

**DIARYLMETHYLIDENE PIPERIDINE DERIVATIVES, PREPARATIONS
THEREOF AND USES THEREOF**

FIELD OF THE INVENTION

5 The present invention is directed to novel compounds, to a process for their preparation, their use and pharmaceutical compositions comprising the novel compounds. The novel compounds are useful in therapy, and in particular for the treatment of pain, anxiety and functional gastrointestinal disorders.

10 **BACKGROUND OF THE INVENTION**

 The δ receptor has been identified as having a role in many bodily functions such as circulatory and pain systems. Ligands for the δ receptor may therefore find potential use as analgesics, and/or as antihypertensive agents. Ligands for the δ receptor have also been shown to possess immunomodulatory activities.

15 The identification of at least three different populations of opioid receptors (μ , δ and κ) is now well established and all three are apparent in both central and peripheral nervous systems of many species including man. Analgesia has been observed in various animal models when one or more of these receptors has been activated.

20 With few exceptions, currently available selective opioid δ ligands are peptidic in nature and are unsuitable for administration by systemic routes. One example of a non-peptidic δ -agonist is SNC80 (Bilsky E.J. et al., Journal of Pharmacology and Experimental Therapeutics, 273(1), pp. 359-366 (1995)).

 Many δ agonist compounds that have been identified in the prior art have
25 many disadvantages in that they suffer from poor pharmacokinetics and are not analgesic when administered by systemic routes. Also, it has been documented that many of these δ agonist compounds show significant convulsive effects when administered systemically.

 U.S. Patent No. 6,187,792 to Delorme et al. describes some δ -agonists.

However, there is still a need for improved δ -agonists.

DESCRIPTION OF THE INVENTION

Unless specified otherwise within this specification, the nomenclature used in this specification generally follows the examples and rules stated in *Nomenclature of Organic Chemistry, Sections A, B, C, D, E, F, and H*, Pergamon Press, Oxford, 1979, which is incorporated by references herein for its exemplary chemical structure names and rules on naming chemical structures.

The term " C_{m-n} " or " C_{m-n} group" used alone or as a prefix, refers to any group having m to n carbon atoms.

The term "hydrocarbon" used alone or as a suffix or prefix, refers to any structure comprising only carbon and hydrogen atoms up to 14 carbon atoms.

The term "hydrocarbon radical" or "hydrocarbyl" used alone or as a suffix or prefix, refers to any structure as a result of removing one or more hydrogens from a hydrocarbon.

The term "alkyl" used alone or as a suffix or prefix, refers to a saturated monovalent straight or branched chain hydrocarbon radical comprising 1 to about 12 carbon atoms. Illustrative examples of alkyls include, but are not limited to, C_{1-6} alkyl groups, such as methyl, ethyl, propyl, isopropyl, 2-methyl-1-propyl, 2-methyl-2-propyl, 2-methyl-1-butyl, 3-methyl-1-butyl, 2-methyl-3-butyl, 2,2-dimethyl-1-propyl, 2-methyl-1-pentyl, 3-methyl-1-pentyl, 4-methyl-1-pentyl, 2-methyl-2-pentyl, 3-methyl-2-pentyl, 4-methyl-2-pentyl, 2,2-dimethyl-1-butyl, 3,3-dimethyl-1-butyl, 2-ethyl-1-butyl, butyl, isobutyl, t-butyl, pentyl, isopentyl, neopentyl, and hexyl, and longer alkyl groups, such as heptyl, and octyl. An alkyl can be unsubstituted or substituted with one or two suitable substituents.

The term "alkylene" used alone or as suffix or prefix, refers to divalent straight or branched chain hydrocarbon radicals comprising 1 to about 12 carbon atoms, which serves to link two structures together.

The term "alkenyl" used alone or as suffix or prefix, refers to a monovalent straight or branched chain hydrocarbon radical having at least one carbon-carbon double bond and comprising at least 2 up to about 12 carbon atoms. The double bond of an alkenyl

can be unconjugated or conjugated to another unsaturated group. Suitable alkenyl groups include, but are not limited to C₂₋₆alkenyl groups, such as vinyl, allyl, butenyl, pentenyl, hexenyl, butadienyl, pentadienyl, hexadienyl, 2-ethylhexenyl, 2-propyl-2-butenyl, 4-(2-methyl-3-butene)-pentenyl. An alkenyl can be unsubstituted or substituted with one or two suitable substituents.

The term “alkynyl” used alone or as suffix or prefix, refers to a monovalent straight or branched chain hydrocarbon radical having at least one carbon-carbon triple bond and comprising at least 2 up to about 12 carbon atoms. The triple bond of an alkynyl group can be unconjugated or conjugated to another unsaturated group. Suitable alkynyl groups include, but are not limited to, C₂₋₆alkynyl groups, such as ethynyl, propynyl, butynyl, pentynyl, hexynyl, methylpropynyl, 4-methyl-1-butynyl, 4-propyl-2-pentynyl, and 4-butyl-2-hexynyl. An alkynyl can be unsubstituted or substituted with one or two suitable substituents.

The term “cycloalkyl,” used alone or as suffix or prefix, refers to a saturated monovalent ring-containing hydrocarbon radical comprising at least 3 up to about 12 carbon atoms. Examples of cycloalkyls include, but are not limited to, C₃₋₇cycloalkyl groups, such as cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and cycloheptyl, and saturated cyclic and bicyclic terpenes. A cycloalkyl can be unsubstituted or substituted by one or two suitable substituents. Preferably, the cycloalkyl is a monocyclic ring or bicyclic ring.

The term “cycloalkenyl” used alone or as suffix or prefix, refers to a monovalent ring-containing hydrocarbon radical having at least one carbon-carbon double bond and comprising at least 3 up to about 12 carbon atoms.

The term “cycloalkynyl” used alone or as suffix or prefix, refers to a monovalent ring-containing hydrocarbon radical having at least one carbon-carbon triple bond and comprising about 7 up to about 12 carbon atoms.

The term “aryl” used alone or as suffix or prefix, refers to a monovalent hydrocarbon radical having one or more polyunsaturated carbon rings having aromatic character, (e.g., $4n + 2$ delocalized electrons) and comprising 5 up to about 14 carbon atoms.

The term "arylene" used alone or as suffix or prefix, refers to a divalent hydrocarbon radical having one or more polyunsaturated carbon rings having aromatic character, (*e.g.*, $4n + 2$ delocalized electrons) and comprising 5 up to about 14 carbon atoms, which serves to link two structures together.

5 The term "heterocycle" used alone or as a suffix or prefix, refers to a ring-containing structure or molecule having one or more multivalent heteroatoms, independently selected from N, O, P and S, as a part of the ring structure and including at least 3 and up to about 20 atoms in the ring(s). Heterocycle may be saturated or unsaturated, containing one or more double bonds, and heterocycle may
10 contain more than one ring. When a heterocycle contains more than one ring, the rings may be fused or unfused. Fused rings generally refer to at least two rings share two atoms therebetween. Heterocycle may have aromatic character or may not have aromatic character.

15 The term "heteroaromatic" used alone or as a suffix or prefix, refers to a ring-containing structure or molecule having one or more multivalent heteroatoms, independently selected from N, O, P and S, as a part of the ring structure and including at least 3 and up to about 20 atoms in the ring(s), wherein the ring-containing structure or molecule has an aromatic character (*e.g.*, $4n + 2$ delocalized electrons).

20 The term "heterocyclic group," "heterocyclic moiety," "heterocyclic," or "heterocyclo" used alone or as a suffix or prefix, refers to a radical derived from a heterocycle by removing one or more hydrogens therefrom.

 The term "heterocyclyl" used alone or as a suffix or prefix, refers to a monovalent radical derived from a heterocycle by removing one hydrogen therefrom.

25 The term "heterocyclylene" used alone or as a suffix or prefix, refers to a divalent radical derived from a heterocycle by removing two hydrogens therefrom, which serves to links two structures together.

 The term "heteroaryl" used alone or as a suffix or prefix, refers to a heterocyclyl having aromatic character.

30 The term "heterocylcoalkyl" used alone or as a suffix or prefix, refers to a monocyclic or polycyclic ring comprising carbon and hydrogen atoms and at least one

heteroatom, preferably, 1 to 3 heteroatoms selected from nitrogen, oxygen, and sulfur, and having no unsaturation. Examples of heterocycloalkyl groups include pyrrolidinyl, pyrrolidino, piperidinyl, piperidino, piperazinyl, piperazino, morpholinyl, morpholino, thiomorpholinyl, thiomorpholino, and pyranyl. A

- 5 heterocycloalkyl group can be unsubstituted or substituted with one or two suitable substituents. Preferably, the heterocycloalkyl group is a monocyclic or bicyclic ring, more preferably, a monocyclic ring, wherein the ring comprises from 3 to 6 carbon atoms and from 1 to 3 heteroatoms, referred to herein as C₃₋₆heterocycloalkyl.

- 10 The term "heteroarylene" used alone or as a suffix or prefix, refers to a heterocyclylene having aromatic character.

The term "heterocycloalkylene" used alone or as a suffix or prefix, refers to a heterocyclylene that does not have aromatic character.

The term "six-membered" used as prefix refers to a group having a ring that contains six ring atoms.

- 15 The term "five-membered" used as prefix refers to a group having a ring that contains five ring atoms.

A five-membered ring heteroaryl is a heteroaryl with a ring having five ring atoms wherein 1, 2 or 3 ring atoms are independently selected from N, O and S.

- 20 Exemplary five-membered ring heteroaryls are thienyl, furyl, pyrrolyl, imidazolyl, thiazolyl, oxazolyl, pyrazolyl, isothiazolyl, isoxazolyl, 1,2,3-triazolyl, tetrazolyl, 1,2,3-thiadiazolyl, 1,2,3-oxadiazolyl, 1,2,4-triazolyl, 1,2,4-thiadiazolyl, 1,2,4-oxadiazolyl, 1,3,4-triazolyl, 1,3,4-thiadiazolyl, and 1,3,4-oxadiazolyl.

A six-membered ring heteroaryl is a heteroaryl with a ring having six ring atoms wherein 1, 2 or 3 ring atoms are independently selected from N, O and S.

- 25 Exemplary six-membered ring heteroaryls are pyridyl, pyrazinyl, pyrimidinyl, triazinyl and pyridazinyl.

- The term "substituted" used as a prefix refers to a structure, molecule or group, wherein one or more hydrogens are replaced with one or more C₁₋₆hydrocarbon groups, or one or more chemical groups containing one or more
30 heteroatoms selected from N, O, S, F, Cl, Br, I, and P. Exemplary chemical groups containing one or more heteroatoms include -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃,

-C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, oxo (=O), imino (=NR), thio (=S), and oximino (=N-OR), wherein each "R" is a C₁₋₆hydrocarbyl. For example, substituted phenyl may refer to nitrophenyl, methoxyphenyl, chlorophenyl, aminophenyl, etc.,
5 wherein the nitro, methoxy, chloro, and amino groups may replace any suitable hydrogen on the phenyl ring.

The term "substituted" used as a suffix of a first structure, molecule or group, followed by one or more names of chemical groups refers to a second structure, molecule or group, which is a result of replacing one or more hydrogens of the first
10 structure, molecule or group with the one or more named chemical groups. For example, a "phenyl substituted by nitro" refers to nitrophenyl.

Heterocycle includes, for example, monocyclic heterocycles such as: aziridine, oxirane, thiirane, azetidine, oxetane, thietane, pyrrolidine, pyrroline, imidazolidine, pyrazolidine, pyrazoline, dioxolane, sulfolane 2,3-dihydrofuran, 2,5-
15 dihydrofuran tetrahydrofuran, thiophane, piperidine, 1,2,3,6-tetrahydro-pyridine, piperazine, morpholine, thiomorpholine, pyran, thiopyran, 2,3-dihydropyran, tetrahydropyran, 1,4-dihydropyridine, 1,4-dioxane, 1,3-dioxane, dioxane, homopiperidine, 2,3,4,7-tetrahydro-1*H*-azepine homopiperazine, 1,3-dioxepane, 4,7-dihydro-1,3-dioxepin, and hexamethylene oxide.

20 In addition, heterocycle includes aromatic heterocycles, for example, pyridine, pyrazine, pyrimidine, pyridazine, thiophene, furan, furazan, pyrrole, imidazole, thiazole, oxazole, pyrazole, isothiazole, isoxazole, 1,2,3-triazole, tetrazole, 1,2,3-thiadiazole, 1,2,3-oxadiazole, 1,2,4-triazole, 1,2,4-thiadiazole, 1,2,4-oxadiazole, 1,3,4-triazole, 1,3,4-thiadiazole, and 1,3,4-oxadiazole.

25 Additionally, heterocycle encompass polycyclic heterocycles, for example, indole, indoline, isoindoline, quinoline, tetrahydroquinoline, isoquinoline, tetrahydroisoquinoline, 1,4-benzodioxan, coumarin, dihydrocoumarin, benzofuran, 2,3-dihydrobenzofuran, isobenzofuran, chromene, chroman, isochroman, xanthene, phenoxathiin, thianthrene, indolizine, isoindole, indazole, purine, phthalazine,
30 naphthyridine, quinoxaline, quinazoline, cinnoline, pteridine, phenanthridine, perimidine, phenanthroline, phenazine, phenothiazine, phenoxazine, 1,2-

benzisoxazole, benzothiophene, benzoxazole, benzthiazole, benzimidazole, benztriazole, thioxanthine, carbazole, carboline, acridine, pyrrolizidine, and quinolizidine.

In addition to the polycyclic heterocycles described above, heterocycle
5 includes polycyclic heterocycles wherein the ring fusion between two or more rings includes more than one bond common to both rings and more than two atoms common to both rings. Examples of such bridged heterocycles include quinuclidine, diazabicyclo[2.2.1]heptane and 7-oxabicyclo[2.2.1]heptane.

Heterocyclyl includes, for example, monocyclic heterocyclyls, such as:
10 aziridinyl, oxiranyl, thiiranyl, azetidiny, oxetanyl, thietanyl, pyrrolidinyl, pyrrolinyl, imidazolidinyl, pyrazolidinyl, pyrazolinyl, dioxolanyl, sulfolanyl, 2,3-dihydrofuranyl, 2,5-dihydrofuranyl, tetrahydrofuranyl, thiophanyl, piperidinyl, 1,2,3,6-tetrahydro-pyridinyl, piperazinyl, morpholinyl, thiomorpholinyl, pyranyl, thiopyranyl, 2,3-dihydropyranyl, tetrahydropyranyl, 1,4-dihydropyridinyl, 1,4-dioxanyl, 1,3-dioxanyl,
15 dioxanyl, homopiperidinyl, 2,3,4,7-tetrahydro-1*H*-azepinyl, homopiperazinyl, 1,3-dioxepanyl, 4,7-dihydro-1,3-dioxepinyl, and hexamethylene oxidyl.

In addition, heterocyclyl includes aromatic heterocyclyls or heteroaryl, for example, pyridinyl, pyrazinyl, pyrimidinyl, pyridazinyl, thienyl, furyl, furazanyl, pyrrolyl, imidazolyl, thiazolyl, oxazolyl, pyrazolyl, isothiazolyl, isoxazolyl, 1,2,3-
20 triazolyl, tetrazolyl, 1,2,3-thiadiazolyl, 1,2,3-oxadiazolyl, 1,2,4-triazolyl, 1,2,4-thiadiazolyl, 1,2,4-oxadiazolyl, 1,3,4-triazolyl, 1,3,4-thiadiazolyl, and 1,3,4-oxadiazolyl.

Additionally, heterocyclyl encompasses polycyclic heterocyclyls (including both aromatic or non-aromatic), for example, indolyl, indolinyl, isoindolinyl,
25 quinolinyl, tetrahydroquinolinyl, isoquinolinyl, tetrahydroisoquinolinyl, 1,4-benzodioxanyl, coumarinyl, dihydrocoumarinyl, benzofuranyl, 2,3-dihydrobenzofuranyl, isobenzofuranyl, chromenyl, chromanyl, isochromanyl, xanthenyl, phenoxathiinyl, thianthrenyl, indolizinyl, isoindolyl, indazolyl, purinyl, phthalazinyl, naphthyridinyl, quinoxalinyl, quinazolinyl, cinnolinyl, pteridinyl,
30 phenanthridinyl, perimidinyl, phenanthrolinyl, phenazinyl, phenothiazinyl, phenoxazinyl, 1,2-benzisoxazolyl, benzothiophenyl, benzoxazolyl, benzthiazolyl,

benzimidazolyl, benzotriazolyl, thioxanthinyl, carbazolyl, carbolinyl, acridinyl, pyrolizidinyl, and quinolizidinyl.

In addition to the polycyclic heterocyclyls described above, heterocyclyl includes polycyclic heterocyclyls wherein the ring fusion between two or more rings includes more than one bond common to both rings and more than two atoms common to both rings. Examples of such bridged heterocycles include quinuclidinyl, diazabicyclo[2.2.1]heptyl; and 7-oxabicyclo[2.2.1]heptyl.

The term "alkoxy" used alone or as a suffix or prefix, refers to radicals of the general formula $-O-R$, wherein R is selected from a hydrocarbon radical. Exemplary alkoxy includes methoxy, ethoxy, propoxy, isopropoxy, butoxy, t-butoxy, isobutoxy, cyclopropylmethoxy, allyloxy, and propargyloxy.

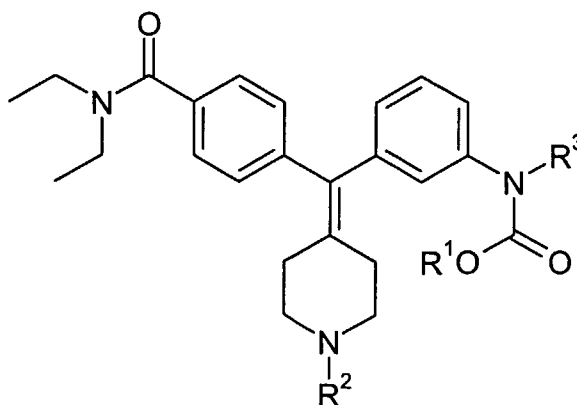
The term "amine" or "amino" used alone or as a suffix or prefix, refers to radicals of the general formula $-NRR'$, wherein R and R' are independently selected from hydrogen or a hydrocarbon radical.

Halogen includes fluorine, chlorine, bromine and iodine.

"Halogenated," used as a prefix of a group, means one or more hydrogens on the group is replaced with one or more halogens.

"RT" or "rt" means room temperature.

In one aspect, the invention provides a compound of formula I, a pharmaceutically acceptable salt thereof, diastereomers thereof, enantiomers thereof, and mixtures thereof:



I

wherein

R^1 and R^3 are, independently, selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl; and

R^2 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen, C_{3-6} cycloalkyl or C_{1-6} alkyl.

In one embodiment, the compounds of the present invention are represented by formula I, wherein R^1 is selected from C_{1-3} alkyl and halogenated C_{1-3} alkyl;

R^3 is selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from C_{1-6} alkyl, halogenated C_{1-6} alkyl, -NO₂, -CF₃, C_{1-6} alkoxy, chloro, fluoro, bromo, and iodo; and

R^2 is selected from C_{1-6} alkyl, C_{3-6} cycloalkyl and C_{3-6} cycloalkyl-methyl, wherein said C_{1-6} alkyl, C_{3-6} cycloalkyl and C_{3-6} cycloalkyl-methyl are optionally substituted with one or more groups selected from C_{1-6} alkyl, halogenated C_{1-6} alkyl, -CF₃, C_{1-6} alkoxy, chloro, fluoro and bromo.

In another embodiment, the compounds of the present invention are represented by formula I, wherein R^1 is C_{1-3} alkyl;

R^3 is hydrogen; and

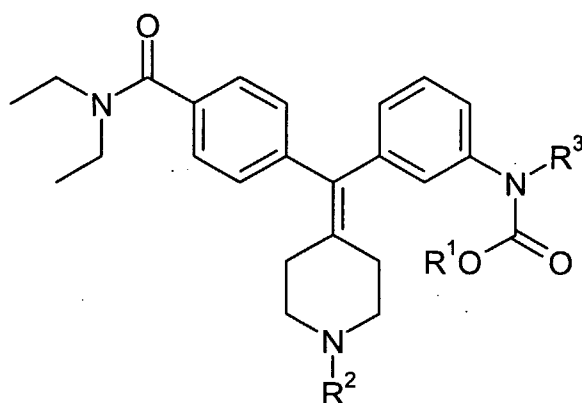
R^2 is selected from C_{1-6} alkyl and C_{3-6} cycloalkyl-methyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl-methyl are optionally substituted with one or more groups selected from methoxy, ethoxy and isopropoxy.

In a further embodiment, the compounds of the present invention are represented by formula I, wherein R^1 is selected from methyl and ethyl;

R^3 is hydrogen; and

R^2 is selected from n-propyl, cyclopropylmethyl, n-pentyl, 2-methoxyethyl, n-butyl, 2-isopropoxyethyl, 2-ethoxyethyl, 3-methoxypropyl, cyclobutylmethyl, methyl, and ethyl.

- 5 In an even further embodiment, the present invention provides a compound of formula I or pharmaceutically acceptable salts thereof,



I

- 10 wherein R^3 is hydrogen, R^1 is selected from methyl and ethyl; and R^2 is C_{1-3} alkoxy- C_{1-4} alkyl.

It will be understood that when compounds of the present invention contain one or more chiral centers, the compounds of the invention may exist in, and be isolated as, enantiomeric or diastereomeric forms, or as a racemic mixture. The present invention includes any possible enantiomers, diastereomers, racemates or mixtures thereof, of a compound of Formula I. The optically active forms of the compound of the invention may be prepared, for example, by chiral chromatographic separation of a racemate, by synthesis from optically active starting materials or by asymmetric synthesis based on the procedures described thereafter.

- 20 It will also be appreciated that certain compounds of the present invention may exist as geometrical isomers, for example E and Z isomers of alkenes. The present invention includes any geometrical isomer of a compound of Formula I. It will further be understood that the present invention encompasses tautomers of the compounds of the formula I.

It will also be understood that certain compounds of the present invention may exist in solvated, for example hydrated, as well as unsolvated forms. It will further be understood that the present invention encompasses all such solvated forms of the compounds of the formula I.

5 Within the scope of the invention are also salts of the compounds of the formula I. Generally, pharmaceutically acceptable salts of compounds of the present invention may be obtained using standard procedures well known in the art, for example by reacting a sufficiently basic compound, for example an alkyl amine with a suitable acid, for example, HCl or acetic acid, to afford a physiologically acceptable
10 anion. It may also be possible to make a corresponding alkali metal (such as sodium, potassium, or lithium) or an alkaline earth metal (such as a calcium) salt by treating a compound of the present invention having a suitably acidic proton, such as a carboxylic acid or a phenol with one equivalent of an alkali metal or alkaline earth metal hydroxide or alkoxide (such as the ethoxide or methoxide), or a suitably basic
15 organic amine (such as choline or meglumine) in an aqueous medium, followed by conventional purification techniques.

In one embodiment, the compound of formula I above may be converted to a pharmaceutically acceptable salt or solvate thereof, particularly, an acid addition salt such as a hydrochloride, hydrobromide, phosphate, acetate, fumarate, maleate,
20 tartrate, citrate, methanesulphonate or *p*-toluenesulphonate.

The novel compounds of the present invention are useful in therapy, especially for the treatment of various pain conditions such as chronic pain, neuropathic pain, acute pain, cancer pain, pain caused by rheumatoid arthritis, migraine, visceral pain etc. This list should however not be interpreted as exhaustive.

25 Compounds of the invention are useful as immunomodulators, especially for autoimmune diseases, such as arthritis, for skin grafts, organ transplants and similar surgical needs, for collagen diseases, various allergies, for use as anti-tumour agents and anti viral agents.

Compounds of the invention are useful in disease states where degeneration or
30 dysfunction of opioid receptors is present or implicated in that paradigm. This may involve the use of isotopically labelled versions of the compounds of the invention in

diagnostic techniques and imaging applications such as positron emission tomography (PET).

Compounds of the invention are useful for the treatment of diarrhoea, depression, anxiety and stress-related disorders such as post-traumatic stress disorders, panic disorder, generalized anxiety disorder, social phobia, and obsessive compulsive disorder, urinary incontinence, premature ejaculation, various mental illnesses, cough, lung oedema, various gastro-intestinal disorders, e.g. constipation, functional gastrointestinal disorders such as Irritable Bowel Syndrome and Functional Dyspepsia, Parkinson's disease and other motor disorders, traumatic brain injury, stroke, cardioprotection following myocardial infarction, spinal injury and drug addiction, including the treatment of alcohol, nicotine, opioid and other drug abuse and for disorders of the sympathetic nervous system for example hypertension.

Compounds of the invention are useful as an analgesic agent for use during general anaesthesia and monitored anaesthesia care. Combinations of agents with different properties are often used to achieve a balance of effects needed to maintain the anaesthetic state (e.g. amnesia, analgesia, muscle relaxation and sedation). Included in this combination are inhaled anaesthetics, hypnotics, anxiolytics, neuromuscular blockers and opioids.

Also within the scope of the invention is the use of any of the compounds according to the formula I above, for the manufacture of a medicament for the treatment of any of the conditions discussed above.

A further aspect of the invention is a method for the treatment of a subject suffering from any of the conditions discussed above, whereby an effective amount of a compound according to the formula I above, is administered to a patient in need of such treatment.

Thus, the invention provides a compound of formula I, or pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined for use in therapy.

In a further aspect, the present invention provides the use of a compound of formula I, or a pharmaceutically acceptable salt or solvate thereof, as hereinbefore defined in the manufacture of a medicament for use in therapy.

In the context of the present specification, the term "therapy" also includes "prophylaxis" unless there are specific indications to the contrary. The term "therapeutic" and "therapeutically" should be construed accordingly. The term "therapy" within the context of the present invention further encompasses to
5 administer an effective amount of a compound of the present invention, to mitigate either a pre-existing disease state, acute or chronic, or a recurring condition. This definition also encompasses prophylactic therapies for prevention of recurring conditions and continued therapy for chronic disorders.

The compounds of the present invention are useful in therapy, especially for
10 the therapy of various pain conditions including, but not limited to: chronic pain, neuropathic pain, acute pain, back pain, cancer pain, and visceral pain.

In use for therapy in a warm-blooded animal such as a human, the compound of the invention may be administered in the form of a conventional pharmaceutical composition by any route including orally, intramuscularly, subcutaneously, topically,
15 intranasally, intraperitoneally, intrathoracically, intravenously, epidurally, intrathecally, intracerebroventricularly and by injection into the joints.

In one embodiment of the invention, the route of administration may be orally, intravenously or intramuscularly.

The dosage will depend on the route of administration, the severity of the
20 disease, age and weight of the patient and other factors normally considered by the attending physician, when determining the individual regimen and dosage level at the most appropriate for a particular patient.

For preparing pharmaceutical compositions from the compounds of this invention, inert, pharmaceutically acceptable carriers can be either solid and liquid.
25 Solid form preparations include powders, tablets, dispersible granules, capsules, cachets, and suppositories.

A solid carrier can be one or more substances, which may also act as diluents, flavoring agents, solubilizers, lubricants, suspending agents, binders, or table disintegrating agents; it can also be an encapsulating material.

30 In powders, the carrier is a finely divided solid, which is in a mixture with the finely divided compound of the invention, or the active component. In tablets, the

active component is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

For preparing suppository compositions, a low-melting wax such as a mixture of fatty acid glycerides and cocoa butter is first melted and the active ingredient is dispersed therein by, for example, stirring. The molten homogeneous mixture is then poured into convenient sized moulds and allowed to cool and solidify.

Suitable carriers are magnesium carbonate, magnesium stearate, talc, lactose, sugar, pectin, dextrin, starch, tragacanth, methyl cellulose, sodium carboxymethyl cellulose, a low-melting wax, cocoa butter, and the like.

The term composition is also intended to include the formulation of the active component with encapsulating material as a carrier providing a capsule in which the active component (with or without other carriers) is surrounded by a carrier which is thus in association with it. Similarly, cachets are included.

Tablets, powders, cachets, and capsules can be used as solid dosage forms suitable for oral administration.

Liquid form compositions include solutions, suspensions, and emulsions. For example, sterile water or water propylene glycol solutions of the active compounds may be liquid preparations suitable for parenteral administration. Liquid compositions can also be formulated in solution in aqueous polyethylene glycol solution.

Aqueous solutions for oral administration can be prepared by dissolving the active component in water and adding suitable colorants, flavoring agents, stabilizers, and thickening agents as desired. Aqueous suspensions for oral use can be made by dispersing the finely divided active component in water together with a viscous material such as natural synthetic gums, resins, methyl cellulose, sodium carboxymethyl cellulose, and other suspending agents known to the pharmaceutical formulation art.

Depending on the mode of administration, the pharmaceutical composition will preferably include from 0.05% to 99%w (per cent by weight), more preferably from 0.10 to 50%w, of the compound of the invention, all percentages by weight being based on total composition.

A therapeutically effective amount for the practice of the present invention may be determined, by the use of known criteria including the age, weight and response of the individual patient, and interpreted within the context of the disease which is being treated or which is being prevented, by one of ordinary skills in the art.

5 Within the scope of the invention is the use of any compound of formula I as defined above for the manufacture of a medicament.

Also within the scope of the invention is the use of any compound of formula I for the manufacture of a medicament for the therapy of pain.

10 Additionally provided is the use of any compound according to Formula I for the manufacture of a medicament for the therapy of various pain conditions including, but not limited to: chronic pain, neuropathic pain, acute pain, back pain, cancer pain, and visceral pain.

A further aspect of the invention is a method for therapy of a subject suffering from any of the conditions discussed above, whereby an effective amount of a
15 compound according to the formula I above, is administered to a patient in need of such therapy.

Additionally, there is provided a pharmaceutical composition comprising a compound of Formula I, or a pharmaceutically acceptable salt thereof, in association with a pharmaceutically acceptable carrier.

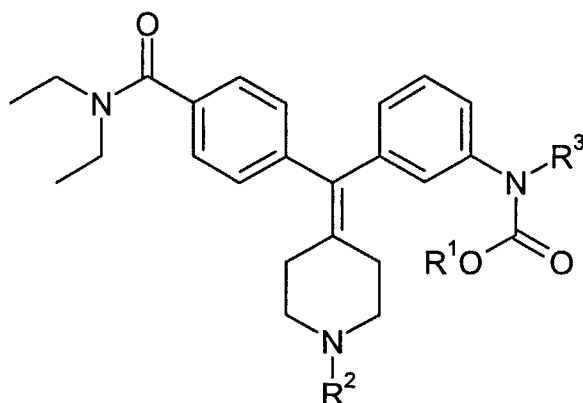
20 Particularly, there is provided a pharmaceutical composition comprising a compound of Formula I, or a pharmaceutically acceptable salt thereof, in association with a pharmaceutically acceptable carrier for therapy, more particularly for therapy of pain.

Further, there is provided a pharmaceutical composition comprising a
25 compound of Formula I, or a pharmaceutically acceptable salt thereof, in association with a pharmaceutically acceptable carrier use in any of the conditions discussed above.

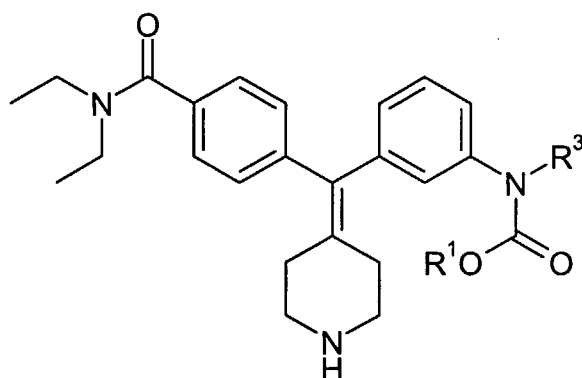
In a further aspect, the present invention provides a method of preparing a compound of formula I.

30 In one embodiment, the present invention provides a process for preparing a compound of formula I, comprising:

16

I

reacting a compound of formula II with R²-X:

II

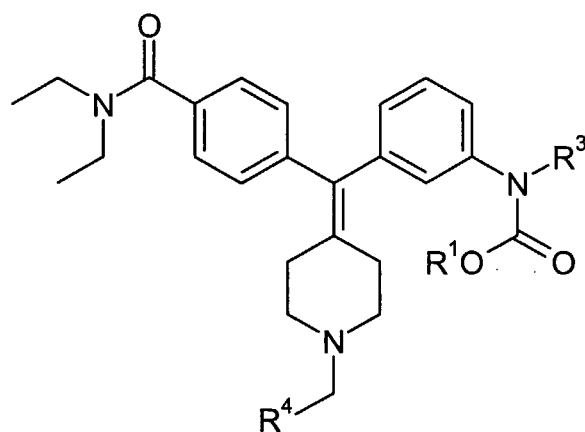
wherein X is halogen;

R¹ and R³ are, independently, selected from hydrogen, C₁₋₆alkyl, and C₃₋₆cycloalkyl, wherein said C₁₋₆alkyl and C₃₋₆cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl; and

R² is selected from C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-C₁₋₄alkyl, wherein said C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-C₁₋₄alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -

SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

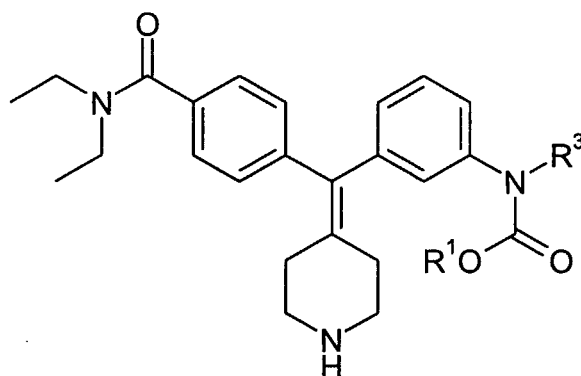
In another embodiment, the present invention provides a process for preparing a compound of formula III, comprising:



5

III

reacting a compound of formula II with R⁴-CHO:



10

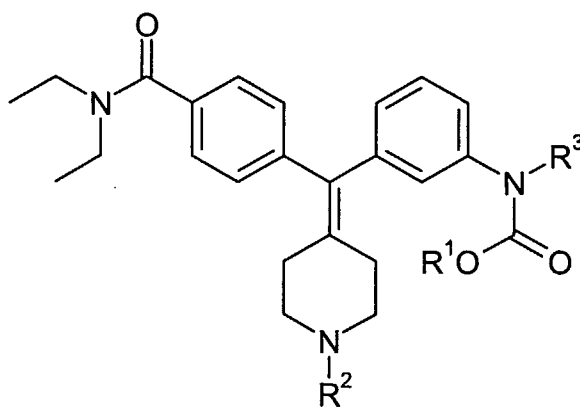
II

wherein R¹ and R³ are, independently, selected from hydrogen, C₁₋₆alkyl, and C₃₋₆cycloalkyl, wherein said C₁₋₆alkyl and C₃₋₆cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl; and

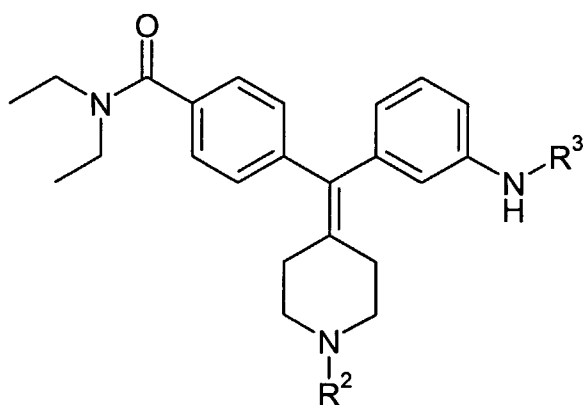
15

R^4 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -
 5 SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl.

In a further embodiment, the present invention provides a process for preparing a compound of formula I, comprising:

**I**

reacting a compound of formula IV with $R^1O-C(=O)-X$:

**IV**

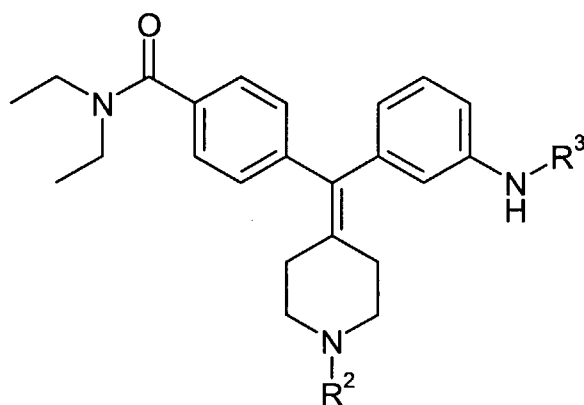
15 wherein X is halogen;

R^1 and R^3 are, independently, selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with

one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl; and

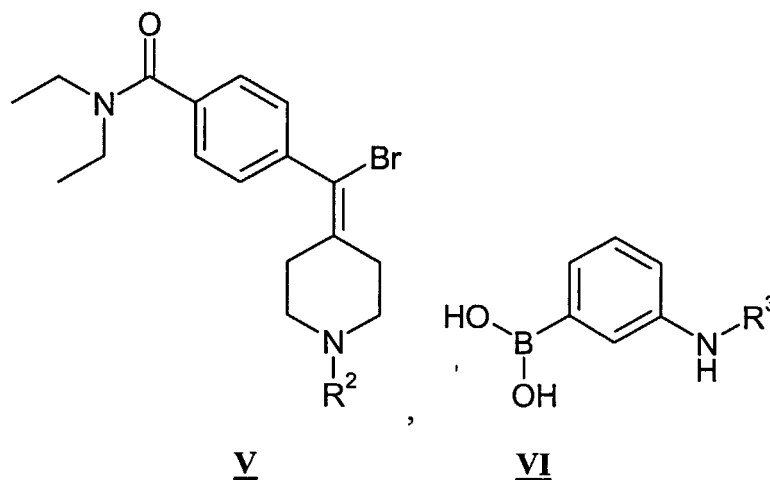
- 5 R² is selected from C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-C₁₋₄alkyl, wherein said C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-C₁₋₄alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -
- 10 NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

In an even further embodiment, the present invention provides a process for preparing a compound of formula IV, comprising:



IV

- 15 reacting a compound of formula V with a compound of formula VI or esters thereof:

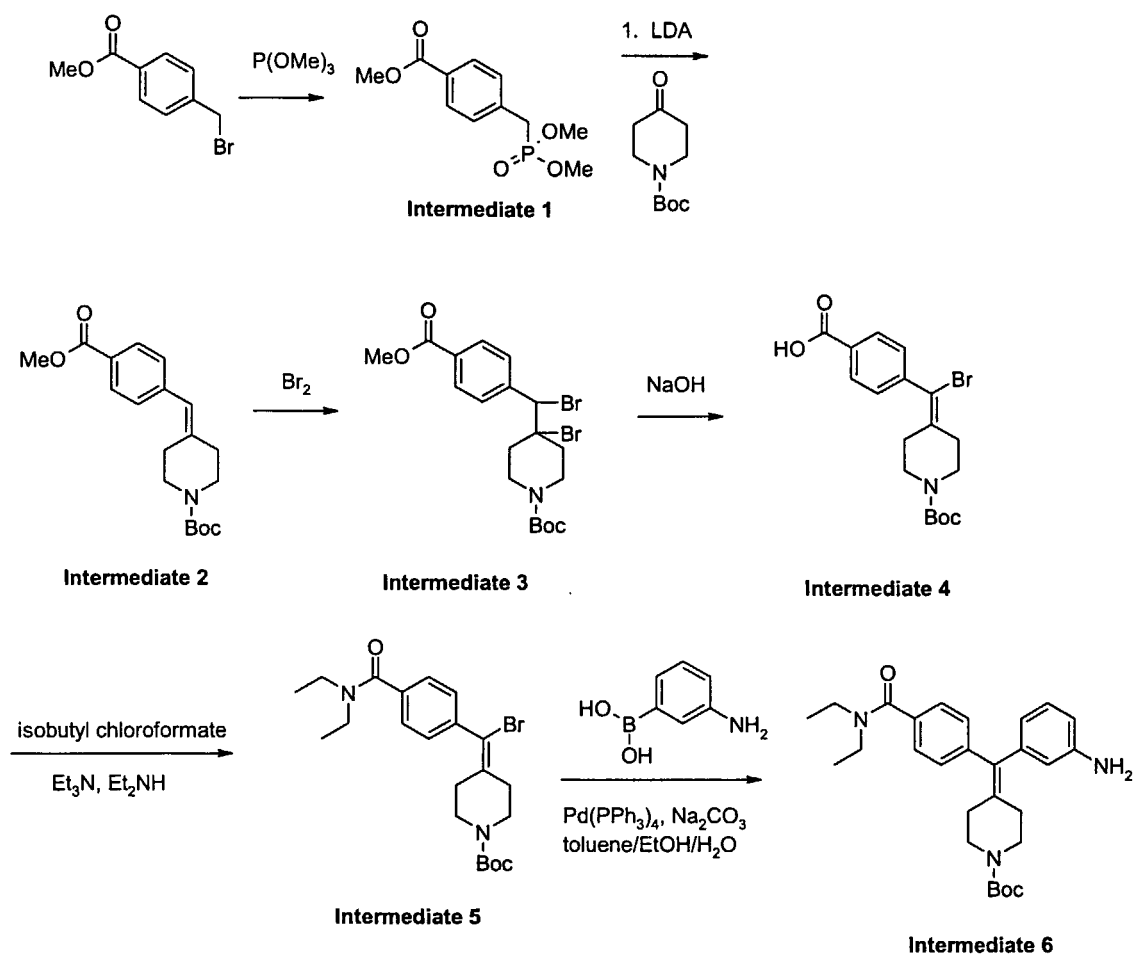


wherein R^3 is selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups
 5 selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl; and

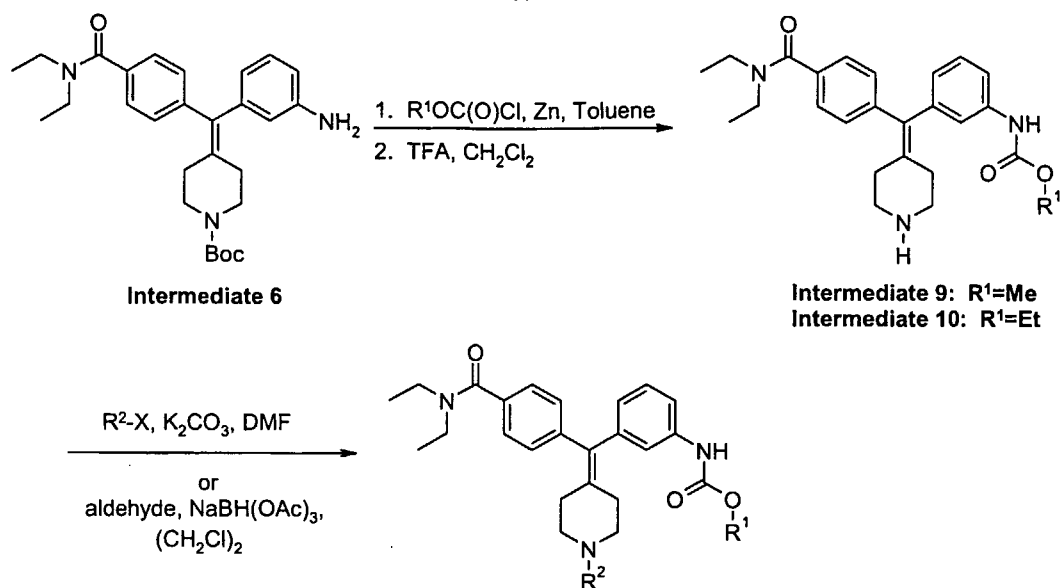
R^2 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl-
 10 C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl.

15 Particularly, the compounds of the present invention and intermediates used for the preparation thereof can be prepared according to the synthetic routes as exemplified in Schemes 1-3.

Scheme 1

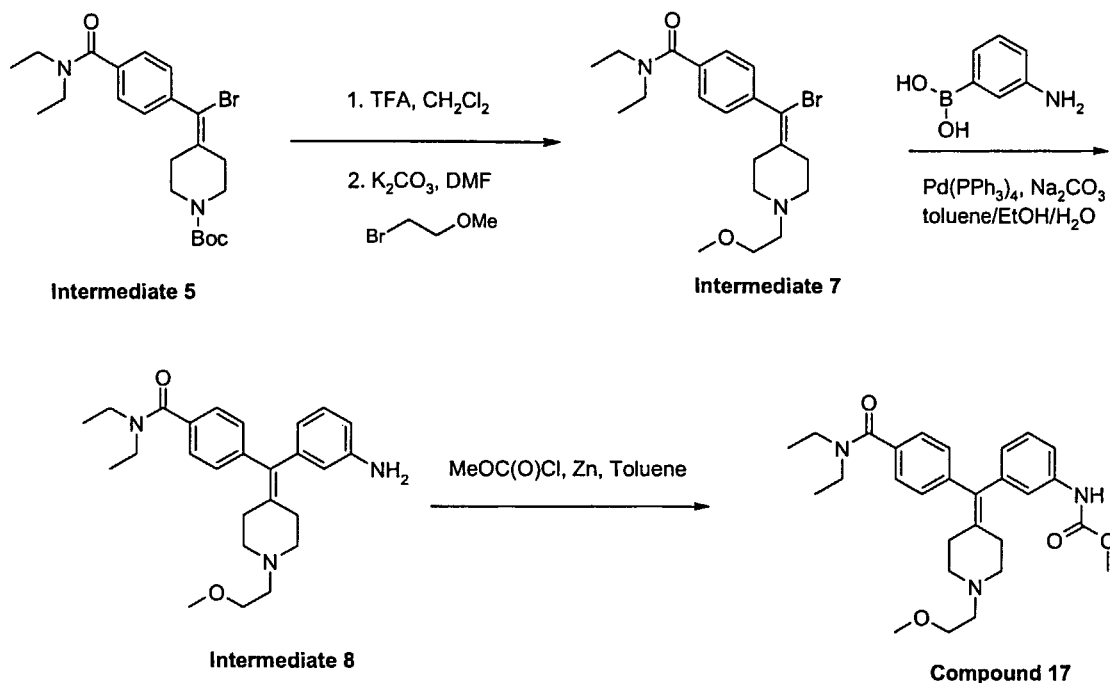


Scheme 2

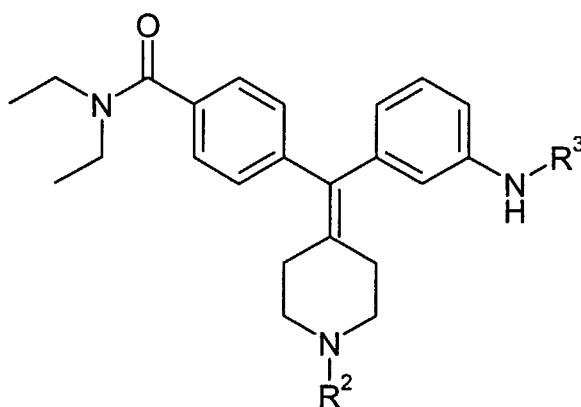


- Compound 1: $R^1=Me$, $R^2=n$ -propyl
 Compound 2: $R^1=Me$, $R^2=cyclopropylmethyl$
 Compound 3: $R^1=Me$, $R^2=n$ -pentyl
 Compound 4: $R^1=Et$, $R^2=n$ -propyl
 Compound 5: $R^1=Et$, $R^2=CH_2CH_2OCH_3$
 Compound 6: $R^1=Et$, $R^2=n$ -butyl
 Compound 7: $R^1=Me$, $R^2=CH_2CH_2OCH(CH_3)_2$
 Compound 8: $R^1=Me$, $R^2=CH_2CH_2OCH_2CH_3$
 Compound 9: $R^1=Me$, $R^2=n$ -butyl
 Compound 10: $R^1=Me$, $R^2=CH_2CH_2CH_2OCH_3$
 Compound 11: $R^1=Me$, $R^2=cyclobutylmethyl$
 Compound 12: $R^1=Me$, $R^2=Me$
 Compound 13: $R^1=Me$, $R^2=Et$
 Compound 14: $R^1=Et$, $R^2=cyclopropylmethyl$
 Compound 15: $R^1=Et$, $R^2=Me$
 Compound 16: $R^1=Et$, $R^2=Et$

Scheme 3



Accordingly, the present invention provides a chemical intermediate of formula IV, a pharmaceutically acceptable salt thereof, diastereomers, enantiomers, or mixtures thereof:

**IV**

wherein R³ is selected from hydrogen, C₁₋₆alkyl, and C₃₋₆cycloalkyl, wherein said C₁₋₆alkyl and C₃₋₆cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂,

-NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl; and

R² is selected from C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-C₁₋₄alkyl, wherein said C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-

5 C₁₋₄alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

Particularly, the present invention presents a compound of formula IV,
10 wherein R³ is hydrogen; and

R² is selected from C₁₋₆alkyl and C₃₋₆cycloalkyl-methyl, wherein said C₁₋₆alkyl and C₃₋₆cycloalkyl-methyl are optionally substituted with one or more groups selected from methoxy, ethoxy and isopropoxy.

More particularly, the present invention provides a compound of formula IV,
15 wherein R³ is hydrogen; and

R² is selected from n-propyl, cyclopropylmethyl, n-pentyl, 2-methoxyethyl, n-butyl, 2-isopropoxyethyl, 2-ethoxyethyl, 3-methoxypropyl, cyclobutylmethyl, methyl, and ethyl.

20 **BIOLOGICAL EVALUATION**

The compounds of the invention are found to be active towards δ receptors in warm-blooded animal, e.g., human. Particularly the compounds of the invention are found to be effective δ receptor ligands. *In vitro* assays, *infra*, demonstrate these surprising activities, especially with regard to agonists potency and efficacy as
25 demonstrated in the rat brain functional assay and/or the human δ receptor functional assay. This feature may be related to *in vivo* activity and may not be linearly correlated with binding affinity. In these *in vitro* assays, a compound is tested for their activity toward δ receptors and IC₅₀ is obtained to determine the selective activity for a particular compound towards δ receptors. In the current context, IC₅₀

generally refers to the concentration of the compound at which 50% displacement of a standard radioactive δ receptor ligand has been observed.

The activities of the compound towards κ and μ receptors are also measured in a similar assay.

5 **In vitro model**

Cell culture

Human 293S cells expressing cloned human κ , δ and μ receptors and neomycin resistance are grown in suspension at 37°C and 5% CO₂ in shaker flasks containing calcium-free DMEM 10% FBS, 5% BCS, 0.1% Pluronic F-68, and 600
10 μ g/ml geneticin.

Rat brains are weighed and rinsed in ice-cold PBS (containing 2.5mM EDTA, pH 7.4). The brains are homogenized with a polytron for 30 sec (rat) in ice-cold lysis buffer (50mM Tris, pH 7.0, 2.5mM EDTA, with phenylmethylsulfonyl fluoride added just prior use to 0.5mM from a 0.5M stock in DMSO:ethanol).

15 **Membrane preparation**

Cells are pelleted and resuspended in lysis buffer (50 mM Tris, pH 7.0, 2.5 mM EDTA, with PMSF added just prior to use to 0.1 mM from a 0.1 M stock in ethanol), incubated on ice for 15 min, then homogenized with a polytron for 30 sec. The suspension is spun at 1000g (max) for 10 min at 4°C. The supernatant is saved on
20 ice and the pellets resuspended and spun as before. The supernatants from both spins are combined and spun at 46,000 g(max) for 30 min. The pellets are resuspended in cold Tris buffer (50 mM Tris/Cl, pH 7.0) and spun again. The final pellets are resuspended in membrane buffer (50 mM Tris, 0.32 M sucrose, pH 7.0). Aliquots (1 ml) in polypropylene tubes are frozen in dry ice/ethanol and stored at -70°C until use.
25 The protein concentrations are determined by a modified Lowry assay with sodium dodecyl sulfate.

Binding assays

Membranes are thawed at 37°C, cooled on ice, passed 3 times through a 25-gauge needle, and diluted into binding buffer (50 mM Tris, 3 mM MgCl₂, 1 mg/ml

BSA (Sigma A-7888), pH 7.4, which is stored at 4°C after filtration through a 0.22 µm filter, and to which has been freshly added 5 µg/ml aprotinin, 10 µM bestatin, 10 µM diprotin A, no DTT). Aliquots of 100 µl are added to iced 12x75 mm polypropylene tubes containing 100 µl of the appropriate radioligand and 100 µl of test compound at various concentrations. Total (TB) and nonspecific (NS) binding are determined in the absence and presence of 10 µM naloxone respectively. The tubes are vortexed and incubated at 25°C for 60-75 min, after which time the contents are rapidly vacuum-filtered and washed with about 12 ml/tube iced wash buffer (50 mM Tris, pH 7.0, 3 mM MgCl₂) through GF/B filters (Whatman) presoaked for at least 2h in 0.1% polyethyleneimine. The radioactivity (dpm) retained on the filters is measured with a beta counter after soaking the filters for at least 12h in minivials containing 6-7 ml scintillation fluid. If the assay is set up in 96-place deep well plates, the filtration is over 96-place PEI-soaked unifilters, which are washed with 3 x 1 ml wash buffer, and dried in an oven at 55°C for 2h. The filter plates are counted in a TopCount (Packard) after adding 50 µl MS-20 scintillation fluid/well.

Functional Assays

The agonist activity of the compounds is measured by determining the degree to which the compounds receptor complex activates the binding of GTP to G-proteins to which the receptors are coupled. In the GTP binding assay, GTP[γ]³⁵S is combined with test compounds and membranes from HEK-293S cells expressing the cloned human opioid receptors or from homogenised rat and mouse brain. Agonists stimulate GTP[γ]³⁵S binding in these membranes. The EC₅₀ and E_{max} values of compounds are determined from dose-response curves. Right shifts of the dose response curve by the delta antagonist naltrindole are performed to verify that agonist activity is mediated through delta receptors. The E_{max} values were determined in relation to the standard δ agonist SNC80, i.e., higher than 100% is a compound that have better efficacy than SNC80.

Procedure for rat brain GTP

Rat brain membranes are thawed at 37°C, passed 3 times through a 25-gauge blunt-end needle and diluted in the GTPγS binding (50 mM Hepes, 20 mM NaOH,

100 mM NaCl, 1 mM EDTA, 5 mM MgCl₂, pH 7.4, Add fresh: 1 mM DTT, 0.1% BSA). 120 μ M GDP final is added membranes dilutions. The EC₅₀ and E_{max} of compounds are evaluated from 10-point dose-response curves done in 300 μ l with the appropriate amount of membrane protein (20 μ g/well) and 100000-130000 dpm of
5 GTP γ ³⁵S per well (0.11 -0.14nM). The basal and maximal stimulated binding are determined in absence and presence of 3 μ M SNC-80

Data analysis

The specific binding (SB) was calculated as TB-NS, and the SB in the presence of various test compounds was expressed as percentage of control SB.
10 Values of IC₅₀ and Hill coefficient (n_H) for ligands in displacing specifically bound radioligand were calculated from logit plots or curve fitting programs such as Ligand, GraphPad Prism, SigmaPlot, or ReceptorFit. Values of K_i were calculated from the Cheng-Prusoff equation. Mean $\pm$ S.E.M. values of IC₅₀, K_i and n_H were reported for ligands tested in at least three displacement curves.
15 Based on the above testing protocols, we find that the compounds of the present invention are active toward human δ receptors. Generally, the IC₅₀ towards human δ receptor for most compounds of the present invention is in the range of 0.18 nM – 3.7 nM with an average of 0.56 nM. The EC₅₀ and %E_{max} towards human δ receptor for these compounds are generally in the range of 2.3 nM -128 nM and 31
20 – 102, respectively. The IC₅₀ towards human κ and μ receptors for the compounds of the invention is generally in the ranges of 116 nM- 3832 nM and 109 nM – 811 nM, respectively.

Receptor Saturation Experiments

Radioligand K _{δ} values are determined by performing the binding assays on
25 cell membranes with the appropriate radioligands at concentrations ranging from 0.2 to 5 times the estimated K _{δ} (up to 10 times if amounts of radioligand required are feasible). The specific radioligand binding is expressed as pmole/mg membrane protein. Values of K _{δ} and B_{max} from individual experiments are obtained from

nonlinear fits of specifically bound (B) vs. nM free (F) radioligand from individual according to a one-site model.

Determination Of Mechano-Allodynia Using Von Frey Testing

Testing is performed between 08:00 and 16:00h using the method described
5 by Chaplan et al. (1994). Rats are placed in Plexiglas cages on top of a wire mesh
bottom which allows access to the paw, and are left to habituate for 10-15 min. The
area tested is the mid-plantar left hind paw, avoiding the less sensitive foot pads. The
paw is touched with a series of 8 Von Frey hairs with logarithmically incremental
stiffness (0.41, 0.69, 1.20, 2.04, 3.63, 5.50, 8.51, and 15.14 grams; Stoelting, Ill,
10 USA). The von Frey hair is applied from underneath the mesh floor perpendicular to
the plantar surface with sufficient force to cause a slight buckling against the paw, and
held for approximately 6-8 seconds. A positive response is noted if the paw is sharply
withdrawn. Flinching immediately upon removal of the hair is also considered a
positive response. Ambulation is considered an ambiguous response, and in such
15 cases the stimulus is repeated.

Testing Protocol

The animals are tested on postoperative day 1 for the FCA-treated group. The
50% withdrawal threshold is determined using the up-down method of Dixon (1980).
Testing is started with the 2.04 g hair, in the middle of the series. Stimuli are always
20 presented in a consecutive way, whether ascending or descending. In the absence of a
paw withdrawal response to the initially selected hair, a stronger stimulus is
presented; in the event of paw withdrawal, the next weaker stimulus is chosen.
Optimal threshold calculation by this method requires 6 responses in the immediate
vicinity of the 50% threshold, and counting of these 6 responses begins when the first
25 change in response occurs, e.g. the threshold is first crossed. In cases where
thresholds fall outside the range of stimuli, values of 15.14 (normal sensitivity) or
0.41 (maximally allodynic) are respectively assigned. The resulting pattern of positive
and negative responses is tabulated using the convention, X = no withdrawal; O =
withdrawal, and the 50% withdrawal threshold is interpolated using the formula:

30
$$50\% \text{ g threshold} = 10^{(X_f + k\delta)} / 10,000$$

where X_f = value of the last von Frey hair used (log units); k = tabular value (from Chaplan et al. (1994)) for the pattern of positive / negative responses; and δ = mean difference between stimuli (log units). Here $\delta = 0.224$.

Von Frey thresholds are converted to percent of maximum possible effect (% MPE), according to Chaplan et al. 1994. The following equation is used to compute % MPE:

$$\% \text{ MPE} = \frac{\text{Drug treated threshold (g)} - \text{allodynia threshold (g)}}{\text{Control threshold (g)} - \text{allodynia threshold (g)}} \times 100$$

Administration Of Test Substance

Rats are injected (subcutaneously, intraperitoneally, intravenously or orally) with a test substance prior to von Frey testing, the time between administration of test compound and the von Frey test varies depending upon the nature of the test compound.

Writhing Test

Acetic acid will bring abdominal contractions when administered intraperitoneally in mice. These will then extend their body in a typical pattern. When analgesic drugs are administered, this described movement is less frequently observed and the drug selected as a potential good candidate.

A complete and typical Writhing reflex is considered only when the following elements are present: the animal is not in movement; the lower back is slightly depressed; the plantar aspect of *both* paws is observable. In this assay, compounds of the present invention demonstrate significant inhibition of writhing responses after oral dosing of 1-100 $\mu\text{mol/kg}$.

(i) Solutions preparation

Acetic acid (AcOH): 120 μL of Acetic Acid is added to 19.88 ml of distilled water in order to obtain a final volume of 20 ml with a final concentration of 0.6% AcOH. The solution is then mixed (vortex) and ready for injection.

Compound (drug): Each compound is prepared and dissolved in the most suitable vehicle according to standard procedures.

(ii) Solutions administration

The compound (drug) is administered orally, intraperitoneally (i.p.) , subcutaneously (s.c.) or intravenously (i.v.) at 10 ml/kg (considering the average mice body weight) 20, 30 or 40 minutes (according to the class of compound and its characteristics) prior to testing. When the compound is delivered centrally:

- 5 Intraventricularly (i.c.v.) or intrathecally (i.t.) a volume of 5 μ L is administered.

The AcOH is administered intraperitoneally (i.p.) in two sites at 10 ml/kg (considering the average mice body weight) immediately prior to testing.

(iii) Testing

- 10 The animal (mouse) is observed for a period of 20 minutes and the number of occasions (Writhing reflex) noted and compiled at the end of the experiment. Mice are kept in individual "shoe box" cages with contact bedding. A total of 4 mice are usually observed at the same time: one control and three doses of drug.

For the anxiety and anxiety-like indications, efficacy has been established in the geller-seifter conflict test in the rat.

- 15 For the functional gastrointestinal disorder indication, efficacy can be established in the assay described by Coutinho SV *et al*, in American Journal of Physiology - Gastrointestinal & Liver Physiology. 282(2):G307-16, 2002 Feb, in the rat.

ADDITIONAL IN VIVO TESTING PROTOCOLS

20 **Subjects and housing**

Naïve male Sprague Dawley rats (175-200g) are housed in groups of 5 in a temperature controlled room (22°C, 40-70% humidity, 12-h light/dark). Experiments are performed during the light phase of the cycle. Animals have food and water ad libitum and are sacrificed immediately after data acquisition.

25 **Sample**

Compound (Drug) testing includes groups of rats that do not receive any treatment and others that are treated with E. coli lipopolysaccharide(LPS). For the LPS-treated experiment, four groups are injected with LPS, one of the four groups is then vehicle-treated whilst the other three groups are injected with the drug and its

vehicle. A second set of experiments are conducted involving five groups of rats; all of which receive no LPS treatment. The naïve group receives no compound (drug) or vehicle; the other four groups are treated with vehicle with or without drug. These are performed to determine anxiolytic or sedative effects of drugs which can contribute to a reduction in USV.

Administration of LPS

Rats are allowed to habituate in the experimental laboratory for 15-20 min prior to treatment. Inflammation is induced by administration of LPS (endotoxin of gram-negative E. coli bacteria serotype 0111:B4, Sigma). LPS (2.4µg) is injected intracerebro-ventricularly (i.c.v.), in a volume of 10µl, using standard stereotaxic surgical techniques under isoflurane anaesthesia. The skin between the ears is pushed rostrally and a longitudinal incision of about 1cm is made to expose the skull surface. The puncture site is determined by the coordinates: 0.8 mm posterior to the bregma, 1.5 mm lateral (left) to the lambda (sagittal suture), and 5 mm below the surface of the skull (vertical) in the lateral ventricle. LPS is injected via a sterile stainless steel needle (26-G 3/8) of 5 mm long attached to a 100-µl Hamilton syringe by polyethylene tubing (PE20; 10-15 cm). A 4 mm stopper made from a cut needle (20-G) is placed over and secured to the 26-G needle by silicone glue to create the desired 5mm depth.

Following the injection of LPS, the needle remains in place for an additional 10 s to allow diffusion of the compound, then is removed. The incision is closed, and the rat is returned to its original cage and allowed to rest for a minimum of 3.5h prior to testing.

Experimental setup for air-puff stimulation

The rats remains in the experimental laboratory following LPS injection and compound (drug) administration. At the time of testing all rats are removed and placed outside the laboratory. One rat at a time is brought into the testing laboratory and placed in a clear box (9 × 9 × 18 cm) which is then placed in a sound-attenuating ventilated cubicle measuring 62(w) × 35(d) × 46(h) cm (BRS/LVE, Div. Tech-Serv Inc). The delivery of air-puffs, through an air output nozzle of 0.32 cm, is controlled

by a system (AirStim, San Diego Instruments) capable of delivering puffs of air of fixed duration (0.2 s) and fixed intensity with a frequency of 1 puff per 10s. A maximum of 10 puffs are administered, or until vocalisation starts, whichever comes first. The first air puff marks the start of recording.

5 **Experimental setup for and ultrasound recording**

The vocalisations are recorded for 10 minutes using microphones (G.R.A.S. sound and vibrations, Vedbaek, Denmark) placed inside each cubicle and controlled by LMS (LMS CADA-X 3.5B, Data Acquisition Monitor, Troy, Michigan) software. The frequencies between 0 and 32000Hz are recorded, saved and analysed by the same software (LMS CADA-X 3.5B, Time Data Processing Monitor and UPA (User Programming and Analysis)).

Compounds (Drugs)

All compounds (drugs) are pH-adjusted between 6.5 and 7.5 and administered at a volume of 4 ml/kg. Following compound (drug) administration, animals are returned to their original cages until time of testing.

Analysis

The recording is run through a series of statistical and Fourier analyses to filter (between 20-24kHz) and to calculate the parameters of interest. The data are expressed as the mean $\pm$ SEM. Statistical significance is assessed using T-test for comparison between naive and LPS-treated rats, and one way ANOVA followed by Dunnett's multiple comparison test (post-hoc) for drug effectiveness. A difference between groups is considered significant with a minimum p value of ≤ 0.05 . Experiments are repeated a minimum of two times.

25 **EXAMPLES**

The invention will further be described in more detail by the following Examples which describe methods whereby compounds of the present invention may be prepared, purified, analyzed and biologically tested, and which are not to be construed as limiting the invention.

INTERMEDIATE 1: methyl 4-[(dimethoxyphosphoryl)methyl]benzoate

A mixture of 4-(bromomethyl)benzoic acid, methyl ester (11.2 g, 49 mmol) and trimethyl phosphite (25 mL) was refluxed under N₂ for 5 hrs. Excess trimethyl phosphite was removed by co-distillation with toluene to give **INTERMEDIATE 1** in quantitative yield. ¹H NMR (400MHz, CDCl₃) δ 3.20 (d, J = 22.0 Hz, 2H), 3.68 (d, J = 10.8 Hz, 3H), 3.78 (d, J = 11.2 Hz, 3H), 3.91 (s, 3H), 7.38 (m, 2H), 8.00 (d, J = 8.0 Hz, 2H).

INTERMEDIATE 2: 4-(4-Methoxycarbonyl-benzylidene)-piperidine-1-carboxylic acid tert-butyl ester

To a solution of **INTERMEDIATE 1** in dry THF (200 mL) was added dropwise lithium diisopropylamide (32.7 mL 1.5 M in hexanes, 49 mmol) at -78 °C. The reaction mixture was then allowed to warm to room temperature prior to addition of *N*-tert-butoxycarbonyl-4-piperidone (9.76 g, 49 mmol in 100 mL dry THF). After 12 hrs, the reaction mixture was quenched with water (300 mL) and extracted with ethyl acetate (3 x 300 mL). The combined organic phases were dried over MgSO₄ and evaporated to give a crude product, which was purified by flash chromatography to provide **INTERMEDIATE 2** as a white solid (5.64 g, 35%). IR (NaCl) 3424, 2974, 2855, 1718, 1688, 1606, 1427, 1362, 1276 cm⁻¹; ¹H NMR (400MHz, CDCl₃) δ 1.44 (s, 9H), 2.31 (t, J = 5.5 Hz, 2H), 2.42 (t, J = 5.5 Hz, 2H), 3.37 (t, J = 5.5 Hz, 2H), 3.48 (t, J = 5.5 Hz, 2H), 3.87 (s, 3H), 6.33 (s, 1H), 7.20 (d, J = 6.7 Hz, 2H), 7.94 (d, J = 6.7 Hz, 2H); ¹³C NMR (CDCl₃) δ 28.3, 29.2, 36.19, 51.9, 123.7, 127.8, 128.7, 129.4, 140.5, 142.1, 154.6, 166.8.

INTERMEDIATE 3: 4-Bromo-4-[bromo-(4-methoxycarbonyl-phenyl)-methyl]-piperidine-1-carboxylic acid tert-butyl ester

To a mixture of **INTERMEDIATE 2** (5.2 g, 16 mmol) and K₂CO₃ (1.0 g) in dry dichloromethane (200 mL) was added a solution of bromine (2.9 g, 18 mmol) in 30 mL CH₂Cl₂ at 0 °C. After 1.5 hrs at room temperature, the solution after filtration of K₂CO₃ was condensed. The residue was then dissolved in ethyl acetate (200 mL),

washed with water (200 mL), 0.5 M HCl (200 mL) and brine (200 mL), and dried over MgSO₄. Removal of solvents provided a crude product, which was recrystallized from methanol to give **INTERMEDIATE 3** as a white solid (6.07 g, 78%). IR (NaCl) 3425, 2969, 1725, 1669, 1426, 1365, 1279, 1243 cm⁻¹; ¹H NMR (400MHz, CDCl₃) δ 1.28 (s, 9H), 1.75 (m, 1H), 1.90 (m, 1H), 2.10 (m, 2H), 3.08 (br, 2H), 3.90 (s, 3H), 4.08 (br, 3H), 7.57 (d, J = 8.4 Hz, 2H) 7.98 (d, J = 8.4 Hz, 2H); ¹³C NMR (CDCl₃) δ 28.3, 36.6, 38.3, 40.3, 52.1, 63.2, 72.9, 129.0, 130.3, 130.4, 141.9, 154.4, 166.3.

10 **INTERMEDIATE 4: 4-[bromo-(4-carboxy-phenyl)-methylene]-piperidine-1-carboxylic acid tert-butyl ester**

A solution of **INTERMEDIATE 3** (5.4 g 11 mmol) in methanol (300 mL) and 2.0 M NaOH (100 mL) was heated at 40 °C for 3 hrs. The solid was collected by filtration, and dried overnight under vacuum. The dry salt was dissolved in 40% acetonitrile/water, and was adjusted to pH 2 using concentrated HCl. **INTERMEDIATE 4** (3.8 g, 87%) was isolated as a white powder by filtration. ¹H NMR (400MHz, CDCl₃) δ 1.45 (s, 9H), 2.22 (dd, J=5.5 Hz, 6.1 Hz, 2H), 2.64 (dd, J = 5.5 Hz, 6.1 Hz, 2H), 3.34 (dd, J = 5.5 Hz, 6.1 Hz, 2H), 3.54 (dd, J = 5.5 Hz, 6.1 Hz, 2H), 7.35 (d, J = 6.7 Hz, 2H), 8.08 (d, J = 6.7 Hz, 2H); ¹³C NMR (CDCl₃) δ 28.3, 31.5, 34.2, 44.0, 115.3, 128.7, 129.4, 130.2, 137.7, 145.2, 154.6, 170.3.

INTERMEDIATE 5: 4-[bromo-(4-diethylcarbamoyl-phenyl)-methylene]-piperidine-1-carboxylic acid tert-butyl ester

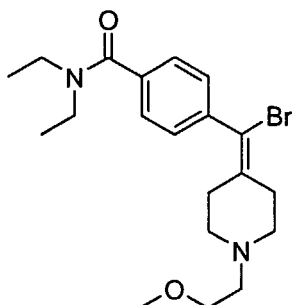
To a solution of **INTERMEDIATE 4** (1.0 g, 2.5 mmol) in dry dichloromethane (10 mL) at -20 °C was added isobutylchloroformate (450 mg, 3.3 mmol). After 20 min at -20 °C diethylamine (4 mL) was added and the reaction was allowed to warm to room temperature. After 1.5 hrs the solvents were evaporated and the residue was partitioned between ethyl acetate and water. The organic phase was washed with brine and dried over MgSO₄. Removal of solvents provided a crude

product, which was purified by flash chromatography to give **INTERMEDIATE 5** as white needles (800 mg, 73%). IR (NaCl) 3051, 2975, 1694, 1633, 1416, 1281, 1168, 1115 cm^{-1} ; ^1H NMR (400MHz, CDCl_3) δ 1.13 (br, 3H), 1.22 (br, 3H), 1.44 (s, 9H), 2.22 (t, $J = 5.5$ Hz, 2H), 2.62 (t, $J = 5.5$ Hz, 2H), 3.33 (m, 4H), 3.55 (m, 4H), 7.31 (d, $J = 8.0$ Hz, 2H), 7.36 (d, $J = 8.0$ Hz, 2H); ^{13}C NMR (CDCl_3) δ 12.7, 14.1, 28.3, 31.5, 34.2, 39.1, 43.2, 79.7, 115.9, 126.3, 129.3, 136.8, 137.1, 140.6, 154.6, 170.5.

**INTERMEDIATE 6: 4-[(3-aminophenyl)[4-
[(diethylamino)carbonyl]phenyl]methylene]-1-piperidinecarboxylic acid, 1,1-
dimethylethyl ester**

To a flask containing **INTERMEDIATE 5** (8.5 g, 18.9 mmol) is added xylene (120 mL), ethanol (80mL) and 3-aminophenylboronic acid (1.5 eq). The solution is degassed for 30 minutes, then aqueous sodium carbonate (2N, 29 mL, 3.0 eq, degassed for 30 minutes) is added via cannula. Then palladium tetrakis(triphenyl)phosphine (0.075 eq) is added. The reaction mixture is degassed for 10 minutes and heated to 80°C overnight. The reaction is cooled, diluted with water and filtered through a pad of diatomaceous earth. The organics are removed and the aqueous extracted with ether (2 x 50 mL). The combined organic extract is dried with anhydrous magnesium sulfate, filtered and concentrated. The residue is purified by flash chromatography, eluting 3% to 5% methanol in dichloromethane, to yield **INTERMEDIATE 6** as a colorless solid. ^1H NMR (400MHz, CDCl_3) 1.08-1.18 (m, 3H), 1.18-1.28 (m, 3H), 2.27-2.36 (m, 4H), 3.23-3.34 (m, 2H), 3.40-3.48 (m, 2H), 3.49-3.58 (m, 2H), 3.60-3.66 (m, 2H), 6.38-6.41 (m, 1H), 6.50-6.59 (m, 2H), 7.08 (t, $J = 7.6$ Hz, 1H), 7.14 (d, $J = 8.3$ Hz, 2H), 7.30 (d, $J = 8.2$ Hz, 2H).

**INTERMEDIATE 7: 4-[bromo[1-(2-methoxyethyl)-4-piperidinylidene]methyl]-
N,N-diethyl-benzamide**

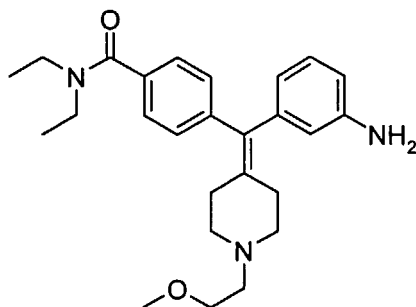


To a solution of **INTERMEDIATE 5** (3.0 g, 6.7 mmol) in dichloromethane was added trifluoroacetic acid (5.1 mL). The reaction was heated to 40°C until the reaction was complete. The reaction was cooled and washed with 1N NaOH. The organic layer was separated and the aqueous extract washed with dichloromethane (5x). The combined organic extracts were dried (Na₂SO₄), filtered and concentrated to give 2.37g (quantitative yield) of secondary amine.

To a solution of secondary amine (1.58 g, 4.5 mmol) in N,N-dimethylformamide was added potassium carbonate (933 mg, 6.75 mmol) and 1-bromoethyl methyl ether (0.64 mL, 6.75 mmol). The reaction was stirred at room temperature for 15 hours. The reaction was then concentrated, and the residue was partitioned between dichloromethane and saturated aqueous sodium bicarbonate. The layers were separated, and the aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by flash chromatography, eluting 0% to 10% methanol in dichloromethane to yield **INTERMEDIATE 7** (1.58 g, 86% yield) as a yellow oil.

INTERMEDIATE 8: 4-[(3-aminophenyl)[1-(2-methoxyethyl)-4-piperidinylidene]methyl]-N,N-diethyl-benzamide

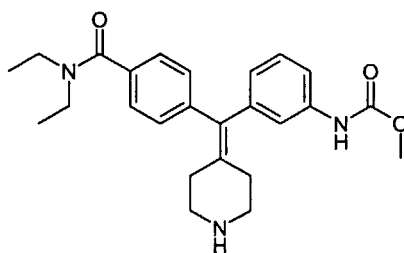
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Synthesized according to the method described for **INTERMEDIATE 6** using **INTERMEDIATE 7** (400mg, 0.98 mmol) as the vinyl bromide to give a quantitative yield of **INTERMEDIATE 8**.

5

INTERMEDIATE 9: methyl [3-[[4-[(diethylamino)carbonyl]phenyl]-4-piperidinylidenemethyl]phenyl]carbamate



A mixture of methyl chloroformate (0.13 mL, 1.7 mmol) and zinc metal (107 mg, 1.64 mmol) in toluene (10 mL) was stirred for 10 minutes. A suspension of **INTERMEDIATE 6** (761 mg, 1.64 mmol) in 3:1 toluene:CH₂Cl₂ (20 mL) was then added via syringe, and the resulting mixture was stirred at room temperature for 24 hours. The reaction was then diluted with dichloromethane and washed with saturated aqueous sodium bicarbonate. The layers were separated, and the aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by silica gel column chromatography, eluting with 3:1 CH₂Cl₂:EtOAc, and the appropriate fractions were combined and concentrated. The residue was dissolved in dichloromethane (30 mL), and trifluoroacetic acid (3 mL) was added. After 1.5 hours the solution was diluted with dichloromethane and washed with saturated aqueous sodium bicarbonate. The layers were separated, and the

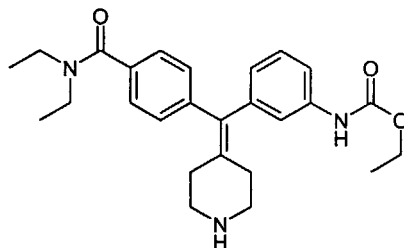
aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated to give **INTERMEDIATE 9** (584 mg, 85% yield). A portion of the product was converted to its trifluoroacetic acid salt by stirring **INTERMEDIATE 9** with

dichloromethane and trifluoroacetic acid for 0.5 hours, concentrating the mixture, and then lyophilizing from CH₃CN/H₂O to give a colorless solid. Purity (HPLC) > 99%.

¹H NMR (400MHz, CD₃OD) δ 1.12 (br t, J = 6.2 Hz, 3H), 1.23 (br t, J = 6.5 Hz, 3H), 2.55-2.64 (m, 4H), 3.21-3.29 (m, 6H), 3.48-3.58 (m, 2H), 3.71 (s, 3H), 6.78-6.83 (m, 1H), 7.23-7.29 (m, 4H), 7.35 (d, J = 8.4 Hz, 2H), 7.38 (s, 1H). Found: C, 53.88; H,

5.32; N, 6.59. C₂₅H₃₁N₃O₃ x 1.8 TFA x 0.6 H₂O has C, 53.88; H, 5.38; N, 6.59 %.

INTERMEDIATE 10: ethyl [3-[4-[(diethylamino)carbonyl]phenyl]-4-piperidinylidenemethyl]phenyl]carbamate



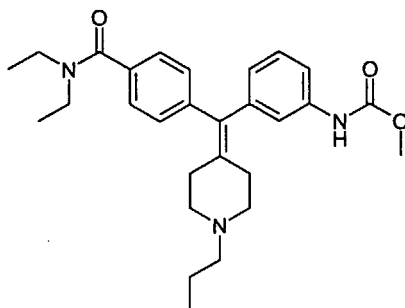
Using the same method as for **INTERMEDIATE 9** and using ethyl chloroformate (0.12 mL, 1.3 mmol), zinc metal (83.7 mg, 1.28 mmol), and **INTERMEDIATE 6** (593 mg, 1.28 mmol) afforded **INTERMEDIATE 10** (479 mg, 86% yield). A

portion of the product was converted to its trifluoroacetic acid salt by stirring **INTERMEDIATE 10** with dichloromethane and trifluoroacetic acid for 0.5 hours,

concentrating the mixture, and then lyophilizing from CH₃CN/H₂O to give a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.12 (br t, J = 6.5 Hz, 3H), 1.23 (br t, J = 7.0 Hz, 3H), 1.28 (t, J = 7.1 Hz, 3H), 2.55-2.64 (m, 4H), 3.20-3.29 (m, 6H), 3.47-3.59 (m, 2H), 4.15 (q, J = 7.1 Hz, 2H), 6.78-6.83 (m, 1H), 7.22-7.28 (m, 4H), 7.33-7.38 (m, 2H), 7.39 (s, 1H). Found: C, 54.17; H, 5.39; N, 6.37. C₂₆H₃₃N₃O₃

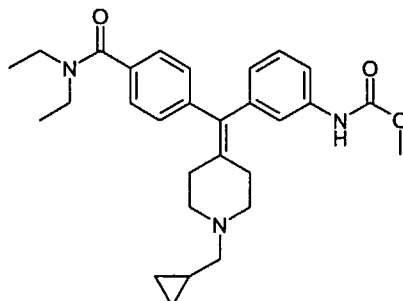
x 2.0 CF₃CO₂H x 0.1 H₂O has C, 54.15; H, 5.33; N, 6.31 %.

COMPOUND 1: methyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-propyl-4-piperidinylidene)methyl]phenyl]carbamate



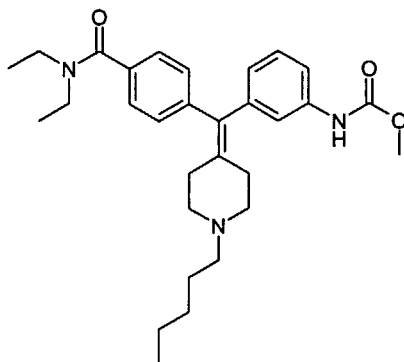
A mixture of **INTERMEDIATE 9** (197 mg, 0.466 mmol), potassium carbonate (96.7 mg, 0.700 mmol), and 1-iodopropane (0.055 mL, 0.56 mmol) in N,N-dimethylformamide (6 mL) was stirred at room temperature for 15 hours. The reaction was then concentrated, and the residue was partitioned between dichloromethane and saturated aqueous sodium bicarbonate. The layers were separated, and the aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by reverse phase chromatography, eluting 5% to 50% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized to give **COMPOUND 1** (145 mg, 54% yield) as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.02 (t, J = 7.4 Hz, 3H), 1.12 (br t, J = 6.5 Hz, 3H), 1.24 (br t, J = 6.8 Hz, 3H), 1.71-1.84 (m, 2H), 2.44-2.57 (m, 2H), 2.72-2.88 (m, 2H), 2.99-3.14 (m, 4H), 3.25-3.35 (m, 2H), 3.48-3.57 (m, 2H), 3.58-3.67 (m, 2H), 3.71 (s, 3H), 6.78-6.84 (m, 1H), 7.21-7.29 (m, 4H), 7.33-7.38 (m, 2H), 7.40 (s, 1H). Found: C, 57.95; H, 6.22; N, 6.63. C₂₈H₃₇N₃O₃ x 1.5 CF₃CO₂H x 0.4 H₂O has C, 58.01; H, 6.17; N, 6.55 %.

COMPOUND 2: methyl [3-[[1-(cyclopropylmethyl)-4-piperidinylidene][4-[(diethylamino)carbonyl]phenyl]methyl]phenyl]carbamate



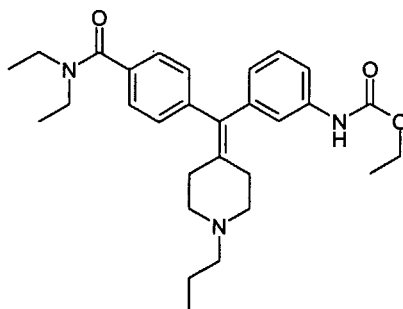
- A mixture of **INTERMEDIATE 9** (193 mg, 0.459 mmol),
5 cyclopropanecarboxaldehyde (0.051 mL, 0.68 mmol), and sodium
triacetoxyborohydride (156 mg, 0.734 mmol) in 1,2-dichloroethane (12 mL) was
stirred at room temperature for 15 hours. The reaction was diluted with
dichloromethane and washed with saturated aqueous sodium bicarbonate. The layers
were separated, and the aqueous layer was extracted with three portions of
10 dichloromethane. The combined organic phases were dried over anhydrous sodium
sulfate, filtered and concentrated. The residue was recrystallized from methanol, and
the recrystallized material was stirred with dichloromethane and trifluoroacetic acid
for 0.5 hours, concentrated, and lyophilized from CH₃CN/H₂O to give the
trifluoroacetic acid salt of **COMPOUND 2** (92.7 mg, 34% yield) as a colorless solid.
15 Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 0.40-0.46 (m, 2H), 0.73-0.80
(m, 2H), 1.08-1.17 (m, 4H), 1.23 (br t, J = 6.4 Hz, 3H), 2.47-2.60 (m, 2H), 2.73-2.89
(m, 2H), 3.02-3.13 (m, 4H), 3.25-3.34 (m, 2H), 3.48-3.58 (m, 2H), 3.66-3.76 (m, 5H),
6.78-6.84 (m, 1H), 7.22-7.30 (m, 4H), 7.36 (d, J = 8.4 Hz, 2H), 7.40 (s, 1H). Found:
C, 55.67; H, 5.66; N, 5.92. C₂₉H₃₇N₃O₃ x 2.0 CF₃CO₂H x 0.5 H₂O has C, 55.62; H,
20 5.66; N, 5.90 %.

COMPOUND 3: methyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-pentyl-4-piperidinylidene)methyl]phenyl]carbamate



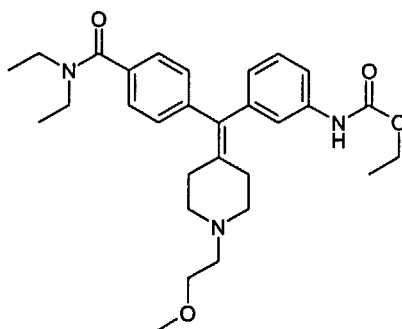
A mixture of the trifluoroacetic acid salt of **INTERMEDIATE 9** (185 mg, 0.345 mmol), potassium carbonate (95.3 mg, 0.690 mmol), and 1-iodopentane (0.054 mL, 0.41 mmol) in N,N-dimethylformamide (4 mL) was stirred at room temperature for 15 hours. The reaction was then concentrated, and the residue was partitioned between dichloromethane and saturated aqueous sodium bicarbonate. The layers were separated, and the aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by reverse phase chromatography, eluting 10% to 50% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized to give **COMPOUND 3** (148 mg, 71% yield) as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 0.95 (t, J = 7.0 Hz, 3H), 1.12 (t, J = 6.8 Hz, 3H), 1.23 (t, J = 7.0 Hz, 3H), 1.32-1.45 (m, 4H), 1.70-1.80 (m, 2H), 2.44-2.56 (m, 2H), 2.73-2.87 (m, 2H), 2.99-3.09 (m, 2H), 3.10-3.16 (m, 2H), 3.26-3.34 (m, 2H), 3.53 (q, J = 7.0 Hz, 2H), 3.58-3.66 (m, 2H), 3.71 (s, 3H), 6.81 (ddd, J = 5.3, 3.3, 1.8 Hz, 1H), 7.24 (d, J = 1.4 Hz, 1H), 7.24-7.28 (m, 3H), 7.34-7.38 (m, 2H), 7.40 (s, 1H). Found: C, 60.22; H, 6.65; N, 6.49. C₃₀H₄₁N₃O₃ x 1.3 CF₃CO₂H x 0.6 H₂O has C, 60.17; H, 6.74; N, 6.46 %.

COMPOUND 4: ethyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-propyl-4-piperidinylidene)methyl]phenyl]carbamate



Using the same method as for **COMPOUND 1** and using **INTERMEDIATE 10** (216 mg, 0.495 mmol), potassium carbonate (103 mg, 0.743 mmol), and 1-iodopropane (0.058 mL, 0.59 mmol) afforded the trifluoroacetic acid salt of **COMPOUND 4** (158 mg, 54% yield) as a colorless solid. Purity (HPLC) > 99%. ^1H NMR (400MHz, CD_3OD) δ 1.02 (t, $J = 7.4$ Hz, 3H), 1.12 (br t, $J = 7.1$ Hz, 3H), 1.23 (br t, $J = 6.5$ Hz, 3H), 1.28 (t, $J = 7.0$ Hz, 3H), 1.72-1.83 (m, 2H), 2.44-2.58 (m, 2H), 2.72-2.87 (m, 2H), 3.00-3.14 (m, 4H), 3.27-3.34 (m, 2H), 3.48-3.67 (m, 4H), 4.15 (q, $J = 7.0$ Hz, 2H), 6.78-6.82 (m, 1H), 7.22-7.29 (m, 4H), 7.33-7.38 (m, 2H), 7.39 (s, 1H). Found: C, 58.44; H, 6.47; N, 6.49. $\text{C}_{29}\text{H}_{39}\text{N}_3\text{O}_3 \times 1.4 \text{ CF}_3\text{CO}_2\text{H} \times 0.9 \text{ H}_2\text{O}$ has C, 58.45; H, 6.51; N, 6.43 %.

COMPOUND 5: ethyl [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-methoxyethyl)-4-piperidinylidene]methyl]phenyl]carbamate



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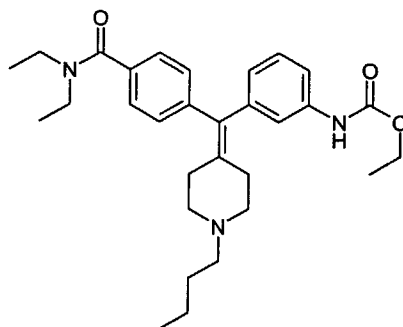
Using the same method as for **COMPOUND 1** and using **INTERMEDIATE 10** (195 mg, 0.449 mmol), potassium carbonate (93.0 mg, 0.673 mmol), and 1-bromo-2-methoxyethane (0.051 mL, 0.54 mmol) afforded the trifluoroacetic acid salt of **COMPOUND 5** (137 mg, 50% yield) as a colorless solid. Purity (HPLC) > 99%. ^1H

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NMR (400MHz, CD₃OD) δ 1.13 (br t, J = 6.8 Hz, 3H), 1.23 (br t, J = 5.9 Hz, 3H), 1.28 (t, J = 7.0 Hz, 3H), 2.48-2.62 (m, 2H), 2.70-2.86 (m, 2H), 3.05-3.16 (br m, 2H), 3.26-3.34 (br m, 2H), 3.34-3.39 (m, 2H), 3.40 (s, 3H), 3.49-3.58 (br m, 2H), 3.59-3.68 (br m, 2H), 3.69-3.74 (m, 2H), 4.15 (q, J = 7.2 Hz, 2H), 6.78-6.82 (m, 1H), 7.22-7.29 (m, 4H), 7.36 (d, J = 8.2 Hz, 2H), 7.39 (s, 1H). Found: C, 57.51; H, 6.12; N, 6.06. C₂₉H₃₉N₃O₄ x 1.5 TFA x 0.2 H₂O has C, 57.51; H, 6.17; N, 6.29%.

COMPOUND 6: ethyl [3-[(1-butyl-4-piperidinylidene)]4-[(diethylamino)carbonyl]phenyl]methyl]phenyl]carbamate

10

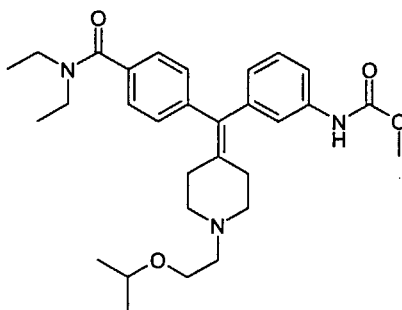


A mixture of **INTERMEDIATE 10** (44.5 mg, 0.102 mmol), butyraldehyde (0.014 mL, 0.16 mmol), and sodium triacetoxyborohydride (34.6 mg, 0.163 mmol) in 1,2-dichloroethane (3 mL) was stirred at room temperature for 5 days. The reaction was diluted with dichloromethane and washed with saturated aqueous sodium bicarbonate. The layers were separated, and the aqueous layer was extracted with three portions of dichloromethane. The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by reverse phase chromatography, eluting 10% to 50% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized to give **COMPOUND 6** (36.7 mg, 59% yield) as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 0.99 (t, J = 7.3 Hz, 3H), 1.12 (br t, J = 6.1 Hz, 3H), 1.23 (br t, J = 6.8 Hz, 3H), 1.28 (t, J = 7.1 Hz, 3H), 1.42 (sextet, J = 7.4 Hz, 2H), 1.67-1.78 (m, 2H), 2.45-2.58 (m, 2H), 2.71-2.87 (m, 2H), 2.99-3.09 (m, 2H),

3.10-3.17 (m, 2H), 3.24-3.37 (m, 2H), 3.48-3.58 (m, 2H), 3.58-3.67 (m, 2H), 4.15 (q, J=7.1 Hz, 2H), 6.78-6.84 (m, 1H), 7.22-7.29 (m, 4H), 7.36 (d, J = 8.2 Hz, 2H), 7.39 (s, 1H). Found: C, 56.40; H, 5.95; N, 5.77. $C_{30}H_{41}N_3O_3 \times 2.0 \text{ TFA} \times 0.2 \text{ H}_2\text{O}$ has C, 56.46; H, 6.05; N, 5.81%

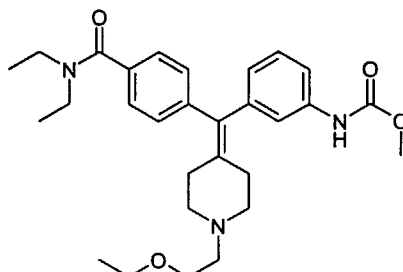
5

COMPOUND 7: [3-[[4-[(diethylamino)carbonyl]phenyl][1-[2-(1-methylethoxy)ethyl]-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester



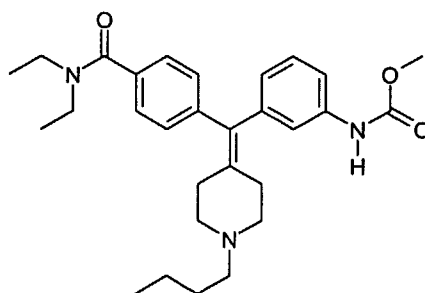
- 10 Using the same method as for **COMPOUND 2** and using **INTERMEDIATE 9** (25 mg, 0.06 mmol), excess (1-methylethoxy)-acetaldehyde and sodium triacetoxymethylborohydride afforded the trifluoroacetic acid salt of **COMPOUND 7** as a colorless solid. Purity (HPLC) > 95%. ^1H NMR (400MHz, CD_3OD) δ 1.09-1.15 (m, 3H), 1.19 (d, J = 6.2 Hz, 3H), 1.24 (t, J = 6.7 Hz, 6H), 2.49-2.60 (m, 2H), 2.73-2.87 (m, 2H), 3.07-3.17 (m, 2H), 3.26-3.34 (m, 2H), 3.50-3.58 (m, 2H), 3.59-3.72 (m, 6H), 3.74-3.78 (m, 2H), 6.79-6.83 (m, 1H), 7.22-7.28 (m, 4H), 7.34-7.38 (m, 2H), 7.42 (s, 1H). Found: C, 53.00; H, 5.99; N, 5.59. $C_{30}H_{41}N_3O_4 \times 2.0 \text{ TFA} \times 1.1 \text{ H}_2\text{O}$ has C, 54.05; H, 6.03; N, 5.56%.
- 15

COMPOUND 8: [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-ethoxyethyl)-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester



Using the same method as for **COMPOUND 1** and using **INTERMEDIATE 9** (25
 5 mg, 0.059 mmol), potassium carbonate (12 mg, 0.09 mmol), and 1-bromoethoxy
 ethane (0.01 mL, 0.09 mmol) afforded the trifluoroacetic acid salt of **COMPOUND 8**
 as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.12 (t,
 J=6.9 Hz, 3H), 1.20-1.27 (m, 6H), 2.49-2.60 (m, 2H), 2.72-2.87 (m, 2H), 3.07-3.17
 (m, 2H), 3.26-3.34 (m, 2H), 3.35-3.39 (m, 2H), 3.50-3.58 (m, 2H), 3.58 (q, J = 7.03
 10 Hz, 3H), 3.61-3.68 (m, 2H), 3.71 (s, 3H), 3.76-3.79 (m, 2H), 6.79-6.83 (m, 1H), 7.23-
 7.29 (m, 4H), 7.34 (d, J = 8.4 Hz, 2H), 7.41 (s, 1H). Found: C, 58.29; H, 6.65; N,
 6.67. C₂₉H₃₉N₃O₄ x 1.4 TFA has C, 58.47; H, 6.23; N, 6.43%.

**COMPOUND 9: methyl 3-((1-butylpiperidin-4-ylidene){4-
 15 [(diethylamino)carbonyl]phenyl}methyl)phenylcarbamate**



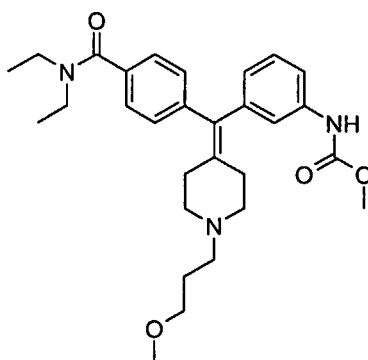
To a mixture of **INTERMEDIATE 9** (500 mg, 1.186 mmol) and potassium carbonate
 (246 mg, 1.779 mmol) in N,N-dimethylformamide (15 mL) was added 1-iodobutane
 (0.162 mL, 1.423 mmol). The reaction was stirred overnight at room temperature,
 20 concentrated, dissolved in dichloromethane, and washed with saturated aqueous
 sodium bicarbonate. The layers were separated, and the aqueous layer was extracted

with dichloromethane (2x). The combined organic phases were dried over anhydrous sodium sulfate, filtered and concentrated. The residue was purified by silica gel column chromatography, eluting with 5% MeOH/CH₂Cl₂. The residue was then dissolved in dichloromethane (15 mL) and 1.0M HCl in ether (1.2 mL) was added.

- 5 The solution was stirred for 1 hour then concentrated. The product was obtained as the hydrochloric acid salt and was lyophilized in acetonitrile and water to give **COMPOUND 9** (410 mg, 67% yield) as a pale yellow solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.02 (t, J = 7.42 Hz, 3H), 1.10-1.19 (m, 3H), 1.25 (br t, J = 6.44 Hz, 3H), 1.44 (dq, J = 14.96, 7.38 Hz, 2H), 1.70-1.81 (m, 2H), 2.48-2.62 (m, 2H), 2.73-2.90 (m, 2H), 3.07 (br t, J = 12.30 Hz, 2H), 3.12-3.19 (m, 2H), 3.27-3.36 (m, 2H), 3.51-3.59 (m, 2H), 3.60-3.69 (m, 2H), 3.72 (s, 3H), 6.83 (dt, J = 4.25, 1.46 Hz, 1H), 7.24-7.30 (m, 4H), 7.38 (d, J = 8.01 Hz, 2H), 7.41 (s, 1H). Found: C, 64.84; H, 7.60; N, 7.71. C₂₉H₃₉N₃O₃ x 1.60 HCl x 0.10 H₂O has C, 64.77; H, 7.65; N, 7.81 %.

15

COMPOUND 10: methyl 3-{{4-[(diethylamino)carbonyl]phenyl}[1-(3-methoxypropyl)piperidin-4-ylidene]methyl}phenylcarbamate

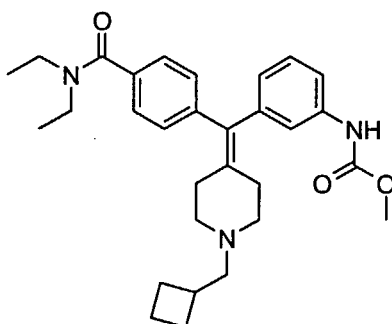


- 20 Using the same method as for **COMPOUND 9** and using **INTERMEDIATE 9** (500 mg, 1.186 mmol), potassium carbonate (246 mg, 1.779 mmol), and 1-bromo-3-methoxypropane (0.161 mL, 1.423 mmol) afforded the hydrochloric acid salt of **COMPOUND 10** (323 mg, 51% yield) as a beige solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.13 (br t, J = 6.54 Hz, 3H), 1.25 (br t, J = 6.35 Hz, 3H), 1.99-2.08 (m, 2H), 2.48-2.61 (m, 2H), 2.81 (dd, J = 25.87, 15.13 Hz, 2H), 3.08 (dt, J =
- 25

12.20, 1.76 Hz, 2H), 3.24-3.33 (m, 4H), 3.35 (s, 3H), 3.51 (t, J = 5.66 Hz, 2H), 3.49-3.53 (m, 2H), 3.61-3.70 (m, 2H), 3.72 (s, 3H), 6.82 (dt, J = 4.34, 1.46 Hz, 1H), 7.24-7.30 (m, 4H), 7.37 (d, J = 8.20 Hz, 2H), 7.40 (s, 1H). Found: C, 62.84; H, 7.33; N, 7.42. $C_{29}H_{39}N_3O_4 \times 1.60 \text{ HCl} \times 0.10 \text{ H}_2\text{O}$ has C, 62.90; H, 7.43; N, 7.59 %.

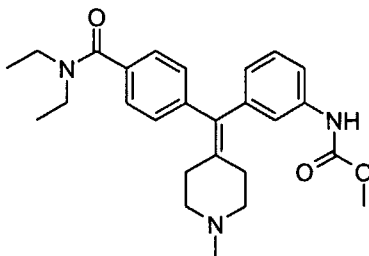
5

COMPOUND 11: methyl 3-([1-(cyclobutylmethyl)piperidin-4-ylidene]{4-[(diethylamino)carbonyl]phenyl)methyl}phenylcarbamate



- 10 Synthesized according to the method described for **COMPOUND 1** using **INTERMEDIATE 9** (200 mg, 0.474 mmol), potassium carbonate (98 mg, 0.711 mmol), and bromomethylcyclobutane (0.128 mL, 1.138 mmol). The residue was purified by reverse phase chromatography, eluting with 15% to 40% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the
- 15 trifluoroacetic acid salt and was lyophilized from $\text{CH}_3\text{CN}/\text{H}_2\text{O}$ to give **COMPOUND 11** (175 mg, 61% yield) as a pale yellow solid. Purity (HPLC) > 99%. ^1H NMR (400MHz, CD_3OD) δ 1.14 (br t, J = 5.96 Hz, 3H), 1.25 (br t, J = 6.35 Hz, 3H), 1.84-2.11 (m, 4H), 2.17-2.26 (m, 2H), 2.45-2.58 (m, 2H), 2.73-2.88 (m, 3H), 3.05 (dt, J = 12.40, 2.54 Hz, 2H), 3.22 (d, J = 7.03 Hz, 2H), 3.27-3.36 (m, 2H), 3.50-3.60 (m, 4H),
- 20 3.73 (s, 3H), 6.80-6.85 (m, 1H), 7.24-7.29 (m, 4H), 7.37 (d, J = 8.20 Hz, 2H), 7.41 (s, 1H). Found: C, 59.15; H, 6.07; N, 6.14. $C_{30}H_{39}N_3O_3 \times 1.6 \text{ TFA} \times 0.1\text{H}_2\text{O}$ has C, 59.17; H, 6.10; N, 6.24%

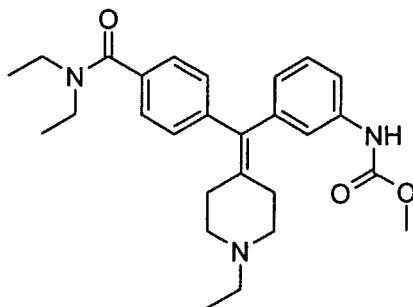
COMPOUND 12: methyl 3-[{4-[(diethylamino)carbonyl]phenyl}{(1-methylpiperidin-4-ylidene)methyl}phenyl]carbamate



Synthesized according to the method described for **COMPOUND 2** using

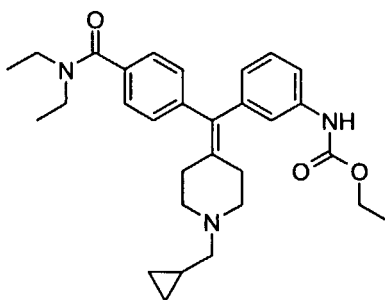
- 5 **INTERMEDIATE 9** (150 mg, 0.356 mmol), formaldehyde, 37% wt in H₂O (0.244 mL, 3.274 mmol), and sodium triacetoxyborohydride (347 mg, 1.637 mmol) in 1,2-dichloroethane (7 mL). The residue was purified by reverse phase chromatography, eluting with 5% to 30% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized from
- 10 CH₃CN/H₂O to give **COMPOUND 12** (165 mg, 84% yield) as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.10-1.20 (m, 3H), 1.26 (br t, J = 6.54 Hz, 3H), 2.44-2.58 (m, 2H), 2.82 (dd, J = 27.34, 15.04 Hz, 2H), 2.93 (s, 3H), 3.11 (t, J = 11.53 Hz, 2H), 3.27-3.37 (m, 2H), 3.51-3.63 (m, 4H), 3.73 (s, 3H), 6.81-6.86 (m, 1H), 7.25-7.30 (m, 4H), 7.38 (d, J = 8.20 Hz, 2H), 7.42 (s, 1H). Found: C, 57.37; H, 5.87; N, 6.94. C₂₆H₃₃N₃O₃ x 1.4 CF₃CO₂H x 0.4 H₂O has C, 57.42; H, 5.89; N, 6.98%
- 15

COMPOUND 13: methyl 3-[{4-[(diethylamino)carbonyl]phenyl}{(1-ethylpiperidin-4-ylidene)methyl}phenyl]carbamate



Synthesized according to the method described for **COMPOUND 2** using **INTERMEDIATE 9** (150 mg, 0.356 mmol), acetaldehyde (0.03 mL, 0.534 mmol), and sodium triacetoxyborohydride (121 mg, 0.569 mmol) in 1,2-dichloroethane (9 mL). The residue was purified by reverse phase chromatography, eluting with 15% to 40% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized from CH₃CN/H₂O to give **COMPOUND 13** (36 mg, 18% yield) as a beige solid. Purity (HPLC) > 96%. ¹H NMR (400MHz, CD₃OD) δ 1.13 (br t, J = 6.25 Hz, 3H), 1.24 (br t, J = 5.86 Hz, 3H), 1.36 (t, J = 7.32 Hz, 3H), 2.44-2.57 (m, 2H), 2.74-2.92 (m, 2H), 3.04 (dt, J = 12.40, 2.54 Hz, 2H), 3.22 (q, J = 7.42 Hz, 2H), 3.27-3.35 (m, 2H), 3.54 (br q, J = 7.29 Hz, 2H), 3.59-3.67 (m, 2H), 3.72 (s, 3H), 6.79-6.85 (m, 1H), 7.23-7.30 (m, 4H), 7.37 (d, J = 7.81 Hz, 2H), 7.41 (s, 1H). Found: C, 59.60; H, 6.36; N, 7.02. C₂₇H₃₅N₃O₃ x 1.2 CF₃CO₂H x 0.3 H₂O has C, 59.67; H, 6.27; N, 7.10%

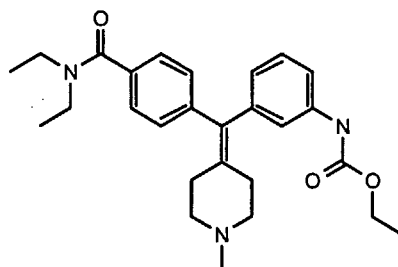
COMPOUND 14: ethyl 3-([1-(cyclopropylmethyl)piperidin-4-ylidene]{4-[(diethylamino)carbonyl]phenyl}methyl)phenylcarbamate



Synthesized according to the method described for **COMPOUND 2** using **INTERMEDIATE 10** (250 mg, 0.574 mmol), cyclopropanecarboxaldehyde (0.064 mL, 0.861 mmol), and sodium triacetoxyborohydride (195 mg, 0.918 mmol) in 1,2-dichloroethane (15 mL). The residue was purified by reverse phase chromatography, eluting with 15% to 40% acetonitrile in water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized from CH₃CN/H₂O to give **COMPOUND 14** (214 mg, 62% yield) as a white solid. Purity (HPLC) > 99%. ¹H NMR (400 MHz, CD₃OD) δ 0.42-0.47 (m, 2H), 0.74-0.81 (m,

2H), 1.09-1.18 (m, 4H), 1.25 (br t, $J = 6.44$ Hz, 3H), 1.29 (t, $J = 7.13$ Hz, 3H), 2.48-2.60 (m, 2H), 2.82 (dd, $J = 25.29, 14.55$ Hz, 2H), 3.03-3.14 (m, 4H), 3.27-3.35 (m, 2H), 3.54 (br q, $J = 6.44$ Hz, 2H), 3.68-3.76 (m, 2H), 4.16 (q, $J = 7.03$ Hz, 2H), 6.82 (ddd, $J = 5.86, 2.73, 1.76$ Hz, 1H), 7.22-7.30 (m, 4H), 7.37 (d, $J = 8.40$ Hz, 2H), 7.41 (s, 1H). Found: C, 60.07; H, 6.22; N, 6.42. $C_{30}H_{39}N_3O_3 \times 1.5 CF_3CO_2H$ has C, 59.99; H, 6.18; N, 6.36%

COMPOUND 15: ethyl {3-[{4-[(diethylamino)carbonyl]phenyl}(1-methylpiperidin-4-ylidene)methyl}phenyl}carbamate



10

Using the same method as for **COMPOUND 2** and using **INTERMEDIATE 10** (590 mg, 1.353 mmol), formaldehyde (37% wt. in H_2O ; 81.2 mg, 2.706 mmol), and sodium triacetoxyborohydride (574 mg, 2.706 mmol) afforded the trifluoroacetic acid salt of **COMPOUND 15** as a colorless solid (390 mg, 58% yield). Purity (HPLC) > 99%.

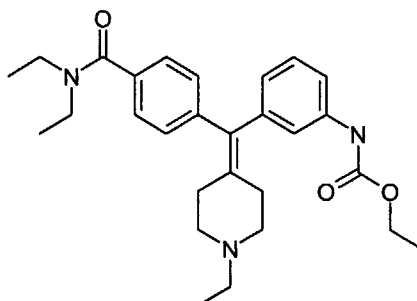
1H NMR (400MHz, CD_3OD) δ 1.13 (s, 3H), 1.24 (s, 3H), 1.31 (t, $J = 7.13$ Hz, 4H), 2.09 (s, 2H), 2.73 (d, $J = 11.52$ Hz, 6H), 2.84 (s, 4H), 3.28 (s, 2H), 3.55 (s, 2H), 3.64 (s, 2H), 4.21 (q, $J = 7.03$ Hz, 2H), 6.74-6.76 (m, 1H), 7.13 (d, $J = 8.40$ Hz, 2H), 7.17 (ddd, $J = 8.20, 2.25, 1.07$ Hz, 1H), 7.23 (d, $J = 7.81$ Hz, 1H), 7.30-7.34 (m, 3H).

Found: C, 57.39; H, 5.84; N, 6.65. $C_{27}H_{35}N_3O_3 \times 1.6 C_2HO_2F_3$ has C, 57.31; H, 6.02;

N, 6.71%.

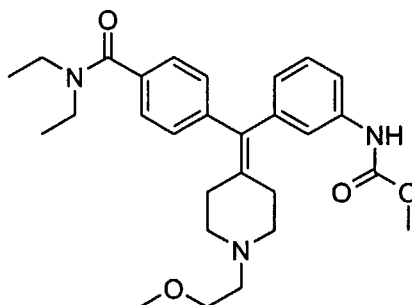
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COMPOUND 16: ethyl {3-[[4-(aminocarbonyl)phenyl](1-ethylpiperidin-4-ylidene)methyl]phenyl}carbamate



Using the same method as for **COMPOUND 2** and using **INTERMEDIATE 10** (590 mg, 1.353 mmol), acetaldehyde (119.2 mg, 2.706 mmol), and sodium triacetoxymethylborohydride (574 mg, 2.706 mmol) afforded the trifluoroacetic acid salt of **COMPOUND 16** as a colorless solid (69 mg, 9% yield). Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.11 (t, J = 5.96 Hz, 3H) 1.17-1.25 (m, 3H), 1.27 (t, J = 7.13 Hz, 3H), 1.34 (t, J = 7.23 Hz, 3H), 2.34-2.61 (m, 2H), 2.68-2.89 (m, 2H), 3.01 (t, J = 11.62 Hz, 2H), 3.20 (q, J = 7.09 Hz, 2H), 3.29 (s, 4H), 3.43-3.70 (m, 4H), 4.14 (q, J = 7.03 Hz, 2H), 6.59-6.99 (m, 1H), 7.20-7.29 (m, 2H), 7.30-7.40 (m, 2H). Found: C, 53.90; H, 5.48; N, 5.92. C₂₈H₃₇N₃O₃ x 2.3 C₂HO₂F₃ has C, 53.94; H, 5.46; N, 5.79%.

COMPOUND 17: [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-methoxyethyl)-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester

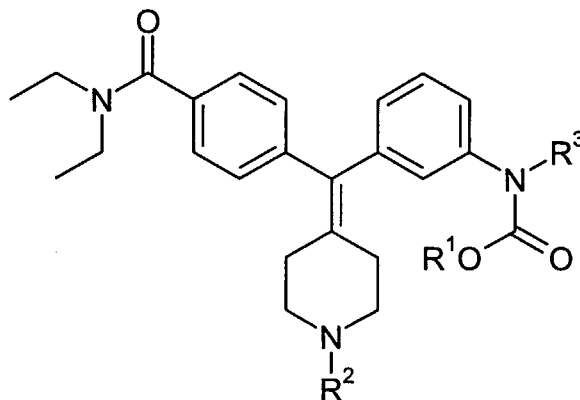


Synthesized according to the method described for **INTERMEDIATE 9** using **INTERMEDIATE 8** (279 mg, 0.66 mmol) and methyl chloroformate. The residue was purified by reverse phase chromatography, eluting 10% to 65% acetonitrile in

water containing 0.1% trifluoroacetic acid. The product was obtained as the trifluoroacetic acid salt and was lyophilized to give **COMPOUND 17** (185 mg, 47% yield) as a colorless solid. Purity (HPLC) > 99%. ¹H NMR (400MHz, CD₃OD) δ 1.12 (t, J = 6.7 Hz, 3H), 1.23 (t, J = 6.7 Hz, 3H), 2.49-2.60 (m, 2H), 2.72-2.86 (m, 2H), 3.05-3.16 (m, 2H), 3.26-3.34 (m, 2H), 3.35-3.40 (m, 2H), 3.41 (s, 3H), 3.50-3.57 (m, 2H), 3.59-3.68 (m, 2H), 3.69-3.74 (m, 5H), 6.81 (m, 1H), 7.25 (m, 4H), 7.36 (d, J = 8.4 Hz, 2H), 7.40 (br s, 1H). Found: C, 59.84; H, 6.43; N, 6.82. C₂₈H₃₇N₃O₄ x 1.2 C₂HF₃O₂ x 1.4 H₂O has C, 59.90; H, 6.44; N, 6.55 %.

What is claimed is :

1. A compound of formula I, a pharmaceutically acceptable salt thereof, diastereomers, enantiomers, or mixtures thereof:

**I**

wherein

R^1 and R^3 are, independently, selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl; and

R^2 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen, C_{3-6} cycloalkyl or C_{1-6} alkyl.

2. A compound according to claim 1, wherein R^1 is C_{1-3} alkyl; R^3 is hydrogen; and

R^2 is selected from C_{1-6} alkyl and C_{3-6} cycloalkyl-methyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl-methyl are optionally substituted with one or more groups selected from methoxy, ethoxy and isopropoxy.

5 3. A compound according to claim 1,

wherein R^1 is selected from C_{1-3} alkyl and halogenated C_{1-3} alkyl;

R^3 is selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from C_{1-6} alkyl, halogenated C_{1-6} alkyl, $-NO_2$, $-CF_3$, C_{1-6} alkoxy, chloro,
10 fluoro, bromo, and iodo; and

R^2 is selected from C_{1-6} alkyl, C_{3-6} cycloalkyl and C_{3-6} cycloalkyl-methyl, wherein said C_{1-6} alkyl, C_{3-6} cycloalkyl and C_{3-6} cycloalkyl-methyl are optionally substituted with one or more groups selected from C_{1-6} alkyl, halogenated C_{1-6} alkyl, $-CF_3$, C_{1-6} alkoxy, chloro, fluoro and bromo.

15

4. A compound according to claim 1,

wherein R^1 is selected from methyl and ethyl;

R^3 is hydrogen; and

R^2 is selected from n-propyl, cyclopropylmethyl, n-pentyl, 2-methoxyethyl,
20 n-butyl, 2-isopropoxyethyl, 2-ethoxyethyl, 3-methoxypropyl, cyclobutylmethyl, methyl, and ethyl.

5. A compound according to claim 1, wherein the compound is selected from:

COMPOUND 1: methyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-propyl-4-
25 piperidinylidene)methyl]phenyl]carbamate;

COMPOUND 2: methyl [3-[[1-(cyclopropylmethyl)-4-piperidinylidene][4-
[(diethylamino)carbonyl]phenyl]methyl]phenyl]carbamate;

COMPOUND 3: methyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-pentyl-4-
piperidinylidene)methyl]phenyl]carbamate;

30 COMPOUND 4: ethyl [3-[[4-[(diethylamino)carbonyl]phenyl](1-propyl-4-
piperidinylidene)methyl]phenyl]carbamate;

COMPOUND 5: ethyl [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-methoxyethyl)-4-piperidinylidene]methyl]phenyl]carbamate;

COMPOUND 6: ethyl [3-[(1-butyl-4-piperidinylidene)[4-[(diethylamino)carbonyl]phenyl]methyl]phenyl]carbamate;

5 COMPOUND 7: [3-[[4-[(diethylamino)carbonyl]phenyl][1-[2-(1-methylethoxy)ethyl]-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester;

COMPOUND 8: [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-ethoxyethyl)-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester;

COMPOUND 9: methyl 3-((1-butylpiperidin-4-ylidene){4-
10 [(diethylamino)carbonyl]phenyl} methyl)phenylcarbamate;

COMPOUND 10: methyl 3-{ {4-[(diethylamino)carbonyl]phenyl}[1-(3-methoxypropyl)piperidin-4-ylidene]methyl}phenylcarbamate;

COMPOUND 11: methyl 3-([1-(cyclobutylmethyl)piperidin-4-ylidene]{4-[(diethylamino)carbonyl]phenyl} methyl)phenylcarbamate;

15 COMPOUND 12: methyl 3-[{4-[(diethylamino)carbonyl]phenyl}(1-methylpiperidin-4-ylidene)methyl]phenylcarbamate;

COMPOUND 13: methyl 3-[{4-[(diethylamino)carbonyl]phenyl}(1-ethylpiperidin-4-ylidene)methyl]phenylcarbamate;

COMPOUND 14: ethyl 3-([1-(cyclopropylmethyl)piperidin-4-ylidene]{4-
20 [(diethylamino)carbonyl]phenyl} methyl)phenylcarbamate;

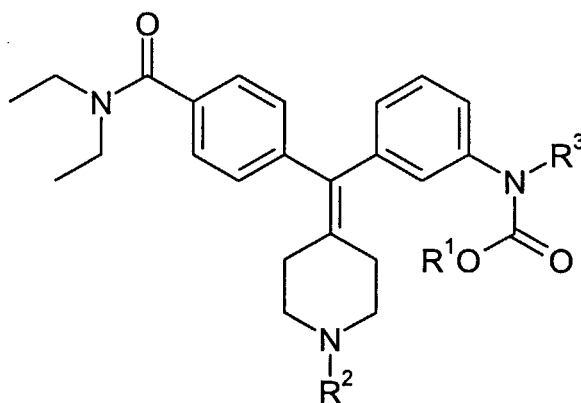
COMPOUND 15: ethyl {3-[{4-[(diethylamino)carbonyl]phenyl}(1-methylpiperidin-4-ylidene)methyl]phenyl} carbamate;

COMPOUND 16: ethyl {3-[[4-(aminocarbonyl)phenyl](1-ethylpiperidin-4-ylidene)methyl]phenyl} carbamate;

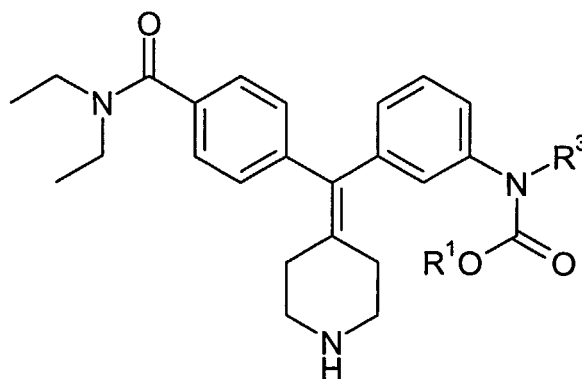
25 COMPOUND 17: [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-methoxyethyl)-4-piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester;
and pharmaceutically acceptable salts thereof.

6. A compound according to any one of claims 1-5 for use as a medicament.

7. The use of a compound according to any one of claims 1-5 in the manufacture of a medicament for the therapy of pain, anxiety or functional gastrointestinal disorders.
- 5 8. A pharmaceutical composition comprising a compound according to any one of claims 1-5 and a pharmaceutically acceptable carrier.
9. A method for the therapy of pain in a warm-blooded animal, comprising the step of administering to said animal in need of such therapy a therapeutically effective
- 10 amount of a compound according to any one of claims 1-5.
10. A method for the therapy of functional gastrointestinal disorders in a warm-blooded animal, comprising the step of administering to said animal in need of such therapy a therapeutically effective amount of a compound according to any one of
- 15 claims 1-5.
11. A process for preparing a compound of formula I, comprising:

**I**

- 20 reacting a compound of formula II with R²-X:

**II**

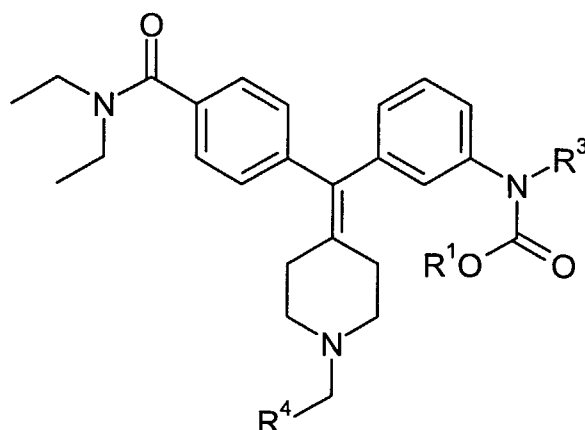
wherein X is halogen;

R^1 and R^3 are, independently, selected from hydrogen, C_{1-6} alkyl, and

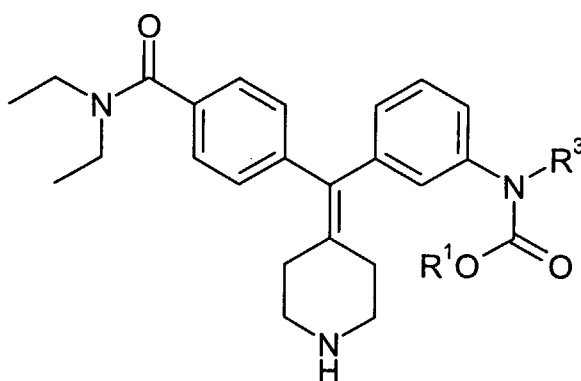
- 5 C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl; and
- 10 R^2 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and
- 15 -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl.

12. A process for preparing a compound of formula III, comprising:

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III

reacting a compound of formula II with R^4 -CHO:

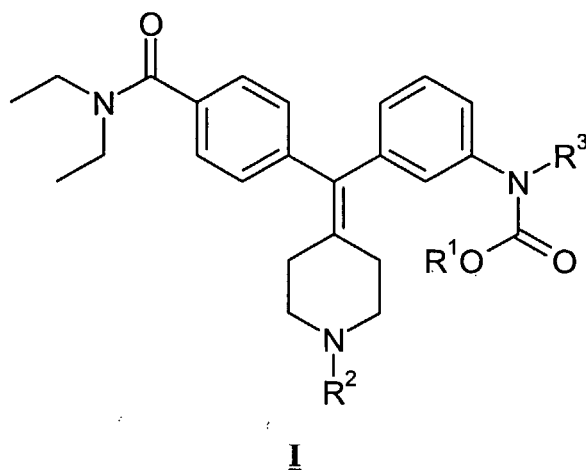
II

wherein R^1 and R^3 are, independently, selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl; and

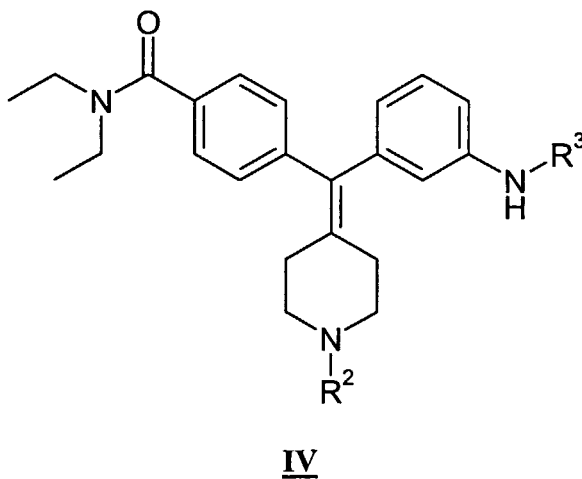
R^4 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR,

-SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

13. A process for preparing a compound of formula I, comprising:



reacting a compound of formula IV with R¹O-C(=O)-X:

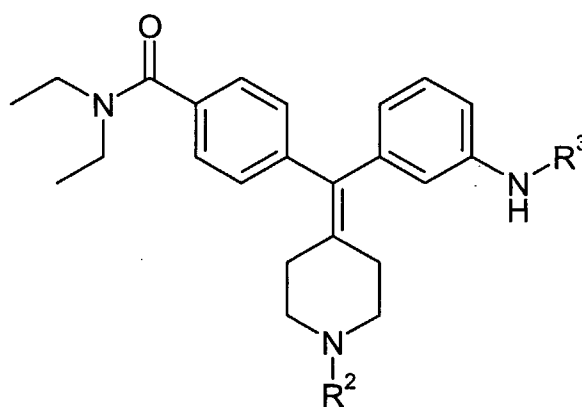


wherein X is halogen;

R¹ and R³ are, independently, selected from hydrogen, C₁₋₆alkyl, and C₃₋₆cycloalkyl, wherein said C₁₋₆alkyl and C₃₋₆cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl; and

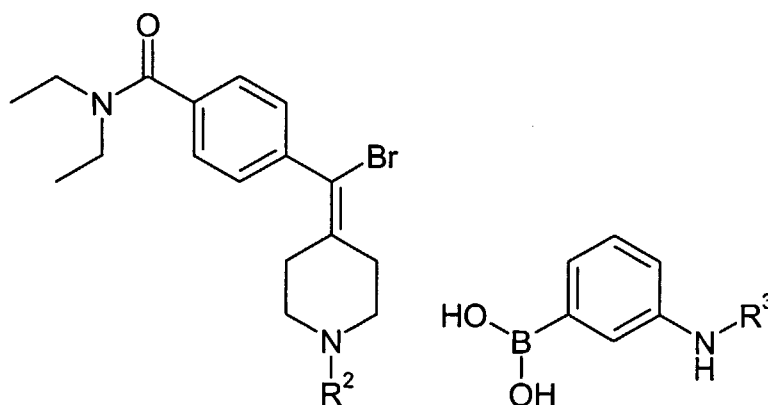
R^2 is selected from C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl, wherein said C_{1-6} alkyl, C_{2-6} alkenyl, C_{3-6} cycloalkyl, and C_{3-6} cycloalkyl- C_{1-4} alkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C_{1-6} alkyl.

14. A process for preparing a compound of formula IV, comprising:



IV

reacting a compound of formula V with a compound of formula VI or esters thereof:



V

VI

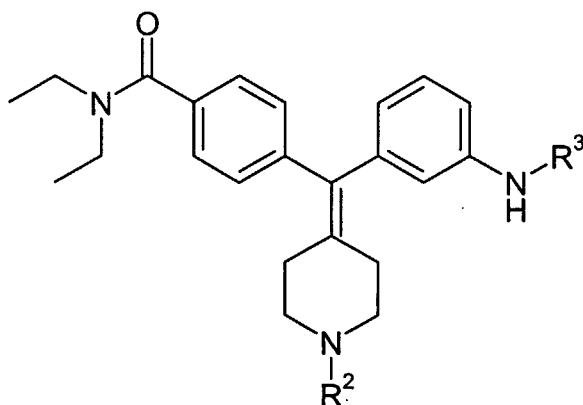
wherein R^3 is selected from hydrogen, C_{1-6} alkyl, and C_{3-6} cycloalkyl, wherein said C_{1-6} alkyl and C_{3-6} cycloalkyl are optionally substituted with one or more groups selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH,

-NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂,
-NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or
C₁₋₆alkyl; and

R² is selected from C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-
5 C₁₋₄alkyl, wherein said C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-
C₁₋₄alkyl are optionally substituted with one or more groups selected from -R, -NO₂,
-OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR,
-SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and
-NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

10

15. A compound of formula IV, a pharmaceutically acceptable salt thereof,
diastereomers, enantiomers, or mixtures thereof:

**IV**

15 wherein R³ is selected from hydrogen, C₁₋₆alkyl, and C₃₋₆cycloalkyl, wherein
said C₁₋₆alkyl and C₃₋₆cycloalkyl are optionally substituted with one or more groups
selected from -R, -NO₂, -OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH,
-NHR, -NR₂, -SR, -SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂,
-NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or
20 C₁₋₆alkyl; and

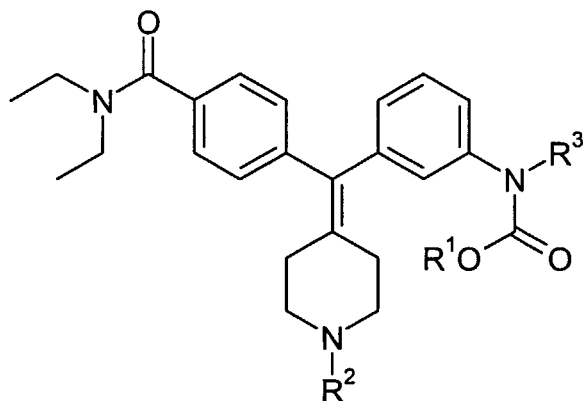
R² is selected from C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-
C₁₋₄alkyl, wherein said C₁₋₆alkyl, C₂₋₆alkenyl, C₃₋₆cycloalkyl, and C₃₋₆cycloalkyl-
C₁₋₄alkyl are optionally substituted with one or more groups selected from -R, -NO₂,
-OR, -Cl, -Br, -I, -F, -CF₃, -C(=O)R, -C(=O)OH, -NH₂, -SH, -NHR, -NR₂, -SR,

-SO₃H, -SO₂R, -S(=O)R, -CN, -OH, -C(=O)OR, -C(=O)NR₂, -NRC(=O)R, and -NRC(=O)-OR, wherein R is, independently, a hydrogen or C₁₋₆alkyl.

16. A compound as claimed in claim 15, wherein the compound is selected from
 5 4-[(3-aminophenyl)[1-(2-methoxyethyl)-4-piperidinylidene]methyl]-*N,N*-diethylbenzamide and pharmaceutically acceptable salts thereof.

17. A compound selected from:
 [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-ethoxyethyl)-4-
 10 piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester;
 methyl 3-{{4-[(diethylamino)carbonyl]phenyl}[1-(3-methoxypropyl)piperidin-4-ylidene]methyl}phenylcarbamate;
 [3-[[4-[(diethylamino)carbonyl]phenyl][1-(2-methoxyethyl)-4-
 piperidinylidene]methyl]phenyl]- carbamic acid, methyl ester; and pharmaceutically
 15 acceptable salts thereof.

18. A compound of formula I or pharmaceutically acceptable salts thereof,



20

I

wherein R³ is hydrogen, R¹ is selected from methyl and ethyl; and R² is C₁₋₃alkoxy-C₁₋₄alkyl.