, paremethasone, prednicarbate, prednisolone and its derivatives (such as 21-stearoylglycolate, sodium phosphate and the like), prednisone, prednival, prednylidene and its derivatives (such as 21-diethylaminoacetate and the like), rimexolone, tixocortol, trimcinolone and its derivatives (such as acetamide, benetonide and the like), and the like. Suitable NSAIDs are described more fully in the literature, such as in Goodman and Gilman, The Pharmacological Basis of Therapeutics (9th Edition), McGraw-Hill, 1995, Pgs. 617-657; the Merck Index on CD-ROM, 13th Edition; and in U.S. Patent Nos. 6,057,347 and 6,297,260 assigned to NitroMed Inc., the disclosures of which are incorporated herein by reference in their entirety.

In some embodiments the steroids are dexamethasone, fluorometholone, hydrocortisone, and prednisolone.

Another embodiment of the invention provides methods for treating bacterial infections by administering to the patient in need thereof an effective amount of the compounds and/or compositions described herein. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H₂ receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide enhancing compounds, and/or

therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

In one embodiment the invention provides methods for treating bacterial infections associated with pulmonary infections in patients with disease including, but not limited to, endobronchial infections, cystic fibrosis, bronchiectasis, pneumonia, tuberculosis, emphysema, AIDS, pneumococcal meningitis, bacteremia, otitis media, chronic obstructive pulmonary disease, sinus congestion, common cold, septicemia and the like; gastrointestinal infections, including, but not limited to, chronic gastritis, gastric ulcer, duodenal ulcer, *Helicobacter pylori*, gastric malignant lymphoma, gastroenteritis, diarrhea, dysentery, inflammatory bowel disease, Crohn's disease, ulcerative colitis, infections resulting from *E. Coli*, and the like; and infections of the eyes, ear or nose, by administering to the patient in need thereof an effective amount of the compounds and/or compositions described herein. In one embodiment, the invention provides methods for treating cystic fibrosis. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide enhancing compounds, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

In one embodiment the invention provides methods for treating *Bacillus anthracis*

infections, by administering to the patient in need thereof an effective amount of the compounds and/or compositions described herein. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. In one embodiment the therapeutic agent is an antioxidant. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide enhancing compounds, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

Another embodiment of the invention provides methods for treating viral infections by administering to the patient in need thereof an effective amount of the compounds and/or compositions described herein. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-

converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide donors, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

Yet another embodiment of the invention provides methods for treating fungal infections by administering to the patient in need thereof an effective amount of the compounds and/or compositions described herein. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide enhancing compounds, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

Yet another embodiment of the invention provides methods for treating lesions by administering to the patient in need thereof an effective amount of the compounds and/or

compositions described herein. For example, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound. In another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound. In yet another embodiment, the patient can be administered an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, at least one therapeutic agent, including but not limited to, such as, for example, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics, endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and, optionally, at least one nitric oxide enhancing compound. The organic nitric oxide donor salts of antimicrobial compounds, nitric oxide enhancing compounds, and/or therapeutic agents can be administered separately or as components of the same composition in one or more pharmaceutically acceptable carriers.

When administered separately, the organic nitric oxide donor of an antimicrobial, nitric oxide donor and/or therapeutic agent can be administered about the same time as part of the overall treatment regimen, i.e., as a combination therapy. "About the same time" includes administering the organic nitric oxide donor salt of the antimicrobial compound, simultaneously, sequentially, at the same time, at different times on the same day, or on different days, as long as they are administered as part of an overall treatment regimen, i.e., combination therapy or a therapeutic cocktail.

When administered in vivo, the compounds and compositions of the invention can be administered in combination with pharmaceutically acceptable carriers and in dosages described herein. When the compounds and compositions of the invention are administered as a combination of at least one organic nitric oxide donor salt of an antimicrobial compound and/or at least one nitric oxide enhancing compound and/or therapeutic agent, they can also be used in combination with one or more additional compounds which are known to be effective against the specific disease state targeted for treatment. The nitric oxide enhancing

compounds, therapeutic agents and/or other additional compounds can be administered simultaneously with, subsequently to, or prior to administration of the nitrosated and/or nitrosylated compound of the invention.

The compounds and compositions of the invention can be administered by any available and effective delivery system including, but not limited to, orally, buccally, parenterally, by inhalation, by topical application, by injection, transdermally, or rectally (e.g., by the use of suppositories) in dosage unit formulations containing conventional nontoxic pharmaceutically acceptable carriers, adjuvants, and vehicles, as desired. Parenteral includes subcutaneous injections, intravenous, intramuscular, intrasternal injection, or infusion techniques.

Transdermal compound administration, which is known to one skilled in the art, involves the delivery of pharmaceutical compounds via percutaneous passage of the compound into the systemic circulation of the patient. Topical administration can also involve the use of transdermal administration such as transdermal patches or iontophoresis devices. Other components can be incorporated into the transdermal patches as well. For example, compositions and/or transdermal patches can be formulated with one or more preservatives or bacteriostatic agents including, but not limited to, methyl hydroxybenzoate, propyl hydroxybenzoate, chlorocresol, benzalkonium chloride, and the like. Dosage forms for topical administration of the compounds and compositions can include creams, sprays, lotions, gels, ointments, eye drops, nose drops, ear drops, and the like. In such dosage forms, the compositions of the invention can be mixed to form white, smooth, homogeneous, opaque cream or lotion with, for example, benzyl alcohol 1% or 2% (wt/wt) as a preservative, emulsifying wax, glycerin, isopropyl palmitate, lactic acid, purified water and sorbitol solution. In addition, the compositions can contain polyethylene glycol 400 or 300. They can be mixed to form ointments with, for example, benzyl alcohol 2% (wt/wt) as preservative, white petrolatum, emulsifying wax, and tenox II (butylated hydroxyanisole, propyl gallate, citric acid, propylene glycol). Woven pads or rolls of bandaging material, e.g., gauze, can be impregnated with the compositions in solution, lotion, cream, ointment or other such form can also be used for topical application. The compositions can also be applied topically using a transdermal system, such as one of an acrylic-based polymer adhesive with a resinous crosslinking agent impregnated with the composition and laminated to an impermeable backing.

The compositions can also be applied topically using a transdermal system, such as one of an acrylic-based polymer adhesive with a resinous crosslinking agent impregnated with

the composition and laminated to an impermeable backing. In a particular embodiment, the compositions of the invention are administered as a transdermal patch, more particularly as a sustained-release transdermal patch. The transdermal patches of the invention can include any conventional form such as, for example, adhesive matrix, polymeric matrix, reservoir patch, matrix or monolithic-type laminated structure, and are generally comprised of one or more backing layers, adhesives, penetration enhancers, an optional rate controlling membrane and a release liner which is removed to expose the adhesives prior to application. Polymeric matrix patches also comprise a polymeric-matrix forming material. Suitable transdermal patches are described in more detail in, for example, U. S. Patent Nos. 5,262,165, 5,948,433, 6,010,715 and 6,071,531, the disclosure of each of which are incorporated herein in their entirety.

Solid dosage forms for oral administration can include capsules, sustained-release capsules, tablets, sustained release tablets, chewable tablets, sublingual tablets, effervescent tablets, pills, powders, granules and gels. In such solid dosage forms, the active compounds can be admixed with at least one inert diluent such as sucrose, lactose or starch. Such dosage forms can also comprise, as in normal practice, additional substances other than inert diluents, e.g., lubricating agents such as magnesium stearate. In the case of capsules, tablets, effervescent tablets, and pills, the dosage forms can also comprise buffering agents. Soft gelatin capsules can be prepared to contain a mixture of the active compounds or compositions of the invention and vegetable oil. Hard gelatin capsules can contain granules of the active compound in combination with a solid, pulverulent carrier such as lactose, saccharose, sorbitol, mannitol, potato starch, corn starch, amylopectin, cellulose derivatives of gelatin. Tablets and pills can be prepared with enteric coatings.

Liquid dosage forms for oral administration can include pharmaceutically acceptable emulsions, solutions, suspensions, syrups, and elixirs containing inert diluents commonly used in the art, such as water. Such compositions can also comprise adjuvants, such as wetting agents, emulsifying and suspending agents, and sweetening, flavoring, and perfuming agents.

Suppositories for vaginal or rectal administration of the compounds and compositions of the invention, such as for treating pediatric fever and the like, can be prepared by mixing the compounds or compositions with a suitable nonirritating excipient such as cocoa butter and polyethylene glycols which are solid at room temperature but liquid at rectal temperature, such that they will melt in the rectum and release the drug.

Injectable preparations, for example, sterile injectable aqueous or oleaginous

suspensions can be formulated according to the known art using suitable dispersing agents, wetting agents and/or suspending agents. The sterile injectable preparation can also be a sterile injectable solution or suspension in a nontoxic parenterally acceptable diluent or solvent, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that can be used are water, Ringer's solution, and isotonic sodium chloride solution. Sterile fixed oils are also conventionally used as a solvent or suspending medium.

Inhaled formulations can be administered, for example, as pressurized aerosols and/or nebulized formulations to the patient's lungs. Such formulations may contain a variety of known aerosol propellants useful for endopulmonary and/or intranasal inhalation administration. In addition, water may be present, with or without any of a variety of cosolvents, surfactants, stabilizers (such as, for example, antioxidants, chelating agents, inert gases, buffers and the like). The formulation may also be aerosolized by atomizing which can produce aerosols and/or dry powder particles between 1 and 5 microns for the efficacious delivery of the inhaled formulation.

The compositions of this invention can further include conventional excipients, i.e., pharmaceutically acceptable organic or inorganic carrier substances suitable for parenteral application which do not deleteriously react with the active compounds. Suitable pharmaceutically acceptable carriers include, for example, water, salt solutions, alcohol, vegetable oils, polyethylene glycols, gelatin, lactose, amylose, magnesium stearate, talc, surfactants, silicic acid, viscous paraffin, perfume oil, fatty acid monoglycerides and diglycerides, petroethral fatty acid esters, hydroxymethyl-cellulose, polyvinylpyrrolidone, and the like. The pharmaceutical preparations can be sterilized and if desired, mixed with auxiliary agents, e.g., lubricants, preservatives, stabilizers, wetting agents, emulsifiers, salts for influencing osmotic pressure, buffers, colorings, flavoring and/or aromatic substances and the like which do not deleteriously react with the active compounds. For parenteral application, particularly suitable vehicles consist of solutions, preferably oily or aqueous solutions, as well as suspensions, emulsions, or implants. Aqueous suspensions may contain substances which increase the viscosity of the suspension and include, for example, sodium carboxymethyl cellulose, sorbitol and/or dextran. Optionally, the suspension may also contain stabilizers.

The composition, if desired, can also contain minor amounts of wetting agents, emulsifying agents and/or pH buffering agents. The composition can be a liquid solution, suspension, emulsion, tablet, pill, capsule, sustained release formulation, or powder. The composition can be formulated as a suppository, with traditional binders and carriers such as

triglycerides. Oral formulations can include standard carriers such as pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, and the like.

Various delivery systems are known and can be used to administer the compounds or compositions of the invention, including, for example, encapsulation in liposomes, microbubbles, emulsions, microparticles, microcapsules and the like. The required dosage can be administered as a single unit or in a sustained release form.

The bioavailability of the compositions can be enhanced by micronization of the formulations using conventional techniques such as grinding, milling, spray drying and the like in the presence of suitable excipients or agents such as phospholipids or surfactants.

Sustained release dosage forms of the invention may comprise microparticles and/or nanoparticles having a therapeutic agent dispersed therein or may comprise the therapeutic agent in pure, preferably crystalline, solid form. For sustained release administration, microparticle dosage forms comprising pure, crystalline, therapeutic agents. The therapeutic dosage forms of this aspect of the invention may be of any configuration suitable for sustained release.

Nanoparticle sustained release therapeutic dosage forms are preferably biodegradable and, optionally, bind to the vascular smooth muscle cells and enter those cells, primarily by endocytosis. The biodegradation of the nanoparticles occurs over time (e.g., 30 to 120 days; or 10 to 21 days) in prelysosomal vesicles and lysosomes. Larger microparticle therapeutic dosage forms of the invention release the therapeutic agents for subsequent target cell uptake with only a few of the smaller microparticles entering the cell by phagocytosis. A practitioner in the art will appreciate that the precise mechanism by which a target cell assimilates and metabolizes a dosage form of the invention depends on the morphology, physiology and metabolic processes of those cells. The size of the particle sustained release therapeutic dosage forms is also important with respect to the mode of cellular assimilation. For example, the smaller nanoparticles can flow with the interstitial fluid between cells and penetrate the infused tissue. The larger microparticles tend to be more easily trapped interstitially in the infused primary tissue, and thus are useful to deliver anti-proliferative therapeutic agents.

Particular sustained release dosage forms of the invention comprise biodegradable microparticles or nanoparticles. More particularly, biodegradable microparticles or nanoparticles are formed of a polymer containing matrix that biodegrades by random, nonenzymatic, hydrolytic scissioning to release therapeutic agent, thereby forming pores

within the particulate structure.

In a particular embodiment, the compositions of the invention are administered by inhalation. For example, the inhaled formulations can comprise an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and, optionally at least one nitric oxide enhancing compound, or the inhaled formulations can comprise an effective amount of at least one organic nitric oxide donor salt of an antimicrobial compound, and at least one nitric oxide enhancing compound, and, optionally at least one therapeutic agent

The compositions of the invention can be formulated as pharmaceutically acceptable salt forms. Pharmaceutically acceptable salts include, for example, alkali metal salts and addition salts of free acids or free bases. The nature of the salt is not critical, provided that it is pharmaceutically-acceptable. Suitable pharmaceutically-acceptable acid addition salts may be prepared from an inorganic acid or from an organic acid. Examples of such inorganic acids include, but are not limited to, hydrochloric, hydrobromic, hydroiodic, nitric, carbonic, sulfuric and phosphoric acid and the like. Appropriate organic acids include, but are not limited to, aliphatic, cycloaliphatic, aromatic, heterocyclic, carboxylic and sulfonic classes of organic acids, such as, for example, formic, acetic, propionic, succinic, glycolic, gluconic, lactic, malic, tartaric, citric, ascorbic, glucuronic, maleic, fumaric, pyruvic, aspartic, glutamic, benzoic, anthranilic, mesylic, salicylic, p-hydroxybenzoic, phenylacetic, mandelic, embonic (pamoic), methanesulfonic, ethanesulfonic, benzenesulfonic, pantothenic, toluenesulfonic, 2-hydroxyethanesulfonic, sulfanilic, stearic, algenic, β -hydroxybutyric, cyclohexylaminosulfonic, galactaric and galacturonic acid and the like. Suitable pharmaceutically-acceptable base addition salts include, but are not limited to, metallic salts made from aluminum, calcium, lithium, magnesium, potassium, sodium and zinc or organic salts made from primary, secondary and tertiary amines, cyclic amines, N,N'-dibenzylethylenediamine, chlorprocaine, choline, diethanolamine, ethylenediamine, meglumine (N-methylglucamine) and procaine and the like. All of these salts may be prepared by conventional means from the corresponding compound by reacting, for example, the appropriate acid or base with the compound.

While individual needs may vary, determination of optimal ranges for effective amounts of the compounds and/or compositions is within the skill of the art. Generally, the dosage required to provide an effective amount of the compounds and compositions, which can be adjusted by one of ordinary skill in the art, will vary depending on the age, health, physical condition, sex, diet, weight, extent of the dysfunction of the recipient, frequency of treatment and the nature and scope of the dysfunction or disease, medical condition of the

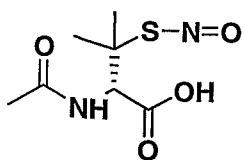
patient, the route of administration, pharmacological considerations such as the activity, efficacy, pharmacokinetic and toxicology profiles of the particular compound used, whether a drug delivery system is used, and whether the compound is administered as part of a drug combination.

5 The amount of a given organic nitric oxide donor salt of an antimicrobial compound that will be effective in the treatment of a particular disorder or condition will depend on the nature of the disorder or condition, and can be determined by standard clinical techniques, including reference to Goodman and Gilman, *supra*; The Physician's Desk Reference, Medical Economics Company, Inc., Oradell, N.J., 1995; and Drug Facts and Comparisons, Inc., St. Louis, MO, 1993. The precise dose to be used in the formulation will also depend on
10 the route of administration, and the seriousness of the disease or disorder, and should be decided by the physician and the patient's circumstances. For example, in one embodiment anorganic nitric oxide donor salt of an antimicrobial compound is administered at about 2.5 mg to 1 gram, once a day or multiple times per day.

5 The invention also provides pharmaceutical kits comprising one or more containers filled with one or more of the ingredients of the pharmaceutical compounds and/or compositions of the invention, including, at least, one or more of the novel organic nitric oxide donor salts of antimicrobial compounds and one or more of the Nitric oxide enhancing compounds described herein. Associated with such kits can be additional therapeutic agents
10 or compositions (e.g., including, but not limited to, aldosterone antagonists, alpha-adrenergic receptor antagonists, β -adrenergic agonists, anti-allergic compounds, antidiabetic compounds, anti-hyperlipidemic drugs, antitussive compounds, angiotensin II antagonists, angiotensin-converting enzyme (ACE) inhibitors, antioxidants, antithrombotic and vasodilator compounds, β -adrenergic antagonists, bronchodilators, calcium channel blockers, diuretics,
15 endothelin antagonists, expectorants, hydralazine compounds, H_2 receptor antagonists, neutral endopeptidase inhibitors, nonsteroidal antiinflammatory compounds (NSAIDs), phosphodiesterase inhibitors, potassium channel blockers, platelet reducing agents, proton pump inhibitors, renin inhibitors, selective cyclooxygenase-2 (COX-2) inhibitors, steroids, and combinations of two or more thereof) devices for administering the compositions, and notices in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products which reflects approval by the agency of
20 manufacture, use or sale for humans.

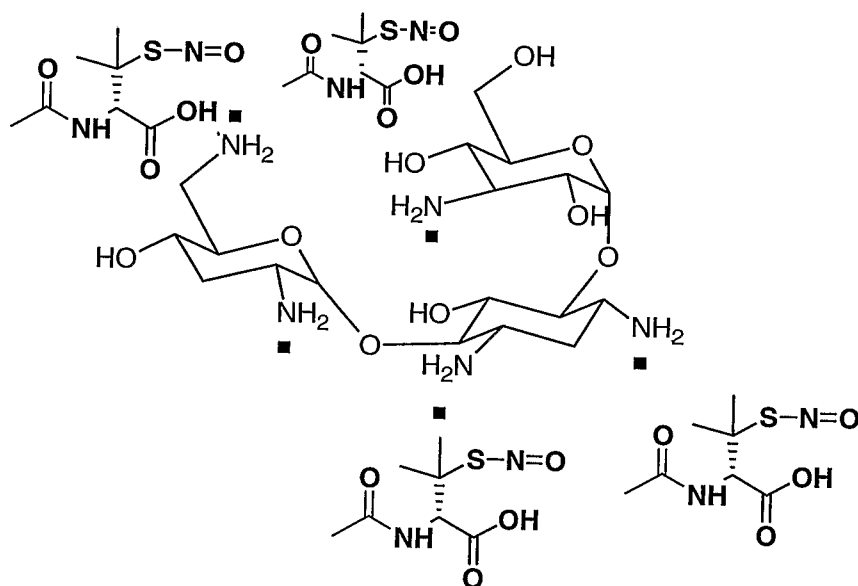
EXAMPLES

Example 1: D-valine, N-acetyl-3-(nitrosothio)-

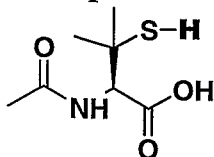


Pulverized D-valine, N-acetyl-3-mercapto- (Fluka, 1.91 g, 10 mmol) was suspended in methanol (20 mL). 1M HCl (20 mL) and sulfuric acid (2 mL) were added and the reaction mixture was cool to approximately room temperature. Sodium nitrite (1.38 g, 20 mmol) in water (20 mL) was added dropwisely over 5 minutes. D-valine, N-acetyl-3-mercapto- dissolved and formed a green solid. The suspension was stirred at room temperature for 25 minutes. The crystals were collected by filtration and washed with water, dried in vacuum to give the title compound (1.40 g, 64% yield). ^1H NMR (300 MHz, CD_3OD) δ 5.32 (s, 1 H), 2.04 (s, 3 H), 2.01 (s, 3 H), 1.97 (s, 3 H). . LRMS (APIMS) m/z 221 (MH^+), 238 (MNH_4^+).

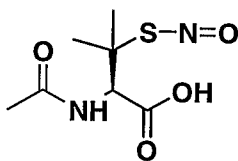
Example 2: D-valine, N-acetyl-3-(nitrosothio)-, salt of hexopyranoside, 4,6-diamino-3-[(3-amino-3-deoxyhexopyranosyl)oxy]-2-hydroxycyclohexyl 2,6-diamino-2,3,6-trideoxy- (5:1)



Hexopyranoside, 4,6-diamino-3-[(3-amino-3-deoxyhexopyranosyl)oxy]-2-hydroxycyclohexyl 2,6-diamino-2,3,6-trideoxy- (SAFC, 31.32 mg, 67.15 mmol) and the product of Example 1 (73.942 mg, 335.72 mmol) were mixed and dissolved in water (5 mL). The resultant solution was freeze dried to give 105 mg of the title compound. NMR (300 MHz, D_2O) δ 5.67 (d, $J = 3.9$ Hz, 1 H), 5.03 (d, $J = 3.9$ Hz, 1 H), 4.89 (s, 3.75 H), 4.18 (s, 1.25 H), 3.93-3.31 (m, 16 H), 3.18 (dd, $J = 7.2$ & 13.8 Hz, 1 H), 2.46 (m, 1 H), 2.21 (m 1 H), 2.13-1.71 (m, 2 H), 1.97 (s, 3.4 H), 1.91 (S, 23 H), 1.88 (s, 11.7 H), 1.33 (s, 3.4 H), 1.29 (s, 3.4 H).

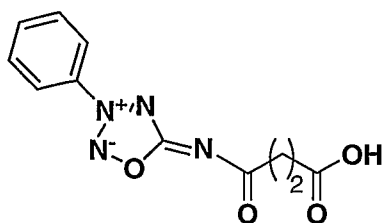
Example 3: L-valine, N-acetyl-3-(nitrosothio)-**3a. L-valine, N-acetyl-3-mercapto-**

L-Valine, 3-mercapto- (Acros, 4.04 g, 27.08 mmol) was suspended in water (11 mL) and sodium acetate trihydrate (4.97 g, 36.52 mmol) was added. HBr (48%, 3.06 mL, 27.05 mmol) was added dropwisely. The resultant suspension was stirred at room temperature for 15 minutes. Acetic anhydride (2.93 mL, 31.02 mmol) was added dropwisely. The reaction mixture was then stirred at room temperature for 1 hour and filtered. The solid was washed with water (~4 mL) and dried under vacuum to give a crude product (4.05 g). The crude product was re-crystalized from hot water (75 mL) to give the title compound (3.23 g, 62 % yield). ¹H NMR (300 MHz, CD₃OD) δ 4.35 (s, 1 H), 1.97 (s, 3 H), 1.39 (s, 3 H), 1.33 (s, 3 H). . LRMS (APIMS) *m/z* 192 (MH⁺), 209 (MNH₄⁺).

**3b. L-valine, N-acetyl-3-(nitrosothio)-**

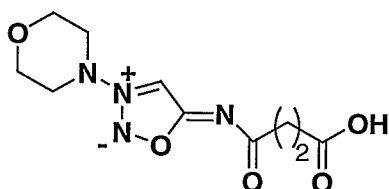
Pulverized L-valine, N-acetyl-3-mercapto- (484 mg, 2.53 mmol) was suspended in methanol (5 mL). 1M HCl (5 mL) and sulfuric acid (0.5 mL) were added and the reaction mixture allowed to approximately room temperature. Sodium nitrite (348.4 mg, 5.05 mmol) in water (5 mL) was added dropwisely over 3 minutes. L-valine, N-acetyl-3-mercapto- dissolved and formed a green solid. The suspension was stirred at room temperature for 25 minutes. The crystals were collected by filtration, washed with water, and dried under vacuum to give the title compound (290 g, 52 % yield). ¹H NMR (300 MHz, CD₃OD) δ 5.32 (s, 1 H), 2.04 (s, 3 H), 2.01 (s, 3 H), 1.97 (s, 3 H). . LRMS (APIMS) *m/z* 221 (MH⁺), 238 (MNH₄⁺).

Example 4: 1,2,3,4-oxatriazolium, 5-[(3-carboxy-1-oxopropyl)imino]-2,5-dihydro-3-phenyl-, inner salt, (5E)-



1,2,3,4-oxatriazolium, 2,5-dihydro-5-imino-3-phenyl-, inner salt, monohydrochloride (prepared according to the procedure described in WO 92/013847 A1) will be dissolved in a mixture of chloroform and water. In an ice-water bath, potassium carbonate solution will be added dropwisely. The resultant mixture will be transferred into a rapid stirring chloroform solution of succinyl chloride (10 eq.) The product will be purified by chromatography.

Example 5: 1,2,3-oxadiazolium, 5-[(3-carboxy-1-oxopropyl)imino]-2,5-dihydro-3-(4-morpholinyl)-, inner salt, (5*E*)-



1,2,3-oxadiazolium, 2,5-dihydro-5-imino-3-(4-morpholinyl)-, inner salt, monohydrochloride (prepared as described in US Patent Appl. 2003/050256; Chem. Pharm. Bull. (1970), 18(1), 128-32)) will be dissolved in a mixture of chloroform and water. In an ice-water bath, potassium carbonate solution will be added dropwisely. The resultant mixture will be transferred into a rapid stirring chloroform solution of succinyl chloride (10 eq.) The product will be purified by chromatography.

The disclosure of each patent, patent application and publication cited or described in the present specification is hereby incorporated by reference herein in its entirety.

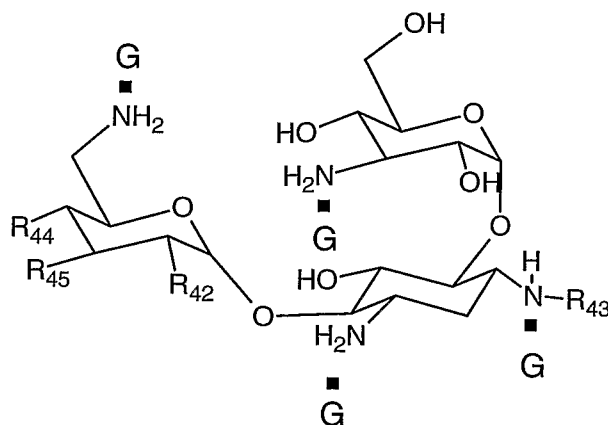
Although the invention has been set forth in detail, one skilled in the art will appreciate that numerous changes and modifications can be made to the invention, and that such changes and modifications can be made without departing from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A compound of Formula (I), (II), (III) or (IV):

wherein the compound of Formula (I) is:



I

wherein:

R_{42} is $-\text{OH}$, $-\text{NH}_2$ or $-\text{NH}_2 \cdot \text{G}$;

R_{43} is a hydrogen, $(2S)\text{-C(O)-CH(OH)-(CH}_2\text{)}_2\text{-NH}_2$, $(2S)\text{-C(O)-CH(OH)-(CH}_2\text{)}_2\text{-NH}_2 \cdot \text{G}$; $(2R)\text{-C(O)-CH(OH)-(CH}_2\text{)}_2\text{-NH}_2$ or $(2R)\text{-C(O)-CH(OH)-(CH}_2\text{)}_2\text{-NH}_2 \cdot \text{G}$;

R_{44} and R_{45} are each independently is a hydrogen or OH;

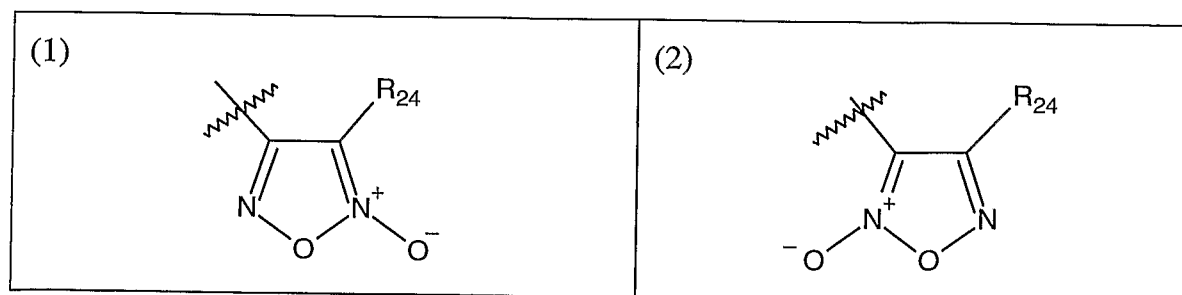
G is either not present, an organic acid, an inorganic acid, or K;

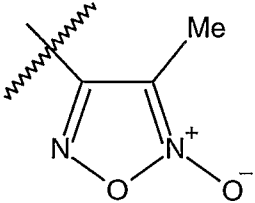
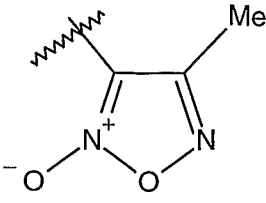
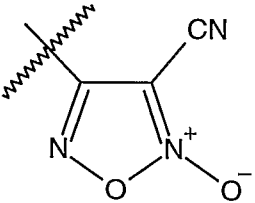
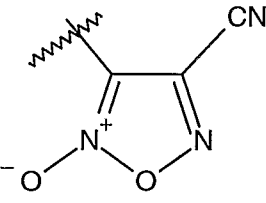
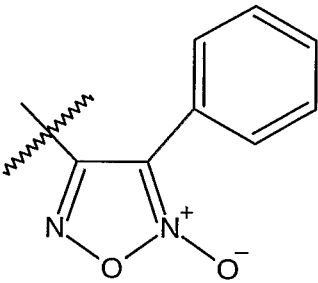
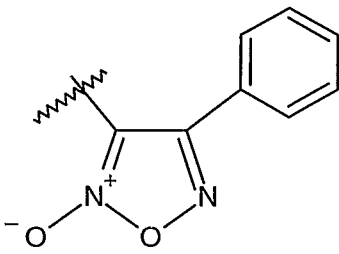
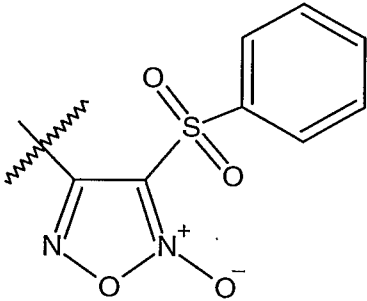
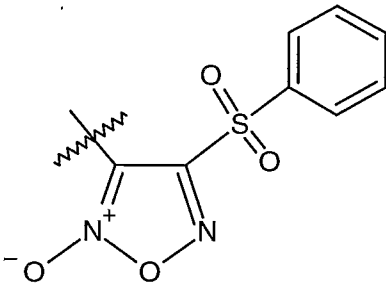
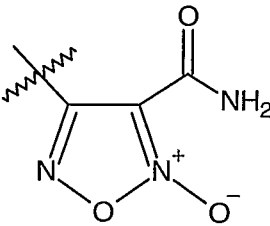
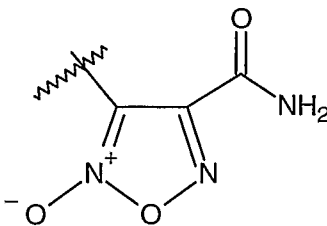
K is $\text{Z-(W}_3\text{)}_a\text{-E}_b\text{-(C(R}_e\text{)(R}_f\text{))}_{p1}\text{-E}_c\text{-(C(R}_e\text{)(R}_f\text{))}_x\text{-(W}_3\text{)}_d\text{-(C(R}_e\text{)(R}_f\text{))}_y\text{-(W}_3\text{)}_i\text{-E}_j\text{-(W}_3\text{)}_g\text{-(C(R}_e\text{)(R}_f\text{))}_z\text{-V}_7$;

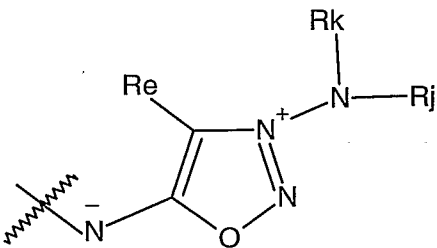
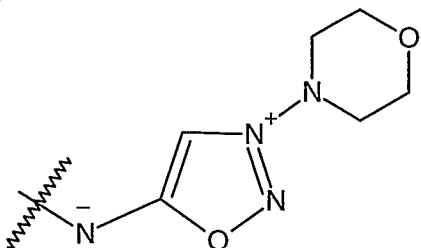
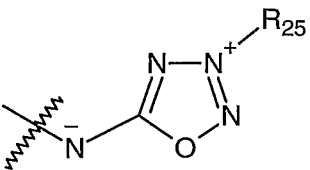
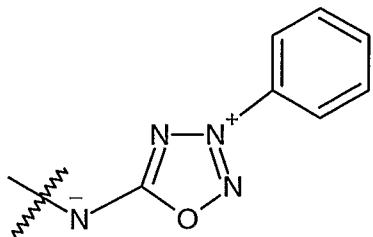
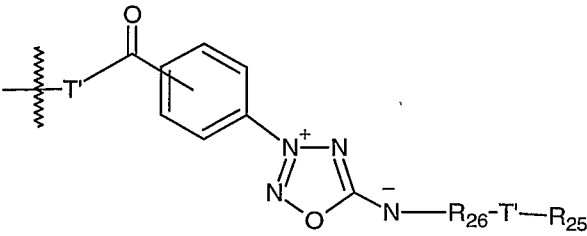
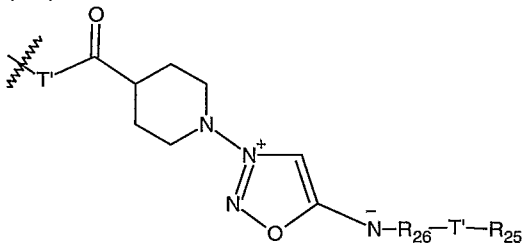
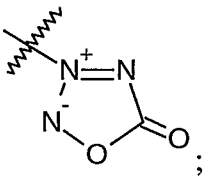
Z is $-\text{CO}_2\text{H}$, $-\text{SO}_3\text{H}$ or $-\text{P(O)OR}_{25}\text{OH}$;

V_7 is V_3 , R_e , $-\text{U}_3\text{-V}_5$ or V_6 ;

V_3 is:



(3) 	(4) 
(5) 	(6) 
(7) 	(8) 
(9) 	(10) 
(11) 	(12) 

(13) 	(14) 
(15) 	(16) 
(17) 	(18)  or
(19) 	

R_{24} is $-C_6H_4R_{29}$, $-CN$, $-S(O)_2-C_6H_4R_{29}$, $-C(O)-N(R_a)(R_i)$, $-NO_2$, $-C(O)-OR_{25}$ or $-S(O)_2-R_{25}$;

R_{25} is an aryl group, a lower alkyl group, a haloalkyl group, a hydroxyalkyl group or an arylalkyl group;

R_{26} is $-C(O)-$ or $-S(O)_2-$;

R_{29} is a hydrogen, $-CN$, $-S(O)_2-R_{25}$, $-C(O)-N(R_a)(R_i)$, $-NO_2$ or $-C(O)-OR_{25}$;

T' is oxygen, sulfur or NR_6 ;

R_6 is a hydrogen, a lower alkyl group, an aryl group;

a, b, c, d, g, i and j are each independently an integer from 0 to 3;

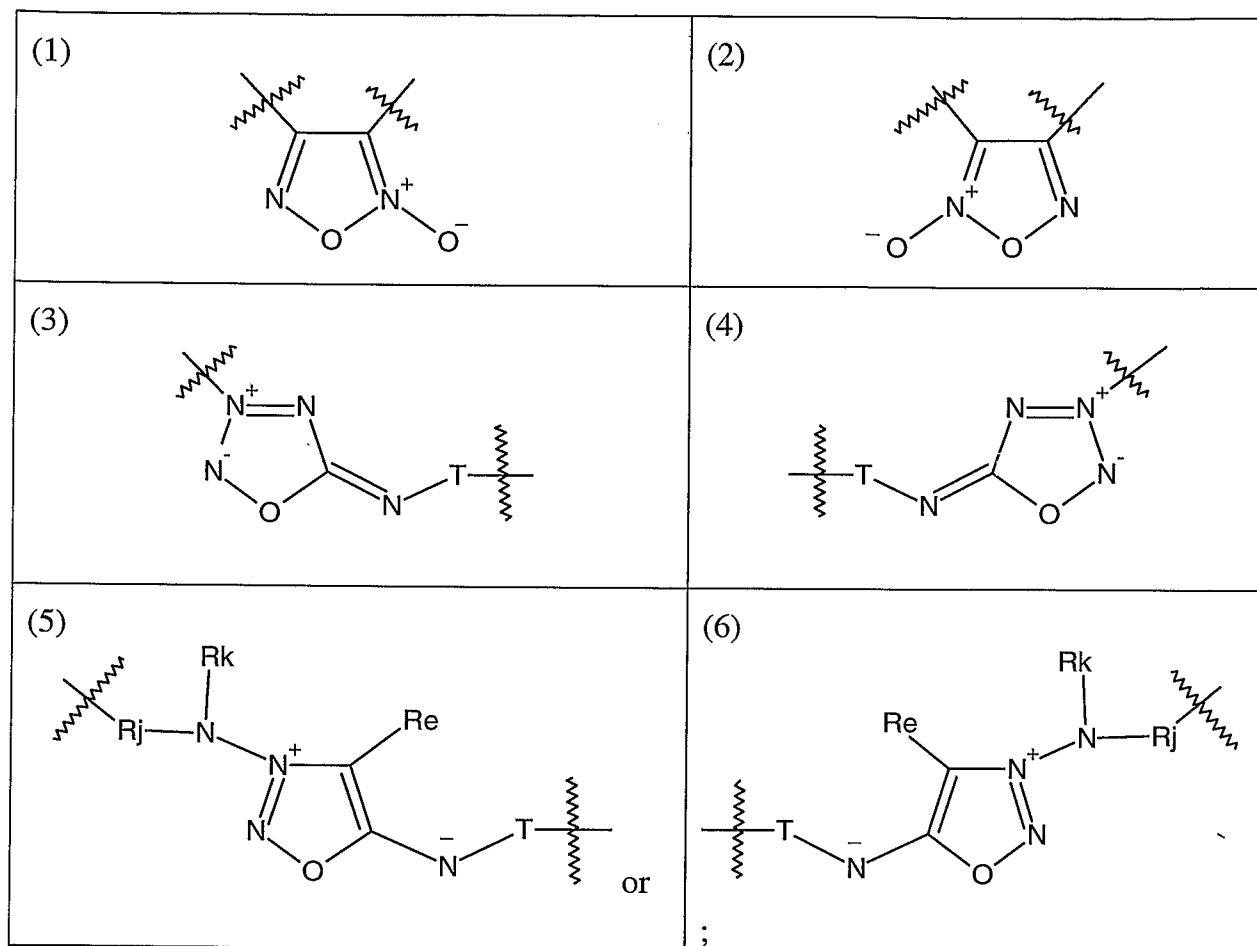
p_1 , x, y and z are each independently an integer from 0 to 10;

W_3 at each occurrence is independently $-C(O)-$, $-C(S)-$, $-T_3-$, $-(C(R_e)(R_f))_h-$, $-N(R_a)R_i$,

an alkyl group, an aryl group, a heterocyclic ring, an arylheterocyclic ring, $-(\text{CH}_2\text{CH}_2\text{O})_{q_1}-$ or a heterocyclic nitric oxide donor;

E at each occurrence is independently $-\text{T}_3-$, an alkyl group, an aryl group, $-(\text{C}(\text{R}_e)(\text{R}_f))_h-$, a heterocyclic ring, an arylheterocyclic ring, $-(\text{CH}_2\text{CH}_2\text{O})_{q_1}-$ or Y_3 ;

Y_3 is:



T is a $-\text{S}(\text{O})_o-$; a carbonyl or a covalent bond;

o is an integer from 0 to 2;

R_j and R_k are independently selected from an alkyl group, an aryl group, or R_j and R_k taken together with the nitrogen atom to which they are attached are a heterocyclic ring;

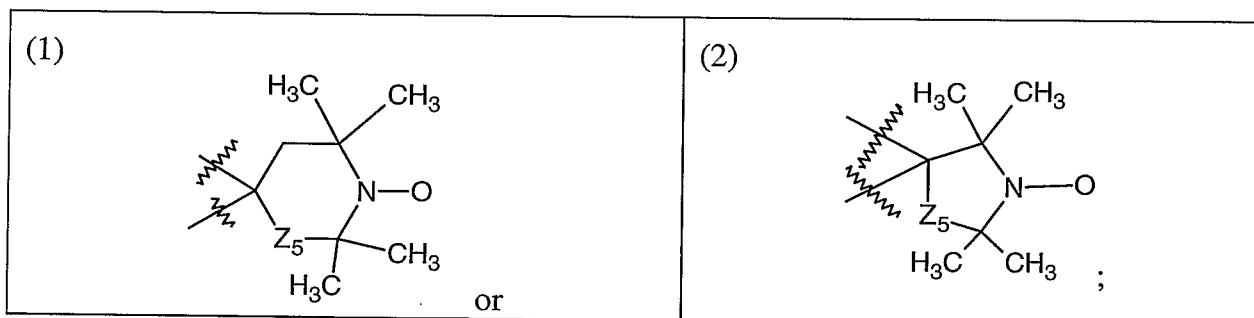
T_3 at each occurrence is independently a covalent bond, a carbonyl, an oxygen, $-\text{S}(\text{O})_o-$ or $-\text{N}(\text{R}_a)\text{R}_i$;

h is an integer from 1 to 10;

q_1 is an integer from 1 to 5;

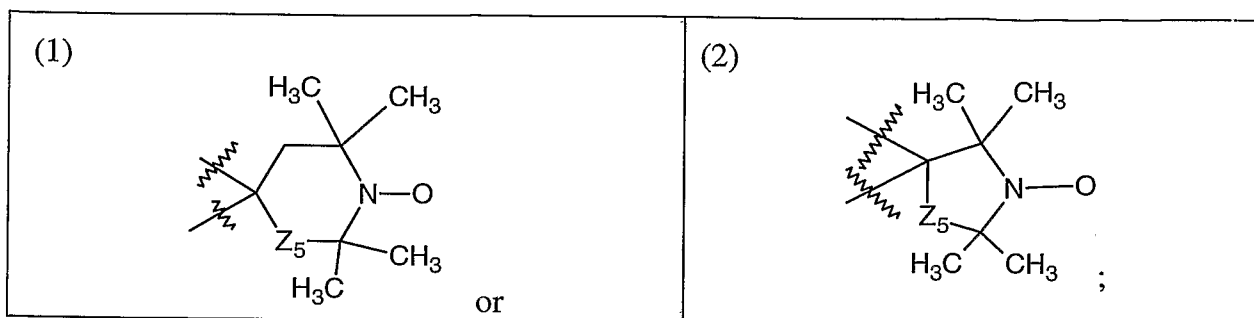
R_e and R_f are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an

alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalklythio, an arylalklythioalkyl, an alkylthioalkyl, a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an alkylarylamino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano, an aminoalkyl, an aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, -U₃-V₅, V₆, -(C(R_o)(R_p))_{k1}-U₃-V₅, -(C(R_o)(R_p))_{k1}-U₃-V₄, -(C(R_o)(R_p))_{k1}-U₃-C(O)-V₆, or R_e and R_f taken together with the carbons to which they are attached form a carbonyl, a methanthial, a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, an imine, a hydrazone, a bridged cycloalkyl group,



R_o and R_p are each independently a hydrogen, an alkyl, a cycloalkoxy, a halogen, a hydroxy, an hydroxyalkyl, an alkoxyalkyl, an arylheterocyclic ring, an alkylaryl, an alkylcycloalkyl, an alkylheterocyclic ring, a cycloalkylalkyl, a cycloalkylthio, an arylalklythio, an arylalklythioalkyl, an alkylthioalkyl, a cycloalkenyl, an heterocyclicalkyl, an alkoxy, a haloalkoxy, an amino, an alkylamino, a dialkylamino, an arylamino, a diarylamino, an alkylarylamino, an alkoxyhaloalkyl, a sulfonic acid, a sulfonic ester, an alkylsulfonic acid, an arylsulfonic acid, an arylalkoxy, an alkylthio, an arylthio, a cyano an aminoalkyl, an aminoaryl, an aryl, an arylalkyl, an alkylaryl, a carboxamido, an alkylcarboxamido, an arylcarboxamido, an amidyl, a carboxyl, a carbamoyl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarbonyl, an arylcarbonyl, an ester, a carboxylic ester, an alkylcarboxylic ester, an arylcarboxylic ester, a sulfonamido, an alkylsulfonamido, an

arylsulfonamido, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfonyl, arylsulphonyloxy, a sulfonic ester, an alkyl ester, an aryl ester, a urea, a phosphoryl, a nitro, $-U_3-V_5$, V_6 , or R_o and R_p taken together with the carbons to which they are attached form a carbonyl, a methanthial, a heterocyclic ring, a cycloalkyl group, an aryl group, an oxime, an imine, a hydrazone a bridged cycloalkyl group,

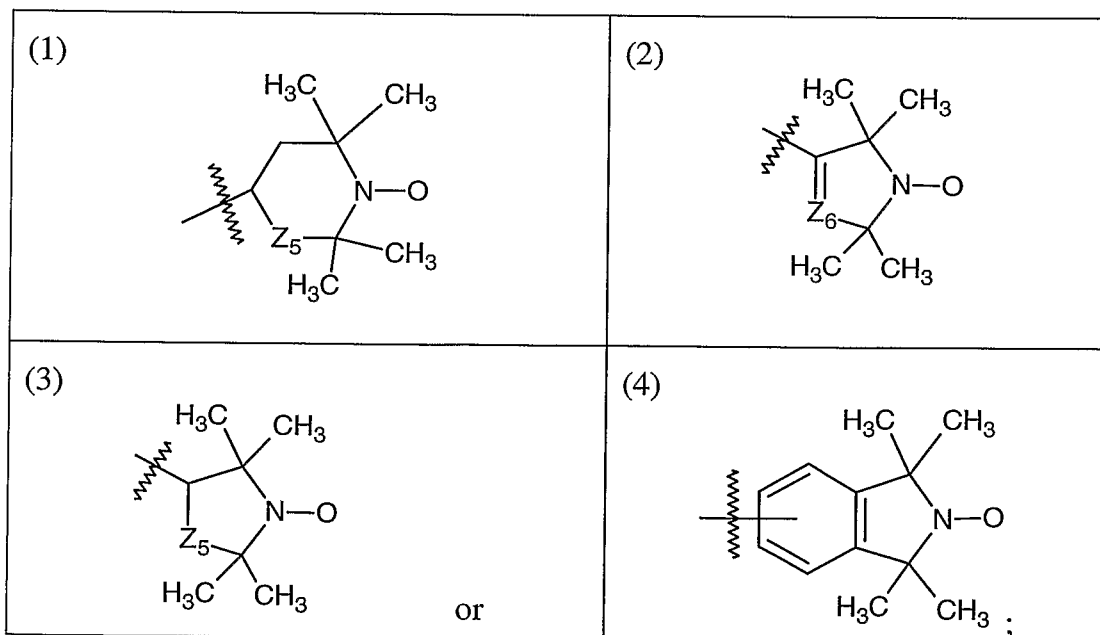


V_4 is V_3 or V_6 ;

U_3 is an oxygen, sulfur or $-N(R_a)R_i$;

V_5 is $-NO$ or $-NO_2$ (i.e. an oxidized nitrogen);

V_6 is:



Z_5 is $-CH_2$ or oxygen;

Z_6 is $-CH$ or nitrogen;

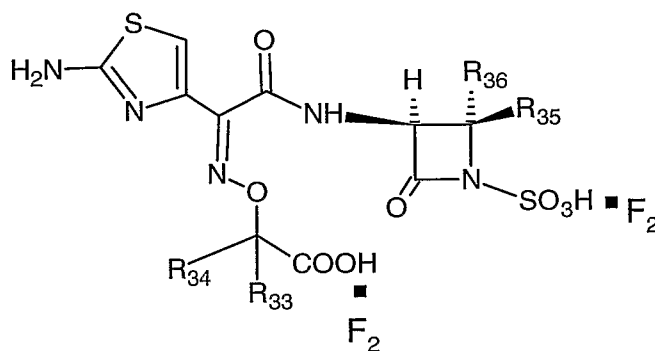
k_1 is an integer from 1 to 3;

R_a is a lone pair of electrons, a hydrogen or an alkyl group;

R_i is a hydrogen, an alkyl, an aryl, an alkylcarboxylic acid, an arylcarboxylic acid, an alkylcarboxylic ester, an arylcarboxylic ester, an alkylcarboxamido, an arylcarboxamido, an alkylaryl, an alkylsulfinyl, an alkylsulfonyl, an alkylsulfonyloxy, an arylsulfinyl, an arylsulfonyl, an arylsulphonyloxy, a sulfonamido, a carboxamido, a carboxylic ester, an aminoalkyl, an aminoaryl, $-\text{CH}_2-\text{C}-(\text{U}_3-\text{V}_5)(\text{R}_e)(\text{R}_f)$, a bond to an adjacent atom creating a double bond to that atom or $-(\text{N}_2\text{O}_2^-) \cdot \text{M}_1^+$, wherein M_1^+ is an organic or inorganic cation; and

with the proviso that the compound of Formula (I) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., $\bullet$) to at least one amine group in the compound of Formula (I);

wherein the compound of Formula (II) is:



II

wherein:

R_{33} , R_{34} and R_{36} are each independently selected from a hydrogen or CH_3 ;

R_{35} is hydrogen or $-\text{CH}_2-\text{OC}(\text{O})-\text{NH}_2$;

F_2 is not present, an organic base, or $-\text{N}(\text{R}_{37})(\text{R}_{38})(\text{R}_{39})$;

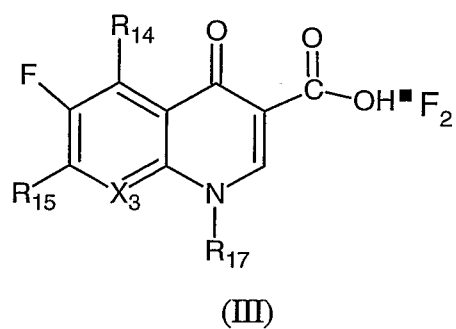
R_{37} , R_{38} and R_{39} are each independently selected from L or R_e , or R_{37} and R_{38} taken together with the nitrogen to which they are attached are a heterocyclic ring, with the proviso that when the heterocyclic ring is an aromatic ring it can be substituted at any position by L and R_{38} is not present;

L is $-(\text{W}_3)_a-\text{E}_b-(\text{C}(\text{R}_e)(\text{R}_f))_{p1}-\text{E}_c-(\text{C}(\text{R}_e)(\text{R}_f))_x-(\text{W}_3)_d-(\text{C}(\text{R}_e)(\text{R}_f))_y-(\text{W}_3)_i-\text{E}_j-(\text{W}_3)_g-(\text{C}(\text{R}_e)(\text{R}_f))_z-\text{V}_7$;

W_3 , E, R_e , R_f , V_7 , a, b, c, d, g, i, j, p_1 , x, y and z are as defined herein; and

with the proviso that the compound of Formula (II) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., $\bullet$) to at least one carboxylic acid group or sulfonic group in the compound of Formula (II);

wherein the compound of Formula (III) is:



5 wherein:

X_3 is a C- R_{16} or a nitrogen;

R_{14} is a hydrogen, $-CH_3$, $-NH_2$ or $NH_2 \cdot G$;

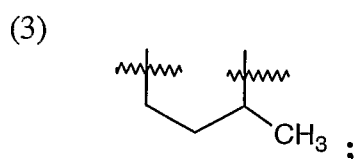
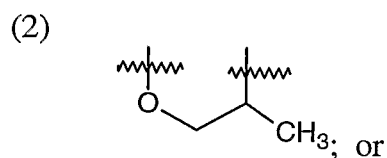
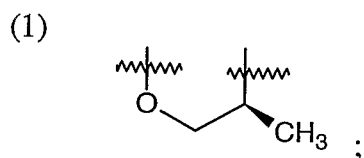
R_{16} is a hydrogen, a fluorine or a chlorine;

R_{17} is:

(1) $-CH_2-CH_2F$	(2) $-C_2H_5$
(3) or	(4) ; or

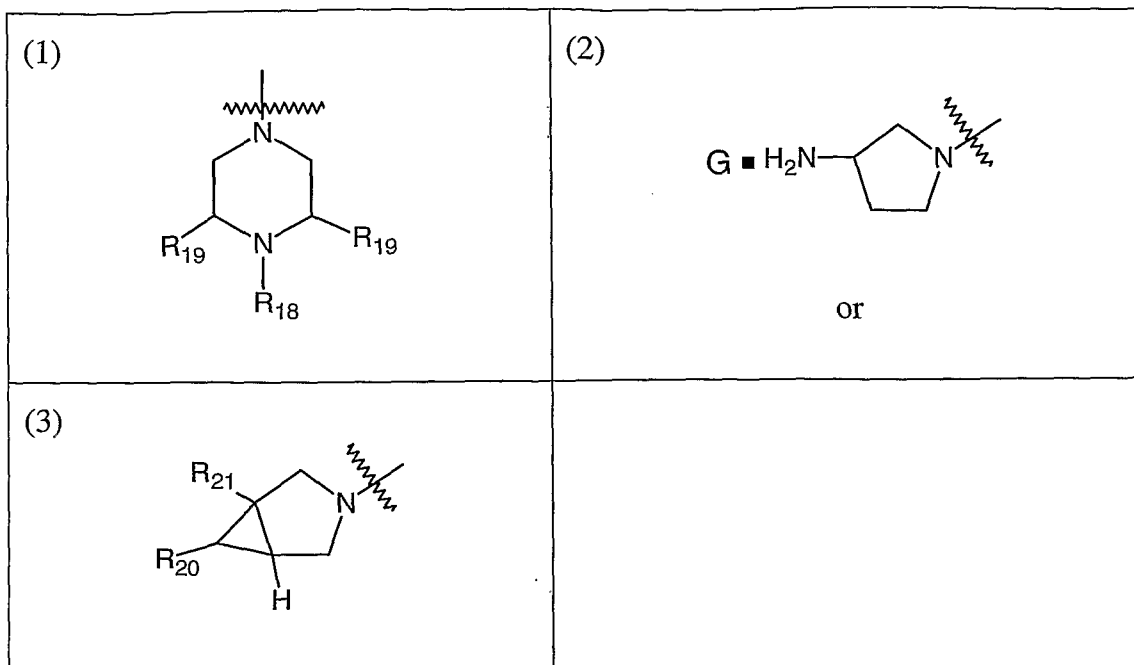
0

R_{16} and R_{17} together with the atoms to which they are attached are:



R_{15} is:

5



R₁₈ is a hydrogen, -CH₃ or -CH₂-CH₃;

R₁₉ at each occurrence is independently a hydrogen or -CH₃;

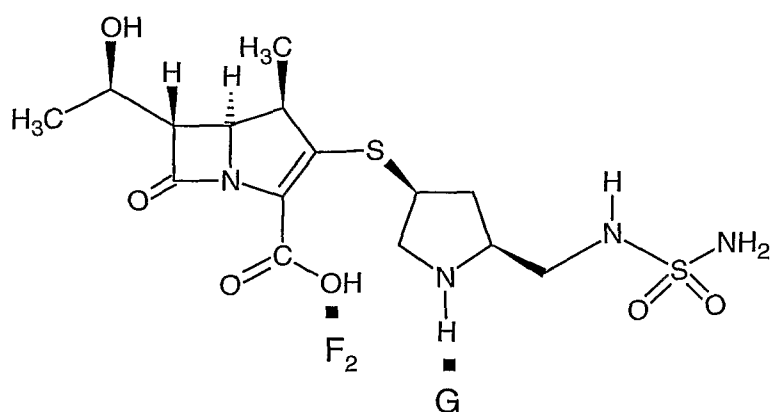
R₂₀ is a hydrogen, -NH₂, NH₂•G, -CH₂-NH₂, -CH₂-NH₂•G;

R₂₁ is a hydrogen, -CH₂-NH₂ or -CH₂-NH₂•G;

F₂ and G are as defined herein; and

with the proviso that the compound of Formula (III) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., •) to at least one amine group or carboxylic acid group in the compound of Formula (III);

wherein the compound of Formula (IV) is:



(IV)

wherein F₂ and G are as defined herein; and

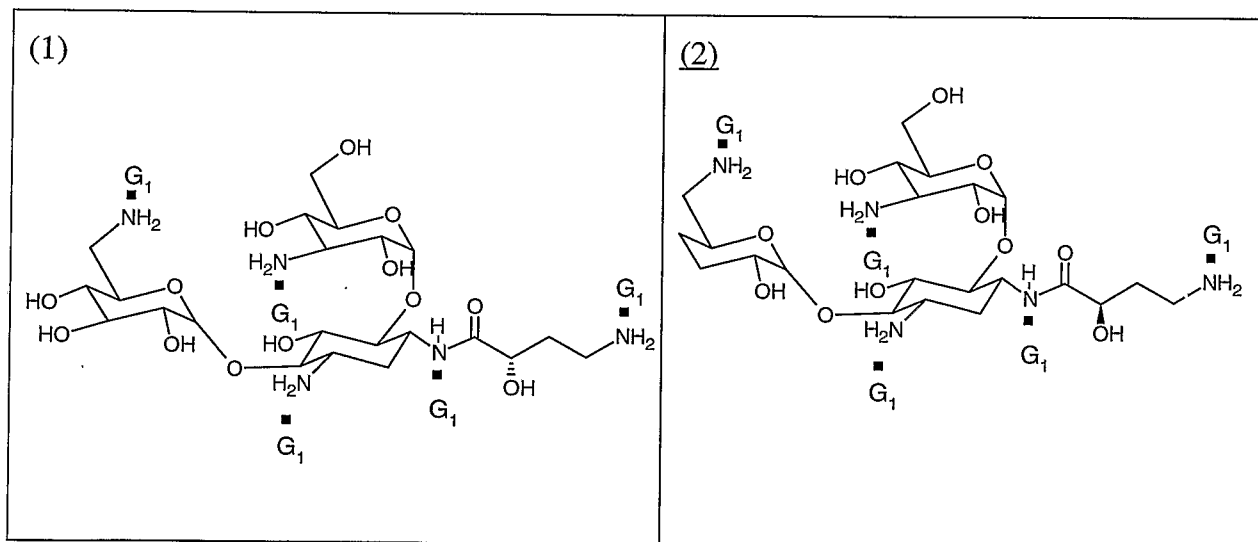
with the proviso that the compound of Formula (IV) must contain at least one organic nitric oxide donor compound linked via a salt bridge (i.e., •) to at least one amine group or

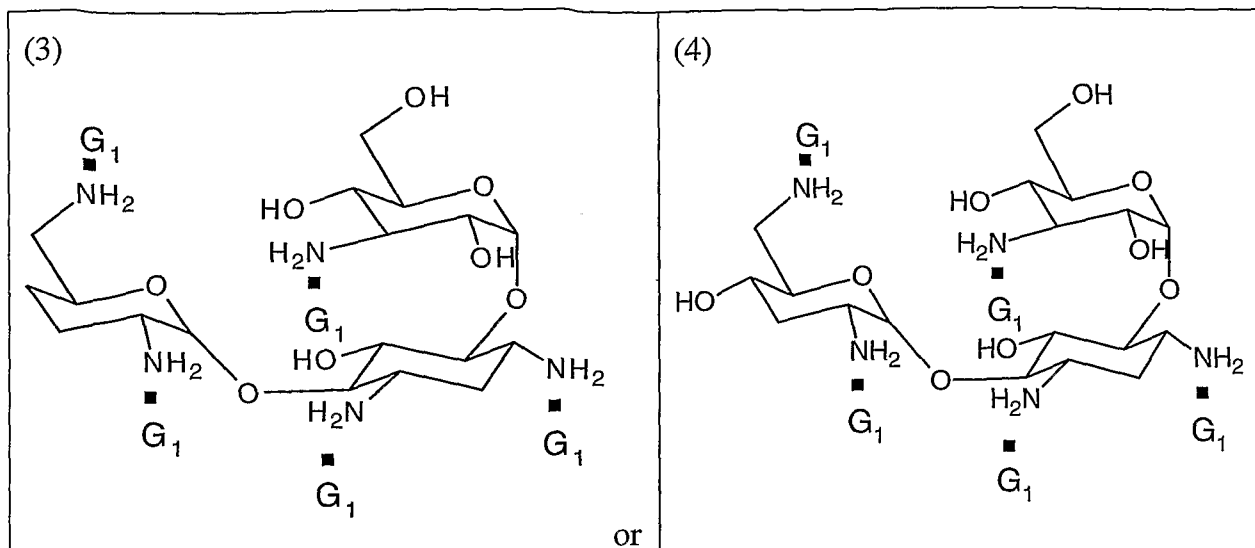
carboxylic acid group in the compound of Formula (IV).

2. A composition comprising the compound of claim 1 and a pharmaceutically acceptable carrier.

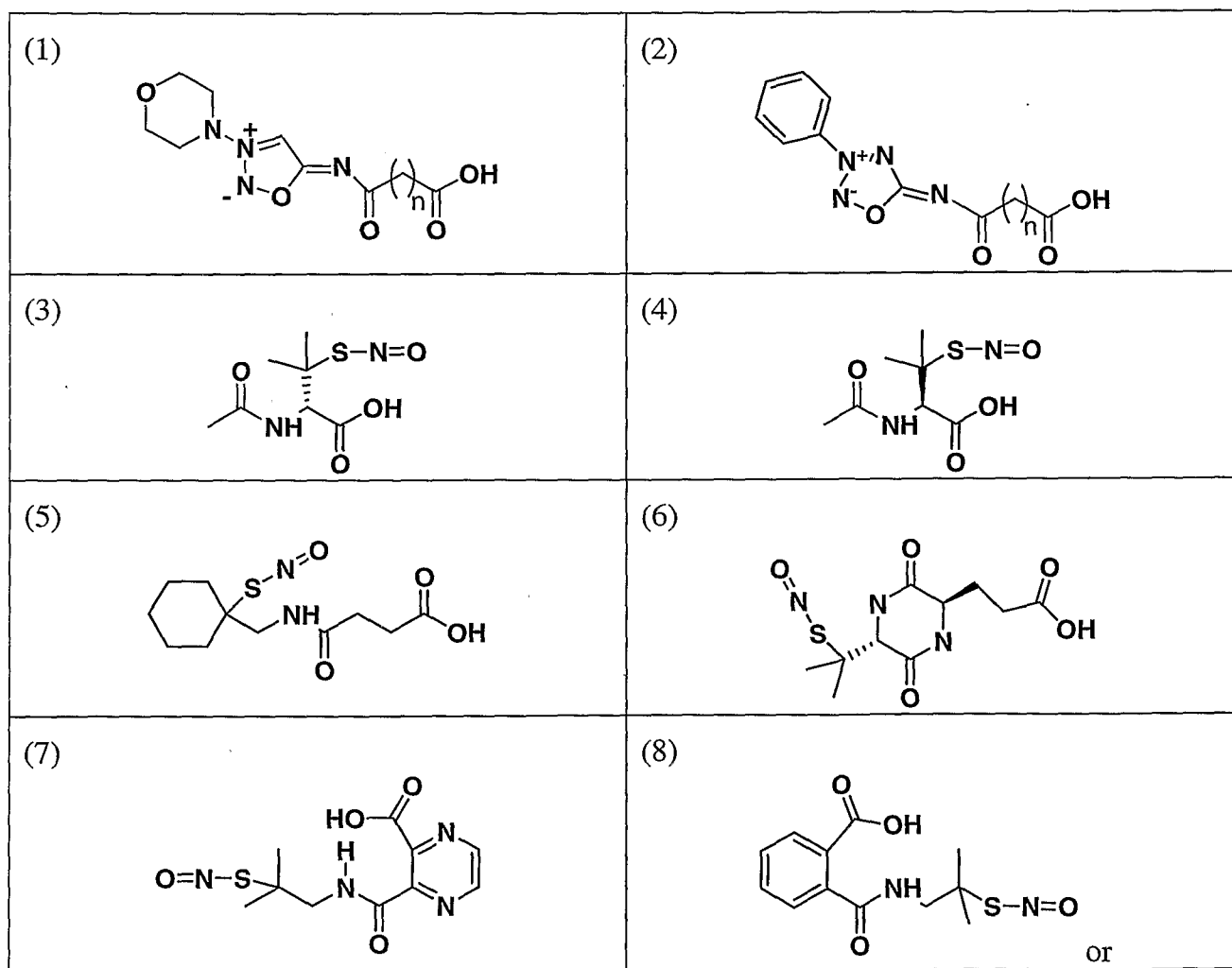
3. The compound of claim 1, the compound of Formula (I) is an organic nitric oxide donor salt of amikacin, an organic nitric oxide donor salt of arbekacin, an organic nitric oxide donor salt of dibekacin or an organic nitric oxide donor salt of tobramycin; the compound of Formula (II) is an organic nitric oxide donor salt of aztreonam, or an organic nitric oxide donor salt of carumonam; the compound of Formula (III) is an organic nitric oxide donor salt of ciprofloxacin, an organic nitric oxide donor salt of clinafloxacin, an organic nitric oxide donor salt of enoxacin, an organic nitric oxide donor salt of enrofloxacin, an organic nitric oxide donor salt of fleroxacin, an organic nitric oxide donor salt of flumequine, an organic nitric oxide donor salt of grepafloxin, an organic nitric oxide donor salt of lomefloxacin, an organic nitric oxide donor salt of levofloxacin, an organic nitric oxide donor salt of norfloxacin, an organic nitric oxide donor salt of ofloxacin, an organic nitric oxide donor salt of pefloxacin, an organic nitric oxide donor salt of sparfloxacin, an organic nitric oxide donor salt of tosufloxacin or an organic nitric oxide donor salt of trovafloxacin; and the compound of Formula (IV) is an organic nitric oxide donor salt of doripenam.

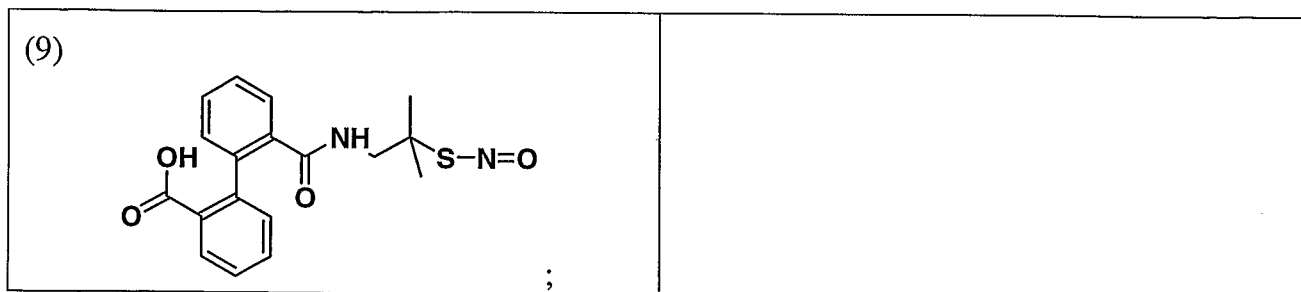
4. The compound of claim 1, wherein the Formula (I) is:



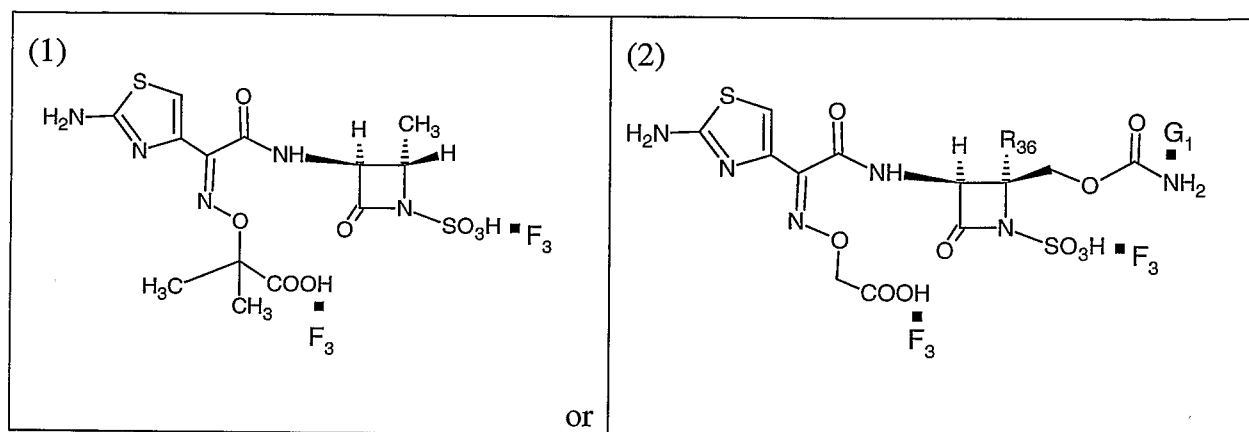


wherein G_1 is:

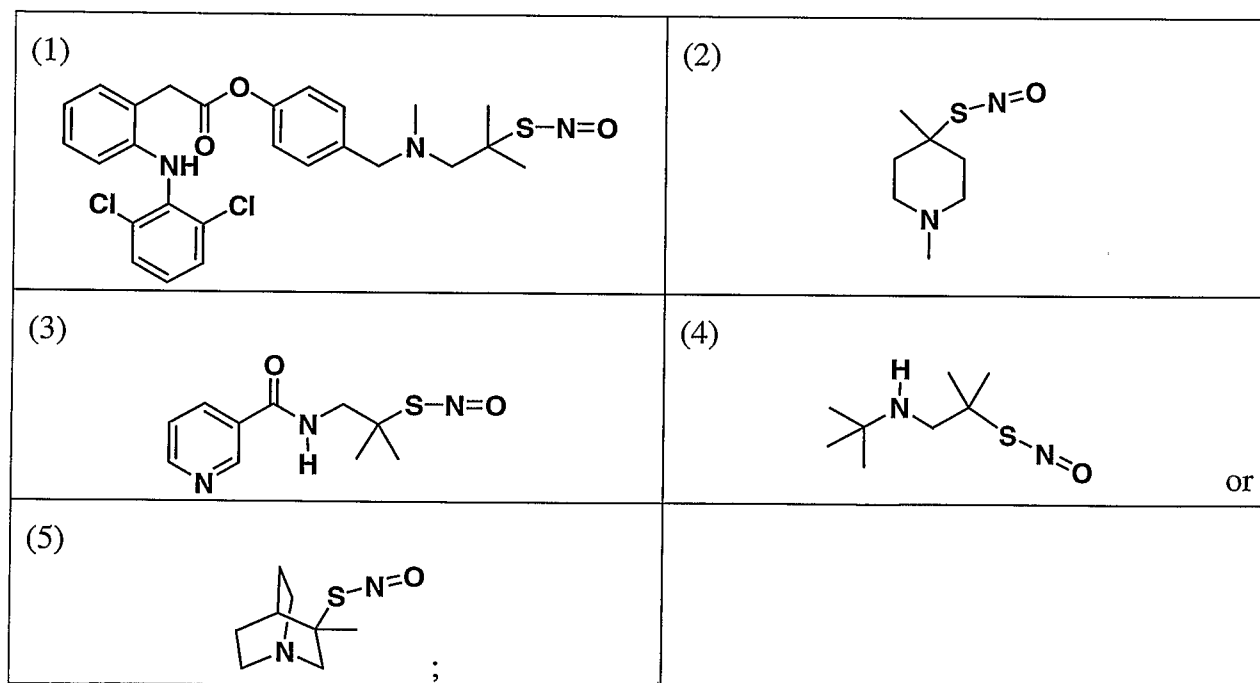




the compound of Formula (II) is:



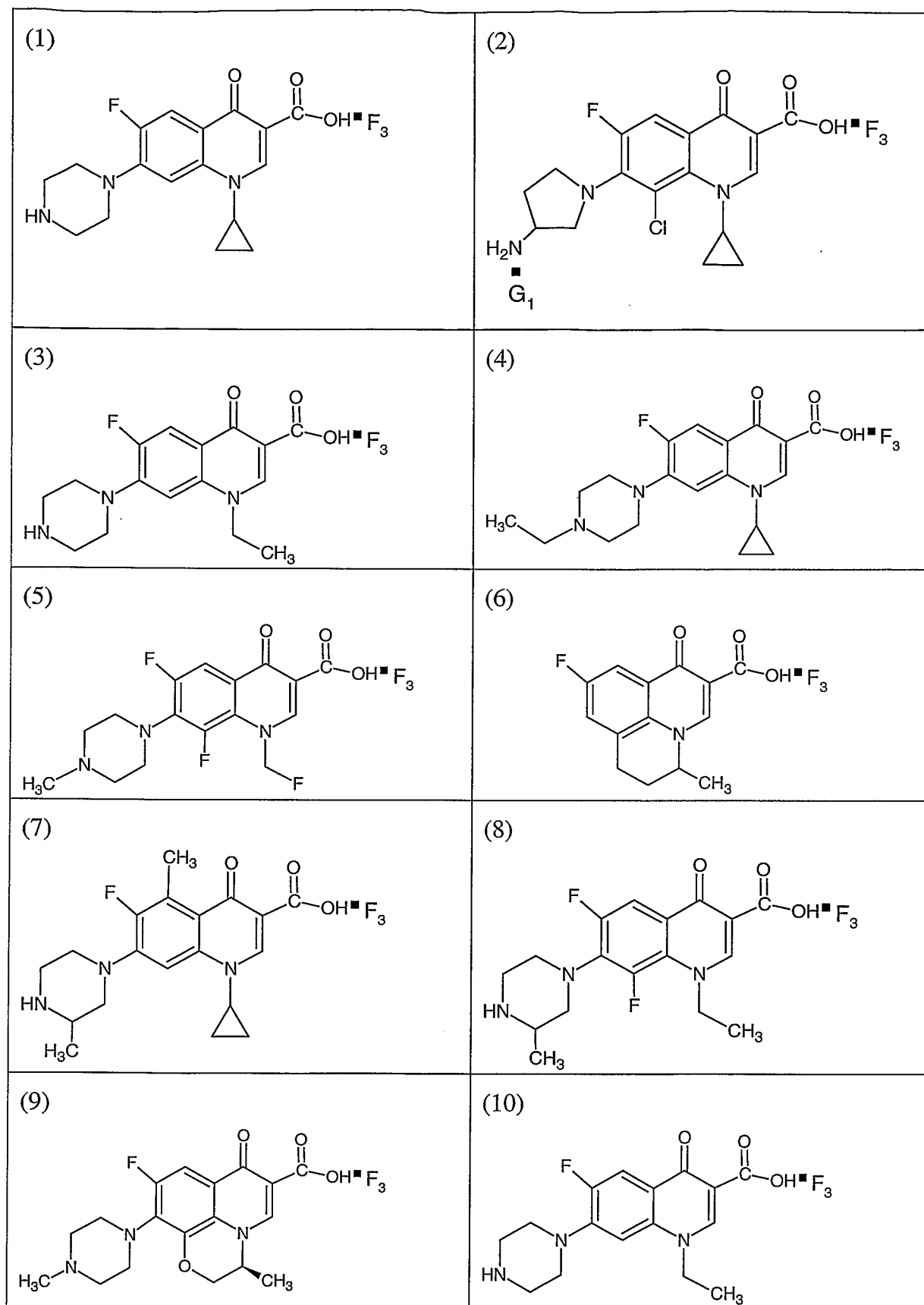
wherein F_3 is:

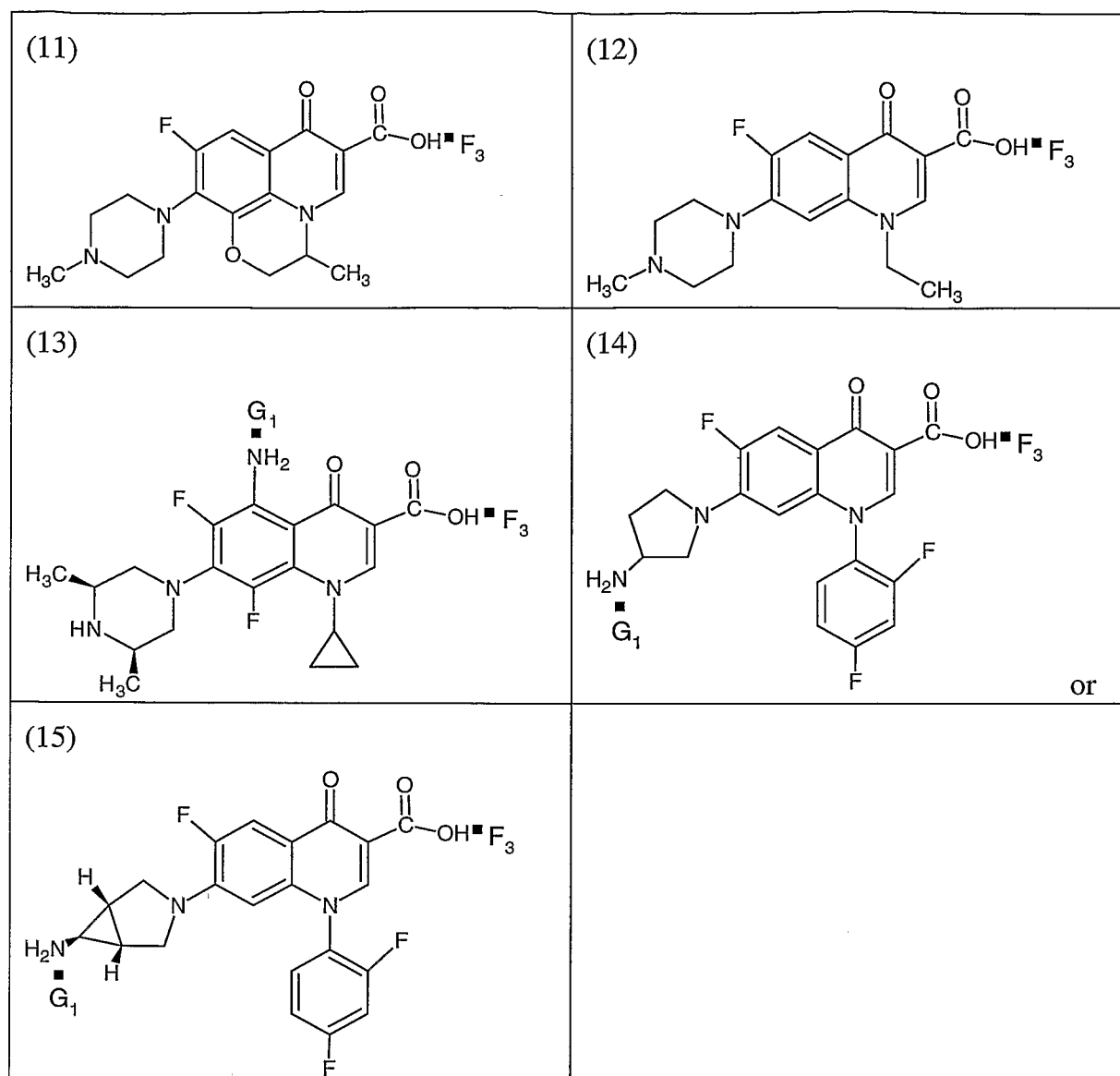


5

and G_1 is as defined herein;

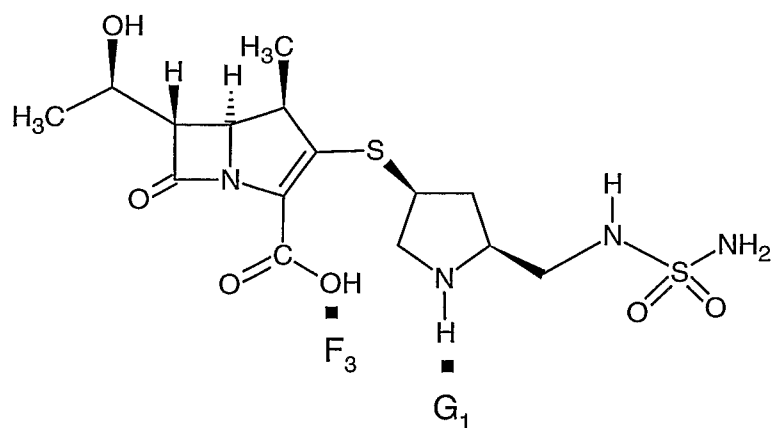
the compound of Formula (III) is:





and G₁ and F₃ are as defined herein;

the antimicrobial compound of Formula (IV) is:



5 wherein G₁ and F₃ are as defined herein.

5. A method for treating (a) a bacterial infection; (b) a viral infection; (c) a fungal

infection; or (d) a lesion in a patient in need thereof comprising administering to the patient an effective amount of the composition of claim 2.

6. The method of claim 5, wherein the bacterial infection is associated with a pulmonary disease.

7. The method of claim 6, wherein the bacterial infection associated with the pulmonary disease is cystic fibrosis.

8. A method for treating a *Bacillus anthracis* infection in a patient in need thereof comprising administering to the patient an effective amount of the composition of claim 2.

9. The composition of claim 2, further comprising (i) at least one therapeutic agent; (ii) at least one nitric oxide enhancing compound; or (iii) at least one therapeutic agent and at least one nitric oxide enhancing compound.

10. The composition of claim 9, wherein the therapeutic agent is an aldosterone antagonist, a α -adrenergic receptor antagonist, a β -adrenergic agonist, an anti-allergic compound, an antidiabetic compound, an anti-hyperlipidemic drug, an antitussive compound, an angiotensin II antagonist, an angiotensin-converting enzyme inhibitor, an antioxidant, an antithrombotic and vasodilator compound, a β -adrenergic antagonist, a bronchodilator, a calcium channel blocker, a diuretic, an endothelin antagonist, an expectorant, a hydralazine compound, a H_2 receptor antagonist, a neutral endopeptidase inhibitor, a nonsteroidal antiinflammatory compound, a phosphodiesterase inhibitor, a potassium channel blocker, a platelet reducing agent, a proton pump inhibitor, a renin inhibitor, selective a cyclooxygenase-2 inhibitors, a steroid or a combination of two or more thereof.

11. The composition of claim 10, wherein the therapeutic agent is selected from the group consisting of a β -adrenergic agonist, an anti-allergic compound, an antitussive compound, an antioxidant, a bronchodilator, an expectorant, a H_2 receptor antagonist, a nonsteroidal antiinflammatory compound, a phosphodiesterase inhibitor, a proton pump inhibitor, a selective cyclooxygenase-2 (COX-2) inhibitor, or a steroid.

12. The composition of claim 9, wherein the nitric oxide enhancing compound is selected from the group consisting of a S-nitrosothiol, a nitrite, a nitrate, a S-nitrothiol, a sydnonimine, a NONOate, a N-nitrosoamine, a N-hydroxyl nitrosamine, a nitrosimine, a diazetine dioxide, an oxatriazole 5-imine, an oxime, a hydroxylamine, a N-hydroxyguanidine, a hydroxyurea, a furoxan or a nitroxide.

13. The method of claims 5 or 8, further comprising administering (i) at least one therapeutic agent; (ii) at least one nitric oxide enhancing compound; or (iii) at least one

therapeutic agent and at least one nitric oxide enhancing compound.

14 The method of claim 13, wherein the therapeutic agent is selected from the group consisting of an aldosterone antagonist, a α -adrenergic receptor antagonist, a β -adrenergic agonist, an anti-allergic compound, an antidiabetic compound, an anti-
5 hyperlipidemic drug, an antitussive compound, an angiotensin II antagonist, an angiotensin-converting enzyme inhibitor, an antioxidant, an antithrombotic and vasodilator compound, a β -adrenergic antagonist, a bronchodilator, a calcium channel blocker, a diuretic, an endothelin antagonist, an expectorant, a hydralazine compound, a H_2 receptor antagonist, a neutral
0 endopeptidase inhibitor, a nonsteroidal antiinflammatory compound, a phosphodiesterase inhibitor, a potassium channel blocker, a platelet reducing agent, a proton pump inhibitor, a renin inhibitor, selective a cyclooxygenase-2 inhibitors, a steroid or a combination of two or more thereof.

15 The method of claim 13, wherein the nitric oxide donor compound is selected from the group consisting of a S-nitrosothiol, a nitrite, a nitrate, a S-nitrothiol, a sydnonimine, a NONOate, a N-nitrosoamine, a N-hydroxyl nitrosamine, a nitrosimine, a diazetine dioxide,
5 an oxatriazole 5-imine, an oxime, a hydroxylamine, a N-hydroxyguanidine, a hydroxyurea, a furoxan or a nitroxide.

16 A kit comprising at least one compound of claim 1.

17 The kit of claim 16, further comprising further comprising (i) at least one
0 therapeutic agent; (ii) at least one nitric oxide enhancing compound; or (iii) at least one therapeutic agent and at least one nitric oxide enhancing compound.

18 The kit of claim 17, wherein the (i) at least one therapeutic agent; (ii) at least one nitric oxide enhancing compound; or (iii) at least one therapeutic agent and at least one
5 nitric oxide enhancing compound are in the form of separate components in the kit.