# 4-(4-ALKOXY-3-HYDROXYPHENYL)-2-PYRROLIDONE DERIVATIVES AS PDE-4 INHIBITORS FOR THE TREATMENT OF NEUROLOGICAL SYNDROMES

This application claims benefit of U.S. Provisional Application Serial No. 60/329,314, filed October 16, 2001, the entire disclosure of which is hereby incorporated by reference.

## FIELD OF THE INVENTION

The present invention relates generally to the field of phosphodiesterase 4 (PDE4) enzyme inhibition. More specifically this invention relates to selective PDE4 inhibition by novel compounds, e.g., 4-(substituted-phenyl)-2-pyrrolidinone compounds, methods of preparing such compounds, compositions containing such compounds, and methods of use thereof.

## BACKGROUND OF THE INVENTION

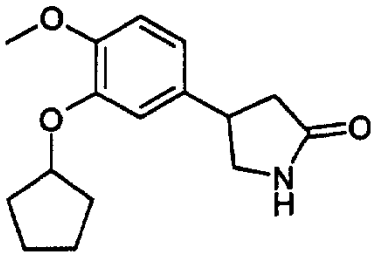
The cyclic nucleotide specific phosphodiesterases (PDEs) represent a family of enzymes that catalyze the hydrolysis of various cyclic nucleoside monophosphates (including cAMP and cGMP). These cyclic nucleotides act as second messengers within cells, and as messengers, carry impulses from cell surface receptors having bound various hormones and neurotransmitters. PDEs act to regulate the level of cyclic nucleotides within cells and maintain cyclic nucleotide homeostasis by degrading such cyclic mononucleotides resulting in termination of their messenger role.

PDE enzymes can be grouped into eleven families according to their specificity toward hydrolysis of cAMP or cGMP, their sensitivity to regulation by calcium, calmodulin or cGMP, and their selective inhibition by various compounds. For example, PDE 1 is stimulated by $Ca^{2+}$/calmodulin. PDE 2 is cGMP-dependent, and is found in the heart and adrenals. PDE 3 is cGMP-inhibited, and inhibition of this enzyme creates positive inotropic activity. PDE 4 is cAMP specific, and its inhibition causes airway relaxation, anti-inflammatory and antidepressant activity. PDE 5 appears to be important

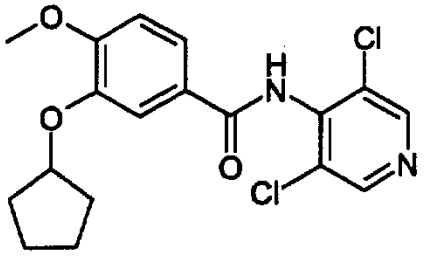
in regulating cGMP content in vascular smooth muscle, and therefore PDE 5 inhibitors may have cardiovascular activity. Since the PDEs possess distinct biochemical properties, it is likely that they are subject to a variety of different forms of regulation.

PDE4 is distinguished by various kinetic properties including low Michaelis constant for cAMP and sensitivity to certain drugs. The PDE4 enzyme family consists of four genes, which produce 4 isoforms of the PDE4 enzyme designated PDE4A, PDE4B, PDE4C, and PDE4D [See: Wang et al., Expression, Purification, and Characterization of human cAMP-Specific Phosphodiesterase (PDE4) Subtypes A, B, C, and D, *Biochem. Biophys. Res. Comm.*, 234, 320-324 (1997)]. In addition, various splice variants of each PDE4 isoform have been identified.

PDE4 isoenzymes are localized in the cytosol of cells and are unassociated with any known membranous structures. PDE4 isoenzymes specifically inactivate cAMP by catalyzing its hydrolysis to adenosine 5'-monophosphate (AMP). Regulation of cAMP activity is important in many biological processes, including inflammation and memory. Inhibitors of PDE4 isoenzymes such as rolipram, piclamilast, CDP-840 and ariflo are powerful anti-inflammatory agents and therefore may be useful in treating diseases where inflammation is problematic such as asthma or arthritis. Further, rolipram improves the cognitive performance of rats and mice in learning paradigms.




**rolipram**




**piclamilast**

In addition to such compounds as rolipram, xanthine derivatives such as pentoxifylline, denbufylline, and theophylline inhibit PDE4 and have received attention of late for their cognition enhancing effects. cAMP and cGMP are second messengers that mediate cellular responses to many different hormones and neurotransmitters. Thus, therapeutically significant effects may result from PDE inhibition and the resulting increase in intracellular cAMP or cGMP in key cells, such as those located in the nervous system and elsewhere in the body.

Rolipram, previously in development as an anti-depressant, selectively inhibits the PDE4 enzyme and has become a standard agent in the classification of PDE enzyme subtypes. Early work in the PDE4 field focused on depression and inflammation, and has subsequently been extended to include indications such as dementia. [see "The PDE IV Family Of Calcium-Phosphodiesterases Enzymes," John A. Lowe,.III, et al., Drugs of the Future 1992, 17(9):799-807 for a general review]. Further clinical developments of rolipram and other first-generation PDE4 inhibitors were terminated due to the side effect profile of these compounds. The primary side effect in primates is emesis, while the primary side effects in rodents are testicular degranulation, weakening of vascular smooth muscle, psychotrophic effects, increased gastric acid secretion and stomach erosion. In humans, the primary side effect is nausea and emesis.

## SUMMARY OF THE INVENTION

The present invention relates to novel compounds that inhibit, preferably selectively, PDE4 enzymes, and especially have improved side effect profiles, e.g., are relatively non-emetic (e.g., as compared to the previously discussed prior art compounds). In particular, the present invention relates to novel rolipram analogs. The compounds of this invention at the same time facilitate entry into cells, especially cells of the nervous system.

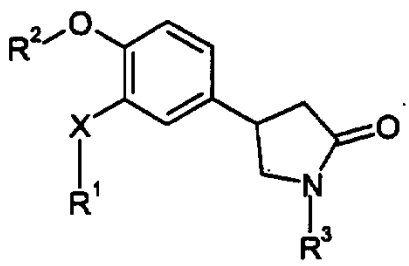
Still further, the present invention provides methods for synthesizing compounds with such activity and selectivity as well as methods of (and corresponding

pharmaceutical compositions for) treating a patient, e.g., mammals, including humans, in need of PDE inhibition, especially PDE4 inhibition, for a disease state that involves elevated intracellular PDE 4 levels or decreased cAMP levels, e.g., involving neurological syndromes, especially those states associated with memory impairment, most especially long term memory impairment, as where such memory impairment is due at least in part to catabolism of intracellular cAMP levels by PDE 4 enzymes, or where such an impaired condition can be improved by increasing cAMP levels.

In a preferred aspect, the compounds of the inventions improve such diseases by inhibiting PDE4 enzymes at doses that do not induce emesis or other side effects.

Upon further study of the specification and appended claims, further aspects, objects and advantages of this invention will become apparent to those skilled in the art.

The present invention includes compounds of Formula I:



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, (e.g., cyclohexenyl, cyclohexadienyl, indanyl, and tetrahydronaphthenyl), which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy (e.g., acetoxy), or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or

combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof;

with the proviso that:

(a) when X is O, $R^2$ is $CH_3$ and $R^3$ is H, then $R^1$ is not methyl, ethyl, n-propyl, isopropyl, sec-butyl, n-butyl, isobutyl, neopentyl, n-pentyl, 2-methylbutyl, isopentyl, n-hexyl, phenyl , cyclobutyl, cyclopentyl, cyclohexyl, cyclopentenyl, methylcyclopentyl, cyclopropylmethyl, cyclopentylmethyl, 2-propenyl, 2-propynyl, 3-methyl-2-butenyl, N-substituted 2-piperazinylethyl, norbornyl, 3-tetrahydrofuryl, 2-tetrahydrofuryl, 3-tetrahydrothienyl, 2-oxacyclopropyl, 2-oxacyclopenyl, 3-oxacyclopentyl, 2-chloroethyl, 2-bromoethyl, 2,2,2-trifluoroethyl, 3-bromopropyl, 3-chloropropyl, or 4-bromobutyl;

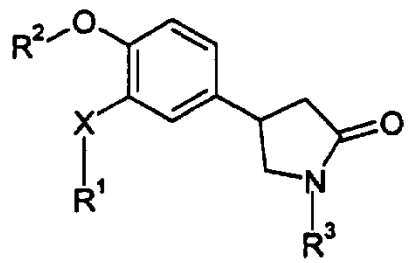
(b) when X is O, $R^1$ is cyclopentyl, and $R^2$ is methyl, then $R^3$ is not H, acetyl, benzyl, 4-hydroxybenzyl, 4-acetoxybenzyl, 4-bromobenzyl, 3,4-dimethoxybenzyl, 4-methylthiobenzyl, 4-cyanobenzyl, 2-aminobenzyl, 3-aminobenzyl, 4-aminobenzyl, 4-dimethylaminobenzyl, 2,4-diaminobenzyl, 4-amino-3,5-dimethoxybenzyl, 3-carboxybenzyl, 3-methoxycarbonylbenzyl, 4-methoxycarbonylbenzyl, 4-methylsulfinylbenzyl, 4-methylsufonylbenzyl, 2-nitrobenzyl, 3-nitrobenzyl, 4-nitrobenzyl, 2,4-dinitrobenzyl, 2-nitro-4-aminobenzyl, 2-amino-4-nitrobenzyl, morpholinoethyl, 2-pyridylmethyl, 3-pyridylmethyl, 4-pyridylmethyl, 4-(6-fluoroquinolyl)methyl, 2-(7-chloroquinolyl)methyl, 2-imidazoylmethyl, or substituted imidazoylmethyl.

(c) when X is O, $R^1$ is $CH_3$, and $R^3$ is H, then $R^2$ is not methyl, ethyl, or butyl.

(d) when X is O and $R^3$ is H, then $R^1$ and $R^2$ are not both ethyl or isobutyl.

(e) When X is O, and $R^1$ and $R^2$ are both difluoromethyl, then $R^3$ is not 4-aminobenzyl, or 4-amino-3,5-dimethoxybenzyl.

In accordance with the method aspect of the invention, there is provided a method of treating a patient (e.g., a mammal such as a human) suffering from a disease state (e.g., memory impairment) involving decreased cAMP levels and/or increased intracellular PDE4 levels, comprising administering to the patient a compound according to formula I':



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms, or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, (e.g., cyclohexenyl, cyclohexadienyl, indanyl, and tetrahydronaphthenyl), which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more

$-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy (e.g., acetoxy), or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N,

O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms (e.g., cyclopentylethyl and cyclopropylmethyl), which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof; and

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted preferably in the aryl portion, one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido (e.g., acetamido), and acyloxy (e.g., acetoxy), or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom (e.g., 3-thienyl, 2-thienyl, 3-tetrahydrofuran), which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heteroaryl portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

The compounds of the present invention are effective in inhibiting, or modulating the activity of PDE4 in animals, e.g., mammals, especially humans. These compounds exhibit neurological activity, especially where such activity affects cognition, including long term memory. These compounds will also be effective in treating diseases where decreased cAMP levels are involved. This includes but is not limited to inflammatory diseases. These compounds may also function as antidepressants, or be useful in treating cognitive and negative symptoms of schizophrenia.

Assays for determining PDE 4 inhibiting activity, selectivity of PDE4 inhibiting activity, and selectivity of inhibiting PDE 4 isoenzymes are known within the art. See, e.g., US 6,136;821, the disclosure of which is incorporated herein by reference.

Halogen herein refers to F, Cl, Br, and I. Preferred halogens are F and Cl.

Alkyl means a straight-chain or branched-chain aliphatic hydrocarbon radical. In the case of $R^1$ and $R^3$ suitable alkyl groups have preferably 1 to 8 carbon atoms, especially 1 to 4 carbon atoms. In the case of $R^2$, suitable alkyl groups have preferably 1 to 4 carbon atoms. In the case of $R^4$ and $R^5$, suitable alkyl groups have preferably 1 to 12 carbon atoms, especially 1 to 8 carbon atoms, in particular 1 to 4 carbon atoms.

Suitable alkyl groups include methyl, ethyl, propyl, isopropyl, butyl, sec-butyl, tert-butyl, pentyl, hexyl, heptyl, octyl, nonyl, decyl, undecyl, and dodecyl. Other examples of suitable alkyl groups include 1-, 2- or 3-methylbutyl, 1,1-, 1,2- or 2,2-dimethylpropyl, 1-ethylpropyl, 1-, 2-, 3- or 4-methylpentyl, 1,1-, 1,2-, 1,3-, 2,2-, 2,3- or 3,3-dimethylbutyl, 1- or 2-ethylbutyl, ethylmethylpropyl, trimethylpropyl, methylhexyl, dimethylpentyl, ethylpentyl, ethylmethylbutyl, dimethylbutyl, and the like.

These alkyl radicals can optionally have one or more $-CH_2CH_2-$ groups replaced in each case by –CH=CH- or -C C- groups. Suitable alkenyl or alkynyl groups are 1-

propenyl, 2-propenyl, 1-propynyl, 1-butenyl, 2-butenyl, 3-butenyl, 1-butynyl, 1,3-butadienyl and 3-methyl-2-butenyl.

The substituted alkyl groups for $R^1$, $R^3$, $R^4$ and $R^5$ are alkyl groups as described above which are substituted in one or more positions by halogens and/or oxo. Halogens are preferred substituents, especially F and Cl. For $R^2$, the substituted alkyl groups have 1 to 4 carbon atoms and are substituted one or more times by halogen, especially F and Cl, e.g., $C_1$-$C_4$ alkyl substituted by up to five F atoms.

In the arylalkyl groups, heterocyclic-alkyl groups, cycloalkyl-alkyl groups and alkoxyalkyl groups, "alkyl" refers to a divalent alkylene group having in general up to about 13 carbon atoms. In the case of the arylalkyl group for $R^1$, the "alkyl" portion has preferably 2 to 10 carbon atoms. In the case of other arylalkyl groups, the "alkyl" portion has preferably 1 to 10. In the heterocyclic-alkyl groups, the "alkyl" portion preferably has 1 to 12 carbon atoms. In the alkoxyalkyl groups, the "alkyl" portion preferably has 2 to 7 carbon atoms. In the cycloalkylalkyl groups, the "alkyl" portion preferably has 1 to 13 carbon atoms.

In the cases where alkyl is a substituent (e.g., alkyl substituents on aryl and heterocyclic groups) or is part of a substituent (e.g., in the alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, alkylthio, alkylsulphinyl, and alkylsulphonyl substituents for aryl), the alkyl portion preferably has 1 to 12 carbon atoms, especially 1 to 8 carbon atoms, in particular 1 to 4 carbon atoms.

Alkoxy means alkyl-O- groups in which the alkyl portion has 1 to 8 carbon atoms. Suitable alkoxy groups include methoxy, ethoxy, propoxy, isopropoxy, isobutoxy, sec-butoxy, pentoxy, hexoxy, heptoxy, octoxy, and trilfuoromethoxy. Preferred alkoxy groups are methoxy and ethoxy. The alkoxyalkyl group for $R^3$ preferably has 3 to 8 carbon atoms, e.g., methoxyethyl.

Similarly, alkoxycarbonyl means an alkyl–O-CO- group in which the alkyl portion has 1 to 8 carbon atoms.

Alkenyl refers to straight-chain or branched-chain aliphatic radicals containing 2 to 12 carbon atoms in which one or more $-CH_2-CH_2-$ structures is replaced by –CH=CH-. Suitable alkenyl groups are ethenyl, 1-propenyl, 2-methylethenyl, 1-butene, 2-butene, 1-pentenyl, and 2-pentenyl. In the arylalkenyl groups, alkenyl refers to an alkyenylene group having preferably 2 to 5 carbon atoms.

Cycloalkyl means a monocyclic, bicyclic or tricyclic saturated hydrocarbon radical having 3 to 8 carbon atoms, preferably 4 to 6 carbon atoms, especially 5 carbon atoms. Suitable cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, and norbornyl. Other suitable cycloalkyl groups include spiropentyl, bicyclo[2.1.0]pentyl, bicyclo[3.1.0]hexyl, spiro[2.4]heptyl, spiro[2.5]octyl, bicyclo[5.1.0]octyl, spiro[2.6]nonyl, bicyclo[2.2.0]hexyl, spiro[3.3]heptyl, and bicyclo[4.2.0]octyl. The preferred cycloalkyl group is cyclopentyl.

The cycloalkyl group can be substituted by halogens, oxo and/or alkyl. Halogens and/or alkyl groups are preferred substituents.

Cycloalkylalkyl refers to a cycloalkyl-alkyl-radical in which the cycloalkyl and alkyl portions are in accordance with the previous descriptions. Suitable examples include cyclopentylethyl and cyclopropylmethyl.

Aryl, as a group or substituent per se or as part of a group or substituent, refers to an aromatic carbocyclic radical containing 6 to 14 carbon atoms, preferably 6 to 12 carbon atoms, especially 6 to 10 carbon atoms. Suitable aryl groups include phenyl, naphthyl and biphenyl. Substituted aryl groups include the above-described aryl groups which are substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl,

hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy (e.g., acetoxy).

Arylalkyl refers to an aryl-alkyl-radical in which the aryl and alkyl portions are in accordance with the previous descriptions. Suitable examples include 1-phenethyl, 2-phenethyl, phenpropyl, phenbutyl, phenpentyl, and naphthylenemethyl. Also, in the case of $R^3$, arylalkyl can be benzyl.

Arylalkenyl refers to an aryl-alkenyl-radical in which the aryl and alkenyl portions are in accordance with the previous descriptions of aryl and alkenyl. Suitable examples include 3-aryl-2-propenyl.

Heterocyclic groups refer to saturated, partially saturated and fully unsaturated heterocyclic groups having one or two rings and a total number of 5 to 10 ring atoms wherein at least one of the ring atoms is an N, O or S atom. Preferably, the heterocyclic group contains 1 to 3, especially 1 or 2, hetero-ring atoms selected from N, O and S. Suitable saturated and partially saturated heterocyclic groups include, but are not limited to tetrahydrofuranyl, tetrahydrothienyl, pyrrolidinyl, isoxazolinyl and the like. Suitable heteroaryl groups include but are not limited to furyl, thienyl, pyrrolyl, pyrazolyl, imidazolyl, pyridyl, pyrimidinyl, indolyl, quinolinyl, naphthyridinyl and the like. Preferred heterocyclic and heteroaryl groups include terahydrofuranyl, tetrahydropyranyl, 2-thienyl, 3-thienyl, 2-, 3- or 4-pyridyl, 2-, 3-, 4-, 5-, 6-, 7- or 8-quinolinyl, and 1-, 3-, 4-, 5-, 6-, 7- or 8-isoquinolinyl.

Substituted heterocyclic groups refer to the heterocyclic groups described above which are substituted in one or more places by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, and dialkylamino.

Heterocyclic-alkyl refers to a heterocyclic-alkyl-group wherein the heterocyclic and alkyl portions are in accordance with the previous discussions. Suitable examples are pyridylmethyl, thienylmethyl, pyrimidinylmethyl, pyrazinylmethyl, isoquinolinylmethyl, pyridylethyl and thienylethyl.

Partially unsaturated carbocyclic structures are non-aromatic monocyclic or bicyclic structures containing 5 to 14 carbon atoms, preferably 6 to 10 carbon atoms, wherein the ring structure(s) contains at least one C=C bond. Suitable examples are cyclopentenyl, cyclohexenyl, tetrahydronaphthenyl and indan-2-yl.

Acyl refers to alkanoyl radicals having 1 to 13 carbon atoms in which the alkyl portion can be substituted by halogen, hydroxy, carboxy, alkyl, aryl and/or alkoxy; or aroyl radicals having 7 to 15 carbon atoms in which the aryl portion can be substituted by halogen, alkyl, alkoxy, nitro, carboxy and/or hydroxy. Suitable acyl groups include formyl, acetyl, propionyl, butanoyl and benzoyl.

Substituted radicals preferably have 1 to 3 substituents, especially 1 to 2 substituents.

$R^1$ is preferably optionally substituted cycloalkyl, cycloalkylalkyl, aryl, heterocyclic, arylalkyl, or a partially unsaturated carbocyclic group, or is $CHF_2$; for example, $CHF_2$, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclopentylethyl, cyclopropylmethyl, phenyl, napthyl, phenethyl, phenpropyl, furanyl, pyrazinyl, pyrimidinyl, pyridyl, quinolinyl, isoquinolinyl, thienyl, indanyl, tetrahydrofuranyl, phenylpropenyl, substituted phenyl, and substituted phenethyl. Preferred substituents are oxo, F, Cl, $CF_3$, alkyl (such as methyl or ethyl), alkoxy (such as methoxy and ethoxy), CN, vinyl, methylenedioxy, COOH, and combinations thereof. When $R^3$ is other than H, $R^1$ is preferably cycloalkyl, cycloalkylalkyl or aryl, as well as $CHF_2$, heterocyclic and arylalkyl. In such a case $R^1$ is especially optionally substituted cyclopentyl and phenethyl as well as 3-tetrahydrofuranyl, $CHF_2$, and cyclopropylmethyl.

$R^2$ is preferably substituted or unsubstituted alkyl having 1 to 4 C atoms, most preferably $CHF_2$ and $CH_3$.

$R^3$ is preferably H, substituted or unsubstituted alkyl, substituted or unsubstituted arylalkyl, $CH_2CONHR^5$ or $COR^4$, especially H, substituted benzyl or $CH_2CONHR^5$. Examples of suitable $R^3$ groups include methyl, ethyl, propyl, n-butyl, methylbenzyl (e.g., 2-methylbenzyl), fluorobenzyl (e.g., 2-fluorobenzyl), difluorobenzyl (e.g., 2,3- or 2,6-difluorobenzyl), chlorobenzyl, methoxy, benzyl, cyanobenzyl, dichlorobenzyl, chlorofluorobenzyl, trifluoromethylbenzyl, and $(CF_3)_2$ benzyl.

$R^4$, if present, is preferably optionally substituted aryl such as phenyl, or is optionally substituted heterocyclic. Preferred substituents for $R^4$ are F, Cl, $CH_3$, $C_2H_5$, $OCH_3$, COOH, and CN.

$R^5$, if present, is preferably 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2-pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

In addition, preferred PDE4 inhibitors in accordance with the invention are compounds described by subformulas Ia-Io which correspond to formula I but exhibit the following preferred groups:

Ia $R^2$ is $CH_3$ or $CHF_2$.

Ib $R^2$ is $CH_3$ or $CHF_2$, and
$R^3$ is H.

Ic $R^3$ is H; and

$R^1$ is optionally substituted cycloalkyl, heterocyclic group, heterocyclic alkyl group, arylalkyl or cycloalkylalkyl, or is $CHF_2$.

Id $R^2$ is $CH_3$ or $CHF_2$;
$R^1$ is cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, as well as $CHF_2$ and phenethyl;
and
$R^3$ is not H.

Ie $R^2$ is $CH_3$ or $CHF_2$
$R^3$ is H; and
$R^1$ is phenethyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, phenpropyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, phenylbutyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, or 3-phenyl-2-propenyl.

If $R^1$ is 3(R)- tetrahydrofuramyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

Ig $R^1$ is cycloalkyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

Ih $R^1$ is cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, as well as $CHF_2$ and phenethyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

Ii $R^1$ is cyclopentyl, tetrahydrofuran, cyclopropylmethyl or $CHF_2$, as well as phenethyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is methylbenzyl, methoxybenzyl, chlorobenzyl, fluorobenzyl, trifluorobenzyl, difluorobenzyl, dichlorobenzyl, fluorochlorobenzyl, or bis(trifluoromethyl)benzyl.

Ij $R^1$ is cycloalkyl, heterocyclic group, or heterocyclic alkyl group, as well as $CHF_2$, cycloalkylalkyl, and arylalkyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is $CH_2CONHR^5$.

Ik $R^1$ is cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, as well as $CHF_2$ and phenethyl;
$R^2$ is $CH_3$ or $CHF_2$; and
$R^3$ is $CH_2CONHR^5$.

Il $R^1$ is cycloalkyl, heterocyclic group, or heterocyclicalkyl group, as well as $CHF_2$ and cycloalkylalkyl;
$R^2$ is $CH_3$ or $CHF_2$;
$R^3$ is $CH_2CONHR^5$; and
$R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

Im $R^1$ is cycloalkyl, heterocyclic group, or heterocyclicalkyl group , as well as $CHF_2$ and cycloalkylalkyl;
$R^2$ is $CH_3$ or $CHF_2$;
$R^3$ is $CH_2CONHR^5$; and
$R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl,4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

In $R^1$ is cyclopentyl, tetrahydrofuran, or cyclopropylmethyl as well as $CHF_2$;
$R^2$ is $CH_3$ or $CHF_2$;
$R^3$ is $CH_2CONHR^5$; and
$R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

Io $R^1$ is cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, as well as $CHF_2$;
$R^2$ is $CH_3$ or $CHF_2$;
$R^3$ is $CH_2CONHR^5$; and
$R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

According to a further preferred compound aspect of the invention, the compound of formula I is selected from:
4-[4-Methoxy-3-(4-methoxyphenoxy)phenyl]-2-pyrrolidone,
4-[4-Methoxy-3-(3-thienyloxy)phenyl]-2-pyrrolidone,
4-[3-(4-Fluorophenoxy)-4-methoxyphenyl]-2-pyrrolidone,

4-(3-(3-Cyclohexyl-1-propyloxy)-4-methoxyphenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(2-phenylethoxy)phenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(3-phenyl-1-propoxy)phenyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-chloro-4-fluorobenzyl)-2-pyrrolidone,
Methyl 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyanomethyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyclopentyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-methoxybenzoyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, or

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

According to a further preferred compound aspect of the invention, the compound of formula I is selected from:

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,
(4*S*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,

(4*S*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,
(4*S*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,
(4*S*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,
(4*R*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,

(4*R*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,
(4*R*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,
(4*R*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4R)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4S)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-chlorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methoxyphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-chloro-2-fluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-nitrophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2,3-difluorophenyl)-amino carbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
1-(N-(2-(6-Aminopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-ethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,6-dimethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-methoxypyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(6-(3-Bromo-2-methylpyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxycarbonyl)-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(3-(2-Cyanopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone, or
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, or

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

Accordingly to a preferred method aspect of the invention, the compound of formula I is selected from:
4-[4-Methoxy-3-(4-methoxyphenoxy)phenyl]-2-pyrrolidone,
4-[4-Methoxy-3-(3-thienyloxy)phenyl]-2-pyrrolidone,
4-[3-(4-Fluorophenoxy)-4-methoxyphenyl]-2-pyrrolidone,
4-(3-(3-Cyclohexyl-1-propyloxy)-4-methoxyphenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(2-phenylethoxy)phenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(3-phenyl-1-propoxy)phenyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-chloro-4-fluorobenzyl)-2-pyrrolidone,
Methyl 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyanomethyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyclopentyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-methoxybenzoyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,
(4*S*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-nitrobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-nitrobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-benzyl-2-pyrrolidone,
(4*S*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,
(4*S*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,
(4*S*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,
(4*S*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,
(4*R*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-nitrobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-nitrobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-benzyl-2-pyrrolidone,
(4*R*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,
(4*R*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,
(4*R*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4R)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4S)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-chlorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methoxyphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-chloro-2-fluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-nitrophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(*R*)-[4-Methoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone,
4-(*S*)-[4-Methoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone,
4-(*R*)-[4-Methoxy-3-(3-(*S*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone,
4-(*S*)-[4-Methoxy-3-(3-(*S*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone,
4-[4-Difluoromethoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone,
4-[4-Difluoromethoxy-3-(2-cyclohexylethoxy)phenyl]-2-pyrrolidone,
4-[4-Difluoromethoxy-3-(2-phenylethoxy)phenyl]-2-pyrrolidone,
4-[4-Difluoromethoxy-3-(cyclopropylmethoxy)phenyl]-2-pyrrolidone,
4-[4-Difluoromethoxy-3-cyclopentoxyphenyl]-2-pyrrolidone,

4-[4-Difluoromethoxy-3-cyclopbutylmethoxyphenyl]-2-pyrrolidone,
(4*R*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*S*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*S*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*R*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*R*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4*R*)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-chloropyridinyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-pyridylethyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-(*N*-methylpyrrolidinyl)ethyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridylmethyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(1-imidazoylpropyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-(4-methylpiperazinyl))-hydrazinocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(*N*-methylpyrrolidinyl)methyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyrimidinyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(5-methylisoxazolyl))-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylpiperazinyl)-hydrazinocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,5-dimethylthiazolyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-methylpiperidinylethyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3,4-dimethoxyphenethyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-pyridinyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-pyridinyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2,4-dimethoxypyridinyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxypyridinyl))-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-aniline)-aminocarbonylmethyl)-2-pyrrolidone, 4-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
1-(N-(2-(6-Aminopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-ethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,6-dimethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,

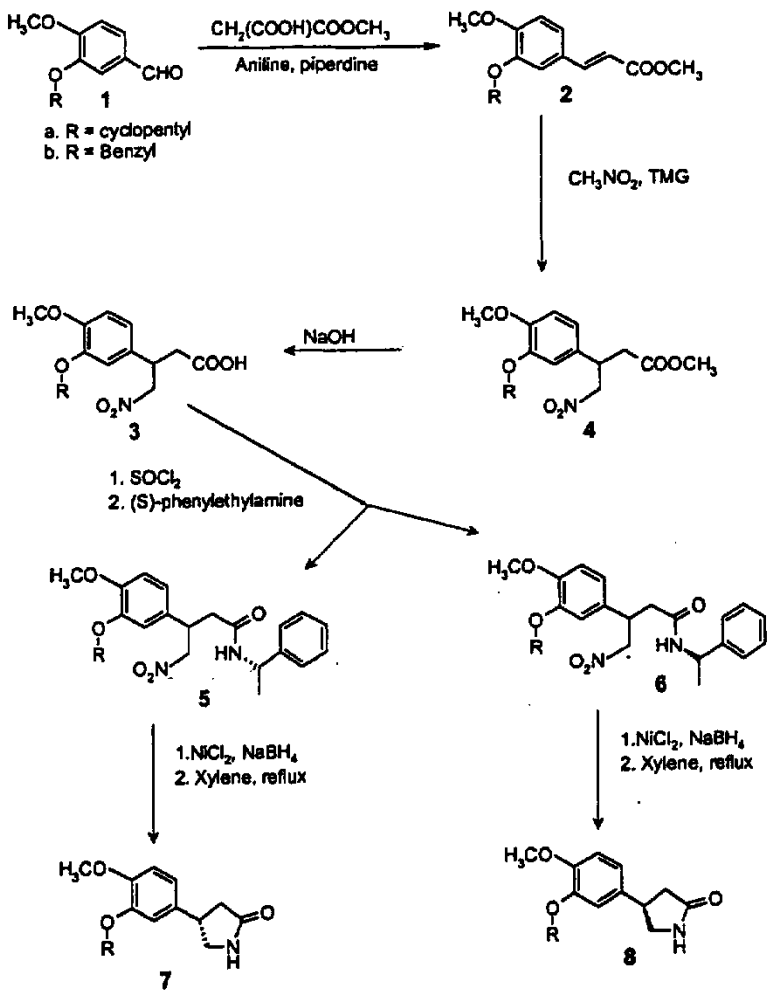
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-methoxypyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(6-(3-Bromo-2-methylpyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxycarbonyl)-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(3-(2-Cyanopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone, or
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, or

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

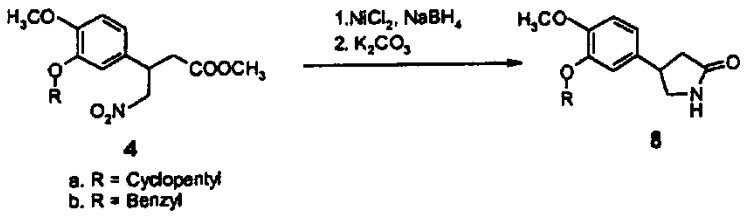
Preferred aspects include pharmaceutical compositions comprising a compound of this invention and a pharmaceutically acceptable carrier and, optionally, another active agent as discussed below; a method of inhibiting a PDE4 enzyme, especially an isoenzyme, e.g., as determined by a conventional assay or one described herein, either *in vitro* or *in vivo* (in an animal, e.g., in an animal model, or in a mammal or in a human); a method of treating a neurological syndrome, e.g., loss of memory, especially long-term memory, cognitive impairment or decline, memory impairment, etc.; a method of treating a disease state modulated by PDE4 activity, in a mammal, e.g., a human, e.g., those disease states mentioned herein.

The compounds of the present invention may be prepared conventionally. Some of the known processes that can be used are described below. All starting materials are known or can be conventionally prepared from known starting materials.

Preparation of starting material (Scheme I)




Enantiomerically pure rolipram, 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone, and the starting material 4-(3-benzyloxy-4-methoxyphenyl)-2-pyrrolidone were prepared as shown in scheme I and in a similar fashion as described previously (J. Demnitz, et.al., Enantiodivergent synthesis of (*R*)-and (*S*)-Rolipram , *Molecules*, 1998, *3*, 107-119). Thus, appropriately substituted benzaldehydes were condensed with monomethyl

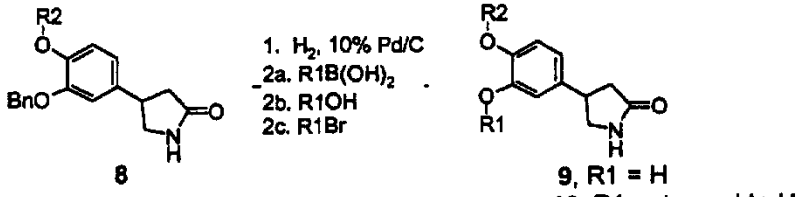


malonate to provide the corresponding methyl cinnamyl esters after decarboxylation. Conjugate addition of nitromethane using tetramethyl guanidine as base provided methyl 4-nitro-3-(substituted-phenyl)butyrate. Racemic 4-(3-benzyloxy-4-methoxyphenyl)-2-pyrrolidone was produced in 85% yield by selective reduction of the nitro group to the corresponding amine using $NiCl_2$ and $NaBH_4$ (Osby, J.O.; Ganem, B., Rapid and efficient reduction of aliphatic nitro compounds to amines, *Tetrahedron Lett.*, 1985, *26*, 6413-6416) and subsequent treatment with $K_2CO_3$.

Methyl 4-nitro-3-(substituted-phenyl)butyrate was enantiomerically resolved by synthesizing diastereomeric phenethylamine amides as shown in scheme I. Nitro group reduction by catalytic hydrogenation as described by Demnitz, J. *Molecules*, 1998, *3*, 107-119 was not successful. However, reduction of the diastereomerically pure nitro amides using $NiCl_2$ and $NaBH_4$ produced 90% yield of the corresponding diastereomerically pure amines. Cyclization by warming to reflux in xylene yielded 51% of (*S*)-(+)-rolipram and 24% of (*R*)-(-)-rolipram, both in better than 99% ee as determined by chiral HPLC (Kusters, E.; Spondlin, C.; Influence of temperature on the enantioseparation of rolipram and structurally related racemates on Chiralcel-OD, *J. Chromatogrampy A*, 1996, *737*, 333-337). Enantiomerically pure 3-benzyloxy derivatives 8 (R=benzyl) were produced in similar yield and purity after cyclization.

3-Aryloxy rolipram derivatives were prepared by cross coupling reaction with aryl boronic acids using a copper catalyst in the presence of an amine base. Suitable copper catalysts include copper diacetate, copper (II) chloride, etc. Generally, halogenated solvents are utilized such as chloroform, dichloromethane, 1,2-dichloroethane, and the like. Commonly used bases include triethylamine, diisopropylamine, and pyrrolidine. Alternatively, 3-phenyloxyrolipram can be prepared by Ullman type coupling starting with iodobenzene and 3-hydroxyrolipram as described previously (Schmiechen, R.; Horowski, R.; Palenschat, D.; Paschelke, G.; Wachtel, H.; Kehr, W., 4-(polyalkoxyphenyl)-2-pyrrolidones., US Patent 4,193,926, filed Mar. 18, 1980). Compounds substituted at the 3-position with arylalkyl, alkyl, cycloalkyl, heteroalkyl or cycloalkylalkyl groups can be prepared by either Mitsunobu reaction

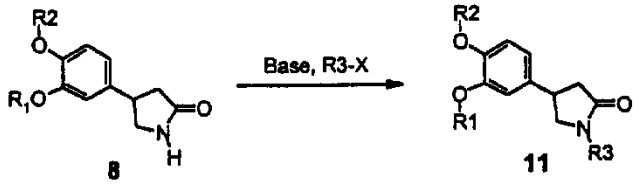
between phenol 9 ($R^1$ = H) and alcohol or by an alkylaton reaction between phenol 9 ($R^1$ = H) and $R^1X$, where X is a suitable leaving group such as Cl, Br, methanesulphonyl, tosyloxy, etc.




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2a: $R^1$ = aryl or heteroaryl
2b: $R^1$ = arylalkyl, alkyl, cycloalkyl, cycloalkyl alkyl
2c: $R^1$ = arylalkyl, alkyl, cycloalkyl, cycloalky alkyl

A series of enantiomerically pure *N*-substituted rolipram derivatives were synthesized by methods common to the art (Christensen, S.B., et.al, 1,4-Cyclohexanecarboxylates: Potent and selective inhibitors of Phosophodiesterase 4 for the treatment of asthma, *J. Med. Chem.*, 1998, *41*, 821-835.). Thus, the target compounds

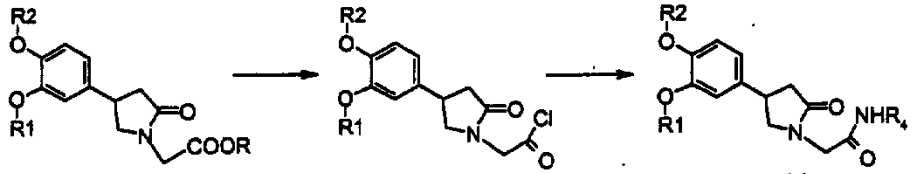



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can be provided by alkylation reaction with alkyl halides, cycloalkyl halides, arylacyl chlorides, alpha bromoacetates, appropriately substituted alpha-bromides, and arylalkyl halides (i.e., benzylbromides) in polar aprotic solvents (i.e., DMF, THF, DMSO) using a non-nucleophilic base such as NaH or LDA, and a phase transfer catalyst such as 15-crown-5 ether.

Reaction of methyl alpha-bromoacetate with a rolipram derivative as described above produces methyl N-acetates 12 (R = $CH_3$), which can be saponified to the acid 12 (R=H) by treatment with a base, such as NaOH or KOH, and then converted to the acid chloride 13 by any number of reagents, such as thionyl chloride or oxalyl chloride. Such acid chlorides undergo reaction with a number of nucleophiles including anilines to provide compounds of type 14.

Alternatively, the acid 12 (R=H) undergoes coupling reactions with amines and a suitable coupling reagent such as DCC or HBTU in the presence of an aprotic solvent such as dichloromethane or THF to produce amides of the type 14. In certain instances where $R^1$ is a protecting group such as benzyl this group can be selectively removed from 14 to give the corresponding ($R^1$ = H). This phenol can then be substituted by common methods in the art such as by reaction with cyclopentyl bromide in the presence of a suitable base or by a Mitsunobu reaction with 3(S)-hydroxy-tetrahydrofuran to generate desired target compounds.




R = H, $C_{1-4}$-alkyl

One of ordinary skill in the art will recognize that some of the compounds of Formula (I) can exist in different geometrical isomeric forms. In addition, some of the compounds of the present invention possess one or more asymmetric carbon atoms and are thus capable of existing in the form of optical isomers, as well as in the form of racemic or nonracemic mixtures thereof, and in the form of diastereomers and diastereomeric mixtures *inter alia*. For example, in the pyrrolidone structure, the carbon atom at the 4-ring position will be chiral. All of these compounds, including *cis* isomers, *trans* isomers, diastereomic mixtures, racemates, nonracemic mixtures of enantiomers, substantially pure, and pure enantiomers, are within the scope of the present invention. Substantially pure enantiomers contain no more than 5% w/w of the corresponding opposite enantiomer, preferably no more than 2%, most preferably no more than 1%.

In the compounds of formula I, when $R^3$ is H, the 4(R) enantiomers are preferred, and when $R^3$ is other than H, the 4(S)-enantiomers are preferred. When $R^1$ is 3-tetrahydrofuran the 3(R) enantiomers are preferred over the 3(S) enantiomers.

The optical isomers can be obtained by resolution of the racemic mixtures according to conventional processes, for example, by the formation of diastereoisomeric salts using an optically active acid or base or formation of covalent diastereomers. Examples of appropriate acids are tartaric, diacetyltartaric, dibenzoyltartaric, ditoluoyltartaric and camphorsulfonic acid. Mixtures of diastereoisomers can be separated into their individual diastereomers on the basis of their physical and/or chemical differences by methods known to those skilled in the art, for example, by chromatography or fractional crystallization. The optically active bases or acids are then liberated from the separated diastereomeric salts. A different process for separation of optical isomers involves the use of chiral chromatography (e.g., chiral HPLC columns), with or without conventional derivation, optimally chosen to maximize the separation of the enantiomers. Suitable chiral HPLC columns are manufactured by Diacel, e.g., Chiracel OD and Chiracel OJ among many others, all routinely selectable. Enzymatic separations, with or without derivitization, are also useful. The optically active compounds of Formula I can likewise be obtained by utilizing optically active starting materials in chiral syntheses processes under reaction conditions which do not cause racemization.

In addition, one of ordinary skill in the art will recognize that the compounds can be used in different enriched isotopic forms, e.g., enriched in the content of $^{2}H$, $^{3}H$, $^{11}C$, $^{13}C$ and/or $^{14}C$. In one particular embodiment, the compounds are deuterated. Such deuterated forms can be made the procedure described in U.S. Patent Nos. 5,846,514 and 6,334,997. As described in U.S. Patent Nos. 5,846,514 and 6,334,997, deuteration can improve the efficacy and increase the duration of action of drugs.

Deuterium substituted compounds can be synthesized using various methods such as described in: Dean, Dennis C.; Editor. Recent Advances in the Synthesis and Applications of Radiolabeled Compounds for Drug Discovery and Development. [In: Curr., Pharm. Des., 2000; 6(10)] (2000), 110 pp. CAN 133:68895 AN 2000:473538 CAPLUS; Kabalka, George W.; Varma, Rajender S. The synthesis of radiolabeled

compounds VIA organometallic intermediates. Tetrahedron (1989), 45(21), 6601-21, CODEN: TETRAB ISSN:0040-4020. CAN 112:20527 AN 1990:20527 CAPLUS; and Evans, E. Anthony. Synthesis of radiolabeled compounds, J. Radioanal. Chem. (1981), 64(1-2), 9-32. CODEN: JRACBN ISSN:0022-4081, CAN 95:76229 AN 1981:476229 CAPLUS.

The present invention also relates to useful forms of the compounds as disclosed herein, such as pharmaceutically acceptable salts or prodrugs of all the compounds of the present invention for which salts or prodrugs can be prepared. Pharmaceutically acceptable salts include those obtained by reacting the main compound, functioning as a base, with an inorganic or organic acid to form a salt, for example, salts of hydrochloric acid, sulfuric acid, phosphoric acid, methane sulfonic acid, camphor sulfonic acid, oxalic acid, maleic acid, succinic acid and citric acid. Pharmaceutically acceptable salts also include those in which the main compound functions as an acid and is reacted with an appropriate base to form, e.g., sodium, potassium, calcium, magnesium, ammonium, and choline salts. Those skilled in the art will further recognize that acid addition salts of the claimed compounds may be prepared by reaction of the compounds with the appropriate inorganic or organic acid via any of a number of known methods. Alternatively, alkali and alkaline earth metal salts are prepared by reacting the compounds of the invention with the appropriate base via a variety of known methods.

The following are further examples of acid salts that can be obtained by reaction with inorganic or organic acids: acetates, adipates, alginates, citrates, aspartates, benzoates, benzenesulfonates, bisulfates, butyrates, camphorates, digluconates, cyclopentanepropionates, dodecylsulfates, ethanesulfonates, glucoheptanoates, glycerophosphates, hemisulfates, heptanoates, hexanoates, fumarates, hydrobromides, hydroiodides, 2-hydroxy-ethanesulfonates, lactates, maleates, methanesulfonates, nicotinates, 2-naphthalenesulfonates, oxalates, palmoates, pectinates, persulfates, 3-phenylpropionates, picrates, pivalates, propionates, succinates, tartrates, thiocyanates, tosylates, mesylates and undecanoates.

Preferably, the salts formed are pharmaceutically acceptable for administration to mammals. However, pharmaceutically unacceptable salts of the compounds are suitable as intermediates, for example, for isolating the compound as a salt and then converting the salt back to the free base compound by treatment with an alkaline reagent. The free base can then, if desired, be converted to a pharmaceutically acceptable acid addition salt.

The compounds of the invention can be administered alone or as an active ingredient of a formulation. Thus, the present invention also includes pharmaceutical compositions of compounds of Formula I, containing, for example, one or more pharmaceutically acceptable carriers.

Numerous standard references are available that describe procedures for preparing various formulations suitable for administering the compounds according to the invention. Examples of potential formulations and preparations are contained, for example, in the Handbook of Pharmaceutical Excipients, American Pharmaceutical Association (current edition); Pharmaceutical Dosage Forms: Tablets (Lieberman, Lachman and Schwartz, editors) current edition, published by Marcel Dekker, Inc., as well as Remington's Pharmaceutical Sciences (Arthur Osol, editor), 1553-1593 (current edition).

In view of their high degree of selective PDE4 inhibition, the compounds of the present invention can be administered to anyone requiring PDE4 inhibition. Administration may be accomplished according to patient needs, for example, orally, nasally, parenterally (subcutaneously, intraveneously, intramuscularly, intrasternally and by infusion) by inhalation, rectally, vaginally, topically and by ocular administration.

Various solid oral dosage forms can be used for administering compounds of the invention including such solid forms as tablets, gelcaps, capsules, caplets, granules, lozenges and bulk powders. The compounds of the present invention can be administered alone or combined with various pharmaceutically acceptable carriers, diluents (such as sucrose, mannitol, lactose, starches) and excipients known in the art, including but not

limited to suspending agents, solubilizers, buffering agents, binders, disintegrants, preservatives, colorants, flavorants, lubricants and the like. Time release capsules, tablets and gels are also advantageous in administering the compounds of the present invention.

Various liquid oral dosage forms can also be used for administering compounds of the inventions, including aqueous and non-aqueous solutions, emulsions, suspensions, syrups, and elixirs. Such dosage forms can also contain suitable inert diluents known in the art such as water and suitable excipients known in the art such as preservatives, wetting agents, sweeteners, flavorants, as well as agents for emulsifying and/or suspending the compounds of the invention. The compounds of the present invention may be injected, for example, intravenously, in the form of an isotonic sterile solution. Other preparations are also possible.

Suppositories for rectal administration of the compounds of the present invention can be prepared by mixing the compound with a suitable excipient such as cocoa butter, salicylates and polyethylene glycols. Formulations for vaginal administration can be in the form of a pessary, tampon, cream, gel, paste, foam, or spray formula containing, in addition to the active ingredient, such suitable carriers as are known in the art.

For topical administration the pharmaceutical composition can be in the form of creams, ointments, liniments, lotions, emulsions, suspensions, gels, solutions, pastes, powders, sprays, and drops suitable for administration to the skin, eye, ear or nose. Topical administration may also involve transdermal administration via means such as transdermal patches.

Aerosol formulations suitable for administering via inhalation also can be made. For example, for treatment of disorders of the respiratory tract, the compounds according to the invention can be administered by inhalation in the form of a powder (e.g., micronized) or in the form of atomized solutions or suspensions. The aerosol formulation can be placed into a pressurized acceptable propellant.

The compounds can be administered as the sole active agent or in combination with other pharmaceutical agents such as other agents used in the treatment of cognitive impairment and/or in the treatment of psychosis, e.g., other PDE4 inhibitors, calcium channel blockers, chloinergic drugs, adenosine receptor modulators, amphakines NMDA-R modulators, mGluR modulators, and cholinesterase inhibitors (e.g., donepezil, rivastigimine, and glanthanamine). In such combinations, each active ingredient can be administered either in accordance with their usual dosage range or a dose below their usual dosage range.

The present invention further includes methods of treatment that involve inhibition of PDE4 enzymes. Thus, the present invention includes methods of selective inhibition of PDE4 enzymes in animals, e.g., mammals, especially humans, wherein such inhibition has a therapeutic effect, such as where such inhibition may relieve conditions involving neurological syndromes, such as the loss of memory, especially long-term memory. Such methods comprise administering to an animal in need thereof, especially a mammal, most especially a human, an inhibitory amount of a compound, alone or as part of a formulation, as disclosed herein.

The condition of memory impairment is manifested by impairment of the ability to learn new information and/or the inability to recall previously learned information. Memory impairment is a primary symptom of dementia and can also be a symptom associated with such diseases as Alzheimer's disease, schizophrenia, Parkinson's disease, Huntington's disease, Pick's disease, Creutzfeld-Jakob disease, HIV, cardiovascular disease, and head trauma as well as age-related cognitive decline.

Dementias are diseases that include memory loss and additional intellectual impairment separate from memory. The present invention includes methods for treating patients suffering from memory impairment in all forms of dementia. Dementias are classified according to their cause and include: neurodegenerative dementias (Alzheimer's, Parkinson's disease, Pick's disease), vascular (Infarcts, Hemorrhage, Cardiac Disorders), mixed vascular and Alzheimer's, bacterial meningitis, Creutzfeld-

Jacob Disease, and multiple sclerosis), traumatic (subdural hematoma or traumatic brain injury), infectious (HIV), toxic (heavy metals, alcohol, medications), metabolic (Vitamin $B_{12}$ or folate deficiency), CNS hypoxia, Cushing's disease, psychiatric (depression and schizophrenia) and hydrocephalus.

The present invention also includes methods for treating memory loss separate from dementias, including mild cognitive impairment (MCI) and age-related cognitive decline. The present invention includes methods of treatment for memory impairment as a result of disease including Huntington's disease and Down's syndrome. According to another aspect, the invention includes methods for treating memory loss from anesthetics, chemotherapy, radiation treatment, and post-surgical trauma.

The compounds of the invention can also be used to treat schizophrenia, bipolar or manic depression, major depression, and drug addiction. PDE4 inhibitors can be used to raise cAMP levels and prevent neurons from undergoing apoptosis. PDE4 inhibitors are also known to be anti-inflammatory. The combination of preventing neuronal apoptosis and inhibiting inflammatory responses make these compounds useful to treat neurodegeneration resulting from any disease or injury, including stroke, Alzheimer's disease, multiple sclerosis, amyolaterosclerosis (ALS), and multiple systems atrophy (MSA).

Thus, in accordance with a preferred embodiment, the present invention includes methods of treating patients suffering from memory impairment due to, for example, mild cognitive impairment due to aging, Alzheimer's disease, schizophrenia, Parkinson's disease, Huntington's disease, Pick's disease, Creutzfeld-Jakob disease, depression, aging, head trauma, stroke, CNS hypoxia, cerebral senility, multiinfarct dementia and other neurological conditions, as well as HIV and cardiovascular diseases, comprising administering an effective amount of a compound according to formula (I) or a pharmaceutically acceptable salt thereof.

As mentioned, the compounds of the invention also exhibit anti-inflammatory activity. As a result, the inventive compounds are useful in the treatment of a variety of allergic and inflammatory diseases, particularly disease states characterized by decreased cyclic AMP levels and/or elevated phosphodiesterase 4 levels. Thus, in accordance with a further embodiment of the invention, there is provided a method of treating allergic and inflammatory disease states, comprising administering an effective amount of a compound according to formula (I) or a pharmaceutically acceptable salt thereof. Such disease states include: asthma, chronic bronchitis, chronic obstructive pulmonary disease (COPD), atopic dermatitis, urticaria, allergic rhinitis, allergic conjunctivitis, vernal conjunctivitis, esoniophilic granuloma, psoriasis, inflammatory arthritis, rheumatoid arthritis, septic shock, ulcerative colitis, Crohn's disease, reperfusion injury of the myocardium and brain, chronic glomerulonephritis, endotoxic shock, adult respiratory distress syndrome, cystic fibrosis, arterial restenosis, artherosclerosis, keratosis, rheumatoid spondylitis, osteoarthritis, pyresis, diabetes mellitus, pneumoconiosis, chronic obstructive airways disease, chronic obstructive pulmonary disease, toxic and allergic contact eczema, atopic eczema, seborrheic eczema, lichen simplex, sunburn, pruritis in the anogenital area, alopecia areata, hypertrophic scars, discoid lupus erythematosus, follicular and wide-area pyodermias, endogenous and exogenous acne, acne rosacea, Beghet's disease, anaphylactoid purpura nephritis, inflammatory bowel disease, leukemia, multiple sclerosis, gastrointestinal diseases, autoimmune diseases, osteoporosis, and the like. The compounds can also be used in a method of treating patients suffering from disease states characterized by decreased NMDA function, such as schizophrenia. The compounds can also be used to treat psychosis characterized by elevated levels of PDE 4, for example, various forms of depression, such as manic depression, major depression, and depression associated with psychiatric and neurological disorders.

The use of trisubstituted phenyl derivatives for treating asthma, chronic bronchitis, psoriasis, allergic rhinitis, and other inflammatory diseases, and for inhibiting tumor necrosis factor is known within the art. See, e.g., WO 98/58901, JP11-18957, JP 10-072415, WO 93/25517, WO 94/14742, US 5,814,651, and US 5,935,978. These

references describe 1,3,4-trisubstituted phenyl compounds said to exhibit PDE4 inhibition activity. They also describe assays for determining PDE4 inhibition activity, and methods for synthesizing such compounds. The entire disclosures of these documents are hereby incorporated by reference.

PDE4 inhibitors may be used to prevent or ameliorate osteoporosis, as an antibiotic, for treatment of cardiovascular disease by mobilizing cholesterol from atherosclerotic lesions, to treat rheumatoid arthritis (RA), for long-term inhibition of mesenchymal-cell proliferation after transplantation, for treatment of urinary obstruction secondary to benign prostatic hyperplasia, for suppression of chemotaxis and reduction of invasion of colon cancer cells, for treatment of B cell chronic lymphocytic leukemia (B-CLL), for inhibition of uterine contractions, to attenuate pulmonary vascular ischemia-reperfusion injury (IRI) , for corneal hydration , for inhibition of IL-2R expression and thereby abolishing HIV-1 DNA nuclear import into memory T cells, for augmentation of glucose-induced insulin secretion, in both the prevention and treatment of colitis, and to inhibit mast cell degranulation.

The compounds of the present invention can be administered as the sole active agent or in combination with other pharmaceutical agents such as other agents used in the treatment of cognitive impairment and/or in the treatment of psychosis, e.g., other PDE4 inhibitors, calcium channel blockers, chloinergic drugs, adenosine receptor modulators, amphakines NMDA-R modulators, mGluR modulators, and cholinesterase inhibitors (e.g., donepezil, rivastigimine, and glanthanamine). In such combinations, each active ingredient can be administered either in accordance with their usual dosage range or a dose below their usual dosage range.

The dosages of the compounds of the present invention depend upon a variety of factors including the particular syndrome to be treated, the severity of the symptoms, the route of administration, the frequency of the dosage interval, the particular compound utilized, the efficacy, toxicology profile, pharmacokinetic profile of the compound, and the presence of any deleterious side-effects, among other considerations.

The compounds of the invention are typically administered at dosage levels and in a mammal customary for PDE4 inhibitors such as those known compounds mentioned above. For example, the compounds can be administered, in single or multiple doses, by oral administration at a dosage level of generally 0.001-100mg/ky/day, for example, 0.01-100 mg/kg/day, preferably 0.1-70 mg/kg/day, especially 0.5-10 mg/kg/day. Unit dosage forms can contain generally 0.01-1000 mg of active compound, for example, 0.1-50 mg of active compound. For intravenous administration, the compounds can be administered, in single or multiple dosages, at a dosage level of, for example, 0.001-50 mg/kg/day, preferably 0.001-10 mg/kg/day, especially 0.01-1 mg/kg/day. Unit dosage forms can contain, for example, 0.1-10 mg of active compound.

In carrying out the procedures of the present invention it is of course to be understood that reference to particular buffers, media, reagents, cells, culture conditions and the like are not intended to be limiting, but are to be read so as to include all related materials that one of ordinary skill in the art would recognize as being of interest or value in the particular context in which that discussion is presented. For example, it is often possible to substitute one buffer system or culture medium for another and still achieve similar, if not identical, results. Those of skill in the art will have sufficient knowledge of such systems and methodologies so as to be able, without undue experimentation, to make such substitutions as will optimally serve their purposes in using the methods and procedures disclosed herein.

The present invention will now be further described by way of the following non-limiting examples. In applying the disclosure of these examples, it should be kept clearly in mind that other and different embodiments of the methods disclosed according to the present invention will no doubt suggest themselves to those of skill in the relevant art.

In the foregoing and in the following examples, all temperatures are set forth uncorrected in degrees Celsius; and, unless otherwise indicated, all parts and percentages are by weight.

The entire disclosures of all applications, patents and publications, cited above and below, are hereby incorporated by reference.

## EXAMPLES

**Intermediate A**

**4-(3-Benzyloxy-4-methoxyphenyl)-2-pyrrolidone**

To a mixture of 8.3 g (34.8 mmol) of $NiCl_2$-$6H_20$ in 750 mL of MeOH was slowly added 14 g (104.5 mmol) of $NaBH_4$. This mixture was stirred for 30 minutes at 0 °C and a solution of 25 g of methyl 3-(3-benzyloxy-4-methoxyphenyl)-4-nitrobutanoate in 500 mL of MeOH was added. Then, 8.3 g (34.8 mmol) of $NiCl_2$-$6H_2O$ was added to the reaction mixture, followed by the slow portion-wise addition of 9.2 g (243 mmol) of $NaBH_4$. The mixture stirred at 0 °C for 1 hour and then 150 g of $K_2CO_3$ was added in one portion. The mixture was allowed to warm to ambient temperature and stirring continued for 18 hours. The suspension was filtered through a pad of celite, washed with 2 x 1000 mL of MeOH and concentrated. The residue was taken up in 2000 mL of EtOAc and the organic fraction was successively washed with 200 mL of $H_2O$, 250 mL of brine, dried ($Na_2SO_4$) and concentrated to a solid. Trituration with hexanes/EtOAc provided 13 g of the desired product. An additional 2.3 g of product was obtained by extracting the aqueous fractions with EtOAc and combining this with the trituration solvent, concentrating and triturating with EtOAc/hexanes. Total yield was 15.3 g (74% yield). $^1$H NMR (400 MHz, $CDCl_3$) δ 7.44–7.26 (m, 5H), 6.87-6.70 (m, 3H), 5.75 (bs, 1H), 5.14 (s, 2H), 3.87 (s, 3H), 3.70-3.50 (m, 2H), 3.28 (t, 1H), 2.70-2.63 (m, 1H), 2.42-2.35 (m, 1H).

4-(3-Benzyloxy-4-difluoromethoxyphenyl)-2-pyrrolidone was prepared in a similar manner starting with methyl 3-(3-benzyloxy-4-difluoromethoxyphenyl)-4-nitrobutanoate.

**Intermediate B**

**4-(3-Hydroxy-4-methoxyphenyl)-2-pyrrolidone**

A mixture of 3.5 g (11.6 mmol) 4-(3-Benzyloxy-4-methoxyphenyl)-2-pyrrolidone and 350 mg of 10% Pd/C in 50 mL of MeOH and 10 mL of $CH_2Cl_2$ was shaken on a Paar apparatus under 20 psi $H_2$ for 8 hours. The mixture was filtered through celite and concentrated leaving 2.4 g (99% yield) of crude material used as such for Examples 1 through 3. $^1$H NMR (300 MHz, $CDCl_3$) δ 6.82 (s, 1H), 6.79 (d, J=7.6 Hz, 1H), 6.70 (d, J=7.6Hz, 1H), 6.50 (s, 1H), 3.87 (s, 3H), 3.77 (t, J=8.4Hz, 1H), 3.62 (t, J=8.0Hz, 1H), 3.40 (t, J=8.4Hz, 1H), 2.71 (dd, J=16.8, 8.8 Hz, 1H), 2.49 (dd, J= 16.8, 9.0 Hz, 1H).

4-(4-Difluoromethoxy-3-hydroxyphenyl)-2-pyrrolidone was prepared in a similar fashion starting with 4-(3-benzyloxy-4-difluoromethoxyphenyl)-2-pyrrolidone

**Example 1**

**4-(4-Chlorophenoxy-3-methoxyphenyl)-2-pyrrolidone**

A mixture of 4-(3-hydroxy-4-methoxyphenyl)-2-pyrrolidone (63 mg, 0.3 mmol), 4-chlorophenylboronic acid (61 mg, 0.45 mmol), copper (II) acetate (54 mg, 0.3 mmol), triethylamine (152 mg, 1.5 mmol), dichloromethane (3 ml) and small amount of molecular sieves is allowed to stir at ambient temperature. After 18 hours, the mixture is filtered over celite and the filtrate is concentrated under vacuum. The resulting residue is dissolved in 30 ml of ethyl acetate and washed successively with saturated aqueous sodium bicarbonate solution and brine. Purification by flash column chromatography (ethyl acetate/hexane 1:1 to methanol/dichloromethane 3:97) gives 26 mg (27%) of 4-(3-(4-chlorophenyloxy)-4-methoxyphenyl)-2-pyrrolidone: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.24 (d, $J$ = 9.2 Hz, 2 H), 7.03 (d, $J$ = 8.4 Hz, 1H), 6.95(d, $J$ = 8.4 Hz, 1H), 6.87 (s, 1H), 6.83(d, $J$ = 9.2 Hz, 2H), 5.83 (b, 1H), 3.80 (s, 3H), 3.72 (t, $J$ =8.4 Hz, 1H), 3.65-3.62 (m, 1H), 3.34 (t, $J$ = 8.4 Hz, 1H), 2.68 (dd, $J$ = 16.8, 8.8 Hz, 1H), 2.41 (dd, $J$ = 16.8, 9.2 Hz, 1H).

The following compounds were prepared in a similar fashion starting with different arylboronic acids and aryl vinyl boronic acids:

A. 4-(4-Methoxy-3-phenoxyphenyl)-2-pyrrolidone

B. 4-[4-Methoxy-3-(4-methoxyphenoxy)phenyl]-2-pyrrolidone

C. 4-[4-Methoxy-3-(3-thienyloxy)phenyl]-2-pyrrolidone

D. 4-[3-(4-Fluorophenoxy)-4-methoxyphenyl]-2-pyrrolidone

E. 4-[3-Cyanophenoxy-4-methoxyphenyl]-2-pyrrolidone

F. 4-[4-Methoxy-3-naphthyloxyphenyl]-2-pyrrolidone

G. 4-[4-Methoxy-3-((2-phenyl)ethenyloxy)phenyl]-2-pyrrolidone

H. 4-[4-Methoxy-3-((2-(4-chlorophenyl)ethenyloxy)phenyl]-2-pyrrolidone

The separate enantiomers of racemic compounds listed above can be obtained through the use of optically active starting materials or by conventional resolution techniques such as chiral HPLC.

**Example 2**

**4-(3-Cinnamyloxy-4-methoxyphenyl)-2-pyrrolidone**

Diisopropylazodicarboxylate (61 mg, 0.6 mmol) is added to a solution of 4-(3-hydroxy-4-methoxyphenyl)-2-pyrrolidone (63 mg, 0.3 mmol), cinnamyl alcohol (43 mg, 0.3 mmol) and triphenyl phosphine (157 mg, 0.6 mmol) in 3 ml of tetrahydrofuran and the reaction mixture is stirred at 70° C. After 12 hours, the same work-up procedure as in Example 1 yields 70 mg (70%) of 4-(3-cinnamyloxy-4-methoxyphenyl)-2-pyrrolidone: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.40 (d, $J$ = 6.8 Hz, 2H), 7.31 (t, $J$ = 6.8 Hz, 2H), 7.25 (d, $J$ = 7.2 Hz, 1H),6.86-6.81(m, 2H), 6.71(d, $J$ = 15.6 Hz, 1H), 6.42 (m, 1H), 5.92 (b, 1H), 4.76 (dd, $J$ = 6.0, 1.2 Hz, 2H), 3.87 (s, 3H), 3.71(t, $J$ = 8.8 Hz, 1H), 3.64-3.56 (m, 1H), 3.35 (t, $J$ = 8.8 Hz, 1H).

The following compounds were prepared in a similar fashion starting with different alcohols:

A. 4-(3-(3-Cyclohexyl-1-propyloxy)-4-methoxyphenyl)-2-pyrrolidone

B. 4-(4-Methoxy-3-(3-phenyl-1-butyloxy)phenyl)-2-pyrrolidone

C. 4-[4-Methoxy-3-indanyloxyphenyl]-2-pyrrolidone

D. 4-[4-Methoxy-3-(2-(4-chlorophenethyl)ethoxy)phenyl]-2-pyrrolidone

E. 4-[4-Methoxy-3-(2-(4-methylphenyl)ethoxy)phenyl]-2-pyrrolidone

F. 4-[4-Methoxy-3-(2-(2-thienyl)ethoxy)phenyl]-2-pyrrolidone

G. 4-[4-Methoxy-3-(2-(3-chlorophenyl)ethoxy)phenyl]-2-pyrrolidone

H. 4-[4-Methoxy-3-(2-(4-fluorophenyl)ethoxy)phenyl]-2-pyrrolidone

I. 4-[4-Methoxy-3-(2-(4-pyridyl)ethoxy)phenyl-2-pyrrolidone

J. 4-[4-Methoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

K. 4-[4-Methoxy-3-(3-(*S*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

L. 4-[4-Methoxy-3-(2-(4-cyanophenyl)ethoxy)phenyl]-2-pyrrolidone

M. 4-[4-Methoxy-3-(3-(4-chlorophenyl)propoxy)phenyl]-2-pyrrolidone

N. 4-[4-Methoxy-3-(2-(3-methylphenyl)ethoxy)phenyl]-2-pyrrolidone

O. 4-(*R*)-[4-Methoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

P. 4-(*S*)-[4-Methoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

Q. 4-(*R*)-[4-Methoxy-3-(3-(*S*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

R. 4-(*S*)-[4-Methoxy-3-(3-(*S*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

S. 4-[4-Methoxy-3-cyclopropylmethoxyphenyl]-2-pyrrolidone

T. 4-[4-Methoxy-3-cyclobutylmethoxyphenyl]-2-pyrrolidone

U. 4-[4-Methoxy-3-cycloheptyloxyphenyl]-2-pyrrolidone

V. 4-[4-Methoxy-3-cyclohexylmethoxyphenyl]-2-pyrrolidone

W. 4-[4-Methoxy-3-(2-cyclohexyl)ethoxyphenyl]-2-pyrrolidone

X. 4-[4-Methoxy-3-cyclopentylmethoxyphenyl]-2-pyrrolidone

Y. 4-[4-Methoxy-3-cyclohexyloxyphenyl]-2-pyrrolidone

Z. 4-[4-Methoxy-3-(3-cyclopentyl)propoxyphenyl]-2-pyrrolidone

AA. 4-[4-Difluoromethoxy-3-(3-(*R*)-tetrahydrofuryloxy)phenyl]-2-pyrrolidone

BB. 4-[4-Difluoromethoxy-3-(2-cyclohexylethoxy)phenyl]-2-pyrrolidone

CC. 4-[4-Difluoromethoxy-3-(2-phenylethoxy)phenyl]-2-pyrrolidone

DD. 4-[4-Difluoromethoxy-3-(cyclopropylmethoxy)phenyl]-2-pyrrolidone

The separate enantiomers of racemic compounds listed above can be obtained through the use of optically active starting materials or by conventional resolution techniques such as chiral HPLC.

**Example 3**

**4-(4-Methoxy-3-phenpropyloxyphenyl)-2-pyrrolidone**

A mixture of 4-(3-hydroxy-4-methoxyphenyl)-2-pyrrolidone (42 mg, 0.2 mmol), 3-phenylpropyl bromide (44 mg, 0.22 mmol), potassium carbonate (83 mg, 0.6 mmol) and *N, N*-dimethylformamide (3 ml) is allowed to stir at 100 °C. After 18 hours, the reaction mixture is cooled to 25 °C. The solid is filtered off and the filtrate is concentrated under vacuum. The same working up procedure gives 47 mg (72%) of 4-(3-(3-phenylpropoxy)-4-methoxyphenyl)-2-pyrrolidone: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.34-7.17 (m, 5H), 6.82 (d, $J$ = 8.4 Hz, 1H), 6.78 (d, $J$ = 12 Hz, 1H), 6.70 (s, 1H), 6.02 (b, 1H), 4.03 (t, $J$ = 7.2 Hz, 2 H), 3.84 (s, 3H), 3.75 (t, $J$ = 8.8 Hz, 1H), 3.63-3.55 (m, 1H), 3.36 (t, $J$ = 8.8 Hz, 1H), 2.82 (t, $J$ = 8.0 Hz, 2H), 2.71 (dd, $J$ = 16.8, 8.8 Hz, 2H), 2.47 (dd, $J$ = 16.6, 8.8 Hz), 2.20-2.13 (m, 2H).

The following compounds were prepared in a similar fashion starting with different arylalkyl bromides and alkyl bromides:

A. 4-(4-Methoxy-3-(2-phenylethoxy)phenyl)-2-pyrrolidone

B. 4-(4-Methoxy-3-(3-phenyl-1-propoxy)phenyl)-2-pyrrolidone

C. 4-[4-methoxy-3-[1-(3-phenyl-2-propenyl)oxyphenyl]-2-pyrrolidone

D. 4-[4-methoxy-3-(2-cyclopropylethoxy)phenyl]-2-pyrrolidone

E. 4-[4-methoxy-3-(2-cyclopentylethoxy)phenyl]-2-pyrrolidone

F. 4-[4-Difluoromethoxy-3-cyclopentoxyphenyl]-2-pyrrolidone

G. 4-[4-Difluoromethoxy-3-cyclopbutylmethoxyphenyl]-2-pyrrolidone

The separate enantiomers of racemic compounds listed above can be obtained through the use of optically active starting materials or by conventional resolution techniques such as chiral HPLC.

**Example 4**

**(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone**

4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone (110 mg, 0.4 mmol) in 2 ml of *N, N*-dimethylformamide and 110 µl of 15-crown-5 is treated with sodium hydride (20 mg, 0.5 mmol) under nitrogen at ambient temperature. After 3 hours, the mixture is

cooled to 0°C and treated with 2,3-difluorobenzyl bromide (166 mg, 0.8 mmol) in 2 ml of tetrahydrofuran. The resulting mixture is allowed to stir at ambient temperature for 6 hours. 100 ml of ethyl acetate is added, followed by 100 ml of ice cold water. After usual aqueous work up, the crude product is purified by flash column chromatography (ethyl acetate/hexane 2:1) to give 112 mg (70%) of 1-(2,3-difluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.18-6.98 (m, 3H), 6.79 (d, $J$ = 8.1 Hz, 1H), 6.90 (d, $J$ = 8.1 Hz, 1H), 6.68 (s, 1H) 4.71-4.69 (m, 1H), 4.60 (s, 2H), 3.81 (s, 3H), 3.68 (t, $J$ = 9.0 Hz, 1H), 3.66-3.54 (m, 1H), 3.29 (dd, $J$ = 9.6, 7.2 Hz, 1H), 2.84 (dd, $J$ = 16.8, 9.0 Hz, 1H), 2.57 (dd, $J$ = 16.8, 8.4 Hz, 1H), 2.00-1.75 (b, 6H), 1.70-1.52 (b, 2H).

The following compounds were prepared in a similar fashion starting with different 4-(3-Substituted)-oxy-4-methoxyphenyl)-2-pyrrolidone and reacting it with different arylalkyl bromides and alkyl bromides:

A. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone
B. (4*S*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone
C. (4*S*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone
D. (4*S*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone
E. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone
F. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-nitrobenzyl)-2-pyrrolidone
G. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-nitrobenzyl)-2-pyrrolidone
H. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone
I. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone
J. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone
K. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-benzyl-2-pyrrolidone
L. (4*S*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone
M. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone
N. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone

O. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone

P. (4*S*)-1-(3,5-Bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

Q. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone

R. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone

S. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone

T. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone

U. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone

V. (4*S*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

W. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone

X. (4*S*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

Y. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone

Z. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone

AA. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone

BB. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone

CC. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone

DD. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone

EE. (4*R*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

FF. (4*R*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

GG. (4*R*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

HH. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone

II. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-nitrobenzyl)-2-pyrrolidone

JJ. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-nitrobenzyl)-2-pyrrolidone

KK. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone

LL. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone

MM. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone

NN. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-benzyl-2-pyrrolidone

OO. (4*R*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

PP. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone

QQ. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone

RR. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone

SS. (4*R*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

TT. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone

UU. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone

VV. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone

WW. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone

XX. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone

YY. (4*R*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

ZZ. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone

AAA. (4*R*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone

BBB. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone

CCC. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone

DDD. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone

EEE. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone

FFF. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone

GGG. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-chloro-4-fluorobenzyl)-2-pyrrolidone

HHH. (4R)-Methyl-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate

III. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyanomethyl-2-pyrrolidone

JJJ. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyclopentyl-2-pyrrolidone

KKK. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-methoxybenzoyl)-2-pyrrolidone

LLL. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-chlorobenzoyl)-2-pyrrolidone

MMM. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-nitrobenzoyl)-2-pyrrolidone

NNN. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-benzoyl-2-pyrrolidone

OOO. (4*R*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*S*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone

PPP. (4*S*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*S*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone

QQQ. (4*R*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*R*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone

RRR. (4*S*)-1-(2,3-Difluorobenzyl)-4-(3-(3-(*R*)-tetrahydrofuryl)oxy-4-methoxyphenyl)-2-pyrrolidone

The separate enantiomers of racemic compounds listed above can be obtained through the use of optically active starting materials or by conventional resolution techniques such as chiral HPLC.

**Example 5 (intermediate)**

**4-(3-Cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetic acid**

4-(3-Cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate (250 mg, 0.72 mmol) was treated with 8 ml of a 1*M* solution of potassium hydroxide in 95% methanol. After 10 hours, the reaction solution was acidified with 2*N* HCl to pH 3 and 30 ml of water was added and the resulting mixture was extracted with 60 ml of ethyl acetate twice. The organic layer was concentrated and chromatographed (methanol/dichloromethane 5:100) to give 242 mg (quantitative yield) of 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetic acid: $^1$H NMR (300 MHz, $CDCl_3$) δ 6.85-73 (m, 3H), 4.84-4.74 (m, 1H), 4.20 (d, *J* = 12.0 Hz, 1H), 4.12 (d, J =

12.0, 1H), 3.82 (s, 4H), 3.66-3.46 (m, 2H), 2.89 (dd, $J$ = 16.8, 8.7 Hz, 1H), 2.58 (dd, $J$ = 16.8, 8.4 Hz, 1H), 2.00-1.72 (b, 6H), 1.70-1.50 (b, 2H).

**Example 6**

**4-(3-Cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetyl chloride**

4-(3-Cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetic acid (50 mg, 0.15 mmol) was dissolved in 3 mL of $CH_2Cl_2$ and treated with oxalylchloride (0.17 mmol) at 4°C. The reaction mixture was stirred at ambient temperature for 2 hours and concentrated in vacuo.

**Example 7**

**4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone**

4-(3-Cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetyl chloride was taken up in 3 ml of $CH_2Cl_2$ and added to a solution of 1,6-dimethylaniline (39 mg, 0.3 mmol) in tetrahydrofuran (2 ml) containing diisopropylethylamine (39 mg,0.3 mmol). After 3 hours, the mixture is concentrated in vacuo, the residue was dissolved in 50 ml of EtOAc, washed with 50 ml of 1 $N$ HCl, 50 mL of water, and 50 mL of aqueous saturated sodium bicarbonate solution. The organic phase was concentrated and chromatographed over $SiO_2$ to give 49 mg (75% yield) of the target acetamide: $^1$H NMR (300 MHz, $CDCl_3$) δ 7.68 (s, 1H), 7.18-7.03 (m, 3H), 6.84-6.73 (m, 3H), 4.84-4.70 (m, 1H), 4.16 (d, $J$ = 11.4 Hz, 1H), 4.13 (d, $J$ = 11.4 Hz, 1H), 3.94 (t, J = 8.0 Hz, 1H), 3.85-3.75 (m, 4H), 3.68-3.46 (m, 2H), 2.86 (dd, $J$ = 16.8, 8.4 Hz, 1H), 2.61 (dd, $J$ = 16.8, 8.4 Hz, 1H),2.19 (s, 6H), 1.98-1.72 (b, 6H), 1.70-1.53 (b, 2H).

The following compounds were synthesized in a similar manner as described above:

A. (4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

B. (4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

C. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

D. (4R)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

E. (4S)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

F. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone

G. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-chlorophenyl)-aminocarbonylmethyl)-2-pyrrolidone

H. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone

I. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methoxyphenyl)-aminocarbonylmethyl)-2-pyrrolidone

J. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-chloro-2-fluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone

K. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

L. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone

M. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-nitrophenyl)-aminocarbonylmethyl)-2-pyrrolidone

N. (4*S*)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone

O. (4*R*)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone

P. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-chloropyridinyl))-aminocarbonylmethyl)-2-pyrrolidone

Q. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-pyridylethyl))-aminocarbonylmethyl)-2-pyrrolidone

R. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-(*N*-methylpyrrolidinyl)ethyl))-aminocarbonylmethyl)-2-pyrrolidone

S. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridylmethyl)-aminocarbonylmethyl)-2-pyrrolidone

T. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(1-imidazoylpropyl)-aminocarbonylmethyl)-2-pyrrolidone

U. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-(4-methylpiperazinyl))-hydrazinocarbonylmethyl)-2-pyrrolidone

V. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(*N*-methylpyrrolidinyl)methyl)-aminocarbonylmethyl)-2-pyrrolidone

W. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyrimidinyl)-aminocarbonylmethyl)-2-pyrrolidone

X. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(5-methylisoxazolyl))-aminocarbonylmethyl)-2-pyrrolidone

Y. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylpiperazinyl)-hydrazinocarbonylmethyl)-2-pyrrolidone

Z. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,5-dimethylthiazolyl))-aminocarbonylmethyl)-2-pyrrolidone

AA. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(2-methylpiperidinyl)ethyl)-aminocarbonylmethyl)-2-pyrrolidone

BB. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3,4-dimethoxyphenethyl)-aminocarbonylmethyl)-2-pyrrolidone

CC. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-pyridinyl)-aminocarbonylmethyl)-2-pyrrolidone

DD. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-pyridinyl)-aminocarbonylmethyl)-2-pyrrolidone

EE. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2,4-dimethoxypyridinyl))-aminocarbonylmethyl)-2-pyrrolidone

FF. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxypyridinyl))-aminocarbonylmethyl)-2-pyrrolidone

GG. 4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-tert-butyloxycarbonylaminophenyl)-aminocarbonylmethyl)-2-pyrrolidone

The separate enantiomers of racemic compounds listed above can be obtained through the use of optically active starting materials or by conventional resolution techniques such as chiral HPLC.

**Example 8**

**4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-anilino)-aminocarbonylmethyl)-2-pyrrolidone**

A mixture of 4-(3-cyclopentyloxy-4-methoxyphenyl)-1-(*N*-(4-tert-butyloxycarbonylaminophenyl)-aminocarbonylmethyl)-2-pyrrolidone was stirred in a 1:2 mixture of TFA and dichloromethane for 2 hours at room temperature. The material was concentrated in vacuo and purified by column chromatography over $SiO_2$ to provide the pure aniline.

**Example 9**

**In Vitro Measurement of Type 4 Phosphodiesterase**

Enzyme Preparation:

Human PDE4 was obtained from baculovirus-infected Sf9 cells that expressed the recombinant enzyme. The cDNA encoding hPDE-4D6 was subcloned into a baculovirus vector. Insect cells (Sf9) were infected with the baculovirus and cells were cultured until protein was expressed. The baculovirus-infected cells were lysed and the lysate was used as source of hPDE-4D6 enzyme. The enzyme was partially purified using a DEAE ion exchange chromatography. This procedure can be repeated using cDNA encoding other PDE-4 enzymes.

Assay:

Type 4 phosphodiesterases convert cyclic adenosine monophosphate (cAMP) to 5'-adenosine monophosphate (5'-AMP). Nucleotidase converts 5'-AMP to adenosine. Therefore the combined activity of PDE4 and nucleotidase converts cAMP to adenosine.

Adenosine is readily separated from cAMP by neutral alumina columns. Phosphodiesterase inhibitors block the conversion of cAMP to adenosine in this assay; consequently, PDE4 inhibitors cause a decrease in adenosine.

Cell lysates (40 ul) expressing hPDE-4D6 were combined with 50 ul of assay mix and 10 ul of inhibitors and incubated for 12 min at room temperature. Final concentrations of assay components were: 0. 4 ug enzyme, 10mM Tris-HCl (pH 7.5), 10mM $MgCl_2$, 3 uM cAMP, 0.002 U 5'-nucleotidase, and 3 x $10^4$ cpm of [3H]cAMP. The reaction was stopped by adding 100 µl of boiling 5mN HCl. An aliquot of 75 µl of reaction mixture was transferred from each well to alumina columns (Multiplate; Millipore). Labeled adenosine was eluted into an OptiPlate by spinning at 2000 rpm for 2 min; 150 µl per well of scintillation fluid was added to the OptiPlate. The plate was sealed, shaken for about 30 min, and cpm of [$^3$H]adenosine was determined using a Packard Topcount 96 counter.

All test compounds are dissolved in 100% DMSO and diluted into the assay such that the final concentration of DMSO is 0.1%. DMSO does not affect enzyme activity at this concentration.

**EXAMPLE 10**

Passive Avoidance in Rats, an in vivo Test for Learning and Memory

The test was performed as previously described (Zhang, H.-T., Crissman, A.M., Dorairaj, N.R., Chandler, L.J., and O'Donnell, J.M., *Neuropsychopharmacology*, 2000, *23*, 198-204.). The apparatus (Model E10-16SC, Coulbourn Instruments, Allentown, PA) consisted of a two-compartment chamber with an illuminated compartment connected to a darkened compartment by a guillotine door. The floor of the darkened compartment consisted of stainless steel rods through which an electric foot-shock could be delivered from a constant current source. All experimental groups were first habituated to the apparatus the day before the start of the experiment. During the training, the rat (Male Spraque-Dawley (Harlan) weighing 250 to 350 g) was placed in the illuminated compartment facing away from the closed guillotine door for 1 minute before the door was raised. The latency for entering the darkened compartment was recorded. After the

rat entered the darkened compartment, the door was closed and a 0.5 mA electric shock was administered for 3 seconds. Twenty-four hours later, the rat was administered 0.1 mg/kg of the test compound or saline, 30 minutes prior to the injection of saline or test compound (dosed from 0.1 to 2.5 mg/kg, i.p.), which was 30 minutes before the retention test started. The rat was again placed in the illuminated compartment with the guillotine door open. The latency for entering the darkened compartment was recorded for up to 180 seconds, at which time the trial was terminated.

All data were analyzed by analyses of variance (ANOVA); individual comparisons were made using Kewman-Keuls tests. Naïve rats required less than 30 seconds, on average, to cross from the illuminated compartment to the darkened compartment.

**EXAMPLE 11**

Radial arm maze task in Rats, an in vivo Test for Learning and Memory

The test was performed as previously described (Zhang, H.-T., Crissman, A.M., Dorairaj, N.R., Chandler, L.J., and O'Donnell, J.M., *Neuropsychopharmacology*, 2000, *23*, 198-204.). Five days after initial housing, rats (male Spraque-Dawley (Harlan) weighing 250 to 350 g) were placed in the eight-arm radial maze (each arm was 60x10x12 cm high; the maze was elevated 70 cm above the floor) for acclimation for two days. Rats were then placed individually in the center of the maze for 5 minutes with food pellets placed close to the food wells, and then, the next day, in the wells at the end of the arms; 2 sessions a day were conducted. Next, four randomly selected arms were then baited with one pellet of food each. The rat was restricted to the center platform (26 cm in diameter) for 15 seconds and then allowed to move freely throughout the maze until it collected all pellets of food or 10 minutes passed, whichever came first. Four parameters were recorded: 1) working memory errors, i.e., entries into baited arms that had already been visited during the same trial; 2) reference memory errors, i.e., entries into unbaited arms; 3) total arm entries; and 4) the test duration (seconds), i.e., the time spent in the collection of all the pellets in the maze. If the working memory error was

zero and the average reference memory error was less than one in five successive trials, the rats began the drug tests. The test compound or saline was injected 15 minutes prior to vehicle or test agent, which was given 45 minutes before the test. Experiments were performed in a lighted room, which contained several extra-maze visual cues.

All data were analyzed by analyses of variance (ANOVA); individual comparisons were made using Kewman-Keuls tests.

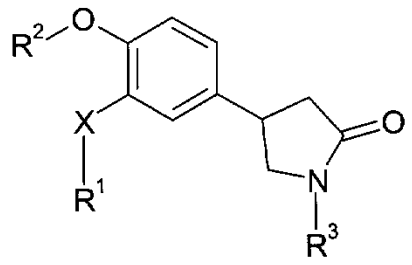
A decrease in adenosine concentration is indicative of inhibition of PDE activity. This procedure was used to screen compounds of the present invention for their ability to inhibit PDE4. $pIC_{50}$ values were determined by screening 6 to 12 concentrations of compound ranging from 0.1 nM to 10,000 nM and then plotting drug concentration versus $^{3}H$-adenosine concentration. Prism® was used to estimate $pIC_{50}$ values.

The preceding examples can be repeated with similar success by substituting the generically or specifically described reactants and/or operating conditions of this invention for those used in the preceding examples.

While the invention has been illustrated with respect to the production and of particular compounds, it is apparent that variations and modifications of the invention can be made without departing from the spirit or scope of the invention.

**What Is Claimed is:**

1. A compound of Formula I:



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof, or

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano,

trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is substituted one or more times by halogen, alkyl, hydroxy, alkoxy, methylenedioxy, ethylenedioxy, alkylamino, hydroxyalkyl, hydroxyalkoxy, cyano, acyl, alkoxycarbonyl,

alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy , or combinations thereof,

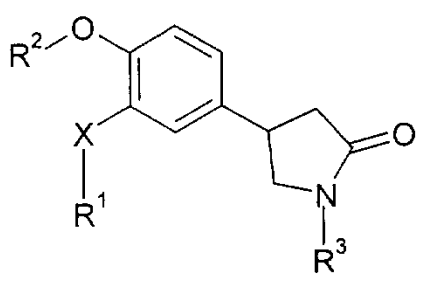
a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof;

with the proviso that:

when X is O, $R^1$ is cyclopentyl, and $R^2$ is methyl, then $R^3$ is not acetyl, benzyl, 4-hydroxybenzyl, 4-acetoxybenzyl, 4-bromobenzyl, 3,4-dimethoxybenzyl, 4-methylthiobenzyl, 4-cyanobenzyl, 3-methoxycarbonylbenzyl, 4-methoxycarbonylbenzyl, 4-methylsulfinylbenzyl, 4-methylsulfonylbenzyl, morpholinoethyl, 2-pyridylmethyl, 3-pyridylmethyl, 4-pyridylmethyl, 4-(6-fluoroquinolyl)methyl, 2-(7-chloroquinolyl)methyl, 2-imidazoylmethyl, or substituted imidazoylmethyl.

2. A compound of Formula I:



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom , which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy , or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy , or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is arylalkyl having 7 to 16 carbon atoms, which is substituted one or more times by halogen, alkyl, hydroxy, alkoxy, methylenedioxy, ethylenedioxy, alkylamino, hydroxyalkyl, hydroxyalkoxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy, or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is aryl having 6 to 14 carbon atoms, which is substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido, and acyloxy, or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof; and

$R^5$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof, or

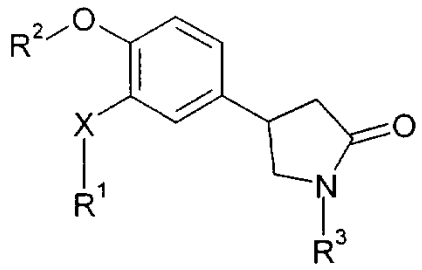
a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

with the proviso that:

(a) when X is O, $R^1$ is cyclopentyl, and $R^2$ is methyl, then $R^3$ is not benzyl, 4-hydroxybenzyl, 4-acetoxybenzyl, 4-bromobenzyl, 3,4-dimethoxybenzyl, 4-methylthiobenzyl, 4-cyanobenzyl, 3-methoxycarbonylbenzyl, 4-methoxycarbonylbenzyl, 4-methylsulfinylbenzyl, 4-methylsulfonylbenzyl,

morpholinoethyl, 2-pyridylmethyl, 3-pyridylmethyl, 4-pyridylmethyl, 4-(6-fluoroquinolyl)methyl, 2-(7-chloroquinolyl)methyl, 2-imidazoylmethyl, or substituted imidazoylmethyl.

3. A compound of Formula I:



wherein

X is O;

$R^1$ is 3(R)-tetrahydrofuranyl;

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl,

alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy , or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof; and

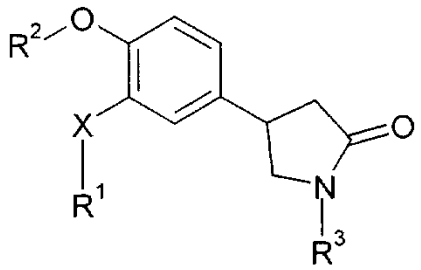
$R^5$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

with the proviso that:

(a) when $R^2$ is $CH_3$, $R^3$ is not H.

4. A compound of Formula I:



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more

$-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy , or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more

times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

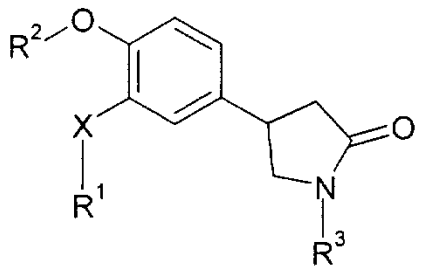
$R^3$ is $-CH_2CONHR^5$; and

$R^5$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino,

hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof.

5. A compound of Formula I:



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy, or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy , or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is $CHF_2$;

$R^3$ is H,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof; and

$R^5$ is aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl,

alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof, or

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof;

with the proviso that:

(a) when X is O, and $R^1$ and $R^2$ are both difluoromethyl, then $R^3$ is not 4-aminobenzyl, or 4-amino-3,5-dimethoxybenzyl.

6. A compound according to claim 1, wherein $R^1$ is optionally substituted cycloalkyl, cycloalkylalkyl, aryl, heterocyclic group, arylalkyl, or a partially unsaturated carbocyclic group, or is $CHF_2$.

7. A compound according to claim 6, wherein $R^1$ is cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclopentylethyl, cyclopropylmethyl, phenyl, napthyl, phenethyl, phenpropyl, furanyl, pyrazinyl, pyrimidinyl, pyridyl, quinolinyl, isoquinolinyl, thienyl, indanyl, tetrahydrofuranyl, phenylpropenyl, phenyl substituted by one or more substituents selected from oxo, F, Cl, $CF_3$, alkyl, alkoxy, CN, vinyl, methylenedioxy, COOH, and combinations thereof, or phenethyl substituted by one or more substituents selected from oxo, F, Cl, $CF_3$, alkyl, alkoxy, CN, vinyl, methylenedioxy, COOH, and combinations thereof.

8. A compound according to claim 1, $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, aryl, arylalkyl or heterocyclic.

9. A compound according to claim 1, $R^1$ is $CHF_2$ or is optionally substituted cyclopentyl, phenethyl, 3-tetrahydrofuranyl, or cyclopropylmethyl.

10. A compound according to claim 1, wherein $R^2$ is substituted or unsubstituted alkyl having 1 to 4 carbon atoms.

11. A compound according to claim 10, wherein $R^2$ is $CHF_2$ or $CH_3$.

12. A compound according to claim 1, wherein $R^3$ is substituted alkyl, substituted arylalkyl, $CH_2CONHR^5$ or $COR^4$.

13. A compound according to claim 12, wherein $R^3$ is substituted benzyl or $CH_2CONHR^5$.

14. A compound according to claim 12, wherein $R^3$ is methylbenzyl, fluorobenzyl, difluorobenzyl, chlorobenzyl, methoxybenzyl, cyanobenzyl, dichlorobenzyl, chlorofluorobenzyl, trifluoromethylbenzyl, or $(CF_3)_2$ benzyl.

15. A compound according to claim 1, wherein $R^3$ is $COR^4$ and $R^4$ is substituted aryl or optionally substituted heterocyclic group.

16. A compound according to claim 15, wherein $R^4$ is phenyl substituted by one or more substituents selected from F, Cl, $CH_3$, $C_2H_5$, $OCH_3$, COOH, CN and combinations thereof.

17. A compound according to claim 1, wherein $R^3$ is - $CH_2CONHR^5$ and $R^5$ is optionally substituted aryl or heteroaryl.

18. A compound according to claim 1, wherein $R^3$ is -$CH_2CONHR^5$

and $R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 2-methylphenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2-pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3COO$-3-pyridyl, and 2-cyano-3-pyridyl.

19. A compound according to claim 1, wherein $R^2$ is $CH_3$ or $CHF_2$.

20. A compound according to claim 1, wherein $R^2$ is $CH_3$ or $CHF_2$, and $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, phenethyl or cyclopropylmethyl.

21. A compound according to claim 1, wherein $R^1$ is 3(R)-tetrahydrofuranyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

22. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, phenethyl, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

23. A compound according to claim 1, wherein $R^1$ is cyclopentyl, tetrahydrofuran, cyclopropylmethyl or $CHF_2$, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is methylbenzyl, methoxybenzyl, chlorobenzyl, fluorobenzyl, trifluorobenzyl, difluorobenzyl, dichlorobenzyl, fluorochlorobenzyl, or bis(trifluoromethyl)benzyl.

24. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, arylalkyl, heterocyclic group, or heterocyclic alkyl group, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is $CH_2CONHR^5$.

25. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, phenethyl, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is $CH_2CONHR^5$.

26. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, heterocyclic group, or heterocyclicalkyl group, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

27. A compound according to claim 1, wherein $R^1$ is cycloalkyl, heterocyclic group, or heterocyclicalkyl group, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

28. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

29. A compound according to claim 1, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, or 2-cyano-3-pyridyl.

30. A compound selected from:
4-[4-Methoxy-3-(4-methoxyphenoxy)phenyl]-2-pyrrolidone,
4-[4-Methoxy-3-(3-thienyloxy)phenyl]-2-pyrrolidone,

4-[3-(4-Fluorophenoxy)-4-methoxyphenyl]-2-pyrrolidone,
4-(3-(3-Cyclohexyl-1-propyloxy)-4-methoxyphenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(2-phenylethoxy)phenyl)-2-pyrrolidone,
4-(4-Methoxy-3-(3-phenyl-1-propoxy)phenyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-chloro-4-fluorobenzyl)-2-pyrrolidone,
Methyl 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyanomethyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyclopentyl-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-methoxybenzoyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, or

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

31. A compound selected from:
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,
(4*S*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,

(4*S*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,

(4*S*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,

(4*S*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,

(4*R*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,

(4*R*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,

(4*R*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,

(4*R*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

(4R)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

(4S)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-chlorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,

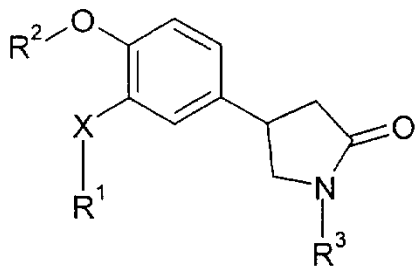
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methoxyphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-chloro-2-fluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-nitrophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2,3-difluorophenyl)-amino carbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
1-(N-(2-(6-Aminopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-ethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,6-dimethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-methoxypyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(6-(3-Bromo-2-methylpyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxycarbonyl)-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(3-(2-Cyanopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone, or
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, or

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

32. Use of a compound according to formula I for the manufacture of a medicament for enhancing cognition



(I)

wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl,

alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more -$CH_2CH_2$- groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more -$CH_2CH_2$- groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

33. A use according to claim 32, wherein said medicament is in a dosage form which can provide 0.0001-100 mg/kg of body weight/day.

34. A use according to claim 32, wherein $R^2$ is $CH_3$ or $CHF_2$.

35. A use according to claim 32, wherein $R^2$ is $CH_3$ or $CHF_2$, $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, phenethyl or cyclopropylmethyl, and $R^3$ is not H.

36. A use according to claim 32, wherein $R^2$ is $CH_3$ or $CHF_2$ $R^3$ is H, and $R^1$ is phenethyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, phenpropyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, phenylbutyl which is unsubstituted or the phenyl portion is substituted by F, Cl, Br, I, CN, $C_{1-4}$-alkyl and/or $C_{1-4}$-alkoxy, or 3-phenyl-2-propenyl.

37. A use according to claim 32, wherein $R^1$ is 3(R)-tetrahydrofuranyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

38. A use according to claim 32, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, phenethyl or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is arylalkyl in which the aryl group is substituted by F, Br, Cl, I, alkyl or alkoxy.

39. A use according to claim 32, wherein $R^1$ is cyclopentyl, tetrahydrofuran, cyclopropylmethyl or $CHF_2$, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is methylbenzyl, methoxybenzyl, chlorobenzyl, fluorobenzyl, trifluorobenzyl, difluorobenzyl, dichlorobenzyl, fluorochlorobenzyl, or bis(trifluoromethyl)benzyl.

40. A use according to claim 32, wherein $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, arylalkyl, heterocyclic group, or heterocyclic alkyl group, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is $CH_2CONHR^5$.

41. A use according to claim 32, wherein $R^1$ is cyclopentyl, $CHF_2$ tetrahydrofuran, phenethyl or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, and $R^3$ is $CH_2CONHR^5$.

42. A use according to claim 32, wherein $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, heterocyclic group, or heterocyclicalkyl group, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

43. A use according to claim 32, wherein $R^1$ is $CHF_2$, cycloalkyl, cycloalkylalkyl, heterocyclic group, or heterocyclicalkyl group, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is CH2CONHR$^5$, and $R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

44. A use according to claim 32, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is substituted or unsubstituted phenyl, 2-pyridyl, 3-pyridyl, or 4-pyridyl.

45. A use according to claim 32, wherein $R^1$ is $CHF_2$, cyclopentyl, tetrahydrofuran, or cyclopropylmethyl, $R^2$ is $CH_3$ or $CHF_2$, $R^3$ is $CH_2CONHR^5$, and $R^5$ is 2-methylphenyl, 2,6-dimethylphenyl, 2,3-difluorophenyl, 4-fluorophenyl, 4-pyridyl, 2-pyridyl, 6-methyl-2- pyridyl, 6-amino-2-pyridyl, 6-ethyl-2-pyridyl, 4,6-dimethyl-2-pyridyl, 6-bromo-2-pyridyl, 6-methyl-5-bromo-2-pyridyl, 2-methoxy-3-pyridyl, 4-$CH_3O$-CO-3-pyridyl, and 2-cyano-3-pyridyl.

46. A use according to claim 32, wherein the compound of formula I is selected from:

4-[4-Methoxy-3-(4-methoxyphenoxy)phenyl]-2-pyrrolidone,

4-[4-Methoxy-3-(3-thienyloxy)phenyl]-2-pyrrolidone,

4-[3-(4-Fluorophenoxy)-4-methoxyphenyl]-2-pyrrolidone,

4-(3-(3-Cyclohexyl-1-propyloxy)-4-methoxyphenyl)-2-pyrrolidone,

4-(4-Methoxy-3-(2-phenylethoxy)phenyl)-2-pyrrolidone,

4-(4-Methoxy-3-(3-phenyl-1-propoxy)phenyl)-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-chloro-4-fluorobenzyl)-2-pyrrolidone,

Methyl 4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone-1-acetate,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyanomethyl-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-cyclopentyl-2-pyrrolidone,

4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-methoxybenzoyl)-2-pyrrolidone,

4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,

1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,

4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, and

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

47. A use according to claim 32, wherein the compound of formula I is selected from:

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,

(4*S*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,

(4*S*)-1-(4-Cyanobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,

(4*S*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,

(4*S*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,

(4*S*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,

(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,

(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methylbenzyl)-2-pyrrolidone,

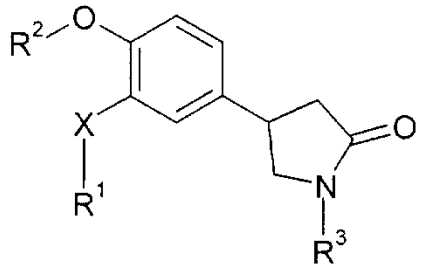
(4*R*)-1-(2-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(4-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-1-(3-Chlorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-methoxybenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-fluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(4-trifluoromethylbenzyl)-2-pyrrolidone,
(4*R*)-1-(3,5-bistrifluoromethylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,5-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,4-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,6-difluorobenzyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2,3-difluorobenzyl)-2-pyrrolidone,
(4*R*)-1-(2-Chloro-4-fluorobenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(3,4-dichlorobenzyl)-2-pyrrolidone,
(4*R*)-1-(4-*tert*-Butylbenzyl)-4-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-ethyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-propyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-butyl-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-methoxyethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(2-phenylbenzyl)-2-pyrrolidone,
(4*S*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4*R*)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,6-dimethylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,

(4R)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
(4S)-4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2,3-difluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-chlorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methoxyphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-chloro-2-fluorophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(4-nitrophenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2,3-difluorophenyl)-amino carbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-difluoromethoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2,3-Difluorophenyl)-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetra hydrofuryloxy)phenyl)-2-pyrrolidone,
1-(N-(2-(6-Aminopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,

4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-ethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(4,6-dimethylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
1-(N-(2-(6-Bromopyridyl))-aminocarbonylmethyl)-4(S)-(4-methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-methylphenyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(2-methoxypyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(6-(3-Bromo-2-methylpyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(3-(4-methoxycarbonyl)-pyridyl)-aminocarbonylmethyl)-2-pyrrolidone,
4(S)-(3-Cyclopentyloxy-4-methoxyphenyl)-1-(N-(2-(6-methylpyridyl))-aminocarbonylmethyl)-2-pyrrolidone,
1-(N-(3-(2-Cyanopyridyl))-aminocarbonylmethyl)-4(S)-(3-cyclopentyloxy-4-methoxyphenyl)-2-pyrrolidone,
4(S)-(4-Methoxy-3-(3(R)-tetrahydrofuryloxy)phenyl)-1-(N-(2-(6-methylpyridinyl))-aminocarbonylmethyl)-2-pyrrolidone, and

physiologically acceptable salts thereof, wherein in each case the compound can be in the form of a mixture of enantiomers such as the racemate, or a mixture of diastereomers, or can be in the form of a single enantiomer or a single diastereomer.

48. Use of a compound according to formula I for the manufacture of a medicament for the treatment of cognition impairment or decline:



(I)

wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl,

alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more -$CH_2CH_2$- groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more -$CH_2CH_2$- groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an

N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino,

hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

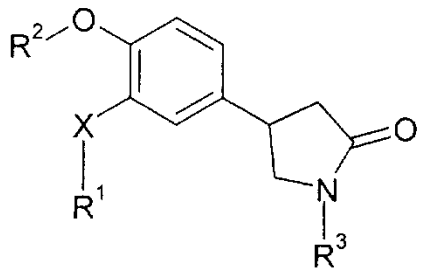
a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

49. A use according to claim 48, wherein the treatment is for memory impairment.

50. A use according to claim 48, wherein said medicament is in a dosageform which can provide 0.0001-100 mg/kg of body weight/day.

51. A use according to claim 49, wherein the treatment is for memory impairment due to Alzheimer's disease, schizophrenia, Parkinson's disease, Huntington's disease, Pick's disease, Creutzfeld-Jakob disease, depression, aging, head trauma, stroke, CNS hypoxia, cerebral senility, multiinfarct dementia, HIV or cardiovascular disease.

52. Use of a compound according to formula I for the manufacture of a medicament for the treatment of a disease involving decreased cAMP levels



wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl,

alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an

N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino,

hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

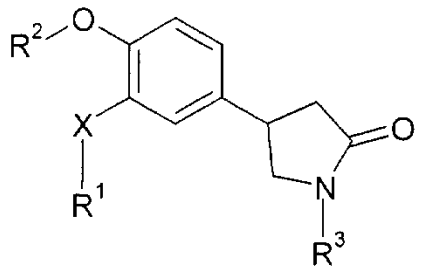
a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by

halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

53. Use of a compound according to any one of claims 1 - 31 for the manufacture of a medicament for inhibiting PDE4 enzyme activity.

54. Use of a compound according to formula I for the manufacture of a medicament for the treatment of a patient suffering from memory impairment due to a neurodegenerative disease:



(I)

wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof ,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy,

ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more

$-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl,

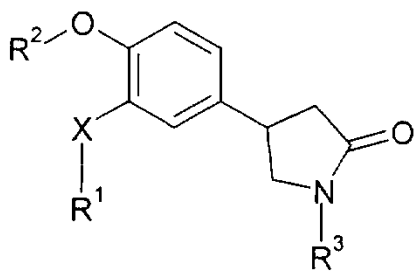
alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

55. Use of a compound according to formula (I) for the manufacture of a medicament for the treatment of memory impairment due to an acute neurodegenerative disorder:




(I)

wherein

X is O;

$R^1$ is alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl having 1 to 4 carbon atoms or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a partially unsaturated carbocyclic group having 5 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, alkoxy, nitro, cyano, oxo, or combinations thereof,

arylalkenyl having 8 to 16 carbon atoms, wherein the alkenyl portion has up to 5 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof;

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof, or

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

$R^2$ is alkyl having 1 to 4 carbon atoms, which is unsubstituted or substituted one or more times by halogen;

$R^3$ is H,

alkyl having 1 to 8 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 8 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

arylalkyl having 7 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, and acyloxy or combinations thereof,

heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an

N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof,

alkoxyalkyl having 3 to 8 carbon atoms,

$-C(O)R^4$, or

$-CH_2CONHR^5$;

$R^4$ is alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro,

methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof; and

$R^5$ is H,

alkyl having 1 to 12 carbon atoms wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

alkyl having 1 to 12 carbon atoms which is substituted one or more times by halogen, oxo, or combinations thereof wherein optionally one or more $-CH_2CH_2-$ groups are replaced in each case by –CH=CH- or –C≡C- groups,

cycloalkyl having 3 to 8 carbon atoms, which is unsubstituted or substituted one or more times by halogen, oxo, alkyl, or combinations thereof,

cycloalkylalkyl having 4 to 16 carbon atoms which is unsubstituted or substituted one or more times by halogen, oxo, alkyl or combinations thereof,

aryl having 6 to 14 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

arylalkyl having 8 to 16 carbon atoms, which is unsubstituted or substituted one or more times by halogen, $CF_3$, $OCF_3$, alkyl, hydroxy, alkoxy, nitro, methylenedioxy, ethylenedioxy, amino, alkylamino, dialkylamino, hydroxyalkyl, hydroxyalkoxy, carboxy, cyano, acyl, alkoxycarbonyl, alkylthio, alkylsulphinyl, alkylsulphonyl, phenoxy, acylamido and acyloxy or combinations thereof,

a heterocyclic group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is a N, O or S atom, which is unsubstituted or substituted one or more times by halogen, aryl, alkyl, alkoxy, alkoxycarbonyl, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, or combinations thereof, or

a heterocyclic-alkyl group, which is saturated, partially saturated or fully unsaturated, having 5 to 10 ring atoms in which at least 1 ring atom is an N, O or S atom, which is unsubstituted or substituted one or more times in the heterocyclic portion by halogen, aryl, alkyl, alkoxy, cyano, trifluoromethyl, nitro, oxo, amino, alkylamino, dialkylamino, carboxy or combinations thereof and/or substituted in the alkyl portion by halogen, oxo, cyano, or combinations thereof.

56. Use of a compound according to any one of claims 1-31 for the manufacture of a medicament for the treatment of an allergic or inflammatory disease.

57. A pharmaceutical composition comprising a compound according to any one of claims 1 - 31 and a pharmaceutically acceptable carrier.

58. A composition according to claim 57, wherein said composition contains 0.01-1000 mg of said compound.