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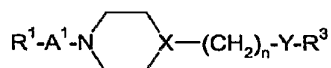
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(54) Title: PIPERIDINE AND PIPERAZINE DERIVATIVES



(Ia)

(57) Abstract: Compounds of general formula (Ia): in which R<sup>1</sup>, A<sup>1</sup>, m, X, n, Y and R<sup>3</sup> have any of the meanings given in the specification, have affinity for sigma receptors and are useful in the treatment of disorders of the central nervous system.



WO 2007/089462 A2

## PIPERIDINE AND PIPERAZINE DERIVATIVES

The present invention relates to novel 1,4-piperidine and piperazine derivatives, to processes for preparing the novel derivatives, to novel intermediates useful in the process, to pharmaceutical compositions comprising the derivatives, and to the use of derivatives in the treatment of disorders of the central nervous system.

It has been disclosed in the scientific literature that certain disorders of the central nervous system may be treated using a modulator of sigma receptor function. Amongst compounds known to possess affinity for sigma ligands are certain piperidine and piperazine derivatives.

WO 91/09594 discloses compounds having affinity for sigma receptors, certain of which are piperidine or piperazine derivatives, and discloses that they are useful in the treatment of schizophrenia and other psychoses.

United States patent number 5,736,546 discloses certain 1,4-(diphenylalkyl)piperazines having one phenyl group unsubstituted and the other phenyl group substituted by two alkoxy groups. One of the compounds disclosed is 1-[2-(3,4-dimethoxyphenyl)ethyl]-4-(3-phenylpropyl)piperazine. It is also referred to in the scientific literature as SA 4503. The compounds of US 5,736,546 are said to be useful in the treatment of dementia, depression, schizophrenia, anxiety neurosis, diseases accompanying abnormal immune response, cryptorrhea and digestive ulcer.

WO 2004/110387 discloses that sigma ligands, in particular SA 4503, are also useful in the treatment of patients to facilitate neuronal regeneration after onset of a neurodegenerative disease, such as ischemic stroke, traumatic brain injury or spinal chord injury.

United States patent number 5,389,630 discloses certain diamine compounds having cerebral protective action. The compound of Example 50 is a piperazine derivative, but the vast majority of the exemplified compounds are homopiperazine derivatives. The mechanism of action of the compounds is not discussed.

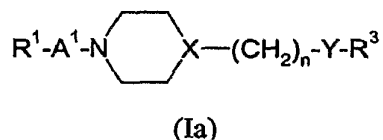
Japanese patent application, publication number 2003-160570 generically discloses certain 1,4-piperidine and piperazine derivatives useful for treating lifestyle diseases, such as diabetes and obesity.

WO 01/24786 also discloses certain 1,4-piperidine and piperazine derivatives useful for treating lifestyle diseases, such as diabetes and obesity. The compound 1-[3-(3,4-dichlorophenoxy)propyl]-4-[(4-chlorophenyl)acetyl]piperazine is exemplified.

The compound 1-[2-phenoxyethyl]-4-[phenylacetyl]piperazine is also known.

It has now been found that certain novel 1,4-piperidine and piperazine derivatives have high affinity for sigma receptors, in particular sigma-1 receptors.

According to one aspect, the present invention provides a compound of general  
5 formula (Ia)



in which:-

$\text{R}^1$  represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or  
10 substituted by one, two or three substituents selected independently from (1-  
2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a  
(3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-4C)alkoxy(1-  
4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-  
4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

15  $\text{A}^1$  represents  $(\text{CH}_2)_m$  or  $(\text{CH}_2)_{m-1}\text{C}(=\text{O})$ ;

$m$  is 2, 3, 4 or 5;

$\text{X}$  is CH or N;

$n$  is 0, 1, 2, 3, 4 or 5, provided that when  $\text{X}$  is N,  $n$  is 2, 3, 4 or 5;

$\text{Y}$  is O,  $\text{NR}^2$  or S;

20  $\text{R}^2$  is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for  $\text{R}^3$ ; and

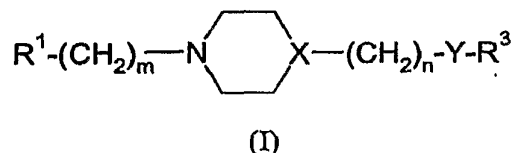
$\text{R}^3$  represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-  
tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic  
carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one,  
two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a  
25 hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl  
group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-  
4C)alkoxy group;

or a pharmaceutically acceptable salt thereof,

but excluding the compounds 1-[2-phenoxyethyl]-4-[phenylacetyl]piperazine and 1-  
30 [3-(3,4-dichlorophenoxy)propyl]-4-[(4-chlorophenyl)acetyl]piperazine.

Compounds according to the invention have been found to have high affinity for  
sigma receptors, in particular sigma-1 receptors.

In one embodiment, the present invention provides a compound of general formula (I)



in which:-

5  $R^1$  represents a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group, a cyano group, and a halo(1-4C)alkoxy group;

$m$  is 2, 3, 4 or 5;

10  $X$  is CH or N;

$n$  is 0, 1, 2, 3, 4 or 5, provided that when  $X$  is N,  $n$  is 2, 3, 4 or 5;

$Y$  is O,  $NR^2$  or S;

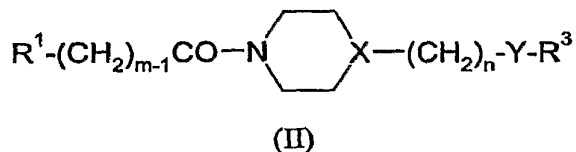
$R^2$  is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for  $R^3$ ; and

15  $R^3$  represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

or a pharmaceutically acceptable salt thereof.

In another embodiment, the present invention provides a compound of general formula

(II)



25

in which  $R^1$ ,  $m$ ,  $n$ ,  $Y$  and  $R^3$  are as defined above for a compound of formula (I), or a pharmaceutically acceptable salt thereof.

As used herein, unless otherwise indicated, the term halogen atom includes fluorine, chlorine and bromine.

30

The term (1-2C)alkylenedioxy includes methylenedioxy and ethylenedioxy.

An example of a (1-4C) alkyl group is methyl. Other examples are ethyl, propyl, 2-propyl, butyl, 2-butyl and t-butyl.

The term halo(1-4C)alkyl as used herein includes perfluoro(1-4C)alkyl, such as trifluoromethyl.

5 The term (1-6C)alkoxy includes (1-4C)alkoxy. An example of a (1-4C)alkoxy group is methoxy. Other examples are ethoxy, propoxy, 2-propoxy, isobutoxy and 2,2-dimethylpropoxy.

An example of a (1-4C)alkoxy(1-4C)alkoxy group is 2-methoxyethoxy.

An example of a hydroxy(1-4C)alkoxy group is hydroxymethyl.

10 The term halo(1-4C)alkoxy as used herein includes perfluoro(1-4C)alkoxy, such as trifluoromethoxy.

An example of a (1-4C)alkylsulfanyl group (also known as a (1-4C)alkylthio group) is methylsulfanyl.

An example of a (1-4C)alkylsulfonyl group is methylsulfonyl.

15 An example of a halo(1-4C)alkylsulfonyl group is trifluoromethylsulfonyl.

Examples of a (3-6C) cycloalkyl group are cyclopentyl and cyclohexyl.

Referring to formula (I), examples of particular values for R<sup>1</sup> are phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 3-fluorophenyl, 4-fluorophenyl, 3,4-difluorophenyl, 3-chlorophenyl, 3-methylphenyl, 2-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-  
20 trifluoromethylphenyl, 2-methoxyphenyl, 3-methoxyphenyl, 4-methoxyphenyl, 4-isopropoxyphenyl, 3,4-dimethoxyphenyl, 2,3,4-trimethoxyphenyl, 3,4,5-trimethoxyphenyl, 2-fluoro-3,4-dimethoxyphenyl, 3-chloro-4-methoxyphenyl, 4-chloro-3-methoxyphenyl, 2-trifluoromethoxyphenyl, 4-trifluoromethoxyphenyl and 3-trifluoromethoxyphenyl. Other examples are 2,3-dihydrobenzofuran-5-yl, 2,3-dihydrobenzo[1,4]dioxin-6-yl, 4-  
25 hydroxyphenyl, 4-isopropylphenyl, 4-ethoxyphenyl, 4-isobutoxyphenyl, 4-(2,2-dimethylpropoxy)phenyl, 4-(2-methoxyethoxy)phenyl, 4-hydroxymethylphenyl, 4-methylsulfanylphenyl, 4-methylsulfonylphenyl and 4-trifluoromethylsulfonylphenyl.

Particular examples of values for R<sup>1</sup> are phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 3,4-difluorophenyl, 2-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-  
30 trifluoromethylphenyl, 2-methoxyphenyl, 3-methoxyphenyl, 4-methoxyphenyl, 3,4-dimethoxyphenyl, 3,4,5-trimethoxyphenyl and 2-trifluoromethoxyphenyl.

Particular mention is made of compounds of formula (I) in which R<sup>1</sup> represents

3,4-dimethoxyphenyl, 4-methoxyphenyl, 4-isopropoxyphenyl, 4-trifluoromethoxyphenyl, or 3,4,5-trimethoxyphenyl. Particular mention is also made of compounds in which R<sup>1</sup> represents 4-hydroxyphenyl.

Examples of values for m are 2 and 3. An example of a particular value for m is 2.

5 Examples of particular values for n are 2 and 3. An example of a particular value for n is 2.

In one embodiment, A<sup>1</sup> is (CH<sub>2</sub>)<sub>m</sub>, such as (CH<sub>2</sub>)<sub>2</sub> or (CH<sub>2</sub>)<sub>3</sub>.

In another embodiment, A<sup>1</sup> is (CH<sub>2</sub>)<sub>m-1</sub>C(=O), such as (CH<sub>2</sub>)C(=O) or (CH<sub>2</sub>)<sub>2</sub>C(=O).

An example of a particular value for R<sup>2</sup> is hydrogen.

10 Examples of particular values for Y are O and NH. In one embodiment, Y is O.

Examples of particular values for R<sup>3</sup> are phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 4-fluorophenyl, 2,4-difluorophenyl, 4-trifluoromethoxyphenyl, 2-chlorophenyl, 4-chlorophenyl, 3,4-dichlorophenyl, 4-methylphenyl, 4-isopropylphenyl, 4-*t*-butylphenyl, 4-cyanophenyl, 2-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 4-  
15 methoxyphenyl, 4-biphenyl, 4-(1-imidazolyl)phenyl, 2-fluoro-4-methoxyphenyl, 3-fluoro-4-methoxyphenyl, 3-chloro-4-methoxyphenyl, 2-trifluoromethoxyphenyl, 3,4,5-trimethoxyphenyl, and 4-trifluoromethoxyphenyl. Another example is 2-methylphenyl.

Particular examples for R<sup>3</sup> are phenyl, 2-fluorophenyl, 4-fluorophenyl, 2-chlorophenyl, 4-chlorophenyl, 4-methylphenyl, 4-isopropylphenyl, 4-cyanophenyl, 3,4,5-  
20 trimethoxygroup, and 2-trifluoromethylphenyl.

Particular mention is made of compounds of formula (I) in which R<sup>3</sup> represents a 4-fluorophenyl group.

It will be appreciated that certain compounds of formula (I) contain a centre of asymmetry. These compounds may therefore exist and be isolated in the form of  
25 stereoisomers. The present invention provides a compound of formula (I) in any stereoisomeric form.

It will also be appreciated that the compounds of formula (I) or their pharmaceutically acceptable salts may be isolated in the form of a solvate, and accordingly that any such solvate is included within the scope of the present invention.

30 Certain compounds of formula (I) have also been found to possess good selectivity for sigma-1 receptors compared with sigma-2 receptors. This is particularly desirable, because the sigma-2 receptors have been shown to play an important role in the sigma receptor-mediated neck dystonia in rats (Matsumoto RR, *et. al.*, Pharmacol. Biochem. Behav. 36, 151-

155, 1996). For example microinjection of DTG (1,3-di-2-tolyl-guanidine, a sigma-1 and sigma-2 receptor agonist) induced neck dystonia in rats while injection of SA-4503 (a selective sigma 1 agonist) had no effect (Nakazawa M *et. al.*, Pharmacol Biochem. Behav. 62, 123-126, 1999). In addition sigma-2 receptors have been implicated in the regulation of cell proliferation. Cytotoxic effects have been correlated with sigma-2 receptor ligands (Vilner and Bowen, Eur. J. Pharmacol Mol Pharmacol Sect 244, 199-201, 1993). Sigma-2 selective drugs can inhibit tumor cell proliferation through mechanisms that may involve apoptosis and intracellular calcium release (Aydar E *et. al.*, Cancer Research 64, 5029-5035, 2004). These compounds are therefore particularly preferred.

10 According to another aspect, therefore, the present invention provides a compound which is selected from

1-(3,4-Dimethoxyphenethyl)-4-(2-(4-fluorophenoxy)ethyl)piperidine;

1-(4-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperidine;

4-(2-(2-Fluorophenoxy)ethyl)-1-(3,4-dimethoxyphenethyl)piperidine;

15 1-(3,4-Dimethoxyphenethyl)-4-(2-phenoxyethyl)piperazine;

1-(3-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine;

1-(4-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine;

1-(2-(Benzo[*a*][1,3]dioxol-5-yl)ethyl)-4-(2-phenoxyethyl)piperazine;

1-(3,4-Difluorophenethyl)-4-(2-phenoxyethyl)piperazine;

20 1-Phenethyl-4-(2-phenoxyethyl)piperazine;

1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperazine ; and

4-(2-(4-(3,4-Dimethoxyphenethyl)piperazin-1-yl)ethyloxy)benzotrile;

1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxyphenyl)propan-1-one;

1-{4-[2-(2-Fluorophenoxy)ethyl]-piperazin-1-yl}-3-(4-trifluoromethoxyphenyl)propan-1-one;

25 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-phenylpropan-1-one;

1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethoxyphenyl)propan-1-one;

1-{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}-2-(3,4,5-trimethoxyphenyl)ethanone;

1-[2-(2-Fluorophenoxy)ethyl]-4-[3-(3,4,5-trimethoxyphenyl)propyl]piperazine;

1-[2-(2-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine;

30 1-[2-(2-Fluorophenoxy)ethyl]-4-[2-(3,4,5-trimethoxyphenyl)ethyl]piperazine;

1-(2-Benzo[1,3]dioxol-5-ylethyl)-4-[2-(4-fluorophenoxy)ethyl]piperazine;

1-[2-(4-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine;

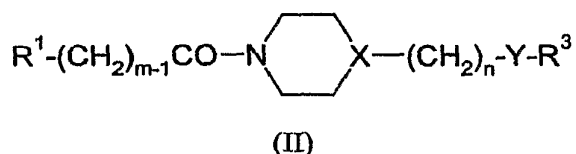
pharmaceutically acceptable salts thereof.

These compounds have both been found to possess good selectivity for sigma-1 over sigma-2 receptors.

The compounds of general formula (Ia) can be prepared by conventional processes.

According to another aspect, therefore, the present invention provides a process for  
 5 preparing a compound of general formula (Ia), or a pharmaceutically acceptable salt thereof, which comprises:

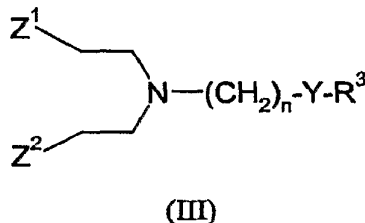
a) for a compound of formula (Ia) in which A<sup>1</sup> is (CH<sub>2</sub>)<sub>m</sub>, reducing a compound of general formula (II)



10

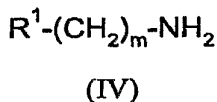
with a reducing agent;

b) for a compound of formula (Ia) in which X is N and A<sup>1</sup> is (CH<sub>2</sub>)<sub>m</sub>, reacting a compound of general formula (III)



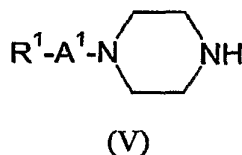
15

in which each of Z<sup>1</sup> and Z<sup>2</sup> independently represents a leaving atom or group, with a compound of general formula (IV)

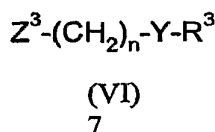


20 or a corresponding compound in which one or two substituents on R<sup>1</sup> are protected;

c) for a compound of formula (Ia) in which X is N, reacting a compound of general formula (V)



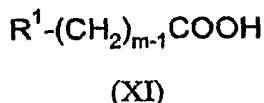
25 with a compound of general formula (VI)



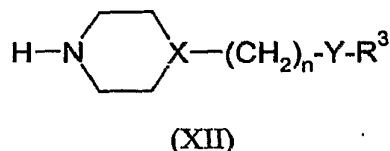


in which  $Z^3$  represents a leaving atom or group; or

d) reacting a compound of formula (XI)



5 or a reactive derivative thereof, with a compound of general formula (XII)

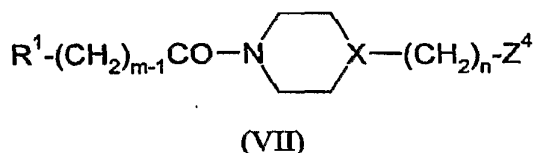


followed by removing any protecting group and, optionally, forming a pharmaceutically acceptable salt.

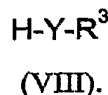
10 Referring to process step a), the reducing agent can conveniently be a borane ( $BH_3$ ), a borohydride reducing agent, such as sodium borohydride, or an alkali metal aluminium hydride, such as lithium aluminium hydride. The reduction is conveniently performed in the presence of a solvent such as an ether, for example tetrahydrofuran. The temperature at which the reduction is carried out is conveniently in the range of from  $-25$  to  $100$  °C, such as from

15  $-10$  to  $40$  °C.

Compounds of general formula (II) can be prepared by reacting a compound of general formula (VII)

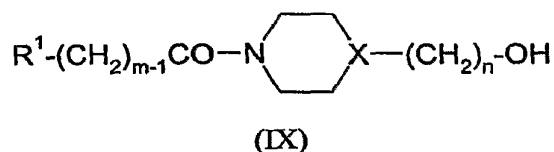


20 in which  $Z^4$  represents a leaving atom or group, such as a *p*-toluenesulfonyloxy group, with a compound of general formula (VIII)



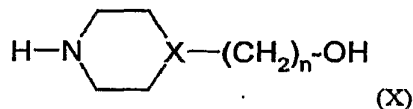
Compounds of general formula (VII) can be prepared from a corresponding compound

25 of general formula (IX),

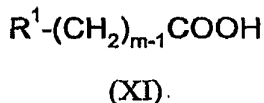


for example by reaction with a sulfonyl halide, such as *p*-toluenesulfonyl chloride.

Compounds of general formula (IX) can be prepared by reacting a compound of general formula (X)

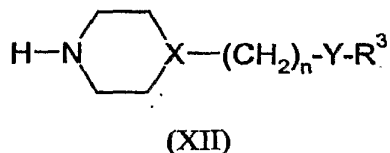


with a compound of general formula (XI)



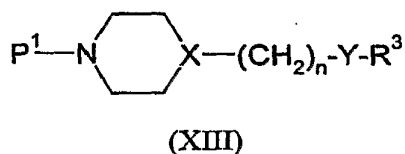
or a reactive derivative thereof, using standard amide bond coupling conditions.

Alternatively, compounds of general formula (II) can be prepared by reacting a compound of general formula (XII)



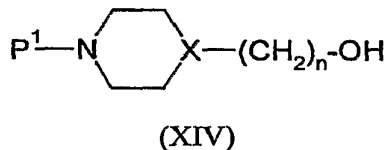
with a compound of general formula (XI), or a reactive derivative thereof, using standard amide bond coupling conditions.

Compounds of general formula (XII) can be prepared by deprotecting a compound of general formula (XIII)



in which  $\text{P}^1$  represents an amino protecting group, such as *t*-butoxycarbonyl.

Compounds of general formula (XIII) can be prepared from the corresponding compounds of general formula (XIV)

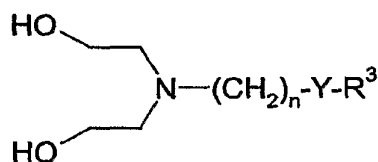


following the procedure for preparing a compound of general formula (II) from a compound of general formula (IX), or for a compound in which X is N, by reacting a compound of formula (VI) with a  $\text{P}^1$ -protected piperazine.

Referring to process step b), the leaving atoms or groups represented by  $Z^1$  and  $Z^2$  may be, for example, hydrocarbylsulfonyloxy groups, such as methanesulfonyloxy or *p*-toluenesulfonyloxy, or halogen atoms, such as chlorine atoms.

The reaction is conveniently performed at a temperature in the range of from 0 to 100 °C, such as from 50 to 90 °C. Convenient solvents include organic solvents, for example amides such as dimethylformamide. The reaction is conveniently performed in the presence of a base, for example an alkali metal carbonate such as potassium carbonate. The reaction may be performed in the presence of a catalyst, such as sodium iodide.

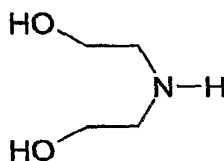
Compounds of general formula (III) can be prepared from the corresponding  
10 compounds of general formula (XV)



(XV)

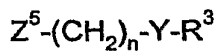
for example by reaction with thionyl chloride to afford a compound of formula (III) in which  $Z^1$  and  $Z^2$  represent chlorine atoms.

15 Compounds of general formula (XV) can be prepared by reacting a compound of general formula (XVI)



(XVI)

with a compound of general formula (XVII)



20

(XVII)

in which  $Z^5$  represents a leaving atom or group, for example a halogen atom such as a bromine atom.

Referring to process step c), the leaving atom or group represented by  $Z^3$  may be, for  
25 example, a hydrocarbylsulfonyloxy group, such as *p*-toluenesulfonyloxy. Convenient solvents include ketones, such as acetone. The reaction is conveniently performed at a temperature in the range of from 0 to 100 °C.

Referring to process step d), the reaction is conveniently conducted under amide-bond coupling conditions, for example in the presence of 1-hydroxybenzotriazole and dicyclohexylcarbodiimide. The reaction is conveniently performed at a temperature in the range of from 0 to 100 °C.

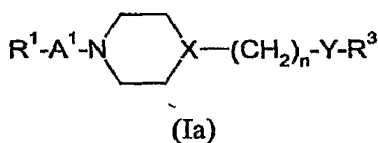
5 A pharmaceutically acceptable salt may be formed by a conventional method, such as by reacting a compound of formula (I) with a pharmaceutically acceptable acid, such as hydrochloric acid.

Certain of the intermediates, for example compounds of formula (II), may be novel. The invention also provides the entire novel intermediates disclosed herein.

10 The compounds of the invention may be administered by any convenient route, e.g. into the gastrointestinal tract (e.g. rectally or orally), the nose, lungs, musculature or vasculature or transdermally. The compounds may be administered in any convenient administrative form, e.g. tablets, powders, capsules, solutions, dispersions, suspensions, syrups, sprays, suppositories, gels, emulsions, patches etc. Such compositions may contain  
15 components conventional in pharmaceutical preparations, e.g. diluents, carriers, pH modifiers, sweeteners, bulking agents, and further active agents. If parenteral administration is desired, the compositions will be sterile and in a solution or suspension form suitable for injection or infusion. Such compositions form a further aspect of the invention.

According to another aspect, the present invention provides a pharmaceutical  
20 composition, which comprises a compound of formula (I) or a pharmaceutically acceptable salt thereof, as defined hereinabove, together with a pharmaceutically acceptable diluent or carrier.

According to another aspect, the present invention provides the use of a compound of formula (Ia)



25

in which:-

R<sup>1</sup> represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-  
30 2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-4C)alkoxy(1-

4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

A<sup>1</sup> represents (CH<sub>2</sub>)<sub>m</sub> or (CH<sub>2</sub>)<sub>m-1</sub>C(=O);

m is 2, 3, 4 or 5;

X is CH or N;

n is 0, 1, 2, 3, 4 or 5, provided that when X is N, n is 2, 3, 4 or 5;

Y is O, NR<sup>2</sup> or S;

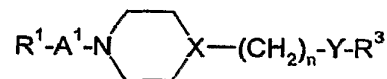
R<sup>2</sup> is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for R<sup>3</sup>; and

R<sup>3</sup> represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

or a pharmaceutically acceptable salt thereof,

in the manufacture of a medicament for the treatment of a condition responsive to a modulator of sigma receptor function.

According to another aspect, the present invention provides a method of treating a condition responsive to a modulator of sigma receptor function in a patient requiring treatment, which comprises administering to said patient an effective amount of a compound general formula (Ia)



(Ia)

in which:-

R<sup>1</sup> represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-4C)alkoxy(1-4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

A<sup>1</sup> represents (CH<sub>2</sub>)<sub>m</sub> or (CH<sub>2</sub>)<sub>m-1</sub>C(=O);

m is 2, 3, 4 or 5;

X is CH or N;

n is 0, 1, 2; 3, 4 or 5, provided that when X is N, n is 2, 3, 4 or 5;

Y is O, NR<sup>2</sup> or S;

5 R<sup>2</sup> is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for R<sup>3</sup>; and

R<sup>3</sup> represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

or a pharmaceutically acceptable salt thereof.

15 The subject may be a human or a non-human animal, such as a non-human mammal, for example a cat, dog, horse, cow or sheep.

The disorder responsive to a sigma receptor modulator may be, for example, a disorder of the central nervous system, such as a neurological disorder or a psychiatric disorder that has been linked to sigma receptors. Examples of neurological disorders include cerebral deficits subsequent to cardiac bypass surgery and grafting, cerebral ischemia (e.g. associated with stroke or cardiac arrest); spinal cord trauma; head trauma; multiple sclerosis, Alzheimer's Disease; Huntington's Chorea; amyotrophic lateral sclerosis; AIDS-induced dementia; muscular spasms; convulsions; drug tolerance, withdrawal, and cessation (i.e. opiates, benzodiazepines, nicotine, cocaine, or ethanol); ocular damage and retinopathy; cognitive disorders; idiopathic and drug-induced Parkinson's Disease; pain; and movement disorders such as tardive dyskinesia. Examples of psychiatric disorders that are treated with a compound of formula I include schizophrenia, anxiety and related disorders (e.g. panic attack and stress-related disorders), depression, bipolar disorders, psychosis, and obsessive compulsive disorders.

30 The compounds according to the invention are of particular interest for use as neuroprotective agents and in the treatment of patients to facilitate neuronal regeneration and functional recovery after onset of a neurodegenerative disease, in particular ischemic stroke, traumatic brain injury, spinal chord injury and multiple sclerosis.

The dosage of the compounds of formula (I) will depend upon the nature and severity of the condition being treated, the administration route and the size and species of the subject. In general, quantities in the range of from 0.01 to 100 mg/kg bodyweight will be administered.

5 As used herein, the term "treatment" includes prophylactic use. The term "effective amount" refers to the amount of the compound of formula (I) that is effective to reduce or inhibit the development of the symptoms of the disorder being treated.

The compound according to the invention may be administered alone or in combination with another therapeutic agent having a different mode of action.

10 The ability of a compound to bind to a sigma receptor may be demonstrated by one or more of the following tests.

Sigma-1 ( $\sigma_1$ ) and sigma-2 ( $\sigma_2$ ) receptor binding assays are carried out in membranes from HEK-293 (Human Embryonic Kidney) cells.

15 Membrane preparation:

Confluent HEK-293 cells are harvested in PBS/5 mM EDTA. They are centrifuged at 2000 rpm for 5 min and then washed two times in PBS. Cells are homogenized in 20 mM Tris-HCL (pH = 7.5) containing 5 mM EDTA, 0.5 mM PMSF and 0.5  $\mu$ g/mL leupeptin using a Dounce homogenizer and sonicated for 5 minutes.

20 Nuclear debris and intact cells are removed by centrifugation at 3000 rpm for 10 minutes at 4 °C. The supernatant is centrifuged at 12000 rpm for 30 minutes and the resulting pellet is resuspended in 25 mM Tris-HCL (pH = 7.5), 25 mM  $Mg_2Cl$ , 10% sucrose containing 0.5 mM PMSF, 2 mM AEBSF, 1 mM EDTA, 130  $\mu$ M bestatin, 14  $\mu$ M E-64, 1  $\mu$ M leupeptin and 0.3 mM aprotinin.

25 Proteins are determined using the Bio Rad Protein Assay Dye Reagent and the membranes are aliquoted and frozen at -80°C.

$\sigma_1$  receptor binding assay

The binding assays are performed in 96-well plates.

30  $\sigma_1$  receptors are labeled using the  $\sigma_1$  selective probe (+) - [ $^3H$ ] Pentazocine (Bowen WD et al, Mol Neuropharmacol 3, 117-126, 1993).

Total binding is determined by incubating 50  $\mu$ g of HEK-293 cell membranes with 10 nM (+) - [ $^3H$ ]-pentazocine (Perkin-Elmer, 35 Ci/mmol) and assay buffer (50 mM Tris-HCl,

pH = 8.3) in a total volume of 200  $\mu$ l. Non specific binding is determined in the presence of 10  $\mu$ M unlabeled pentazocine. For competition experiments, 50  $\mu$ l of displacing compound is added at 8 different concentrations. Incubations are carried out for 120 min at 37 °C. Assays are terminated by dilution with ice-cold 10 mM Tris-HCl, pH = 8.3 and vacuum filtration through glass fibers using a Skatron cell harvester from Molecular Devices. The filters are washed three times and the membrane-bound radioactivity is determined in a Microbeta scintillation counter.

Filters are soaked in 0.5 % polyethyleneimine for 1 hour before use.

Specific binding is determined by subtraction of non specific binding from total binding. IC<sub>50</sub> values (concentration of competing ligand required for 50% inhibition of [<sup>3</sup>H]-pentazocine binding) are analyzed by non-linear regression fit using the GraphPad Prism software.

#### $\sigma$ 2 receptor binding assay

The binding assays are performed in 96-well plates

$\sigma$ 2 receptors are labeled using [<sup>3</sup>H] DTG (Di-o-tolylguanidine), under conditions in which  $\sigma$ 1 receptors are masked with the  $\sigma$ 1 selective compound pentazocine (Hellewell SB et al, Eur. J. Pharmacol, 268, 9-18, 1994).

Total binding is determined by incubating 50  $\mu$ g of HEK-293 cell membranes with 10 nM [<sup>3</sup>H]-DTG (Perkin-Elmer, 58 Ci/mmol) in the presence of 10  $\mu$ M pentazocine and assay buffer (50 mM Tris-HCl, pH = 8.3) in a total volume of 200  $\mu$ l. Non specific binding is determined in the presence of 10  $\mu$ M unlabeled DTG. For competition experiments, 50  $\mu$ l of displacing compound is added at 8 different concentrations. Incubations are carried out for 120 min at 37 °C. Assays are terminated by dilution with ice-cold 10 mM Tris-HCl, pH = 8.3 and vacuum filtration through glass fibers using a Skatron cell harvester from Molecular Devices. The filters are washed three times and the membrane-bound radioactivity is determined in a Microbeta scintillation counter.

Filters are soaked in 0.5 % polyethyleneimine for 1 hour before use.

Specific binding is determined by subtraction of non specific binding from total binding. IC<sub>50</sub> values (concentration of competing ligand required for 50% inhibition of [<sup>3</sup>H]-DTG binding) are analyzed by non-linear regression fit using the GraphPad Prism software



The compounds exemplified herein have all been found to have an  $IC_{50}$  of less than 700 nM in the  $\sigma_1$  receptor binding assay, except for the compounds of Examples 35 and 41, which were found to be a little less active.

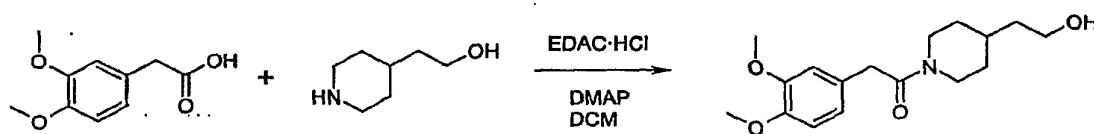
The following examples illustrate the invention.

5

### Example 1

#### 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperidine

##### Step 1: 2-(3,4-Dimethoxyphenyl)-1-[4-(2-hydroxyethyl)piperidin-1-yl]ethanone (A)



A

10

To an ice-cold solution of 3,4-dimethoxyphenylacetic acid (7.60 g, 38.7 mmol), *N,N*-dimethylaminopyridine (DMAP; 11.4 g, 93 mmol), and 4-piperidin-ethanol (5 g, 39 mmol) in dry dichloromethane (DCM; 80 mL) was added *N*-(3-dimethylaminopropyl)-*N'*-ethylcarbodiimide hydrochloride (EDAC·HCl; 9.65 g, 50.3 mmol) in one portion. The cooling bath was removed and the reaction was allowed to warm to room temperature. After five hours, HPLC analysis revealed the 3,4-dimethoxyphenylacetic acid was consumed. The reaction mixture was washed once with 1 N HCl<sub>(aq)</sub> (90 mL) and concentrated *in vacuo*. The residue was chromatographed to yield the title compound (A; 10.67 g, 90% yield) as viscous oil.

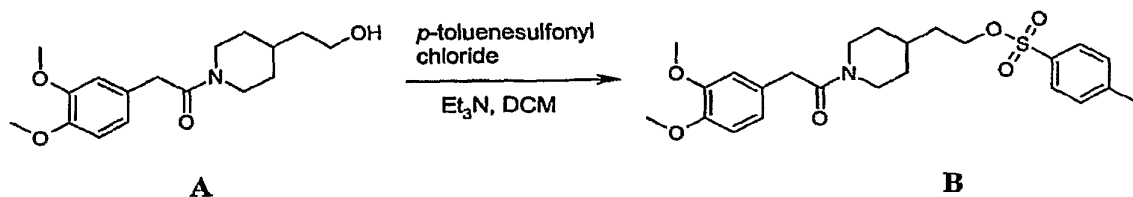
15

<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) 0.91 (br m, 1H), 1.04 (br m, 1H), 1.44 (q, *J* = 6.6 Hz, 2H), 1.64 (m, 3H), 1.73 (br s, 2H), 2.56 (br m, 1H), 2.92 (br m, 1H), 3.64 (m, 4H), 3.84 (s, 3H), 3.84 (s, 3H), 4.59 (br m, 1H), 6.73 (dd, *J* = 2.0, 8.2 Hz, 1H), 6.78 (d, *J* = 2.0 Hz, 1H), 6.79 (d, *J* = 8.2 Hz, 1H).

*m/z* 308 [M+1]<sup>+</sup>.

25

Step 2: Toluene-4-sulfonic acid 2-{1-[2-(3,4-dimethoxyphenyl)-acetyl]piperidin-4-yl}-ethyl ester (B)

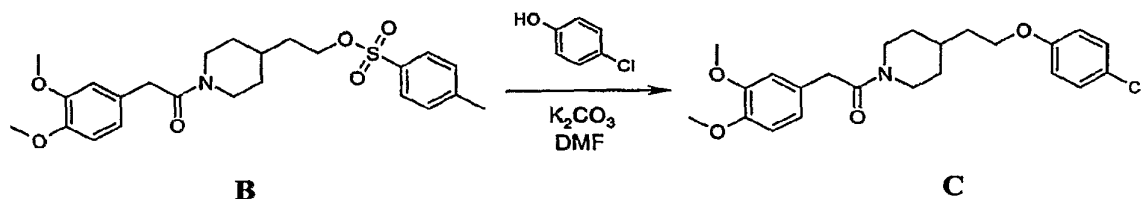


A

B

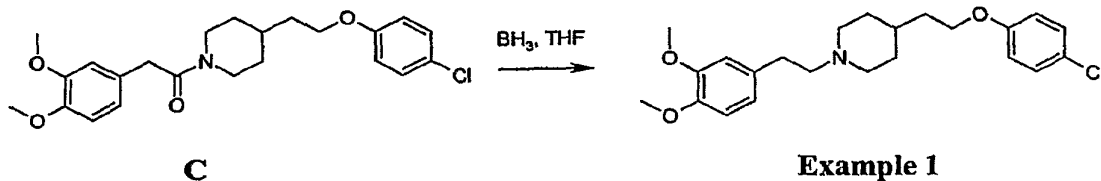
To a solution of A (10.67 g, 34.7 mmol) in dry DCM (100 mL) was added triethylamine (Et<sub>3</sub>N; 7.5 mL, 53.8 mmol). The reaction mixture was cooled to 0 °C. *p*-Toluenesulfonyl chloride (10.0 g, 52.4 mmol) was added in one portion, and the mixture was stirred for five minutes. The cooling bath was removed and the reaction mixture was allowed to warm to  
 5 room temperature as it stirred for 12 h. TLC analysis revealed the reaction to be nearly complete. The reaction mixture was washed once with 1 N HCl<sub>(aq)</sub> (100 mL), concentrated *in vacuo*, and purified by chromatography to yield the title compound (B; 14.2 g, 88% yield) as an oil. *m/z* 462 [M+1]<sup>+</sup>.

10 **Step 3:** 1-{4-[2-(4-Chlorophenoxy)ethyl]piperidin-1-yl}-2-(3,4-dimethoxyphenyl)-ethanone (C)



In a 20-mL reaction vessel equipped with a magnetic stir bar, B (1.4 g, 3.0 mmol), dry *N,N*-  
 15 dimethylformamide (DMF; 11 mL), potassium carbonate (K<sub>2</sub>CO<sub>3</sub>; 1.26 g, 9.1 mmol) and 4-chlorophenol (0.78 g, 6.1 mmol) were heated at 75 °C for 15 h. The starting material was consumed by LC analysis. The reaction mixture was concentrated by heating under a nitrogen stream. The residue was dissolved in DCM (10 mL) and washed with water (10 mL). The organic layer was concentrated by heating under a nitrogen stream, and the residue  
 20 was chromatographed to yield the title compound (C; 1.22 g, 96% yield) as an oil. *m/z* 418 [M+1]<sup>+</sup>.

**Step 4:** 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperidine



25

In a 20-mL reaction vessel equipped with a magnetic stir bar, C (1.22 g, 2.9 mmol) was dissolved in dry tetrahydrofuran (THF; 6.7 mL) with stirring. The solution was cooled to 0 °C, and 1.0 M borane (BH<sub>3</sub>) solution in THF (8.8 mL, 8.8 mmol) was added slowly. After 10 minutes the cooling bath was removed, and the reaction mixture was stirred at room

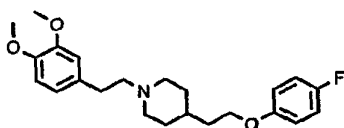
temperature for 12 h. LC analysis revealed complete consumption of C. Methanol was added slowly until gas evolution ceased (3-6 mL). The reaction mixture was concentrated by heating under a nitrogen stream. The residue was chromatographed to afford the title compound (0.17 g, 15%).

- 5  $^1\text{H NMR}$  (400 MHz, DMSO- $d_6$ ):  $\delta$  1.5-1.9 (m, 7H), 2.6-3.0 (m, 8H), 3.71 (s, 3H), 3.74 (s, 3H), 4.01 (m, 2H), 6.75 (m, 1H), 6.81 (d, 1H), 6.88 (d, 1H), 6.96 (m, 2H), 7.30 (m, 2H).  
 $m/z$  404  $[\text{M}+1]^+$ .

The following compounds were prepared using the same method as described in Example 1.

10 **Example 2**

**1-(3,4-Dimethoxyphenethyl)-4-(2-(4-fluorophenoxy)ethyl)piperidine**

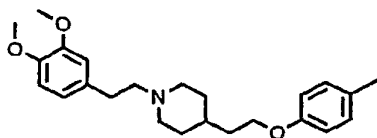


$^1\text{H NMR}$  (400 MHz, DMSO- $d_6$ ):  $\delta$  1.47-1.7 (m, 8H), 2.7-3.1 (m, 7H), 3.72 (s, 3H), 3.75 (t, s, 3H), 3.97 (t, 2H), 6.76 (m, 1H), 6.82 (s, 1H), 6.86 (d, 1H), 6.94 (m, 2H), 7.09 (t, 2H).

- 15  $m/z$  388  $[\text{M}+1]^+$ .

**Example 3**

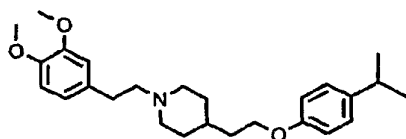
**1-(3,4-Dimethoxyphenethyl)-4-(2-(*p*-tolylloxy)ethyl)piperidine**



- 20  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.4-1.9 (m, 7H), 2.20 (s, 3H), 2.6-3.0 (m, 8H), 3.69 (s, 3H), 3.72 (s, 3H), 3.95 (m, 2H), 6.73 (m, 1H), 6.78 (m, 3H), 6.85 (d, 1H), 7.04 (d, 2H).  
 $m/z$  384  $[\text{M}+1]^+$ .

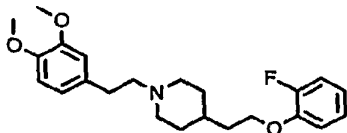
**Example 4**

- 25 **1-(3,4-Dimethoxyphenethyl)-4-(2-(4-isopropylphenoxy)ethyl)piperidine**

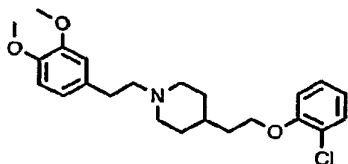


$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  1.13 (d, 6H), 1.5-1.9 (m, 8H), 2.6-3.0 (m, 8H), 3.69 (s, 3H), 3.73 (s, 3H), 3.94 (m, 2H), 6.72 (m, H), 4.06 (m, 2H), 6.72 (m, 1H), 6.80 (s, 1H), 6.85 (d, 1H), 6.90 (m, 1H), 6.09 (t, 1H), 7.16 (m, 2H).  
 $m/z$  388  $[\text{M}+1]^+$ .

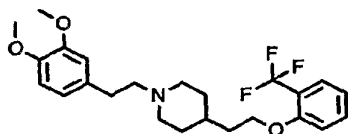
5

**Example 5****4-(2-(2-Fluorophenoxy)ethyl)-1-(3,4-dimethoxyphenethyl)piperidine**

$^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.4-1.9 (m, 8H), 2.6-3.0 (m, 7H), 3.69 (s, 3H), 3.72 (s, 3H),  
 10 4.06 (m, 2H), 6.72 (m, 1H), 6.80 (s, 1H), 6.85 (d, 1H), 6.90 (m, 1H), 6.09 (t, 1H), 7.16 (m, 2H).  
 $m/z$  388  $[\text{M}+1]^+$ .

**Example 6****15 4-(2-(2-Chlorophenoxy)ethyl)-1-(3,4-dimethoxyphenethyl)piperidine**

$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  1.54-1.89 (m, 7H), 2.58-2.66 (t, 1H), 2.80-3.03 (m, 6H),  
 3.71 (s, 3H), 3.74 (s, 3H), 4.09-4.13 (m, 2H), 6.72 (m, 1H), 6.82-6.90 (m, 2H), 6.93 (t, 1H),  
 7.12 (d, 1H), 7.27 (t, 1H), 7.38 (d, 1H).  
 20  $m/z$  404  $[\text{M}+1]^+$ .

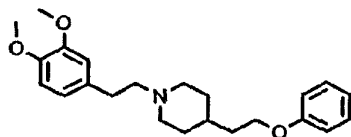
**Example 7****4-(2-(2-(Trifluoromethyl)phenoxy)ethyl)-1-(3,4-dimethoxyphenethyl)piperidine**

25  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.4-1.9 (m, 8H), 2.6-3.0 (m, 7H), 3.69 (s, 3H), 3.72 (s, 3H),  
 4.14 (t, 2H), 6.73 (d, 1H), 6.83 (m, 2H), 7.06 (t, 1H), 7.24 (d, 1H), 7.59 (m, 2H).

$m/z$  438  $[M+1]^+$ .

### Example 8

#### 1-(3,4-Dimethoxyphenethyl)-4-(2-phenoxyethyl)piperidine

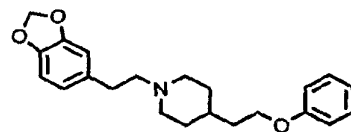


$^1\text{H NMR}$  (400 MHz, DMSO- $d_6$ ):  $\delta$  1.4-1.9 (m, 8H), 2.6-3.0 (m, 7H), 3.69 (s, 3H), 3.72 (s, 3H), 3.99 (m, 2H), 6.71 (t, 1H), 6.80 (s, 1H), 6.84-6.92 (m, 4H), 7.26 (m, 2H).

$m/z$  370  $[M+1]^+$ .

### 10 Example 9

#### 1-(2-(Benzo[*d*][1,3]dioxol-5-yl)ethyl)-4-(2-phenoxyethyl)piperidine



The title compound was prepared using a similar synthetic route as described in Example 1 but starting with methylenedioxyphenylacetic acid instead of 3,4-dimethoxyphenylacetic acid.

15  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.5-1.99 (m, 8H), 2.7-3.0 (m, 7H), 3.98 (m, 2H), 5.95 (s, 2H), 6.66 (m, 1H), 6.79-6.81 (m, 2H), 6.91 (m, 3H), 7.25 (t, 2H)

$m/z$  354  $[M+1]^+$ .

The following compounds can be prepared using the same procedure as described in Example

20 1:

4-[2-(4-Chloro-phenoxy)ethyl]-1-[2-(3,4-dimethoxyphenyl)ethyl]piperidine

4-(2-{1-[2-(3,4-Dimethoxyphenyl)-ethyl]piperidin-4-yl}ethoxy)benzonitrile

1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-methoxyphenoxy)ethyl]piperidine

4-[2-(Biphenyl-4-yloxy)ethyl]-1-[2-(3,4-dimethoxyphenyl)ethyl]piperidine

25 4-[2-(Benzo[1,3]dioxol-5-yloxy)ethyl]-1-[2-(3,4-dimethoxyphenyl)ethyl]piperidine

1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-trifluoromethylphenoxy)ethyl]piperidine

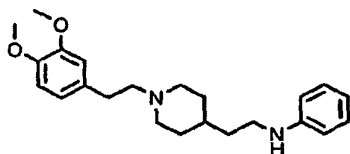
1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-imidazol-1-ylphenoxy)ethyl]piperidine

1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-trifluoromethoxyphenoxy)ethyl]piperidine

1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(2-methoxyphenoxy)ethyl]piperidine

1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(2-trifluoromethoxyphenoxy)ethyl]piperidine  
 1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(3-fluoro-4-methoxyphenoxy)ethyl]piperidine  
 4-[2-(3-Chloro-4-methoxyphenoxy)ethyl]-1-[2-(3,4-dimethoxyphenyl)ethyl]piperidine and  
 4-[2-(3,4-Dichlorophenoxy)ethyl]-1-[2-(3,4-dimethoxyphenyl)ethyl]piperidine.

5

**Example 10*****N*-(2-(1-(3,4-Dimethoxyphenethyl)piperidin-4-yl)ethyl)benzenamine**

The title compound was prepared using the same procedure as described in Example 1 by  
 10 replacing 4-chlorophenol with aniline in Step 3:

<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 1.4-1.9 (m, 8H), 2.6-3.0 (m, 9H), 3.69 (s, 3H), 3.72 (s, 3H),  
 5.35 (m, 1H), 6.47 (t, 1H), 6.51 (d, 2H), 6.73-6.9 (m, 1H), 6.80 (s, 1H), 6.85 (d, 1H), 7.03 (m,  
 2H).

*m/z* 369 [M+1]<sup>+</sup>.

15

The following compounds can be prepared using the same procedure as described in Example  
 10:

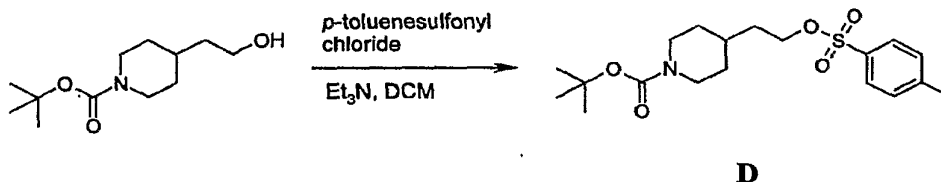
- (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-fluorophenyl)amine  
 (4-Chlorophenyl)-(2-{1-[2-(3,4-dimethoxyphenyl)-ethyl]-piperidin-4-yl}ethyl)amine  
 20 4-(2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethylamino)benzonitrile  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-methoxyphenyl)amine  
 Biphenyl-4-yl-(2-{1-[2-(3,4-dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)amine  
 Benzo[1,3]dioxol-5-yl-(2-{1-[2-(3,4-dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)amine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-trifluoromethylphenyl)-amine  
 25 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-*p*-tolylamine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-isopropylphenyl)amine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-imidazol-1-yl-phenyl)-amine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(4-trifluoromethoxy-  
 phenyl)amine  
 30 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(2-fluorophenyl)amine

- (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]-piperidin-4-yl}ethyl)-(2-methoxyphenyl)amine  
 (2-Chloro-phenyl)-(2-{1-[2-(3,4-dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)amine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]-piperidin-4-yl}ethyl)-(2-trifluoromethylphenyl)-amine  
 (2-{1-[2-(3,4-Dimethoxy-phenyl)ethyl]-piperidin-4-yl}ethyl)-(2-trifluoromethoxy-  
 5 phenyl)amine  
 (2-{1-[2-(3,4-Dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)-(2-fluoro-4-methoxy-  
 phenyl)amine  
 (2-{1-[2-(3,4-Dimethoxy-phenyl)ethyl]piperidin-4-yl}ethyl)-(3-fluoro-4-methoxy-  
 phenyl)amine  
 10 (3-Chloro-4-methoxyphenyl)-(2-{1-[2-(3,4-dimethoxyphenyl)ethyl]piperidin-4-yl}-  
 ethyl)amine and  
 (3,4-Dichloro-phenyl)-(2-{1-[2-(3,4-dimethoxyphenyl)ethyl]piperidin-4-yl}ethyl)amine.

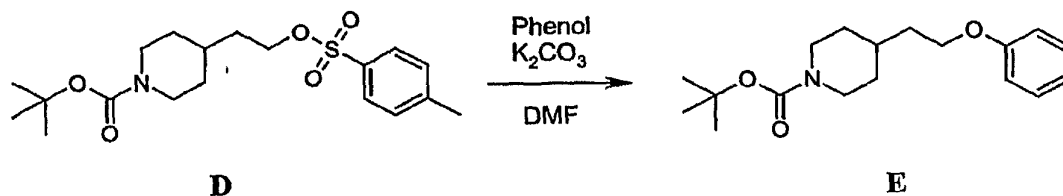
### Example 11

#### 15 1-(2-Methoxyphenethyl)-4-(2-phenoxyethyl)piperidine

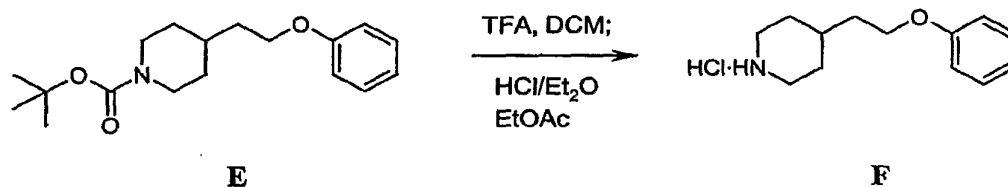
Step 1: 4-[2-(Toluene-4-sulfonyloxy)ethyl]piperidine-1-carboxylic acid *tert*-butyl ester (**D**)



- 20 To an ice-cold solution of *N*-Boc-4-piperidine-ethanol (5.0 g, 21.8 mmol) and Et<sub>3</sub>N (4.6 mL, 33.0 mmol) in dry DCM (10 mL) was added *p*-toluenesulfonyl chloride (6.25 g, 32.8 mmol) slowly. Upon addition, the reaction was warmed to room temperature and stirred for 20 h. The reaction mixture was washed with water (40 mL), 10% (wt/v) citric acid<sub>(aq)</sub> (40 mL), and saturated NaHCO<sub>3(aq)</sub> (40 mL). The DCM layer was dried with MgSO<sub>4</sub>, filtered and  
 25 concentrated *in vacuo* to give a pale yellow oil, which was chromatographed to give the title compound (7.47 g, 89% yield) as a clear and colorless oil.  
<sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) 1.02 (m, 2 H), 1.43 (s, 9 H), 1.50-1.57 (m, 5H), 2.44 (s, 3H), 2.60 (br t, 2H), 4.02 (br d, 2H), 4.06 (t, 2H), 7.34 (d, 2H), 7.78 (d, 2H).

**Step 2: 4-(2-Phenoxy-ethyl)-piperidine-1-carboxylic acid *tert*-butyl ester (E)**

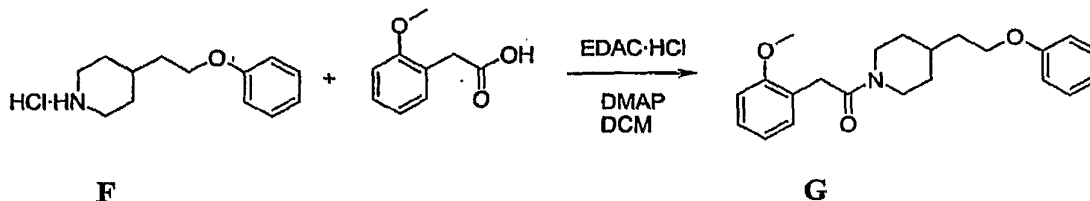
To a solution of **D** (8.24 g, 21.5 mmol) in dry DMF (85 mL) was added potassium carbonate (K<sub>2</sub>CO<sub>3</sub>; 8.9 g, 64 mmol) and phenol (4.0 g, 42.5 mmol). The reaction mixture was heated to 70-75 °C for 4 h, cooled to room temperature, and poured into water (300 mL). The mixture was extracted with ethyl acetate (3 x 100 mL). The ethyl acetate extracts were combined, washed with 0.25 M K<sub>2</sub>CO<sub>3(aq)</sub> (100 mL) and saturated sodium chloride (100 mL), dried over MgSO<sub>4</sub>, and concentrated *in vacuo*. The resultant oil was run through a silica plug to remove very polar material, thus a mixture of the title compound and phenol (7.95 g) was isolated. This material was carried on to the next step without further purification. *m/z* 205 [M-CO<sub>2</sub>C(CH<sub>3</sub>)<sub>3</sub>]<sup>+</sup>.

**Step 3: 4-(2-Phenoxyethyl)-piperidine, hydrochloride salt (F)**

To a solution of **E** and phenol (7.95 g, 21.5 mmol **E** in theory) in DCM (80 mL) was added trifluoroacetic acid (20 mL) in a slow stream, and the mixture was stirred overnight at room temperature. The starting material was consumed by TLC analysis. The reaction mixture was washed with water (110 mL), and the aqueous phase was back-extracted with DCM (25 mL). The combined DCM layers were washed with saturated NaHCO<sub>3(aq)</sub> (100 mL), dried over MgSO<sub>4</sub>, and concentrated to an oil (7.32 g). A portion of the oil (6.60 g) was dissolved in EtOAc (100 mL). With stirring 2 M HCl in Et<sub>2</sub>O (Aldrich; 13.5 mL) was added dropwise. The mixture was stirred for 1.5 h, filtered, washed with EtOAc, and dried *in vacuo* to give **F** (4.0 g, 85% yield) as a white solid.

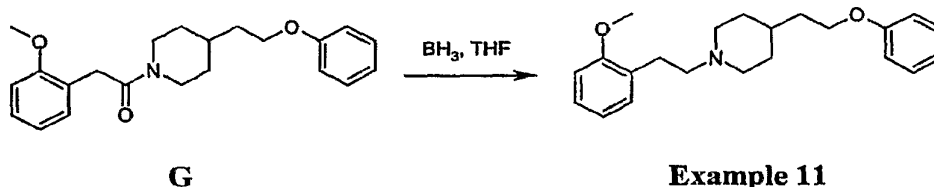
<sup>1</sup>H NMR (400 MHz, DMSO-*d*<sub>6</sub>) 1.39 (m, 2H), 1.67 (q, *J* = 6.4 Hz, 2H), 1.76 (m, 1H), 1.84 (br d, 2H), 2.83 (br q, *J* = 11.3 Hz, 2H), 3.22 (br d, *J* = 12.9 Hz, 2H), 4.00 (t, *J* = 6.3 Hz, 2H), 6.90-6.93 (m, 3H), 7.28 (m, 2H), 8.73 (br s, 1H), 8.96 (br s, 1H).



**Step 4: 2-(2-Methoxy-phenyl)-1-[4-(2-phenoxy-ethyl)piperidin-1-yl]ethanone (G)**

To a solution of **F** (0.32 g, 1.3 mmol), (2-methoxyphenyl)acetic acid (0.26 g, 1.6 mmol), and  
 5 DMAP (0.55 g, 4.5 mmol) in DCM (6.5 mL) was added EDAC·HCl (0.36 g, 1.9 mmol). The  
 reaction was stirred overnight at room temperature. HPLC analysis revealed complete  
 consumption of **F**. The reaction mixture was washed with 1 N HCl<sub>(aq)</sub> (2 x 5 mL), dried over  
 MgSO<sub>4</sub>, and concentrated by heating under a nitrogen stream to afford the title compound,  
 which was carried on to the next step without further purification. *m/z* 354 [M + 1]<sup>+</sup>.

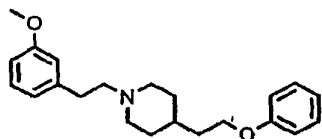
10

**Step 5: 1-[2-(2-Methoxyphenyl)ethyl]-4-(2-phenoxyethyl)piperidine hydrochloride**

To an ice-cold solution of crude residue **G** (1.3 mmol in theory) in dry THF (3 mL) was  
 15 added 1.0 M BH<sub>3</sub> in THF (Aldrich; 4.1 mL, 4.1 mmol) dropwise. Upon addition, the reaction  
 mixture was warmed to room temperature and continued stirring for 19 h. HPLC analysis  
 revealed the complete consumption of **G**. Methanol was added slowly until gas evolution  
 ceased (1-3 mL). The reaction mixture was concentrated by heating under a nitrogen stream.  
 The residue was chromatographed to afford the title compound (0.35 g, 79% from Step 4).  
 20 <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>): δ 1.5-1.7 (m, 8H), 2.8-3.0 (m, 7H), 3.77 (s, 3H), 3.98 (m,  
 2H), 6.84-6.95 (m, 5H), 7.13-7.27 (m, 4H).  
*m/z* 340 [M + 1]<sup>+</sup>.

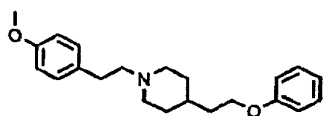
The following compounds were prepared using the same method as described in Example 11.

**25 Example 12****1-(3-Methoxyphenethyl)-4-(2-phenoxyethyl)piperidine**



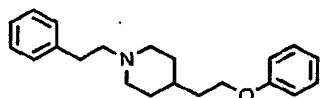
$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.40-1.80 (m, 7H), 2.10-2.40 (m, 1H), 2.48 (t, 1H), 2.89-3.18 (m, 6H), 3.81 (s, 3H), 4.02 (m, 2H), 6.76-6.97 (m, 6H), 7.21-7.31 (m, 3H).  
 $m/z$  340  $[\text{M} + 1]^+$ .

5

**Example 13****1-(4-Methoxyphenethyl)-4-(2-phenoxyethyl)piperidine**

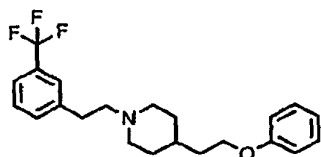
$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  1.40-1.90 (m, 9H), 2.70-3.10 (m, 6H), 3.70 (s, 3H), 3.98 (m, 2H), 6.84 (d, 2H), 6.90 (d, 3H), 7.13 (t, 2H), 7.23 (m, 2H).  
 $m/z$  340  $[\text{M} + 1]^+$ .

10

**Example 14****1-Phenethyl-4-(2-phenoxyethyl)piperidine**

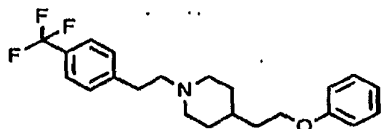
15

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  1.5-1.9 (m, 9H), 2.8-3.1 (m, 6H), 4.01 (m, 2H), 6.91 (m, 3H), 7.2-7.3 (m, 7H).  
 $m/z$  310  $[\text{M} + 1]^+$ .

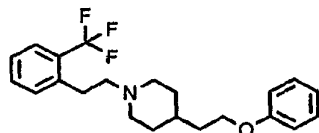
20 **Example 15****1-(3-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperidine**

$^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  1.4-1.9 (m, 8H), 2.6-3.7 (m, 7H), 3.97 (m, 2H), 6.90 (m, 3H), 7.24 (m, 2H), 7.51-7.61 (m, 4H).

25  $m/z$  378  $[\text{M} + 1]^+$ .

**Example 16****1-(4-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperidine**

- 5 <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>): δ 1.4-1.7 (m, 8H), 2.6-3.1 (m, 7H), 3.97 (m, 2H), 6.90 (m, 3H), 7.25 (m, 2H), 7.47 (t, 2H), 7.64 (t, 2H).  
*m/z* 378 [M + 1]<sup>+</sup>.

**Example 17****10 1-(2-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperidine**

- <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ 1.4-1.7 (m, 8H), 2.7-3.2 (m, 7H), 3.97 (t, 2H), 6.91 (m, 3H), 7.25 (m, 2H), 7.44 (t, 1H), 7.49 (d, 1H), 7.63 (t, 1H), 7.68 (d, 1H).  
*m/z* 378 [M + 1]<sup>+</sup>.

15

The following compounds can be prepared using the same procedures as for Example 11:

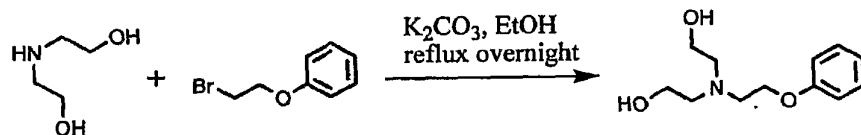
- 1-[2-(2-Fluoro-3,4-dimethoxyphenyl)ethyl]-4-(2-phenoxy-ethyl)piperidine  
 4-(2-Phenoxyethyl)-1-[2-(2,3,4-trimethoxyphenyl)ethyl]piperidine  
 1-[2-(2-Fluorophenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 20 1-[2-(3-Fluorophenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 1-[2-(4-Fluorophenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 1-[2-(3,4-Difluorophenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 4-(2-Phenoxyethyl)-1-(2-*m*-tolylethyl)piperidine  
 1-[2-(3-Chlorophenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 25 1-[2-(4-Chloro-3-methoxyphenyl)ethyl]-4-(2-phenoxyethyl)piperidine  
 4-(2-Phenoxyethyl)-1-[2-(4-trifluoromethoxyphenyl)ethyl]piperidine  
 4-[2-(4-Fluorophenoxy)ethyl]-1-[2-(4-methoxyphenyl)ethyl]piperidine  
 4-[2-(4-Fluorophenoxy)ethyl]-1-[2-(4-trifluoromethoxy-phenyl)ethyl]piperidine  
 4-[2-(2-Fluorophenoxy)ethyl]-1-[2-(4-methoxyphenyl)ethyl]piperidine

4-[2-(2-Fluorophenoxy)ethyl]-1-[2-(4-trifluoromethoxyphenyl)ethyl]piperidine  
 1-(2-Benzo[1,3]dioxol-5-ylethyl)-4-[2-(4-fluorophenoxy)ethyl]piperidine and  
 1-(2-Benzo[1,3]dioxol-5-ylethyl)-4-[2-(2-fluorophenoxy)ethyl]piperidine.

5 **Example 18**

**1-(3,4-Dimethoxyphenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride**

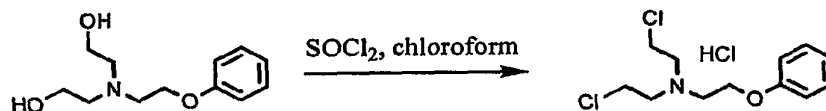
**Step 1:** 2-[(2-Hydroxy-ethyl)-(2-phenoxy-ethyl)-amino]-ethanol (**H**)



**H**

- 10 The reaction mixture of 2-(2-hydroxy-ethylamino)ethanol (32 g, 310 mmol), 1-(2-bromoethoxy)benzene (51 g, 256 mmol), and potassium carbonate (70 g, 512 mmol) in ethanol (200 mL) was refluxed overnight, concentrated, and partitioned between water and ethyl acetate. The organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by column chromatography to afford the title  
 15 compound (45 g, 78%).

**Step 2:** Bis-(2-chloroethyl)-(2-phenoxyethyl)amine hydrochloride (**I**)

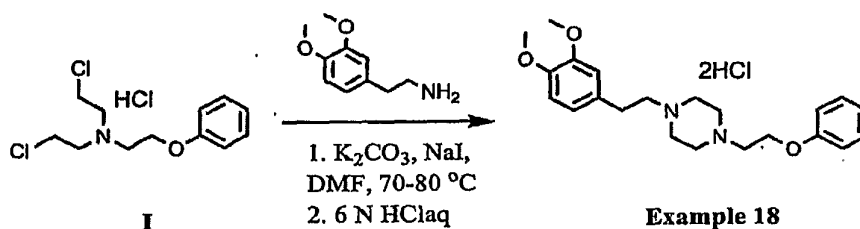


**H**

**I**

- 20 To an ice-cold solution of 2-[(2-hydroxyethyl)-(2-phenoxyethyl)-amino]ethanol (**H**; 43.9 g, 194 mmol) in chloroform (140 mL) was added thionyl chloride ( $SOCl_2$ ; 114.8 g, 965 mmol) dropwise. The reaction mixture was then reflux for 1.5 h and concentrated. The residue was then suspended in the mixture of ethyl acetate and isopropyl ether. The precipitate was filtered and dried in a vacuum oven to afford the title compound quantitatively as a light  
 25 brown crystal. This product was then used without further purification.

**Step 3:** 1-(3,4-Dimethoxyphenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride



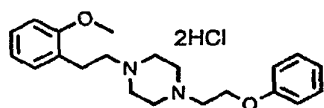
The reaction mixture of bis-(2-chloroethyl)-(2-phenoxyethyl)amine (0.895 g, 3 mmol), 2-(3,4-dimethoxyphenyl)ethylamine (0.548 g, 3 mmol), potassium carbonate ( $K_2CO_3$ ; 1.277 g, 9 mmol), and sodium iodide (NaI; 0.899 g, 6 mmol) in DMF (6 mL) was stirred at 70 – 80 °C for 5 h, quenched with water, and extracted with ethyl acetate. The organic layer was dried over anhydrous sodium sulfate and concentrated. The residue was suspended in 6 N HCl aq (pH = 3-4) and filtered. The filter cake was then washed with ethyl acetate and ethanol and dried to afford the title compound as a pale white solid (330 mg, 23%).

$^1H$  NMR (400 MHz,  $CD_3OD$ ):  $\delta$  3.08 (m, 2H), 3.50 (m, 2H), 3.74-3.84 (m, 16H), 4.44 (t, 2H), 6.85-7.05 (m, 6H), 7.32 (m, 2H).  
 $m/z$  371  $[M-2HCl+1]^+$ .

The following compounds were prepared using the same method as described in Example 18.

#### 15 Example 19

##### 1-(2-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride

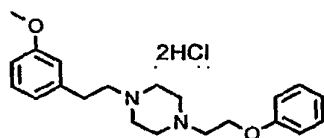


$^1H$  NMR (400 MHz,  $CD_3OD$ ):  $\delta$  3.13 (m, 2H), 3.46 (m, 2H), 3.5-3.9 (m, 13H), 4.45 (t, 2H), 6.90-7.06 (m, 5H), 7.24-7.35 (m, 4H).

20  $m/z$  341  $[M-2HCl+1]^+$ .

#### Example 20

##### 1-(3-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride

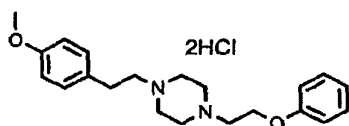


$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.12 (m, 2H), 3.52 (m, 2H), 3.65-3.95 (m, 13), 4.44 (t, 2H), 6.83-6.91 (m, 3H), 7.01-7.05 (m, 3H), 7.23-7.35 (m, 3H).

$m/z$  341  $[\text{M}-2\text{HCl}+1]^+$ .

### 5 Example 21

#### 1-(4-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride

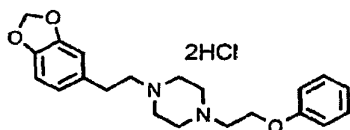


$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.08 (m, 2H), 3.48 (m, 2H), 3.6-3.0 (m, 13H), 4.45 (t, 2H), 6.90 (m, 2H), 7.03 (m, 3H), 7.23 (m, 2H), 7.32 (m, 2H).

10  $m/z$  341  $[\text{M}-2\text{HCl}+1]^+$ .

### Example 22

#### 1-(2-(Benzo[d][1,3]dioxol-5-yl)ethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride

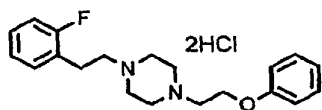


15  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.05 (m, 2H), 3.46 (m, 2H), 3.6-3.9 (m, 10H), 4.42 (t, 2H), 5.93 (s, 2H), 6.38 (s, 2H), 6.84 (s, 1H), 7.01-7.04 (m, 3H), 7.32 (dd, 2H).

$m/z$  355  $[\text{M}-2\text{HCl}+1]^+$ .

### Example 23

#### 20 1-(2-Fluorophenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride



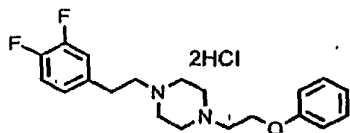
$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.21 (m, 2H), 3.50 (m, 2H), 3.6-3.9 (m, 10H), 4.39 (m, 2H), 6.98-7.21 (m, 5H), 7.30-7.40 (m, 4H).

$m/z$  329  $[\text{M}-2\text{HCl}+1]^+$ .

25

### Example 24

#### 1-(3,4-Difluorophenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride



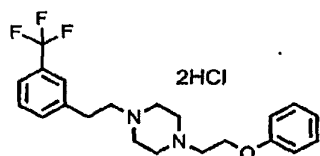
$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.14 (m, 2H), 3.51 (m, 2H), 3.6-3.9 (m, 10H), 4.43 (t, 2H), 6.98-7.05 (m, 3H), 7.06-7.35 (m, 5H).

$m/z$  347  $[\text{M}-2\text{HCl}+1]^+$ .

5

### Example 25

#### 1-(3-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride



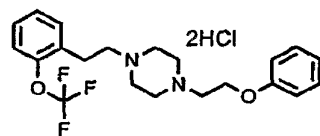
$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.25 (m, 2H), 3.54 (m, 2H), 3.7-3.9 (m, 10H), 4.45 (m, 2H), 7.02 (m, 3H), 7.34 (m, 2H), 7.55-7.69 (m, 4H).

$m/z$  379  $[\text{M}-2\text{HCl}+1]^+$ .

10

### Example 26

#### 1-(2-(Trifluoromethoxy)phenethyl)-4-(2-phenoxyethyl)piperazine dihydrochloride



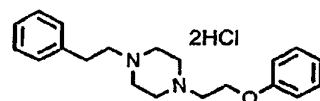
$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}+\text{CDCl}_3$ ):  $\delta$  3.22 (m, 2H), 3.42 (m, 2H), 3.6-3.8 (m, 10H), 4.43 (t, 2H), 6.99 (m, 3H), 7.27-7.39 (m, 5H), 7.47 (d, 1H).

$m/z$  395  $[\text{M}-2\text{HCl}+1]^+$ .

15

### Example 27

#### 1-Phenethyl-4-(2-phenoxyethyl)piperazine dihydrochloride



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}+\text{CDCl}_3$ ):  $\delta$  3.15 (m, 2H), 3.48 (m, 2H), 3.7-4.0 (m, 10H), 4.43 (t, 2H), 6.99 (m, 3H), 7.25-7.34 (m, 7H).

$m/z$  311  $[\text{M}-2\text{HCl}+1]^+$ .

25

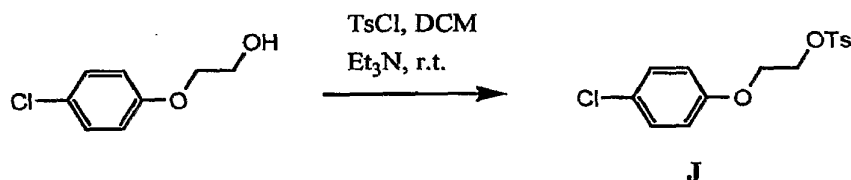
The following compounds can be prepared using the same procedure as described in Example 18:

- 1-[2-(2-Fluoro-3,4-dimethoxyphenyl)ethyl]-4-(2-phenoxyethyl)piperazine  
 5 1-(2-Phenoxyethyl)-4-[2-(2,3,4-trimethoxyphenyl)ethyl]piperazine  
 1-[2-(3-Fluorophenyl)ethyl]-4-(2-phenoxyethyl)piperazine  
 1-[2-(4-Fluorophenyl)-ethyl]-4-(2-phenoxyethyl)piperazine  
 1-(2-Phenoxyethyl)-4-(2-*m*-tolylethyl)piperazine  
 1-(2-Phenoxyethyl)-4-[2-(2-trifluoromethyl-phenyl)ethyl]piperazine  
 10 1-(2-Phenoxyethyl)-4-[2-(4-trifluoromethylphenyl)ethyl]piperazine  
 1-(2-Phenoxyethyl)-4-[2-(3-trifluoromethoxyphenyl)ethyl]piperazine  
 1-[2-(3-Chloro-phenyl)ethyl]-4-(2-phenoxyethyl)piperazine and  
 1-[2-(3-Chloro-4-methoxyphenyl)ethyl]-4-(2-phenoxyethyl)piperazine.

### 15 Example 28

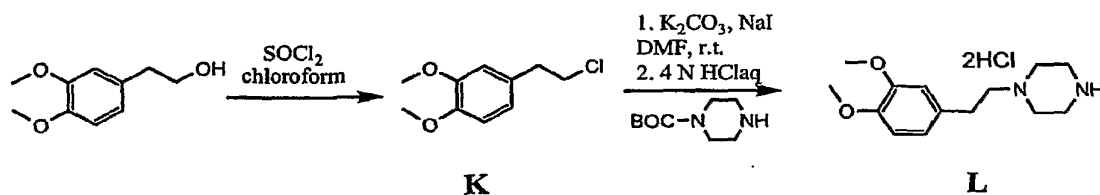
#### 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperazine dihydrochloride

##### Step 1: 2-(4-Chlorophenoxy)ethyl 4-methylbenzenesulfonate (J)



- 20 To a solution of 2-(4-chlorophenoxy)ethanol (2.0 g, 11.6 mmol) in DCM (10 mL) was added Et<sub>3</sub>N (5 mL) and 4-methylbenzene-1-sulfonyl chloride (TsCl; 2.43 g, 12.8 mmol) sequentially. The reaction mixture was stirred at room temperature overnight and partitioned between water and ethyl acetate. The organic layer was washed with water, 5% sodium bicarbonate (NaHCO<sub>3</sub>), and brine and concentrated. The resulting residue was washed with  
 25 hexane to afford the title compound quantitatively.

##### Step 2: 1-(3,4-Dimethoxyphenethyl)piperazine dihydrochloride (L)

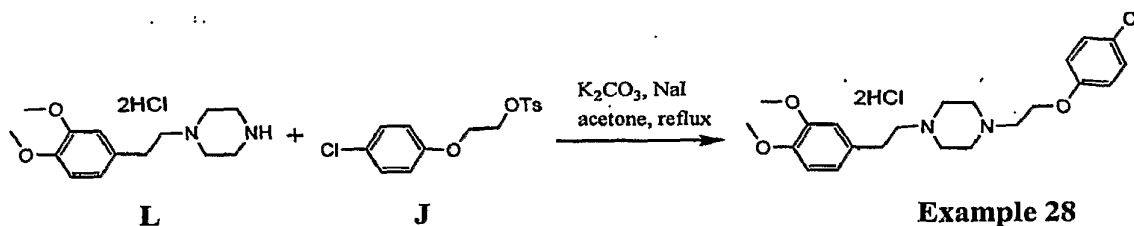




The reaction mixture of 2-(3,4-dimethoxyphenyl)ethanol (6.0 g, 32.8 mmol) and thionyl chloride (19 g, 164 mmol) in chloroform (20 mL) was stirred at reflux for 4 h, concentrated, and partitioned between water and ethyl acetate. The organic layer was washed with NaHCO<sub>3</sub> and brine, dried over anhydrous sodium sulfate, and concentrated to afford 4-(2-chloroethyl)-1,2-dimethoxybenzene (K) quantitatively (6.6 g).

A reaction mixture of 4-(2-chloroethyl)-1,2-dimethoxybenzene (3.6 g, 17.9 mmol), piperazine-1-carboxylic acid *t*-butyl ester (4.0 g, 21.5 mmol), K<sub>2</sub>CO<sub>3</sub> (4.97 g, 36 mmol), and NaI (2.7 g, 18 mmol) in DMF (20 mL) was stirred at 80 °C for 3 h, cooled to room temperature, and partitioned between water and ethyl acetate. The organic layer was washed with water and brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by column chromatography to afford 4-[2-(3,4-dimethoxy-phenyl)-ethyl]-piperazine-1-carboxylic acid *t*-butyl ester (4.8 g, 76%) which was dissolved in 4 N HCl in dioxane. This solution was stirred at room temperature for 4 h, concentrated, and dried in a high vacuum oven to give the title compound quantitatively.

**Step 3:** 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperazine dihydrochloride



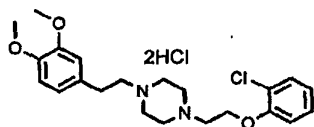
To the solution of 1-(3,4-dimethoxyphenethyl)piperazine dihydrochloride (502 mg, 1.55 mmol) and 2-(4-chlorophenoxy)ethyl 4-methylbenzenesulfonate (460 mg, 1.4 mmol) in acetone (20 mL) was added NaI (465 mg, 3.1 mmol) and K<sub>2</sub>CO<sub>3</sub> (1.1 g, 7.0 mmol). The reaction mixture was then refluxed overnight and concentrated. The residue was partitioned between ethyl acetate and water. The organic layer was washed with water and brine, dried over anhydrous sodium sulfate, and concentrated. The resulting residue was purified by column chromatography to afford 1-(3,4-dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperazine which was suspended in 6 N HCl aq. (pH = 3). The precipitate was filtered, washed with cold ethanol, and dried to afford the title compound (350 mg, 52%).

<sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>): δ 2.96 (m, 2H), 3.4 (m, 12H), 3.70 (s, 3H), 3.74 (s, 3H), 4.36 (b, 2H), 6.76 (d, 1H), 6.89 (m, 2H), 7.03 (m, 2H), 7.34 (m, 2H).

$m/z$  405  $[M-2HCl+1]^+$ .

### Example 29

#### 1-(2-(2-Chlorophenoxy)ethyl)-4-(3,4-dimethoxyphenethyl)piperazine dihydrochloride



5

The title compound was prepared using the same procedure as described in Example 28 by replacing 2-(4-chlorophenoxy)ethyl 4-methylbenzenesulfonate with 2-(2-chlorophenoxy)ethyl 4-methylbenzenesulfonate in Step 1.

$^1H$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  2.96 (b, 2H), 3.4 (m, 12H), 3.70 (s, 3H), 3.72 (s, 3H), 4.44 (b, 2H), 6.76 (d, 1H), 6.89 (m, 2H), 6.98 (m, 1H), 7.20 (d, 1H), 7.33 (m, 1H), 7.46 (d, 1H).

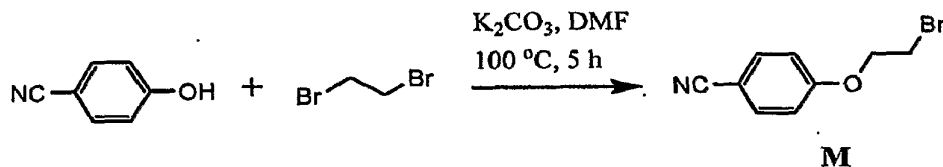
10

$m/z$  405  $[M-2HCl+1]^+$ .

### Example 30

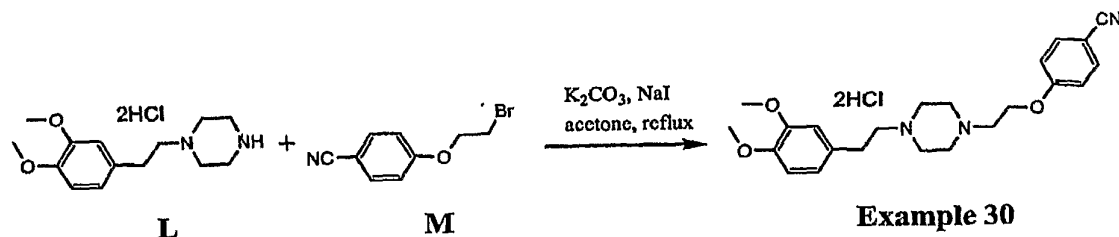
#### 4-(2-(4-(3,4-Dimethoxyphenethyl)piperazin-1-yl)ethoxy)benzonitrile dihydrochloride

15 Step 1: 4-(2-Bromoethoxy)benzonitrile (M)



A reaction mixture of 4-hydroxybenzonitrile (1.19 g, 10 mmol), 1,2-dibromoethane (9.39 g, 50 mmol), and  $K_2CO_3$  (4.14 g, 30 mmol) in DMF (20 mL) was stirred at 100 °C for 5 h and cooled to room temperature. To the reaction mixture was added ethyl acetate and water. The organic layer was washed with brine, dried over anhydrous sodium sulfate, and concentrated. The residue was purified by column chromatography to afford the 4-(2-bromoethoxy)benzonitrile (1.2 g, 53%).

25 Step 2: 4-(2-(4-(3,4-Dimethoxyphenethyl)piperazin-1-yl)ethoxy)benzonitrile dihydrochloride



The title compound was prepared (41% yield) using the same procedures as described in Example 28 (Step 3) by replacing 2-(4-chlorophenoxy)ethyl 4-methylbenzenesulfonate with 4-(2-bromoethoxy)benzonitrile.

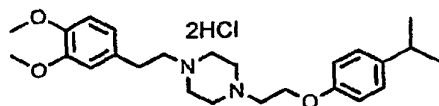
$^1\text{H NMR}$  (400 MHz, DMSO- $d_6$ ):  $\delta$  2.95-3.00 (m, 3H), 3.20-3.60 (m, 11H), 3.70 (s, 3H), 7.73 (s, 3H), 4.46 (b, 2H), 6.77 (d, 1H), 6.88 (d, 2H), 7.17 (d, 2H), 7.79 (d, 2H).

$m/z$  396  $[\text{M}-2\text{HCl}+1]^+$ .

10 The following compounds were prepared using the same procedure as described in Example 30 by replacing 4-hydroxybenzonitrile with the corresponding substituted phenol.

#### Example 31

1-(3,4-Dimethoxyphenethyl)-4-(2-(4-isopropylphenoxy)ethyl)piperazine dihydrochloride



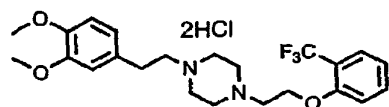
15

$^1\text{H NMR}$  (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  1.20 (d, 6H), 2.69 (s, 1H), 2.85 (m, 1H), 3.09 (m, 2H), 3.51 (m, 2H), 3.73-3.80 (m, 15H), 4.14 (m, 2H), 6.85-6.97 (m, 5H), 7.18 (q, 2H).

$m/z$  413  $[\text{M}-2\text{HCl}+1]^+$ .

#### 20 Example 32

1-(2-(2-(Trifluoromethyl)phenoxy)ethyl)-4-(3,4-dimethoxyphenethyl)piperazine dihydrochloride



$^1\text{H NMR}$  (400 MHz,  $\text{CD}_3\text{OD}$ ):  $\delta$  3.09 (m, 2H), 3.51 (m, 2H), 3.6-4.0 (m, 16H), 4.62 (t, 2H), 6.85-6.96 (m, 3H), 7.16 (t, 1H), 7.26 (d, 1H), 7.63 (m, 2H).

$m/z$  439  $[\text{M}-2\text{HCl}+1]^+$ .

The following compounds can be prepared using the same procedure as described Example 28 and 30:

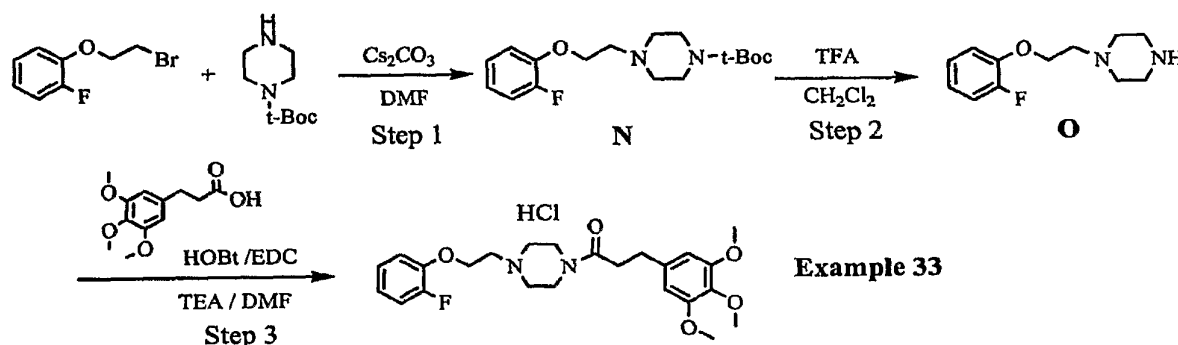
- 1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-fluoro-phenoxy)ethyl]piperazine  
 5 1-[2-(3,4-Dimethoxyphenyl)ethyl]-4-[2-(4-methoxyphenoxy)ethyl]piperazine  
 1-[2-(Biphenyl-4-yloxy)ethyl]-4-[2-(3,4-dimethoxyphenyl)ethyl]piperazine  
 1-[2-(Benzo[1,3]dioxol-5-yloxy)ethyl]-4-[2-(3,4-dimethoxyphenyl)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(4-trifluoromethyl-phenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-(2-*p*-tolylloxyethyl)piperazine  
 10 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(4-imidazol-1-ylphenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(4-trifluoromethoxyphenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(2-fluorophenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(2-methoxyphenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(2-trifluoromethoxyphenoxy)ethyl]piperazine  
 15 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(2-fluoro-4-methoxyphenoxy)ethyl]piperazine  
 1-[2-(3,4-Dimethoxy-phenyl)ethyl]-4-[2-(3-fluoro-4-methoxyphenoxy)ethyl]piperazine  
 1-[2-(3-Chloro-4-methoxy-phenoxy)ethyl]-4-[2-(3,4-dimethoxyphenyl)ethyl]piperazine  
 1-[2-(3,4-Dichloro-phenoxy)ethyl]-4-[2-(3,4-dimethoxyphenyl)ethyl] piperazine  
 1-[2-(4-Isopropoxy-phenyl)ethyl]-4-(2-phenoxy-ethyl)piperazine  
 20 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[2-(4-isopropoxy-phenyl)ethyl]piperazine  
 1-[2-(2-Fluoro-phenoxy)ethyl]-4-[2-(4-isopropoxy-phenyl)ethyl]piperazine  
 1-[2-(2-Fluoro-phenoxy)ethyl]-4-[2-(3,4,5-trimethoxy-phenyl)ethyl]piperazine  
 1-[2-(2-Fluoro-phenoxy)ethyl]-4-[2-(4-methoxy-phenyl)ethyl]piperazine  
 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[2-(4-methoxy-phenyl)ethyl]piperazine  
 25 1-(2-Benzo[1,3]dioxol-5-yloxyethyl)-4-[2-(4-fluoro-phenoxy)ethyl]piperazine  
 1-(2-Phenoxyethyl)-4-[2-(4-trifluoromethoxyphenyl)ethyl]piperazine  
 4-(2-{4-[2-(4-Trifluoromethoxyphenyl)ethyl]piperazin-1-yl}ethoxy)benzonitrile  
 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[2-(4-trifluoromethoxy-phenyl)ethyl]piperazine  
 1-[3-(3,4-Dimethoxy-phenyl)propyl]-4-(2-phenoxyethyl)piperazine  
 30 1-[3-(3,4-Dimethoxy-phenyl)propyl]-4-[2-(4-fluorophenoxy)ethyl]piperazine  
 1-(3-Benzo[1,3]dioxol-5-ylpropyl)-4-(2-phenoxyethyl)piperazine  
 1-(3-Benzo[1,3]dioxol-5-ylpropyl)-4-[2-(4-fluorophenoxy)ethyl]piperazine  
 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[3-(4-methoxyphenyl)propyl]piperazine

1-[2-(4-Fluoro-phenoxy)ethyl]-4-[3-(4-isopropoxyphenyl)propyl]piperazine  
 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine  
 1-[2-(4-Fluoro-phenoxy)ethyl]-4-[3-(3,4,5-trimethoxyphenyl)propyl]piperazine and  
 1-[2-(4-*t*-Butyl-phenoxy)ethyl]-4-[2-(3,4-dimethoxyphenyl)ethyl]piperazine.

5

**Example 33**

1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxy-phenyl)propan-1-one hydrochloride



10

**Step 1:** 4-[2-(2-Fluorophenoxy)-ethyl]-piperazine-1-carboxylic acid *tert*-butyl ester (**N**)

To a solution of piperazine-1-carboxylic acid *tert*-butyl ester (2.79 g, 15 mmol) and 1-(2-bromoethoxy)-2-fluoro-benzene (3.28 g, 15 mmol) in DMF (6 mL) was added cesium carbonate ( $\text{Cs}_2\text{CO}_3$ , 9.75 g, 30 mmol). The mixture was stirred at room temperature for a day and then treated with water. The aqueous solution was extracted with ethyl acetate and the extract was washed with water and brine. The organic layer was concentrated and the residue was dried under the vacuum to yield the title compound quantitatively as an oil (5.1 g).

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  1.39 (s, 9H), 2.44 (t, 4H), 2.73 (t, 2H), 3.29 (t, 4H), 4.45 (t, 2H), 6.93 (m, 1H), 7.11 (t, 1H), 7.18 (m, 2H).

20

**Step 2:** 1-[2-(2-Fluorophenoxy)-ethyl]-piperazine (**O**)

The above oil of 4-[2-(2-fluorophenoxy)ethyl]piperazine-1-carboxylic acid *tert*-butyl ester (4.0 g, 12 mmol) in dichloromethane (60 mL) was mixed with trifluoroacetic acid (10 mL) and was stirred at room temperature for 2 hours. The solvent was evaporated and the residue was treated with a saturated solution of  $\text{NaHCO}_3$ . The aqueous solution was extracted with

25

dichloromethane and the organic layer was concentrated to give 1-[2-(2-fluorophenoxy)ethyl]piperazine as a white solid (2.25 g, 84%).

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  2.40 (b, 4H), 2.67 (m, 6H), 4.13 (t, 2H), 6.92 (m, 1H), 7.11 (t, 1H), 7.18 (m, 2H).

5

**Step 3:** 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxyphenyl)propan-1-one hydrochloride

To a mixture of 3-(3,4,5-trimethoxyphenyl)propionic acid (0.36 g, 1.5 mmol), HOBt (0.24 g, 1.8 mmol), EDAC·HCl (0.34 g, 1.8 mmol) in DMF (4 mL) was added 1-[2-(2-fluorophenoxy)ethyl]piperazine (0.34 g, 1.5 mmol) and triethylamine (0.5 mL, 3.6 mmol). The mixture was then stirred at room temperature for a day, treated with water, and extracted with dichloromethane. The organic layer was washed with water and brine and then concentrated to dryness. The residue was dissolved in ethyl ether and was added with 2N HCl in ether (1 mL). The white solid was filtered and dried under vacuum to give the title compound (408 mg, 52%).

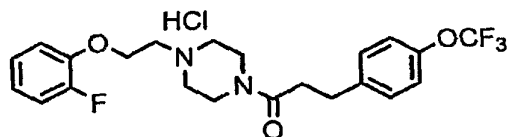
15

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  2.70 (m, 4H), 3.12 (m, 2H), 3.57 (m, 7H), 3.75 (s, 6H), 4.12 (d, 1H), 4.47 (m, 3H), 6.55 (s, 2H), 7.01 (m, 1H), 1.67 (t, 1H), 7.24 (m, 2H), 11.5 (b, 1H).

20 The following compounds were prepared using the same method as described in Example 33.

#### Example 34

1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethoxy-phenyl)propan-1-one hydrochloride

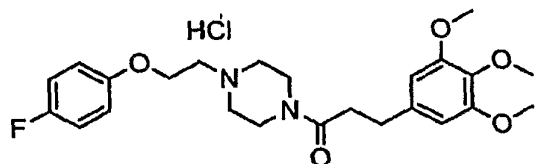


25

$^1\text{H NMR}$  (400 MHz,  $\text{DMSO-d}_6$ ):  $\delta$  2.74 (m, 2H), 2.91 (m, 2H), 3.12 (m, 4H), 3.58 (b, 4H), 4.11 (d, 1H), 4.47 (m, 3H), 7.01 (m, 1H), 7.17 (t, 1H), 7.25 (m, 2H), 7.49 (d, 2H), 7.64 (d, 2H), 11.5 (b, 1H).

30 **Example 35**

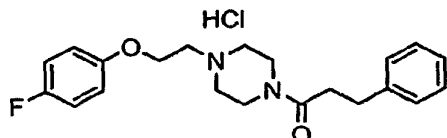
**1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxy-phenyl)propan-1-one hydrochloride**



<sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>): δ 2.66-2.77 (m, 6H), 3.1 (b, 4H), 3.5 (b, 6H), 3.61 (s, 3H),  
 5 3.75 (s, 6H), 4.39 (m, 4H), 6.54 (s, 2H), 7.03 (m, 2H), 7.16 (t, 2H), 11.3 (b, 1H).

**Example 36**

**1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-phenylpropan-1-one hydrochloride**

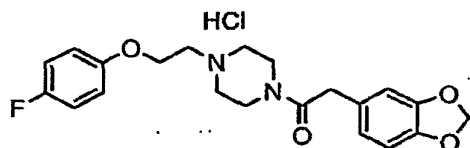


10 <sup>1</sup>H NMR (400 MHz, DMSO-d<sub>6</sub>): δ 2.65-2.84 (m, 6H), 3.06 (b, 2H), 4.07 (d, 1H), 4.37 (t, 2H), 4.45 (d, 2H), 7.03 (m, 2H), 7.17 (m, 3H), 7.26 (m, 4H), 11.1 (b, 1H).

**Example 37**

**2-Benzo[1,3]dioxol-5-yl-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}-ethanone**

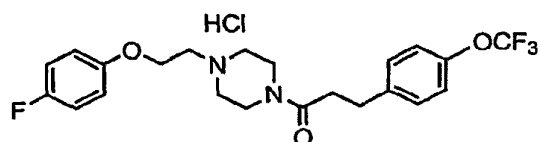
15 **hydrochloride**



<sup>1</sup>H NMR (400 MHz, DMSO-d<sub>4</sub>): δ 3.10 (b, 4H), 3.66 (m, 4H), 4.17 (d, 1H), 4.39 (m, 5H),  
 6.68 (d, 1H), 6.78 (s, 1H), 6.84 (d, 1H), 7.03 (m, 2H), 7.17 (m, 2H), 11.4 (b, 1H).

20 **Example 38**

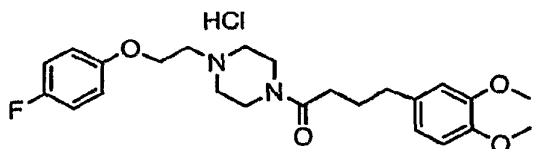
**1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethoxy-phenyl)propan-1-one hydrochloride**



$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  2.74 (m, 2H), 2.91 (t, 2H), 3.10 (m, 4H), 3.51 (t, 4H), 4.08 (d, 1H), 4.41 (m, 3H), 7.03 (m, 2H), 7.17 (m, 2H), 7.48 (d, 2H), 7.64 (d, 2H), 11.1 (b, 1H).

### Example 39

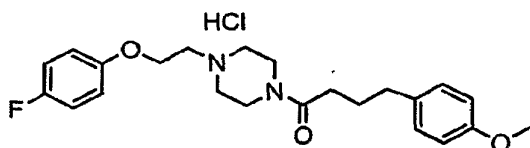
5 **4-(3,4-Dimethoxyphenyl)-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}-butan-1-one hydrochloride**



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  1.92 (m, 2H), 2.45 (t, 2H), 2.63 (t, 2H), 3.13 (b, 2H), 3.86 (m, 6H), 3.79 (s, 3H), 3.82 (s, 3H), 4.13 (b, 1H), 4.38 (t, 2H), 4.65 (b, 1H), 6.75 (d, 2H), 6.82 (m, 2H), 7.05 (m, 4H).

### Example 40

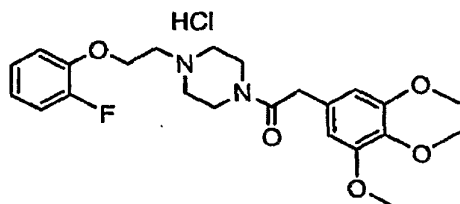
**1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-4-(4-methoxyphenyl)-butan-1-one hydrochloride**



15  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  1.89 (m, 2H), 2.43 (t, 2H), 2.61 (t, 2H), 3.13 (b, 2H), 3.63 (b, 4H), 3.75 (s, 3H), 4.12 (b, 1H), 4.38 (t, 2H), 4.65 (b, 1H), 6.83 (d, 2H), 7.05 (m, 4H), 7.11 (d, 2H).

### 20 Example 41

**1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-2-(3,4,5-trimethoxy-phenyl)ethanone hydrochloride**

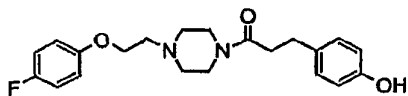


$^1\text{H}$  NMR (400 MHz, DMSO- $d_6$ ):  $\delta$  3.11 (m, 4H), 3.5-3.8 (m, 15H), 4.22 (d, 1H), 4.44 (d, 25 1H), 4.51 (b, 2H), 6.53 (s, 2H), 7.01 (m, 1H), 7.17 (t, 1H), 7.24 (m, 2H), 11.5 (b, 1H).



**Example 42**

1-**{4-[2-(4-Fluoro-phenoxy)-ethyl]-piperazin-1-yl}-3-(4-hydroxy-phenyl)-propan-1-one**

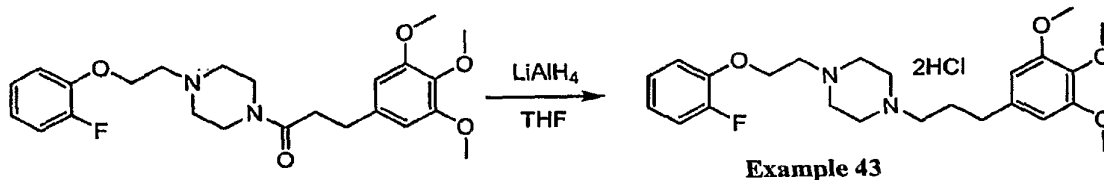


5 <sup>1</sup>H-NMR (400MHz, CD<sub>3</sub>OD-d<sub>4</sub>): δ 2.69 (m, 4H), 2.85 (m, 2H), 3.05 (m, 2H), 3.4-3.7 (m, 4H), 4.09 (d, 1H), 4.34 (b, 2H), 4.66 (d, 1H), 6.72 (d, 2H), 7.05 (m, 6H).

**Example 43**

1-**[2-(2-Fluorophenoxy)-ethyl]-4-[3-(3,4,5-trimethoxyphenyl)propyl]-piperazine**

10 **dihydrochloride**

**Example 43**

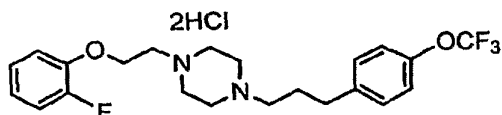
To a solution of 1-**{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxyphenyl)-propan-1-one hydrochloride** (0.2 g, 0.41 mmol) in THF (50 mL) was added LiAlH<sub>4</sub> (0.2 g, 5 mmol). The reaction mixture was stirred under N<sub>2</sub> for a day, cooled with an ice bath, and  
 15 quenched with water (0.2 mL) and 10N NaOH aqueous solution (0.2 mL). The solid was filtered and the filtrate was concentrated to dryness. The residue was treated with ether and 2N HCl in ether (2 mL). The white solid was filtered and dried under vacuum to yield the title compound (0.18 g, 87%).

<sup>1</sup>H NMR (400 MHz, CD<sub>3</sub>OD-d<sub>4</sub>): δ 2.16 (m, 2H), 2.71 (t, 2H), 3.28 (m, 2H), 3.6-4.0 (m,  
 20 19H), 4.52 (t, 2H), 6.58 (s, 2H), 7.04 (m, 1H), 7.18 (m, 3H).

The following compounds were prepared using the same method as described in Example 43.

**Example 44**

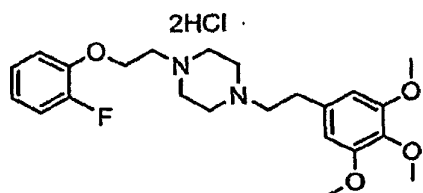
25 1-**[2-(2-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine**  
**dihydrochloride**



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  2.17 (m, 2H), 2.82 (m, 2H), 3.5-4.0 (m, 12H), 4.52 (m, 2H), 7.02 (m, 1H), 7.1-7.3 (m, 4H), 7.47 (m, 2H), 7.62 (d, 1H).

#### Example 45

5 **1-[2-(2-Fluorophenoxy)ethyl]-4-[2-(3,4,5-trimethoxyphenyl)ethyl]-piperazine dihydrochloride**

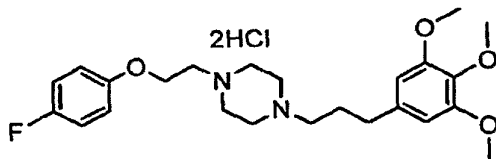


$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  3.10 (m, 2H), 3.52 (m, 2H), 3.6-4.0 (m, 19H), 4.52 (m, 2H), 6.66 (s, 2H), 7.04 (m, 1H), 7.18 (m, 3H).

10

#### Example 46

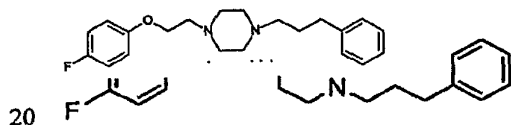
**1-[2-(4-Fluorophenoxy)ethyl]-4-[3-(3,4,5-trimethoxyphenyl)propyl]-piperazine dihydrochloride**



15  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  2.16 (b, 2H), 2.71 (t, 2H), 3.26 (m, 2H), 3.6-4.0 (m, 19H), 4.41 (t, 2H), 6.58 (s, 2H), 7.04 (s, 2H), 7.06 (m, 2H).

#### Example 47

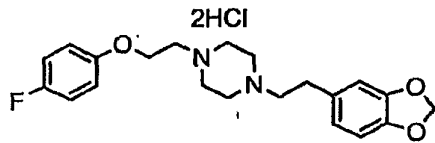
**1-[2-(4-Fluorophenoxy)-ethyl]-4-(3-phenylpropyl)piperazine dihydrochloride**



20  $^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  2.15 (m, 2H), 2.75 (t, 2H), 3.5-4.0 (m, 12H), 4.42 (m, 2H), 7.04 (m, 3H), 7.27 (m, 6H).

#### Example 48

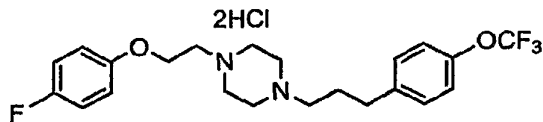
25 **1-(2-Benzo[1,3]dioxol-5-yl-ethyl)-4-[2-(4-fluorophenoxy)ethyl]piperazine dihydrochloride**



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  3.06 (m, 2H), 3.47 (m, 2H), 3.65-3.90 (m, 8H), 4.41 (t, 4H), 5.94 (s, 2H), 6.79 (s, 2H), 6.85 (s, 1H), 6.05 (m, 4H).

### 5 Example 49

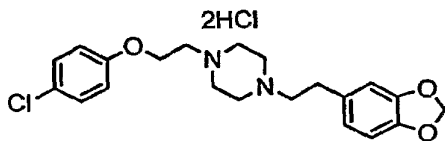
**1-[2-(4-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]-piperazine dihydrochloride**



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  2.17 (m, 2H), 2.82 (m, 2H), 3.6-3.9 (m 10H), 4.41 (m, 4H), 7.05 (m, 4H), 7.28 (dd, 1H), 7.45 (m, 2H), 7.61 (d, 1H).

### Example 50

**1-(2-Benzo[1,3]dioxol-5-yl-ethyl)-4-[2-(4-chlorophenoxy)ethyl]piperazine dihydrochloride**

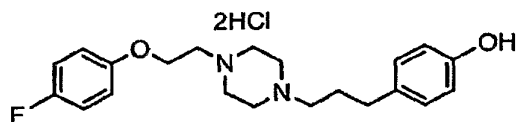


15

$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  3.56-3.74 (m, 12H), 4.39 (m, 4H), 6.03 (s, 2H), 6.93 (d, 1H), 7.01-7.11 (m, 4H), 7.31 (d, 2H).

### Example 51

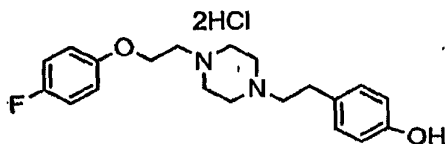
**20 4-(3-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-propyl)phenol dihydrochloride**



$^1\text{H}$  NMR (400 MHz,  $\text{CD}_3\text{OD}-d_4$ ):  $\delta$  2.91 (m, 2H), 2.66 (t, 2H), 3.26 (t, 2H), 3.6-4.0 (b, 10H), 4.41 (t, 2H), 6.72 (d, 2H), 7.05 (m, 6H).

### 25 Example 52

**4-(2-{4-[2-(4-Fluoro-phenoxy)ethyl]piperazin-1-yl}ethyl)phenol dihydrochloride**

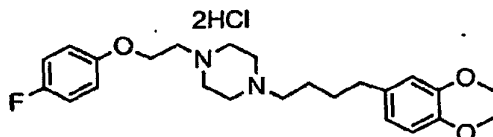


$^1\text{H NMR}$  (400 MHz,  $\text{CD}_3\text{OD-d}_4$ ):  $\delta$  3.04 (q, 2H), 3.46 (t, 2H), 3.6-4.0 (b, 10m), 4.41 (t, 2H), 6.76 (d, 2H), 7.06 (m, 4H), 7.14 (d, 2H).

5

**Example 53**

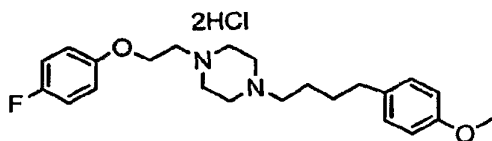
**1-[4-(3,4-Dimethoxyphenyl)butyl]-4-[2-(4-fluorophenoxy)ethyl]piperazine dihydrochloride**



10  $^1\text{H NMR}$  (400 MHz,  $\text{CD}_3\text{OD-d}_4$ ):  $\delta$  1.76 (m, 4H), 2.65 (t, 2H), 3.5-4.0 (m, 18H), 4.40 (t, 2H), 6.76 (d, 1H), 6.83 (d, 1H), 6.86 (d, 1H), 7.05 (m, 4H).

**Example 54**

**1-[2-(4-Fluorophenoxy)-ethyl]-4-[4-(4-methoxyphenyl)butyl]piperazine dihydrochloride**



15

$^1\text{H NMR}$  (400 MHz,  $\text{CD}_3\text{OD-d}_4$ ):  $\delta$  1.71 (m, 2H), 1.81 (m, 2H), 2.65 (t, 2H), 3.29 (m, 2H), 3.5-4.0 (m, 13H), 4.40 (t, 2H), 6.83 (d, 2H), 7.05 (m, 4H), 7.13 (d, 2H).

The following compounds can be prepared using the same method as described in Example 33.

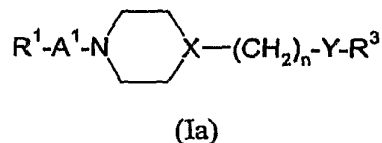
- 20 4-(2,3-Dihydrobenzo[1,4]dioxin-6-yl)-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}butan-1-one
- 3-(2,3-Dihydrobenzofuran-5-yl)-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one
- 3-(4-Ethoxyphenyl)-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one
- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isobutoxyphenyl)propan-1-one
- 25 3-[4-(2,2-Dimethylpropoxy)phenyl]-1-{4-[2-(4-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one

- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-[4-(2-methoxyethoxy)phenyl]propan-1-one
- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isopropylphenyl)propan-1-one
- 1-{4-[2-(4-Fluorophenoxy)ethyl]-piperazin-1-yl}-2-(4-hydroxymethylphenyl)ethanone
- 5 4-(3,4-Dimethoxyphenyl)-1-{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}butan-1-one
- 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-4-(4-methoxyphenyl)butan-1-one
- 4-(2,3-Dihydrobenzo[1,4]dioxin-6-yl)-1-[4-(2-o-tolyloxyethyl)piperazin-1-yl]butan-1-one
- 3-(2,3-Dihydrobenzofuran-5-yl)-1-{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one
- 3-(4-Ethoxyphenyl)-1-{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one
- 10 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isobutoxyphenyl)propan-1-one
- 3-[4-(2,2-Dimethylpropoxy)phenyl]-1-{4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl}propan-1-one
- 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-[4-(2-methoxyethoxy)phenyl]propan-1-one
- 15 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isopropylphenyl)propan-1-one
- 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-2-(4-hydroxymethylphenyl)ethanone
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-4-(3,4,5-trimethoxyphenyl)butan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-4-(3,4-dimethoxyphenyl)-butan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-4-(4-methoxyphenyl)butan-1-one
- 20 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(2,3-dihydrobenzofuran-5-yl)propan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(2,3-dihydrobenzofuran-5-yl)propan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-ethoxyphenyl)propan-1-one
- 25 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isobutoxyphenyl)propan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-[4-(2,2-dimethylpropoxy)phenyl]-propan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-[4-(2-methoxyethoxy)phenyl]-propan-1-one
- 30 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-isopropylphenyl)propan-1-one
- 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-2-(4-hydroxymethylphenyl)ethanone
- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-2-(4-trifluoromethoxyphenyl)ethanone
- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-4-(4-trifluoromethoxyphenyl)butan-1-one

- 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3-trifluoromethoxyphenyl)propan-1-one  
1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(2-trifluoromethoxyphenyl)propan-1-one  
1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methylsulfonylphenyl)propan-1-one  
1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methanesulfonylphenyl)propan-1-one  
5 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethanesulfonylphenyl)-  
propan-1-one  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-2-(4-trifluoromethoxyphenyl)ethanone  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-4-(4-trifluoromethoxyphenyl)butan-1-one  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3-trifluoromethoxyphenyl)propan-1-one  
10 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(2-trifluoromethoxyphenyl)propan-1-one  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methylsulfonylphenyl)propan-1-one  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methanesulfonylphenyl)propan-1-one  
1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethanesulfonylphenyl)-  
propan-1-one  
15 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(3-trifluoromethoxyphenyl)propan-1-  
one  
1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-2-(4-trifluoromethoxyphenyl)ethanone  
1-{4-[2-(2,4-Difluoro-phenoxy)ethyl]piperazin-1-yl}-4-(4-trifluoromethoxyphenyl)butan-1-  
one  
20 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethoxyphenyl)propan-1-  
one  
1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(2-trifluoromethoxyphenyl)propan-1-  
one  
1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methylsulfonylphenyl)propan-1-one  
25 1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-methanesulfonylphenyl)propan-1-  
one  
1-{4-[2-(2,4-Difluorophenoxy)ethyl]piperazin-1-yl}-3-(4-trifluoromethanesulfonylphenyl)-  
propan-1-one

## Claims

1. A compound of general formula (Ia)



in which:-

$R^1$  represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-4C)alkoxy(1-4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

$A^1$  represents  $(CH_2)_m$  or  $(CH_2)_{m-1}C(=O)$ ;

$m$  is 2, 3, 4 or 5;

$X$  is CH or N;

$n$  is 0, 1, 2, 3, 4 or 5, provided that when  $X$  is N,  $n$  is 2, 3, 4 or 5;

$Y$  is O,  $NR^2$  or S;

$R^2$  is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for  $R^3$ ; and

$R^3$  represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

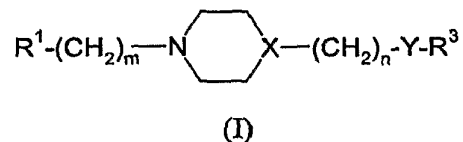
or a pharmaceutically acceptable salt thereof,

but excluding the compounds 1-[2-phenoxyethyl]-4-[phenylacetyl]piperazine and 1-[3-(3,4-dichlorophenoxy)propyl]-4-[(4-chlorophenyl)acetyl]piperazine.

2. A compound as claimed in Claim 1, in which

$R^1$  represents a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group.

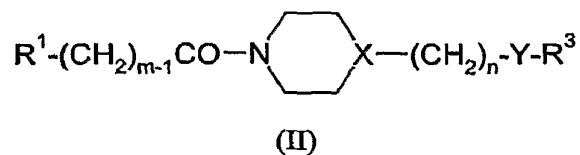
3. A compound as claimed in Claim 1 or Claim 2, which is of general formula (I)



in which:-

$R^1$ ;  $m$ ;  $X$ ;  $n$ ;  $Y$ ; and  $R^3$  are as defined in Claim 1, or a pharmaceutically acceptable salt thereof.

4. A compound as claimed in claim 1 or Claim 2, which is of general formula (II)



in which  $R^1$ ,  $m$ ,  $n$ ,  $Y$  and  $R^3$  are as defined in Claim 1, or a pharmaceutically acceptable salt thereof.

5. A compound as claimed in any one of Claims 1 to 4, in which  $R^1$  represents 2,3-dihydrobenzofuran-5-yl, benzo[1,3]dioxol-5-yl, 2,3-dihydrobenzo[1,4]dioxin-6-yl, 2-fluorophenyl, 3-fluorophenyl, 4-fluorophenyl, 3,4-difluorophenyl, 3-chlorophenyl, 4-hydroxyphenyl, 3-methylphenyl, 4-isopropylphenyl, 2-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 3-methoxyphenyl, 4-methoxyphenyl, 4-ethoxyphenyl, 4-isopropoxyphenyl, 4-isobutoxyphenyl, 4-(2,2-dimethylpropoxy)phenyl, 3,4-dimethoxyphenyl, 2,3,4-trimethoxyphenyl, 3,4,5-trimethoxyphenyl, 4-(2-methoxyethoxy)phenyl, 4-hydroxymethoxyphenyl, 2-fluoro-3,4-dimethoxyphenyl, 3-chloro-4-methoxyphenyl, 4-chloro-3-methoxyphenyl, 2-trifluoromethoxyphenyl, 3-trifluoromethoxyphenyl, 4-trifluoromethoxyphenyl, 4-methylsulfanylphenyl, 4-methylsulfonylphenyl or 4-trifluoromethylsulfonylphenyl.



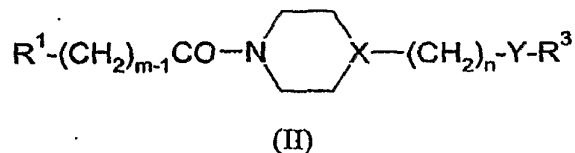
6. A compound as claimed in any one of Claims 2 to 4, in which R<sup>1</sup> represents phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 3-fluorophenyl, 4-fluorophenyl, 3,4-difluorophenyl, 3-chlorophenyl, 3-methylphenyl, 2-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 3-methoxyphenyl, 4-methoxyphenyl, 4-isopropoxyphenyl, 3,4-dimethoxyphenyl, 2,3,4-trimethoxyphenyl, 3,4,5-trimethoxyphenyl, 2-fluoro-3,4-dimethoxyphenyl, 3-chloro-4-methoxyphenyl, 4-chloro-3-methoxyphenyl, 2-trifluoromethoxyphenyl, 4-trifluoromethoxyphenyl, or 3-trifluoromethoxyphenyl.
7. A compound as claimed in Claim 6, in which R<sup>1</sup> represents phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 3,4-difluorophenyl, 2-trifluoromethylphenyl, 3-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 3-methoxyphenyl, 4-methoxyphenyl, 3,4-dimethoxyphenyl or 2-trifluoromethoxyphenyl.
8. A compound as claimed in Claim 7, in which R<sup>1</sup> represents 3,4-dimethoxyphenyl, 3,4,5-trimethoxyphenyl, 4-methoxyphenyl, 4-isopropoxyphenyl, or 4-trifluoromethoxyphenyl.
9. A compound as claimed in any one of Claims 1 to 6, in which m is 2.
10. A compound as claimed in any one of Claims 1 to 9, in which n is 2.
11. A compound as claimed in any one of Claims 1 to 10, in which Y is O or NH.
12. A compound as claimed in any one of Claims 1 to 11, in which R<sup>3</sup> represents phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 4-fluorophenyl, 2,4-difluorophenyl, 4-trifluoromethoxyphenyl, 2-chlorophenyl, 4-chlorophenyl, 3,4-dichlorophenyl, 2-methylphenyl, 4-methylphenyl, 4-isopropylphenyl, 4-*t*-butylphenyl, 4-cyanophenyl, 2-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 4-methoxyphenyl, 4-biphenyl, 4-(1-imidazolyl)phenyl, 2-fluoro-4-methoxyphenyl, 3-fluoro-4-methoxyphenyl, 3-chloro-4-methoxyphenyl, 2-trifluoromethoxyphenyl or 4-trifluoromethoxyphenyl.

13. A compound as claimed in Claim 12, in which R<sup>3</sup> represents phenyl, benzo[1,3]dioxol-5-yl, 2-fluorophenyl, 4-fluorophenyl, 2,4-difluorophenyl, 4-trifluoromethoxyphenyl, 2-chlorophenyl, 4-chlorophenyl, 3,4-dichlorophenyl, 4-methylphenyl, 4-isopropylphenyl, 4-*t*-butylphenyl, 4-cyanophenyl, 2-trifluoromethylphenyl, 4-trifluoromethylphenyl, 2-methoxyphenyl, 4-methoxyphenyl, 4-biphenyl, 4-(1-imidazolyl)phenyl, 2-fluoro-4-methoxyphenyl, 3-fluoro-4-methoxyphenyl, 3-chloro-4-methoxyphenyl, 2-trifluoromethoxyphenyl or 4-trifluoromethoxyphenyl.
14. A compound as claimed in Claim 13, in which R<sup>3</sup> represents phenyl, 2-fluorophenyl, 4-fluorophenyl, 2-chlorophenyl, 4-chlorophenyl, 4-methylphenyl, 4-isopropylphenyl, 4-cyanophenyl or 2-trifluoromethylphenyl.
15. A compound as claimed in Claim 14, in which R<sup>3</sup> represents a 4-fluorophenyl group.
16. A compound as claimed in Claim 1, which is selected from:  
 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-fluorophenoxy)ethyl)piperidine;  
 1-(4-(Trifluoromethyl)phenethyl)-4-(2-phenoxyethyl)piperidine;  
 4-(2-(2-Fluorophenoxy)ethyl)-1-(3,4-dimethoxyphenethyl)piperidine;  
 1-(3,4-Dimethoxyphenethyl)-4-(2-phenoxyethyl)piperazine;  
 1-(3-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine;  
 1-(4-Methoxyphenethyl)-4-(2-phenoxyethyl)piperazine;  
 1-(2-(Benzo[*d*][1,3]dioxol-5-yl)ethyl)-4-(2-phenoxyethyl)piperazine;  
 1-(3,4-Difluorophenethyl)-4-(2-phenoxyethyl)piperazine;  
 1-Phenethyl-4-(2-phenoxyethyl)piperazine;  
 1-(3,4-Dimethoxyphenethyl)-4-(2-(4-chlorophenoxy)ethyl)piperazine ; and  
 4-(2-(4-(3,4-Dimethoxyphenethyl)piperazin-1-yl)ethoxy)benzotrile;  
 1-{4-[2-(2-Fluorophenoxy)ethyl]piperazin-1-yl}-3-(3,4,5-trimethoxyphenyl)propan-1-one;  
 1-{4-[2-(2-Fluorophenoxy)ethyl]-piperazin-1-yl}-3-(4-trifluoromethoxyphenyl)propan-1-one;  
 1-{4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl}-3-phenylpropan-1-one;

1-[4-[2-(4-Fluorophenoxy)ethyl]piperazin-1-yl]-3-(4-trifluoromethoxyphenyl)propan-1-one;  
 1-[4-[2-(2-fluorophenoxy)ethyl]piperazin-1-yl]-2-(3,4,5-trimethoxyphenyl)ethanone;  
 1-[2-(2-Fluorophenoxy)ethyl]-4-[3-(3,4,5-trimethoxyphenyl)propyl]-piperazine;  
 1-[2-(2-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine;  
 1-[2-(2-Fluorophenoxy)ethyl]-4-[2-(3,4,5-trimethoxyphenyl)ethyl]piperazine;  
 1-(2-Benzo[1,3]dioxol-5-ylethyl)-4-[2-(4-fluorophenoxy)ethyl]piperazine;  
 1-[2-(4-Fluorophenoxy)ethyl]-4-[3-(4-trifluoromethoxyphenyl)propyl]piperazine;  
 pharmaceutically acceptable salts thereof.

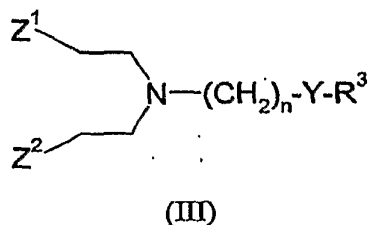
17. A process for preparing a compound as claimed in any one of Claims 1 to 16, which comprises:

a) for a compound of formula (Ia) in which A<sup>1</sup> is (CH<sub>2</sub>)<sub>m</sub>, reducing a compound of general formula (II)

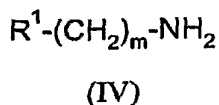


with a reducing agent;

b) for a compound of formula (Ia) in which X is N and A<sup>1</sup> is (CH<sub>2</sub>)<sub>m</sub>, reacting a compound of general formula (III)

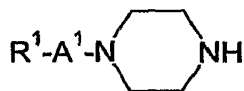


in which each of Z<sup>1</sup> and Z<sup>2</sup> independently represents a leaving atom or group, with a compound of general formula (IV)



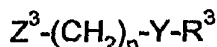
or a corresponding compound in which one or two substituents on R<sup>1</sup> are protected;

c) for a compound of formula (Ia) in which X is N, reacting a compound of general formula (V)



(V)

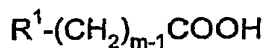
with a compound of general formula (VI)



(VI)

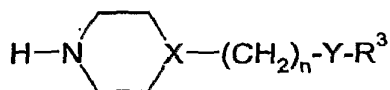
in which  $\text{Z}^3$  represents a leaving atom or group; or

d) reacting a compound of formula (XI)



(XI)

or a reactive derivative thereof, with a compound of general formula (XII)

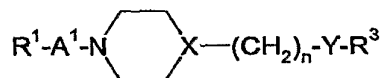


(XII)

followed by removing any protecting group and, optionally, forming a pharmaceutically acceptable salt.

18. A pharmaceutical composition, which comprises a compound as claimed in any one of claims 1 to 16, and a pharmaceutically acceptable diluent or carrier.

19. A method of treating a condition responsive to a modulator of sigma receptor function in a patient requiring treatment, which comprises administering to said patient an effective amount of a compound of general formula (Ia)



(Ia)

in which:-

$\text{R}^1$  represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-

4C)alkoxy(1-4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

$A^1$  represents  $(CH_2)_m$  or  $(CH_2)_{m-1}C(=O)$ ;

$m$  is 2, 3, 4 or 5;

$X$  is CH or N;

$n$  is 0, 1, 2, 3, 4 or 5, provided that when  $X$  is N,  $n$  is 2, 3, 4 or 5;

$Y$  is O,  $NR^2$  or S;

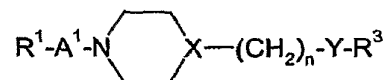
$R^2$  is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for  $R^3$ ; and

$R^3$  represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

or a pharmaceutically acceptable salt thereof.

20. A compound as claimed in any one of Claims 1 to 16, for use in therapy.

21. Use of a compound a compound of general formula (Ia)



(Ia)

in which:-

$R^1$  represents 2,3-dihydrobenzofuran-5-yl or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a cyano group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a halo(1-4C) alkyl group, a (1-6C)alkoxy group, a (1-4C)alkoxy(1-4C)alkoxy group, a hydroxy(1-4C)alkoxy group, a (1-4C)alkylsulfanyl group, a (1-4C)alkylsulfonyl group, a halo(1-4C)alkoxy group and a halo(1-4C)alkylsulfonyl group;

$A^1$  represents  $(CH_2)_m$  or  $(CH_2)_{m-1}C(=O)$ ;

m is 2, 3, 4 or 5;

X is CH or N;

n is 0, 1, 2, 3, 4 or 5, provided that when X is N, n is 2, 3, 4 or 5;

Y is O, NR<sup>2</sup> or S;

R<sup>2</sup> is hydrogen, (1-4C)alkyl or phenyl(1-4C)alkyl, or is as defined for R<sup>3</sup>; and

R<sup>3</sup> represents indan-1-yl, indan-2-yl, 1,2,3,4-tetrahydronaphth-1-yl or 1,2,3,4-tetrahydronaphth-2-yl, each of which may bear a hydroxyl substituent on a non-aromatic carbon atom; (3-6C) cycloalkyl; or a phenyl group that is unsubstituted or substituted by one, two or three substituents selected independently from (1-2C)alkylenedioxy, a halogen atom, a hydroxyl group, a (1-4C) alkyl group, a (3-6C)cycloalkyl group, a cyano group; a phenyl group, an imidazolyl group, a halo(1-4C) alkyl group, a (1-4C)alkoxy group and a halo(1-4C)alkoxy group;

or a pharmaceutically acceptable salt thereof,

in the manufacture of a medicament for the treatment of a condition responsive to a modulator of sigma receptor function.