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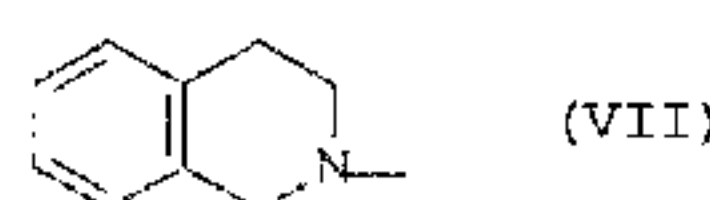
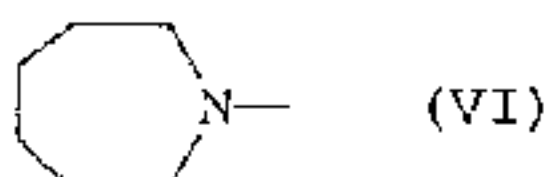
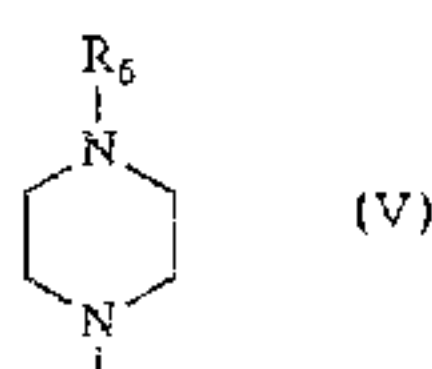
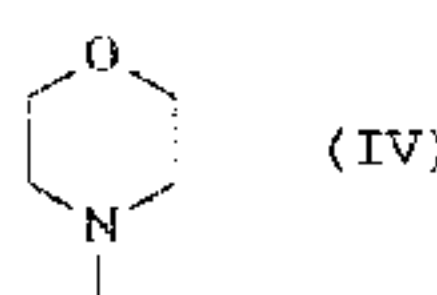
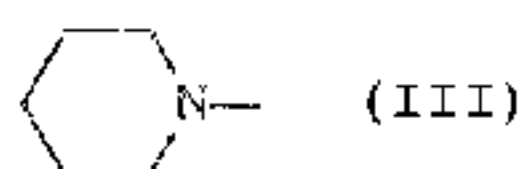
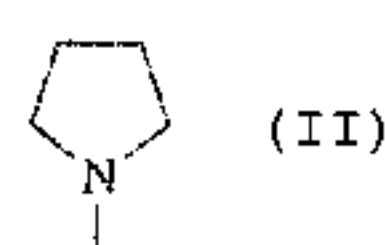
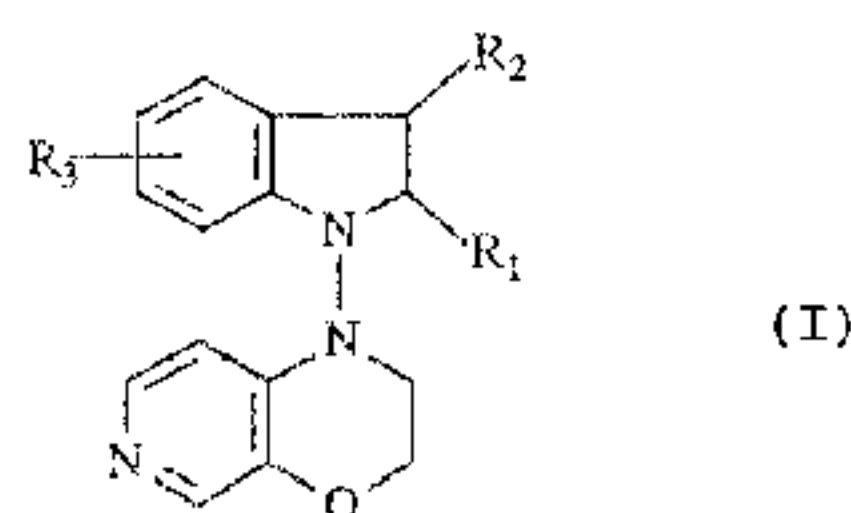
(72) Inventeurs/Inventors:
EFFLAND, RICHARD CHARLES, US;
DAVIS, LARRY, US;
OLSEN, GORDON EDWARD, US

(73) Propriétaire/Owner:
AVENTIS PHARMACEUTICALS INC., US

(74) Agent: BERESKIN & PARR

(54) Titre : 1-(PYRIDO[3,4-B][1,4-OXAZIN-4-YL])-1H-INDOLES; PRODUITS INTERMEDIAIRES ET METHODE DE PREPARATION; UTILISATION COMME MEDICAMENTS

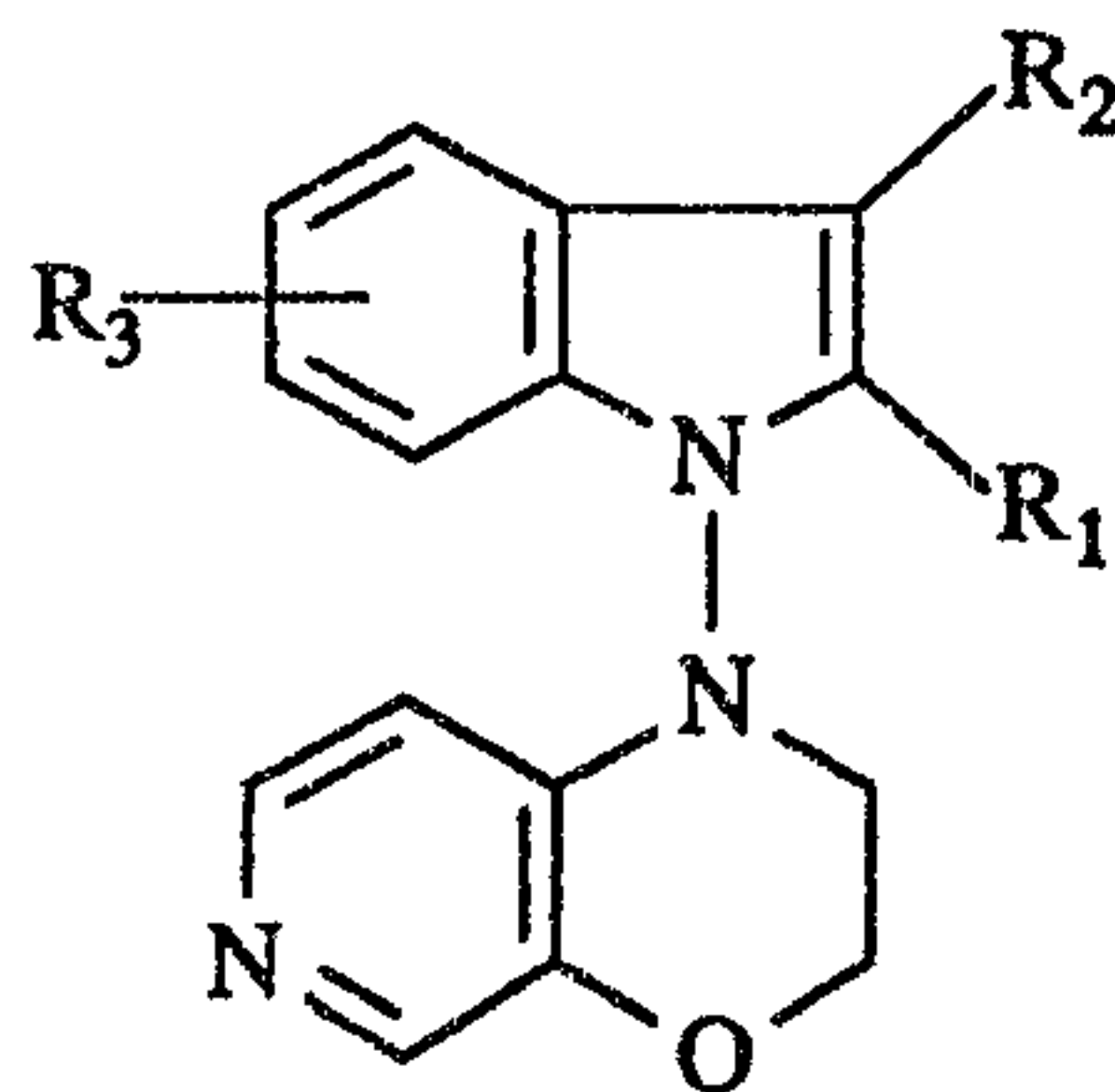
(54) Title: 1-(PYRIDO[3,4-B]-1,4-OXAZINYL-4-YL)-1H-INDOLES, INTERMEDIATES AND A PROCESS FOR THEIR PREPARATION, AND THEIR USE AS MEDICAMENTS



(57) **Abrégé/Abstract:**

This invention relates to compounds of the formula (see formula I) wherein R_1 is hydrogen or loweralkyl; R_2 is hydrogen or loweralkyl; and R_3 is hydrogen, loweralkyl, halogen, nitro, amino, hydroxy, loweralkoxy, benzyloxy or $-O-C(=O)-N(R_4)R_5$ where R_4 is hydrogen or loweralkyl and R_5 is loweralkyl, aryl or arylloweralkyl, or R_4 and R_5 taken together form a heterocyclic ring selected from the group consisting of (see formula II), (see formula III), (see formula IV), (see formula V), (see formula VI) or (see formula VII) wherein R_6 is hydrogen, loweralkyl, aryl or arylloweralkyl or a pharmaceutically acceptable acid addition salt thereof. The compounds of this invention are useful for alleviating depression and various memory dysfunctions characterized by a cholinergic or adrenergic deficit, such as Alzheimer's Disease, and can, therefore, be used as medicaments.

This invention relates to compounds of the formula

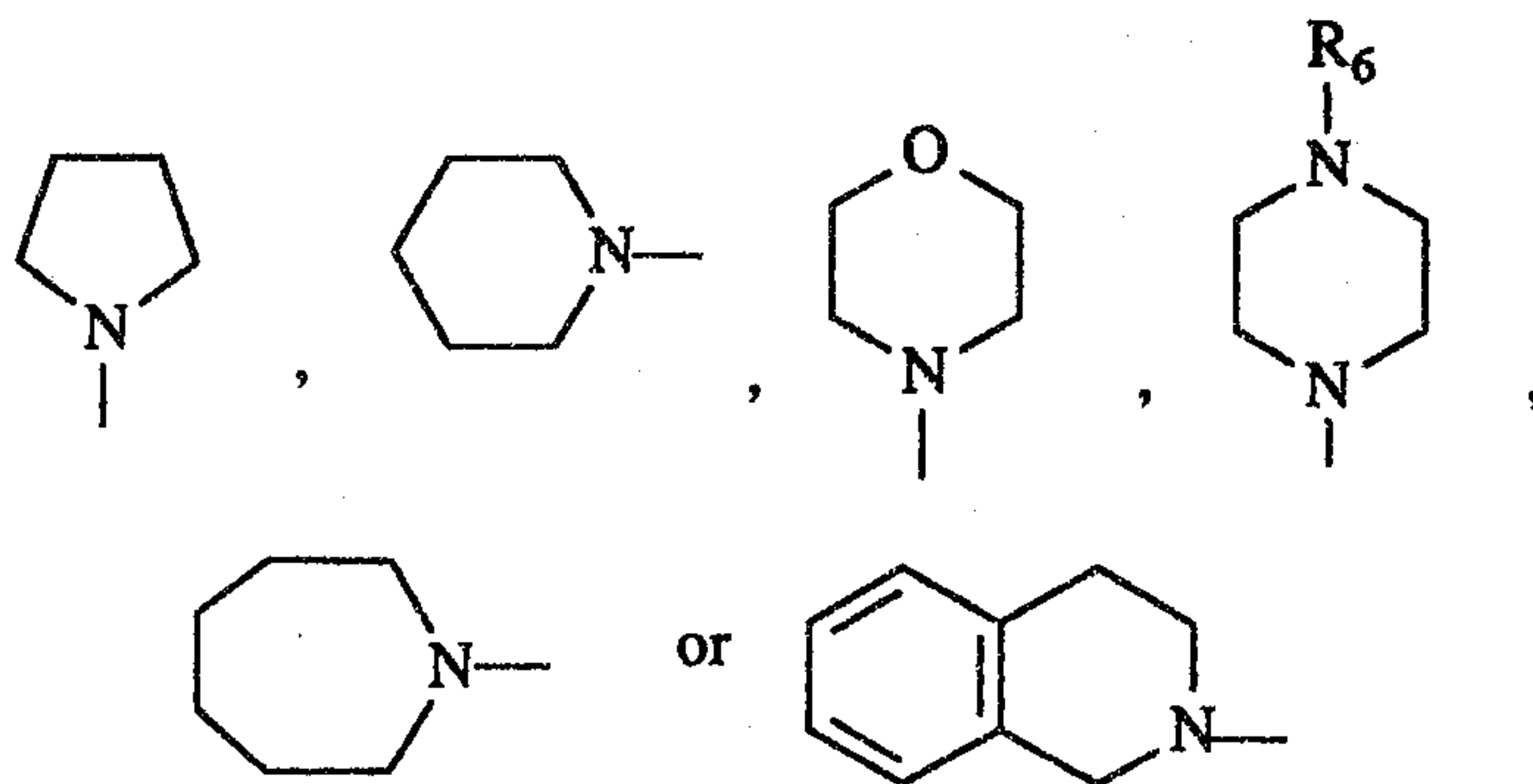


wherein

R₁ is hydrogen or loweralkyl;

R₂ is hydrogen or loweralkyl; and

R₃ is hydrogen, loweralkyl, halogen, nitro, amino, hydroxy, loweralkoxy, benzyloxy or $\text{-O-C(=O)-NR}_4\text{R}_5$ where R₄ is hydrogen or loweralkyl and R₅ is loweralkyl, aryl or arylloweralkyl, or R₄ and R₅ taken together form a heterocyclic ring selected from the group consisting of

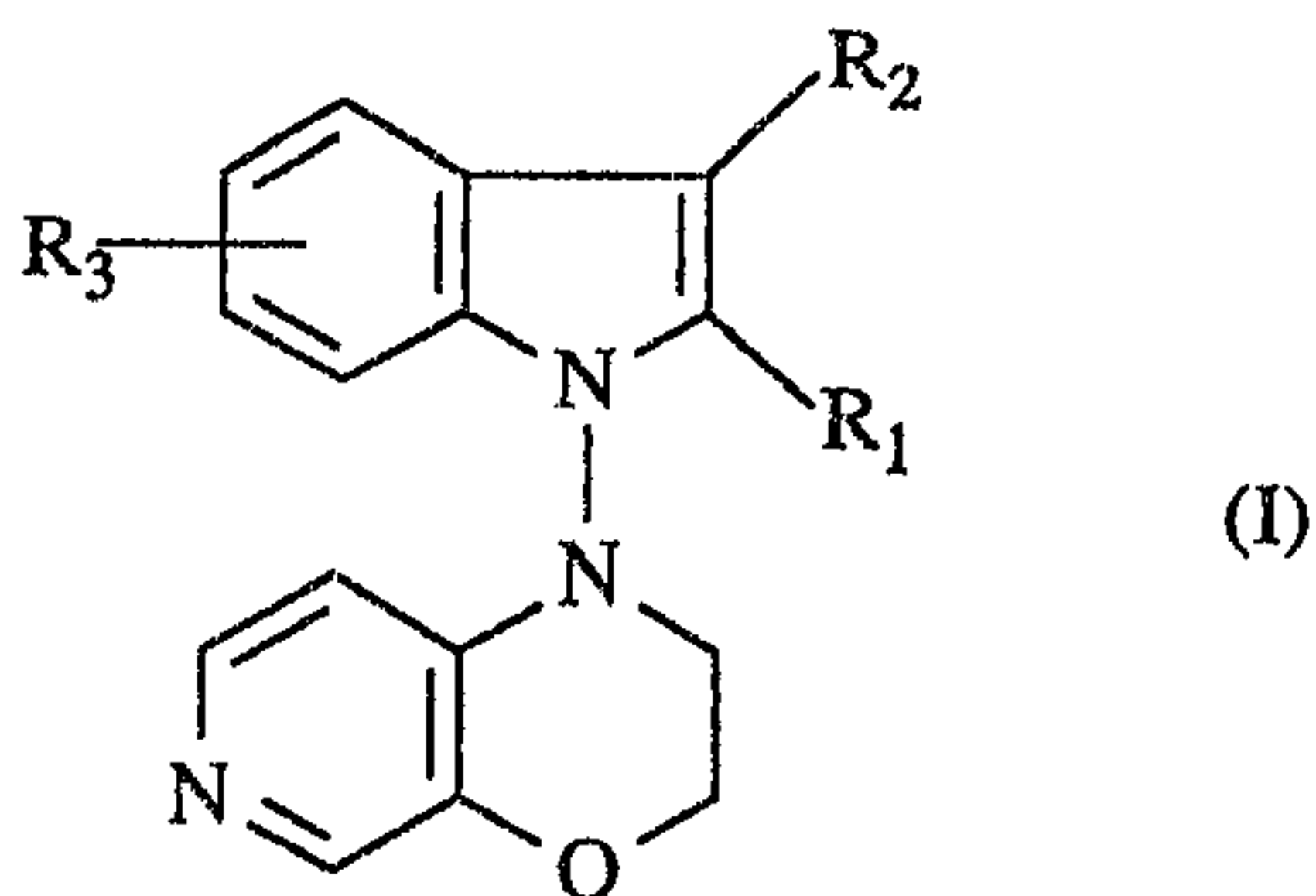


wherein R₆ is hydrogen, loweralkyl, aryl or arylloweralkyl or a pharmaceutically acceptable acid addition salt thereof. The compounds of this invention are useful for alleviating depression and various memory dysfunctions characterized by a cholinergic or adrenergic deficit, such as Alzheimer's Disease, and can, therefore, be used as medicaments.

Description

1-(Pyrido[3,4-b]-1,4-oxazinyl-4-yl)-1H-indoles, intermediates and a process for their preparation, and their use as medicaments.

This invention relates to compound I of the formula



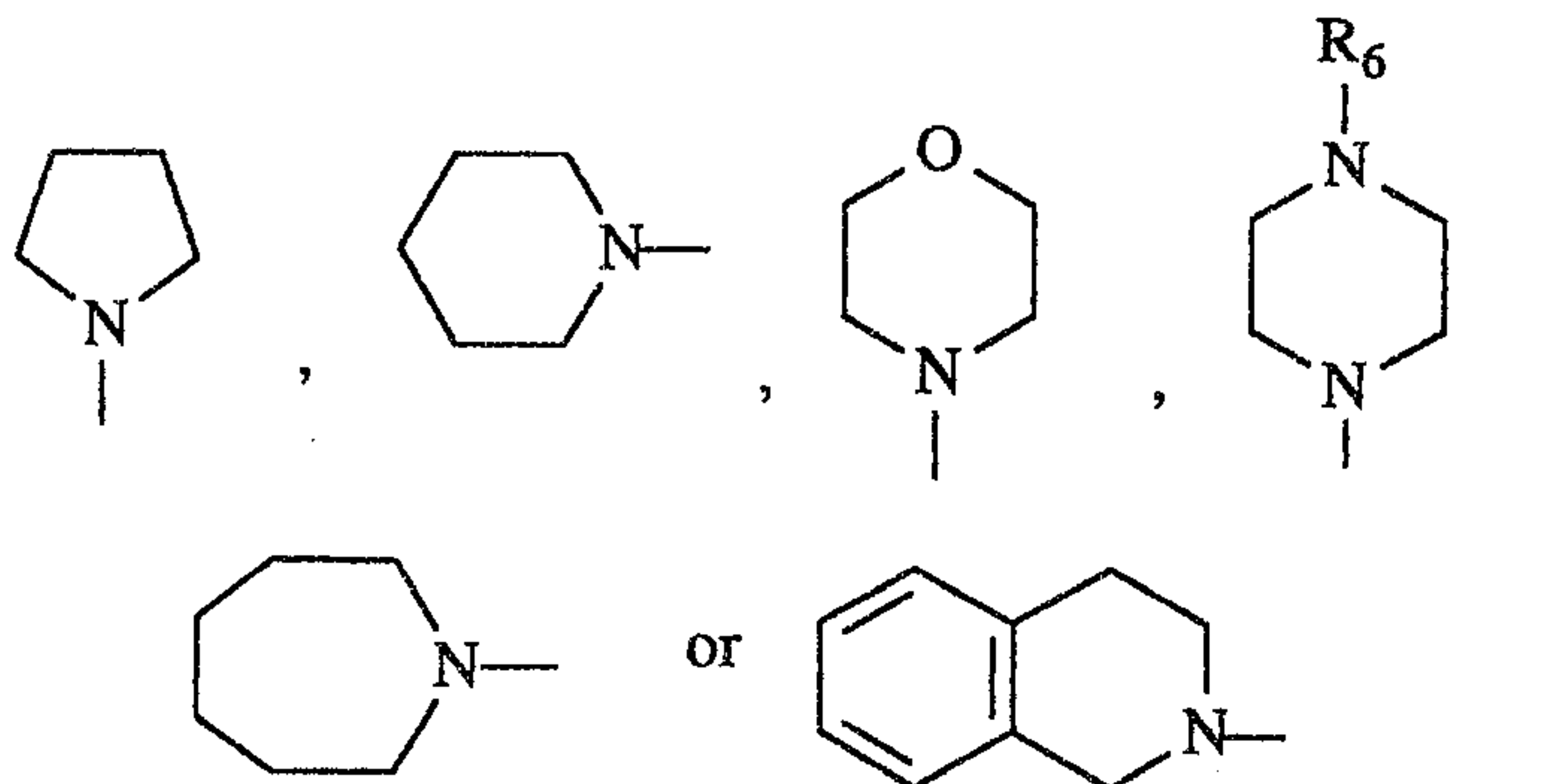
wherein

R_1 is hydrogen or loweralkyl;

R_2 is hydrogen or loweralkyl; and

R_3 is hydrogen, loweralkyl, halogen, nitro, amino, hydroxy, loweralkoxy, benzyloxy or $-O-\overset{\overset{\text{O}}{\parallel}}{\text{C}}-\text{NR}_4\text{R}_5$ where R_4 is hydrogen or loweralkyl and R_5 is loweralkyl, aryl,

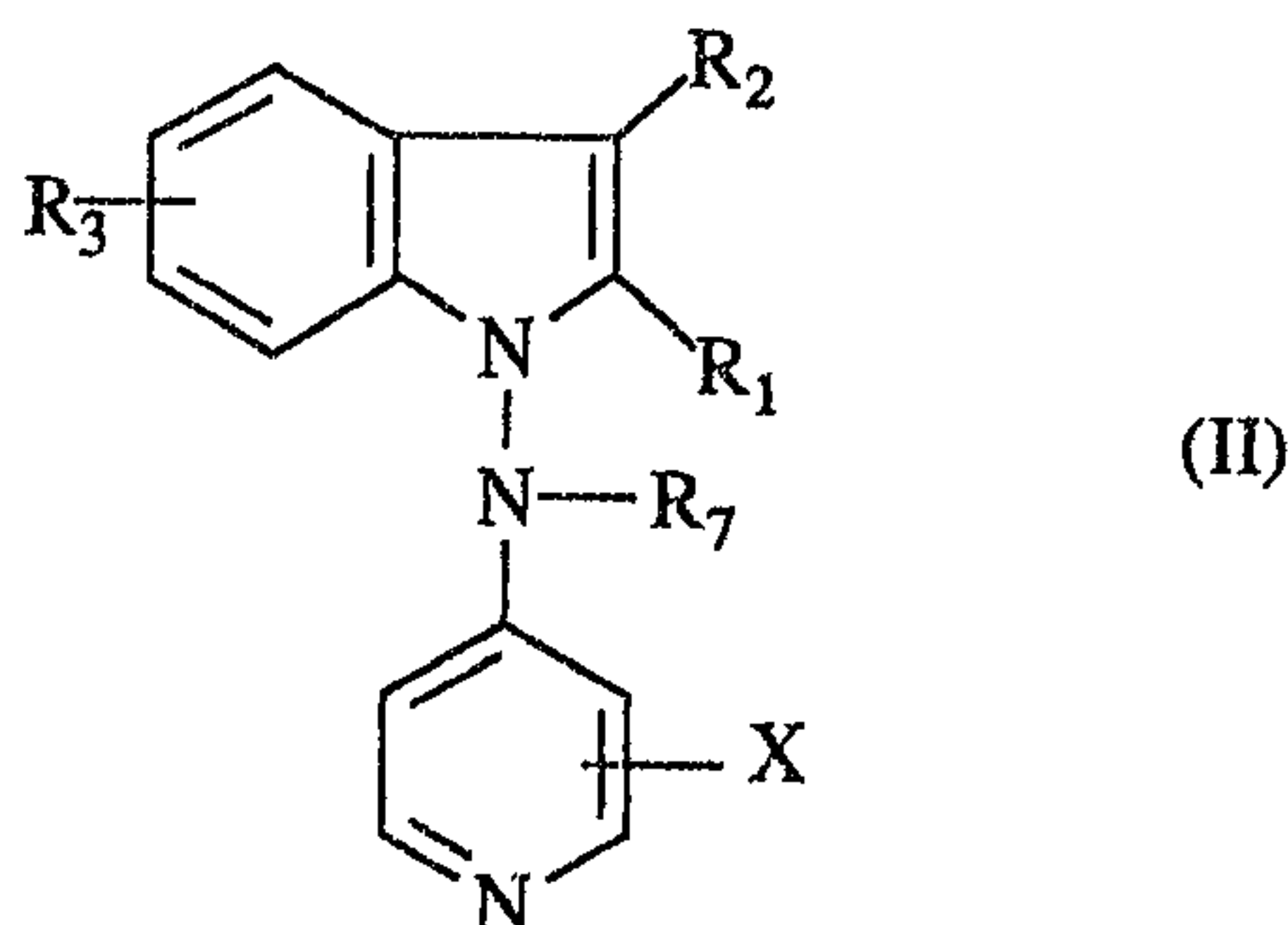
arylloweralkyl or R_4 and R_5 taken together form a heterocyclic ring selected from the group consisting of



wherein R_6 is hydrogen, loweralkyl, aryl or arylloweralkyl; or a pharmaceutically acceptable addition salt thereof.

The compounds of this invention are useful for alleviating depression or various memory dysfunctions characterized by a cholinergic or adrenergic deficit.

This invention also relates to compounds of the formula



wherein R_1 , R_2 and R_3 are as previously defined, X is halogen and R_7 is $(CH_2)_2OH$, $CH_2\overset{\overset{O}{\parallel}}{C}OR_8$ or $CH_2\overset{\overset{O}{\parallel}}{C}H$ where R_8 is hydrogen or loweralkyl. These compounds are useful as intermediates in the preparation of the target compounds.

Unless otherwise stated or indicated, the following definitions shall apply throughout the specification and the appended claims.

The term loweralkyl shall mean a straight or branched alkyl group having from 1 to 7 carbon atoms, e.g., methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl and straight and branched-chain pentyl, hexyl and heptyl.

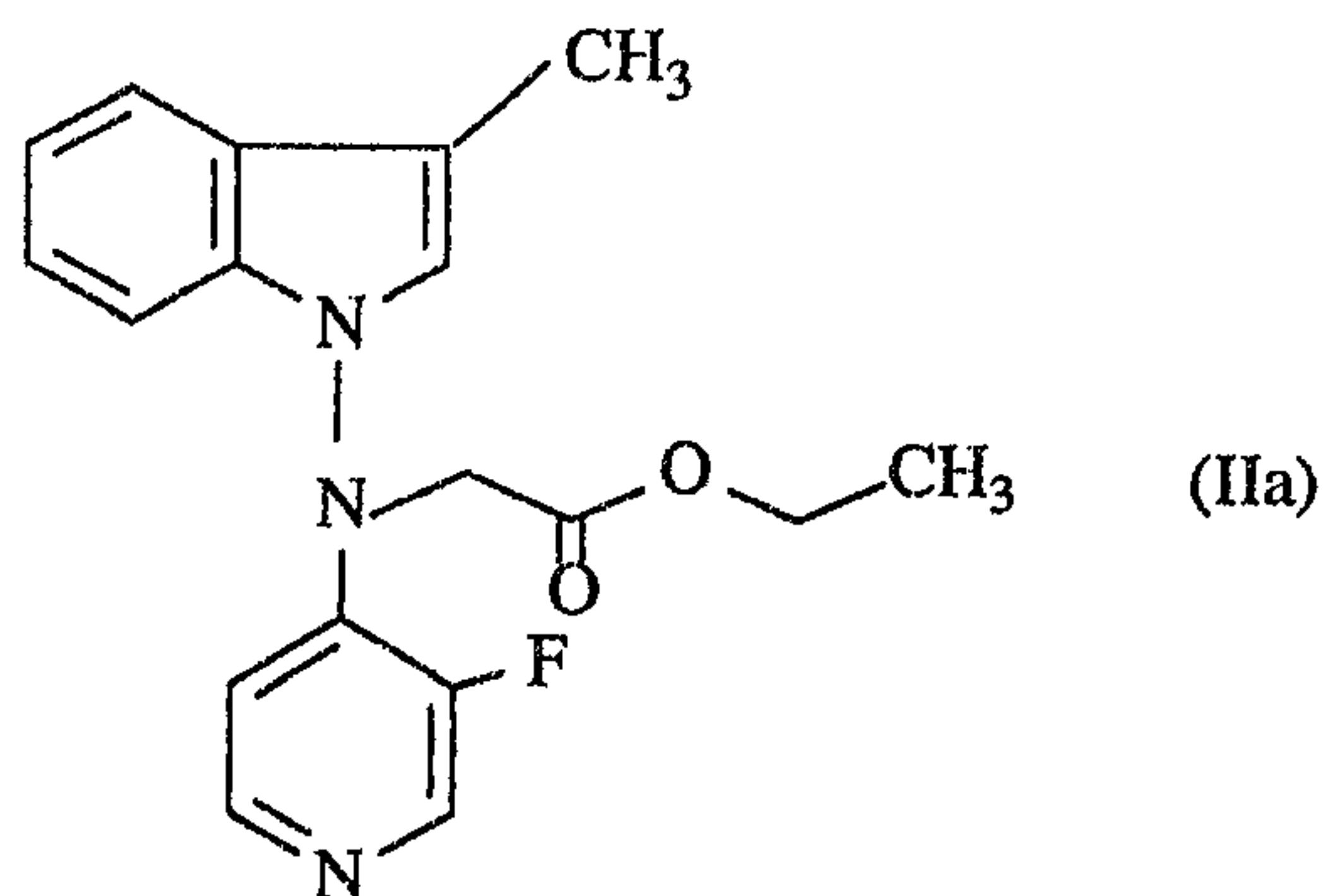
The term halogen shall mean fluorine, chlorine, bromine or iodine.

The term aryl shall mean a phenyl group substituted with 0, 1 or 2 substituents each of which being independently loweralkyl, loweralkoxy, halogen or trifluoromethyl.

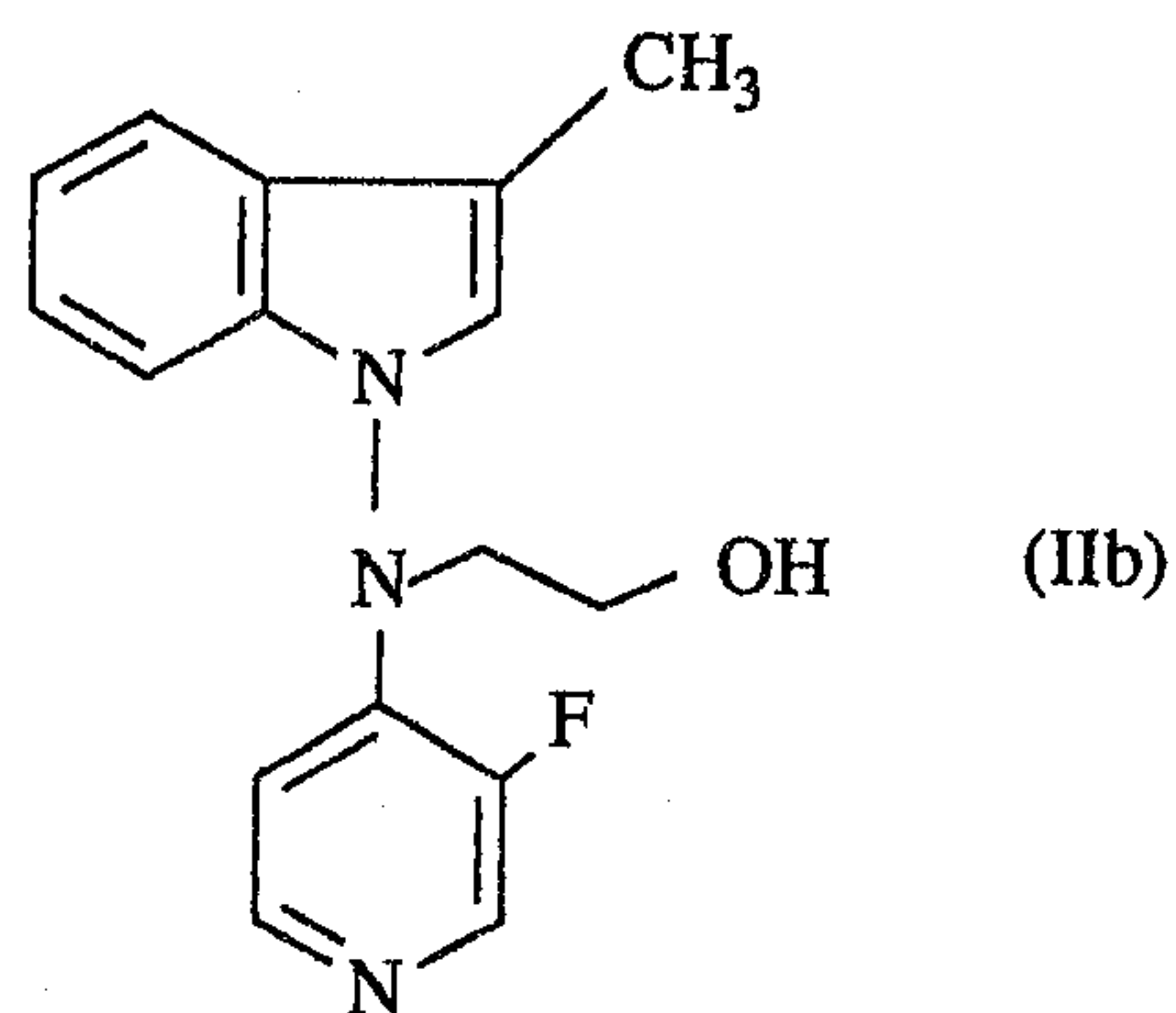
Throughout the specification and appended claims, a given chemical formula or name shall encompass all stereo, optical, geometrical and tautomeric isomers where such isomers exist.

The compounds of the invention are prepared in the following manner. The substituents R_1 , R_2 , R_3 , R_4 , and R_5 shall have the respective meanings given above unless otherwise stated or indicated.

Compound IIa of the formula

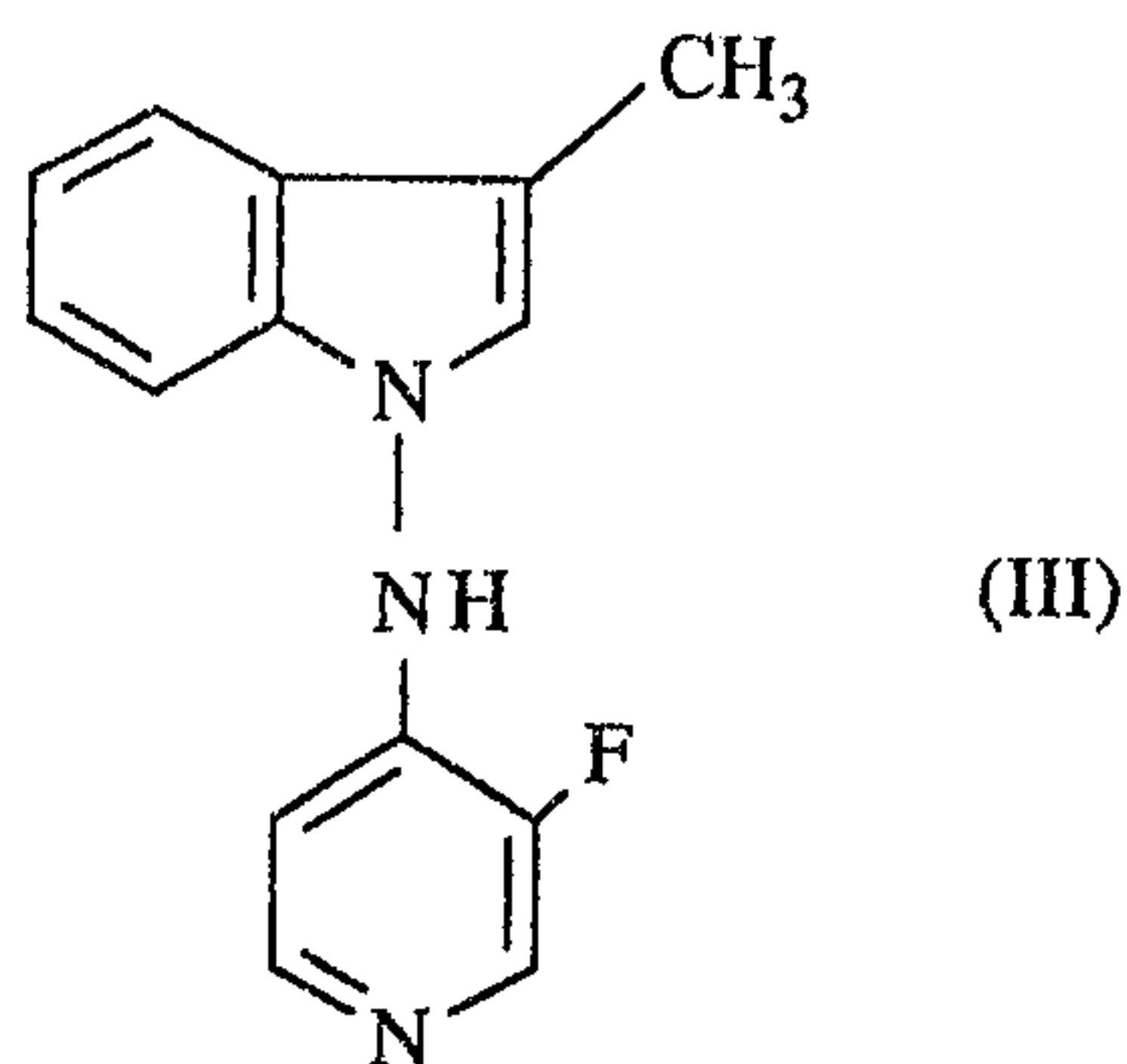


is reacted with lithium aluminum hydride or other suitable reducing agent in a standard reduction to yield Compound IIb of the formula



This reaction is typically conducted in an ethereal solvent such as tetrahydrofuran or ether at a temperature of between about 0°C and 10°C for 1 to 4 hours.

Compound IIa is prepared by the reaction of a compound of the formula III



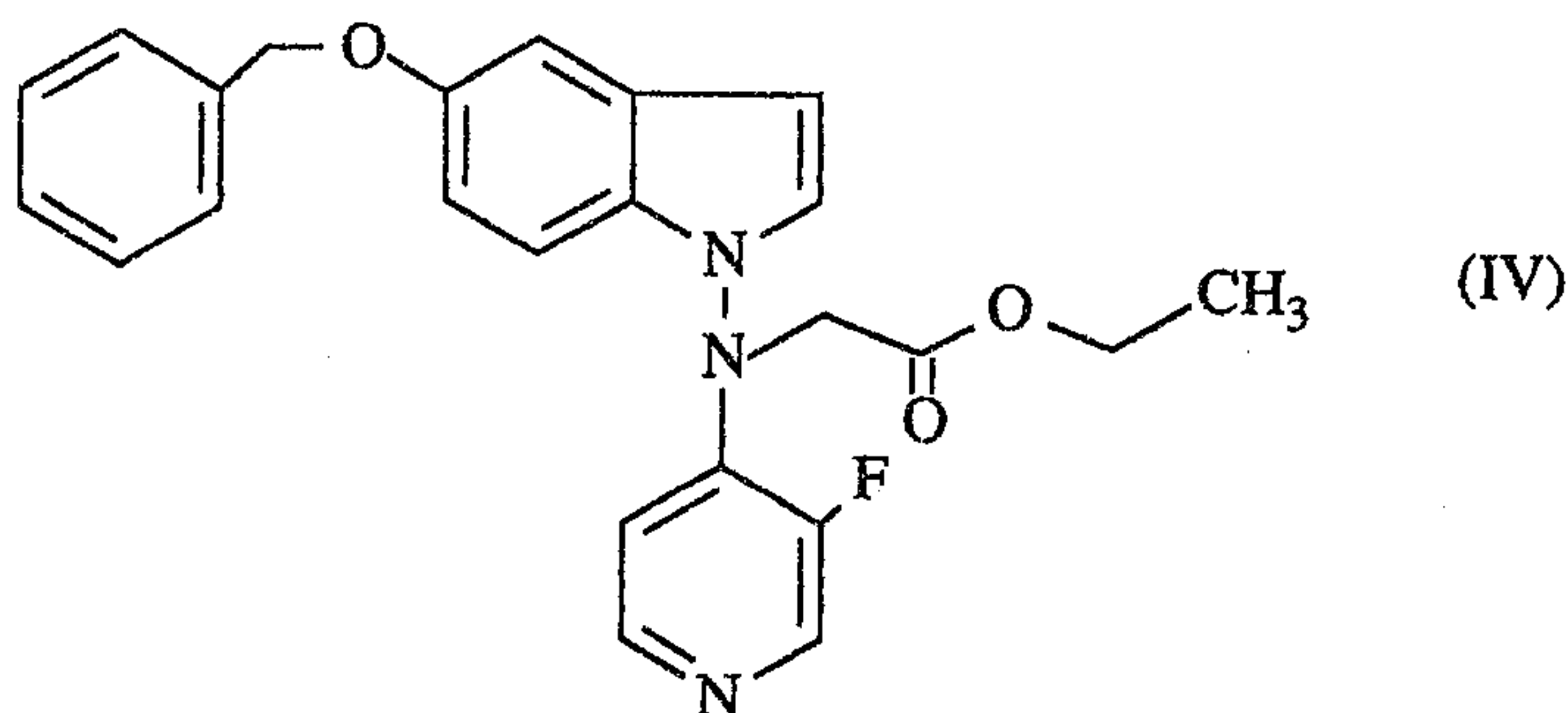
with ethyl chloroacetate in the presence of a strong base such as sodium hydride.

Compound IIb is subsequently cyclized using a strong base such as sodium hydride or potassium t-butoxide to produce Compound I where R_3 is hydrogen.

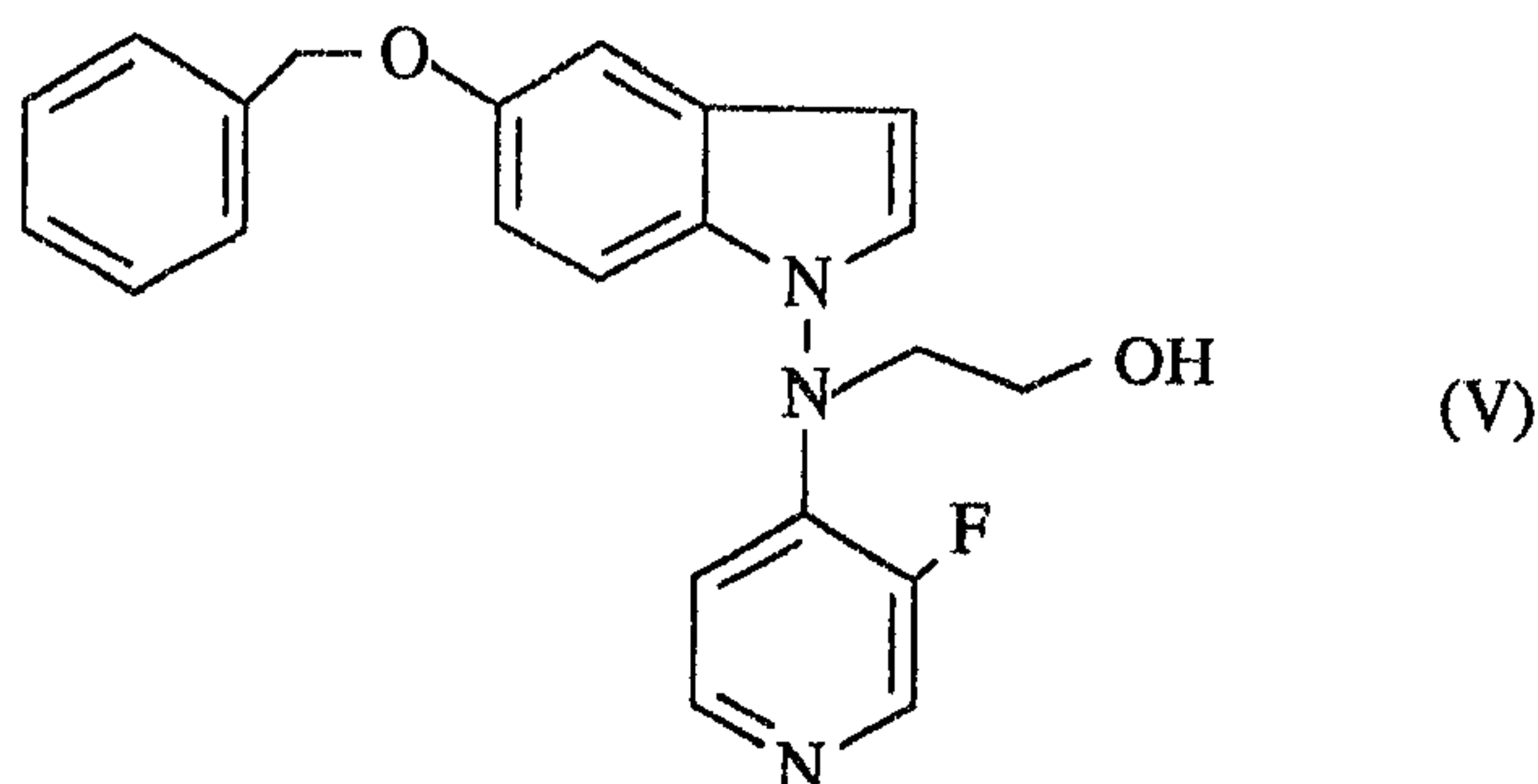
This reaction typically takes place in a polar aprotic solvent such as dimethylformamide, dimethylacetamide, N-methyl-2-pyrrolidone, hexamethylphosphoramide or dimethyl sulfoxide at a temperature of between about 25°C to 100°C for about 1 to 10 hours.

Compounds where $R_3 \neq$ hydrogen can be prepared in the following manner.

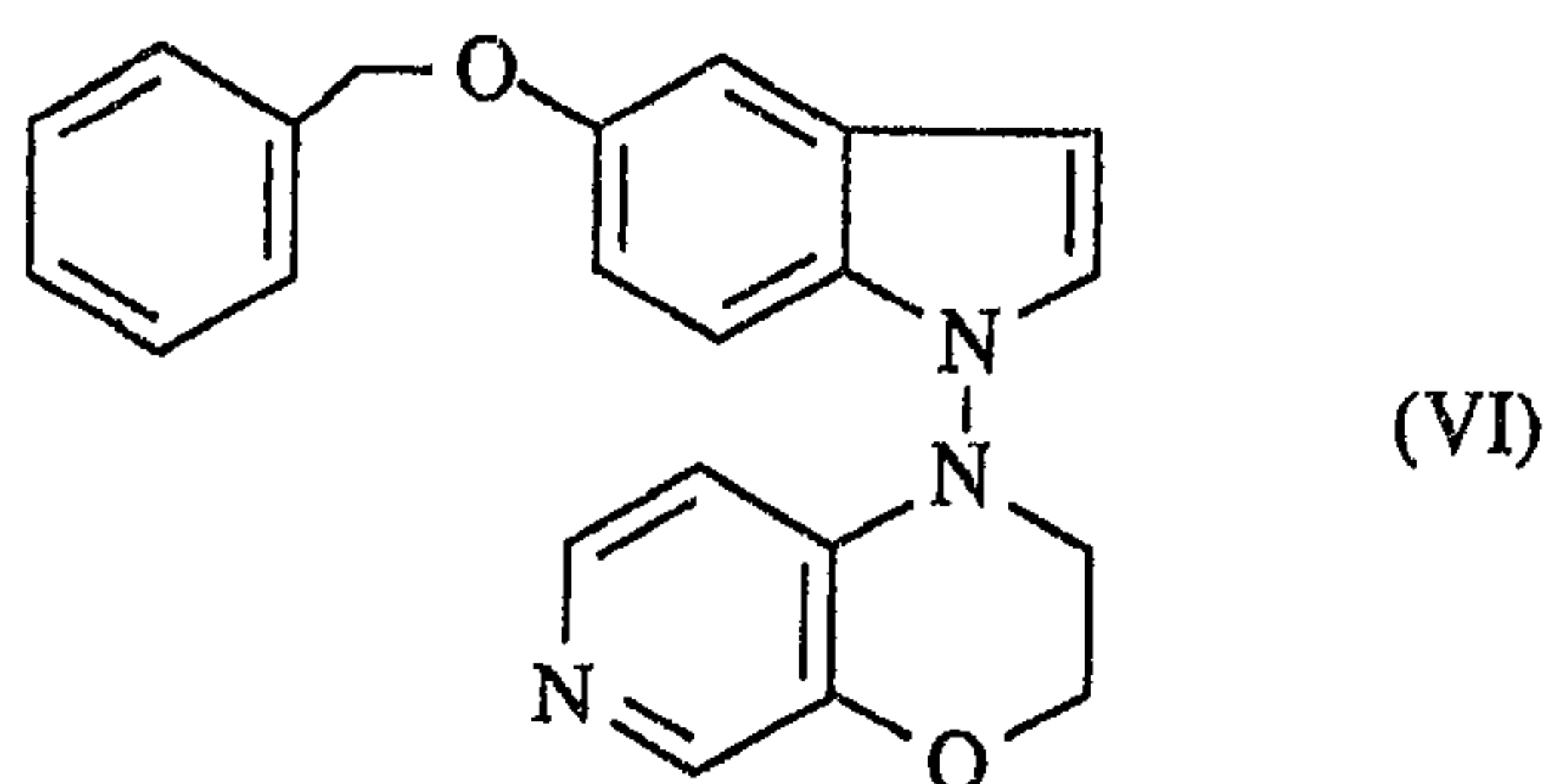
Compound IV of the formula



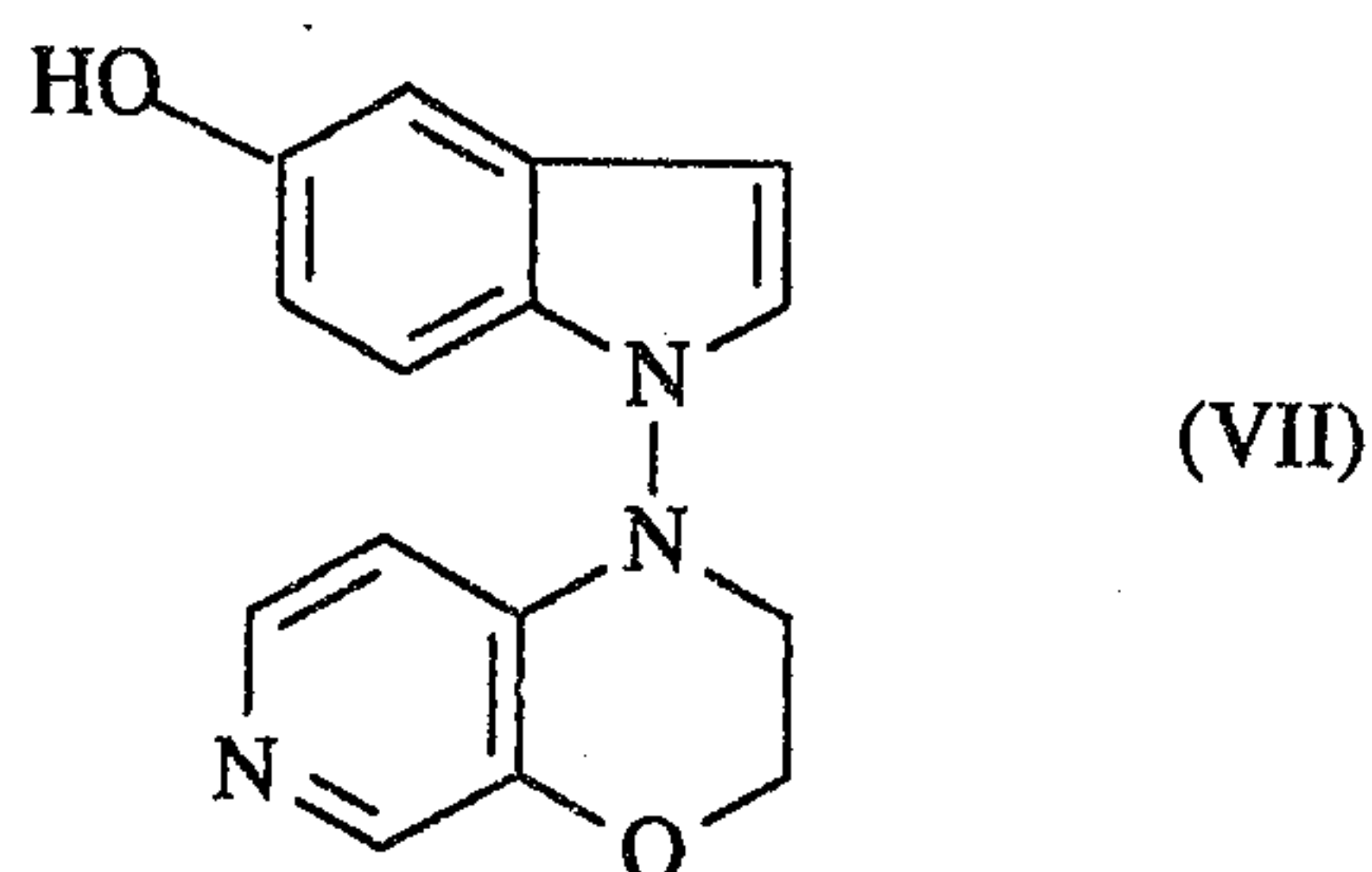
is reduced in a manner similar to that discussed above with lithium aluminum hydride or other suitable reducing agent to afford Compound V of the formula



Compound V is cyclized in a manner similar to that described above to afford Compound VI of the invention of the formula



Compound VI is subjected to catalytic hydrogenolysis to afford Compound VII of the invention of the formula



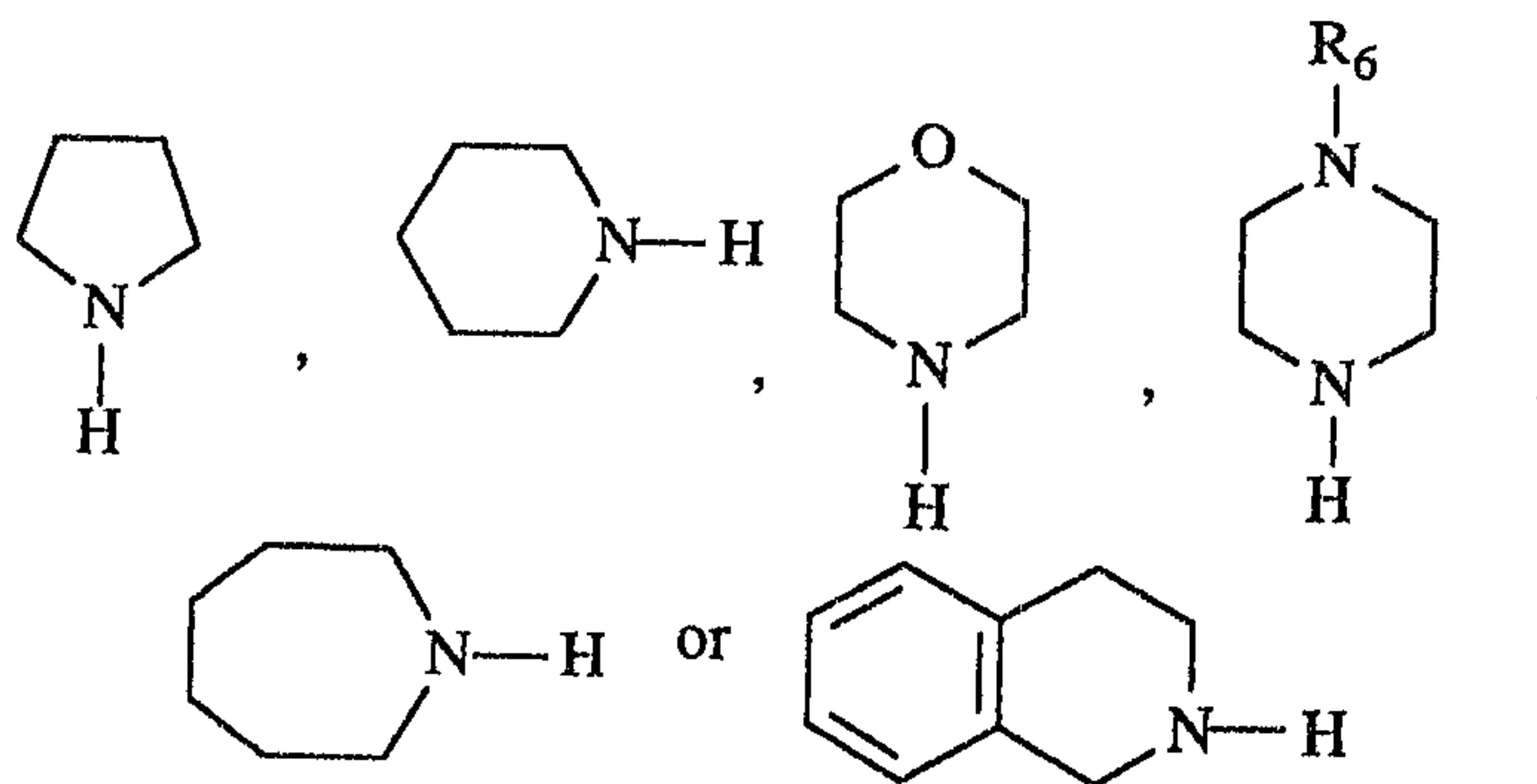
The hydrogenolysis is typically conducted with a noble metal catalyst, such as platinum or palladium on carbon in a loweralkanol solvent such as ethanol or isopropanol at a temperature of between about 25°C to 80°C.

Compound VII is reacted with an isocyanate of the formula $R_5\text{-NCO}$ wherein R_5 is loweralkyl, aryl or arylloweralkyl to afford Compound I wherein R_3 is $-\text{O}-\text{C}(=\text{O})\text{-NHR}_5$.

This reaction typically takes place in the presence of a base such as potassium

carbonate in a solvent such as tetrahydrofuran at a temperature of between about 0°C to 50°C for 1 to 24 hours.

To prepare Compound I where R_4 and R_5 taken together form a heterocyclic ring, Compound VII is reacted with compounds selected from the group consisting of



in the presence of carbonyldiimidazole. This reaction typically takes place in an ethereal solvent such as tetrahydrofuran or dioxane at a temperature of about 0° to 70°C for 1 to 24 hours.

The compounds of Formula I of the present invention are useful for the treatment of various memory dysfunctions characterized by a decreased cholinergic or adrenergic function, such as Alzheimer's disease, and for alleviating depression.

This utility is manifested by the ability of these compounds to inhibit the enzyme acetylcholinesterase and thereby increase acetylcholine levels in the brain.

Cholinesterase Inhibition Assay

Cholinesterases are found throughout the body, both in the brain and in serum. However, only brain acetylcholinesterase (AChE) distribution is correlated with central cholinergic innervation. This same innervation is suggested to be weakened in Alzheimer patients. We have determined *in vitro* inhibition of acetylcholinesterase activity in rat striatum according to the method described below.

Acetylcholinesterase (AChE), which is sometimes called true or specific cholinesterase, is found in nerve cells, skeletal muscle, smooth muscle, various glands and red blood cells. AChE may be distinguished from other cholinesterases by substrate and inhibitor specificities and by regional distribution. Its distribution in the brain correlates with cholinergic innervation and subfractionation shows the highest level in nerve terminals.

It is generally accepted that the physiological role of AChE is the rapid hydrolysis and inactivation of acetylcholine. Inhibitors of AChE show marked cholinomimetic effects in cholinergically-innervated effector organs and have been used therapeutically in the treatment of glaucoma, myasthenia gravis and paralytic ileus. However, recent studies have suggested that AChE inhibitors may also be beneficial in the treatment of Alzheimer's dementia.

The method described below was used in this invention for assaying anticholinesterase activity. This is a modification of the method of Ellman et al., Biochem. Pharmacol. 7, 88 (1961).

Procedure:

A. Reagents

1. 0.05 M Phosphate buffer, pH 7.2
 - (a) 6.85 g $\text{NaH}_2\text{PO}_4 \cdot \text{H}_2\text{O}$ /100 ml distilled H_2O
 - (b) 13.40 g $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$ /100 ml distilled H_2O
 - (c) add (a) to (b) until pH reaches 7.2
 - (d) Dilute 1:10
2. Substrate in buffer
 - (a) 198 mg acetylthiocholine chloride (10 mM)
 - (b) q.s. to 100 ml with 0.05 M phosphate buffer, pH 7.2 (reagent 1)

3. DTNB in buffer
 - (a) 19.8 mg 5,5-dithiobisnitrobenzoic acid (DTNB) (0.5 mM)
 - (b) q.s. to 100 ml with 0.05M phosphate buffer, pH 7.2 (reagent 1)
4. A 2mM stock solution of the test drug is made up in a suitable solvent and q.s. to volume with 0.5 mM DTNB (reagent 3). Drugs are serially diluted (1:10) such that the final concentration (in cuvette) is 10^{-4} M and screened for activity. If active, IC_{50} values are determined from the inhibitory activity of subsequent concentrations.

B. Tissue Preparation

Male Wistar rats are decapitated, brains rapidly removed, corpora striata dissected free, weighed and homogenized in 19 volumes (approximately 7 mg protein/ml) of 0.05 M phosphate buffer, pH 7.2, using a Potter-Elvehjem homogenizer. A 25 microliter aliquot of the homogenate is added to 1 ml of vehicle or various concentrations of the test drug and preincubated for 10 minutes at 37°C.

C. Assay

Enzyme activity is measured with the Beckman DU-50 spectrophotometer. This method can be used for IC_{50} determinations and for measuring kinetic constants.

Instrument Settings

Kinetics Soft-Pac Module #598273 (10)
Program #6 Kindata:
Source - Vis
Wavelength - 412 nm
Sipper - none
Cuvettes - 2 ml cuvettes using auto 6-sampler
Blank - 1 for each substrate concentration
Interval time - 15 seconds (15 or 30 seconds for kinetics)
Total time - 5 minutes (5 or 10 minutes for kinetics)
Plot - yes
Span - autoscale
Slope - increasing
Results - yes (gives slope)
Factor -1

Reagents are added to the blank and sample cuvettes as follows:

Blank:	0.8 ml Phosphate Buffer/DTNB 0.8 ml Buffer/Substrate
Control:	0.8 ml Phosphate Buffer/DTNB/Enzyme 0.8 ml Phosphate Buffer/Substrate
Drug:	0.8 ml Phosphate Buffer/DTNB/Drug/Enzyme 0.8 ml Phosphate Buffer/Substrate

Blank values are determined for each run to control non-enzymatic hydrolysis of substrate and these values are automatically subtracted by the kindata program available on kinetics soft-pac module. This program also calculates the rate of absorbance change for each cuvette.

For IC₅₀ Determinations:

Substrate concentration is 10 mM diluted 1:2 in assay yielding final concentration of 5 mM. DTNB concentration is 0.5 mM yielding 0.25 mM final concentration

$$\left(\frac{\text{slope control} - \text{slope drug}}{\text{slope control}} \right) (100)$$

Results of this assay for some of the compounds of this invention and physostigmine (reference compound) are presented in Table 1.

Table 1

<u>Compound</u>	<u>Inhibitory Concentration (μM)</u> <u>Brain AChE</u>
1-(Pyrido[3,4-b]-1,4-oxazin-4-yl)- 1H-indol-5-yl methylcarbamate	0.054
Physostigmine	0.006

This utility is further demonstrated by the ability of these compounds to restore cholinergically deficient memory in the Dark Avoidance Assay described below.

Dark Avoidance Assay

In this assay mice are tested for their ability to remember an unpleasant stimulus for a period of 24 hours. A mouse is placed in a chamber that contains a dark compartment; a strong incandescent light drives it to the dark compartment, where an electric shock is administered through metal plates on the floor. The animal is removed from the testing apparatus and tested again, 24 hours later, for the ability to remember the electric shock.

If scopolamine, an anticholinergic that is known to cause memory impairment, is administered before an animal's initial exposure to the test chamber, the animal re-enters the dark compartment shortly after being placed in the test chamber 24 hours later. This effect of scopolamine is blocked by an active test compound, resulting in a greater interval before-re-entry into the dark compartment.

The results for an active compound are expressed as the percent of a group of animals in which the effect of scopolamine is blocked, as manifested by an increased interval between being placed in the test chamber and re-entering the dark compartment.

Results of this assay for some of the compounds of this invention and those for tacrine and pilocarpine (reference compounds) are presented in Table 2.

Table 2

Compound	Dose (mg/kg of body weight, s.c.)	% of Animals with Scopolamine Induced Memory Deficit Reversal
1-(Pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methyl-carbamate	0.01	27%
	0.03	20%
	0.10	33%
Tacrine	0.63	13%
Pilocarpine	5.0	13%

These compounds are administered to a subject requiring memory enhancement as an effective oral, parenteral or intravenous dose of from about 1 to 100 mg/kg of body

weight per day. A particularly effective amount is about 10 mg/kg of body weight per day. It is to be understood that for any particular subject, specific dosage regimens should be adjusted according to the individual need and the professional judgment of the person administering or supervising the administration of the aforesaid compound. It is to be further understood that the dosages set forth herein are exemplary only and do not, to any extent, limit the scope or practice of the invention.

³H-Norepinephrine Uptake in Rat Whole Brain Synaptosomes

This assay is used as a biochemical screen for compounds that enhance adrenergic mechanism by blocking norepinephrine uptake.

The neuronal re-uptake mechanism for norepinephrine (NE) is the most important physiological means for inactivating NE by removing the transmitter from the synaptic cleft. NE uptake is accomplished by a saturable, stereospecific, high affinity, sodium dependent, active transport system; which has been shown to exist in both peripheral and central nervous system tissue. NE uptake is potently inhibited by cocaine, phenethylamines and tricyclic antidepressants. It is also inhibited by ouabain, metabolic inhibitors and phenoxybenzamine. The inhibition of NE uptake by clinically effective tricyclic antidepressants is an important link in the catecholamine hypothesis of affective disorders and extensive structure activity relationships for NE uptake have been worked out.

There are large regional variations in NE uptake which correlate with the endogenous levels of NE. The hypothalamus shows the highest level of NE and the greatest uptake. Synaptosomal ³H-NE uptake is a useful marker for the integrity of noreadrenergic neurons, after lesioning experiments, as well as any assay for compounds which potentiate the action of NE by blocking the reuptake mechanism.

Procedure

A. Animals: Male CR Wistar rats (100-125g).

B. Reagents

1. Krebs-Henseleit Bicarbonate Buffer, pH 7.4 (KHBB)

Make a 1 liter batch, containing the following salts.

	<u>grams/L</u>	<u>mM</u>
NaCl	6.92	118.4
KCl	0.35	4.7
MgSO ₄ ·7H ₂ O	0.29	2.2
NaHCO ₃	2.10	24.9
CaCl ₂	0.14	1.3

Prior to use add:

Dextrose	2 mg/ml	11.1
Iproniazid phosphate	0.30 mg/ml	0.1

Aerate for 60 min. with 95% O₂/5% CO₂, check pH (7.4±0.1).

2. 0.32 M Sucrose: 21.9 g of sucrose, Q.S. to 200 ml.
3. A 0.1 mM stock solution of L(-)-Norepinephrine bitartrate is made up in 0.01 N HCl. This is used to dilute the specific activity of radiolabeled NE.
4. Levo-[Ring-2,5,6-³H]-Norepinephrine (40-50 Ci/mmol) is obtained from New England Nuclear.

The final desired concentration of ³H-NE in the assay is 50 nM. The dilution factor is 0.8; therefore the KHBB is made up to contain 62.5 nM [³H]-NE.

Add to 100 ml of KHBB:

A.	59.4 μl of 0.1 mM NE	=	59.4 nM
*B.	0.31 nmoles of ³ H-NE	=	$\frac{3.1 \text{ nM}}{62.5 \text{ nM}}$

*Calculate volume added from the specific activity of ³H-NE.

5. For most assays, a 1 mM stock solution of the test compound is made up in suitable solvent and serially diluted such that the final concentration in the assay ranges from 2x10⁻⁸ to 2x10⁻⁵M. Seven concentrations are used for each assay. Higher or lower concentrations may be used depending on the potency of the test compound.

Male Wistar rats are decapitated and brains rapidly removed. Either whole brain minus cerebella or hypothalamus is weighed and homogenized in 9 volumes of ice-cold 0.32 M sucrose using a Potter-Elvehjem homogenizer. Homogenization should be done with 4-5 up and down strokes at medium speeds to minimize synaptosome lysis. The homogenate is centrifuged at 1000 g for 10 min at 0-4°C. The supernatant (S₁) is decanted and is used for uptake experiments.

D.	<u>Assay</u>	
	800μl	KHBB containing [³ H]-NE
	20μl	Vehicle or appropriate drug concentration
	200μl	Tissue suspension

Tubes are incubated at 37°C under a 95% O₂/5% CO₂ atmosphere for 5 minutes. For each assay, 3 tubes are incubated with 20 μl of vehicle at 0°C in an ice bath. After incubation all tubes are immediately centrifuged at 4000 g for 10 minutes. The supernatant fluid is aspirated and the pellets dissolved by adding 1 ml of solubilizer (Triton X-100 + 50% EtOH, 1:4 v/v). The tubes are vigorously vortexed, decanted into scintillation vials, and counted in 10 ml of Liquiscint scintillation counting cocktail. Active uptake is the difference between cpm at 37°C and 0°C. The per cent inhibition at each drug concentration is the mean of three determinations. Inhibitory concentration (IC₅₀) values are derived from log-probit analysis.

Results of this assay are presented in Table 3.

Table 3

Compound	IC ₅₀ (μM)
4-(3-Methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine	6.0
Amitriptyline (reference)	7.7
Nortriptyline (reference)	4.0

Effective quantities of the compounds of the present invention may be administered to a subject by any one of various methods, for example, orally as in

capsules or tablets, parenterally in the form of sterile solutions or suspensions, and in some cases intravenously in the form of sterile solutions. The compounds of the present invention, while effective themselves, may be formulated and administered in the form of their pharmaceutically acceptable addition salts for purposes of stability, convenience of crystallization, increased solubility and the like.

Acids useful for preparing the pharmaceutically acceptable acid addition salts of the invention include inorganic acids such as hydrochloric, hydrobromic, sulfuric, nitric, phosphoric and perchloric acids, as well as organic acids such as tartaric, citric, acetic, succinic, maleic, fumaric and oxalic acids.

The active compounds of the present invention may be administered orally, for example, with an inert diluent or with an edible carrier. They may be enclosed in gelatin capsules or compressed into tablets. For the purpose of oral therapeutic administration, the compounds may be incorporated with excipients and used in the form of tablets, troches, capsules, elixirs, suspensions, syrups, wafers, chewing gums and the like. These preparations should contain at least 0.5% of active compound, but may be varied depending upon the particular form and may conveniently be between 4% to about 75% of the weight of the unit. The amount of compound present in such composition is such that a suitable dosage will be obtained. Preferred compositions and preparations according to the present invention are prepared so that an oral dosage unit form contains between 1.0-300 mgs of active compound.

The tablets, pills, capsules, troches and the like may also contain the following ingredients: a binder such as microcrystalline cellulose, gum tragacanth or gelatin; an excipient such as starch or lactose, a disintegrating agent such as alginic acid, PrimogelTM, corn starch and the like; a lubricant such as magnesium stearate or Sterotex[®]; a glidant such as colloidal silicon dioxide; and a sweetening agent such as sucrose or saccharin or a flavoring agent such as peppermint, methyl salicylate, or orange flavoring may be added. When the dosage unit form is a capsule, it may contain, in addition to materials of the above type, a liquid carrier such as fatty oil. Other dosage unit forms may contain other various materials which modify the physical form of the dosage unit, for example, as

coatings. Thus tablets or pills may be coated with sugar, shellac, or other enteric coating agents. A syrup may contain, in addition to the active compounds, sucrose as a sweetening agent and certain preservatives, dyes and colorings and flavors. Materials used in preparing these various compositions should be pharmaceutically pure and non-toxic in the amounts used.

For the purpose of parenteral therapeutic administration, the active compounds of the invention may be incorporated into a solution or suspension. These preparations should contain at least 0.1% of the aforesaid compound, but may be varied between 0.5 and about 30% of the weight thereof. The amount of active compound in such compositions is such that a suitable dosage will be obtained. Preferred compositions and preparations according to the present invention are prepared so that a parenteral dosage unit contains between 0.5 to 100 mgs of active compound.

The solutions or suspensions may also include the following components; a sterile diluent such as water for injection, saline solution, fixed oils, polyethylene glycols, glycerine, propylene glycol or other synthetic solvents; antibacterial agents such as benzyl alcohol or methyl parabens; antioxidants such as ascorbic acid or sodium bisulfite; chelating agents such as ethylenediaminetetraacetic acid; buffers such as acetates, citrates or phosphates and agents for the adjustment of tonicity such as sodium chloride or dextrose. The parenteral preparation can be enclosed in ampules, disposable syringes or multiple dose vials made of glass or plastic.

Examples of the compounds of this invention include:

N-(3-fluoropyridin-4-yl)-N-(3-methyl-1H-indol-1-yl)-2-aminoethanol;

N-(3-fluoropyridin-4-yl)-N-(1H-indol-1-yl)-2-aminoethanol;

4-(3-methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;

N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol;

4-(1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;

4-(5-benzyloxy-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;

1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol;

1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methylcarbamate;

1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-2,3-dimethyl-1H-indol-5-yl heptylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 1,2,3,4-tetrahydroisoquinolylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl isopropylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl phenylmethylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-3-ethyl-1H-indol-5-yl piperidinylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl morphinlinylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 4-methylpiperazinylcarbamate;
 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 4-phenylmethylpiperazinylcarbamate;
 N-(3-Fluoro-4-pyridinyl)-N-(1H-indol-1-yl)glycine ethyl ester;
 N-(3-Fluoropyridin-4-yl)-N-(1H-indol-1-yl)-2-aminoethanol;
 4-(1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;
 N-(3-Chloro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)glycine ethyl ester;
 N-(3-Chloro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol;
 N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-2-methyl-1H-indol-1-yl)glycine ethyl ester;
 N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-2-methyl-1H-indol-1-yl)-2-aminoethanol;
 4-(5-Benzyloxy-2-methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;
 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol;
 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methylcarbamate;
 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl phenylmethylcarbamate;
 N-(3-Fluoro-4-pyridinyl)-N-(5-methoxy-1H-indol-1-yl)-2-aminoethanol;
 4-(5-Methoxy-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;
 N-(3-Fluoro-4-pyridinyl)-N-(5-methyl-1H-indol-1-yl)-2-aminoethanol;
 4-(3-Methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;
 N-(3-Fluoro-4-pyridinyl)-N-(6-chloro-1H-indol-1-yl)-2-aminoethanol; and
 4-(6-Chloro-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine;

The following examples are for illustrative purposes and are not to be construed as limiting the invention disclosed herein. All temperatures are given in degrees centigrade (°C) unless indicated otherwise.

Example 1aN-(3-Fluoro-4-pyridinyl)-3-methyl-1H-indol-1-amine

To 200 ml isopropanol was added 4-chloro-3-fluoropyridine hydrochloride (10 g) and 3-methyl-1H-indole-1-amine (5.9 g). The mixture was stirred at 90°C for four hours, cooled; then poured into 500 ml iced-water, pH adjusted to 10 with Na₂CO₃ solution, then extracted with ethyl acetate. The organic layer was washed with water, then dried (saturated NaCl, anhydrous MgSO₄). After filtering, the solvent was evaporated to an oil, which was eluted on a silica gel column with CH₂Cl₂ (DCM) then with ether:petroleum ether (1:1) via flash chromatography. The desired fractions were combined then evaporated to yield 6.2 g of a solid, 45°C. A sample of this material was recrystallized from isopropyl ether/hexanes (1:1) to give a solid, m.p. 141-142°C.

Analysis:

Calculated for C ₁₄ H ₁₂ FN ₃ :	69.69%C	5.02%H	17.42%N
Found:	69.52%C	5.01%H	17.57%N

Example 1b

N-(3-Fluoro-4-pyridinyl)-N-(3-methyl-1H-indol-1-yl)glycine ethyl ester

To a suspension of NaH (60% in oil, 1.48 g) in 10 ml of dimethylformamide (DMF) at ice bath temperature was added dropwise a solution of N-(3-fluoro-4-pyridinyl)-3-methyl-1H-indol-1-amine (8.5 g) in 40 ml of DMF. when addition was complete, the mixture was stirred for 15 minutes at ice bath temperature, and then cooled to -20°C. Ethyl chloroacetate (3.95 ml) was added dropwise in 10 ml of DMF. The mixture was stirred at -20°C for one hour. The mixture was then poured into water and extracted with ethyl acetate. The organic layer was washed with water and dried (sat. NaCl, anhy. MgSO₄). After filtering, the solvent was evaporated to yield an oil (12.2 g) which was eluted with 10% ethyl acetate/DCM on a silica gel column via HPLC. The desired fractions were evaporated to yield 6.9 g of a solid, m.p. 105-108°C.

Analysis:

Calculated for $C_{18}H_{18}FN_3O_2$:	66.04%C	5.54%H	12.84%N
Found:	66.00%C	5.53%H	12.81%N

Example 1c

N-(3-Fluoropyridin-4-yl)-N-(3-methyl-
1H-indol-1-yl)-2-aminoethanol

To N-(3-fluoro-4-pyridinyl)-N-(3-methyl-1H-indol-1-yl)glycine ethyl ester (5.0 g) in 100 ml of tetrahydrofuran cooled to ice bath temperature was added lithium aluminum hydride (1M solution in tetrahydrofuran, 30 ml) via syringe. The reaction was stirred for 0.5 hour. The mixture was quenched with NH_4Cl and extracted three times with ethyl acetate. The organics were combined, washed with sat. NaCl and dried ($MgSO_4$). After filtering, the solvent was evaporated to yield a solid (3.9 g) which was eluted with 50% ethyl acetate/dichloromethane on a silica gel column via high pressure liquid chromatography (HPLC). The desired fractions were evaporated to yield 3.7 g of a solid, m.p. 123-125°C.

Analysis:

Calculated for $C_{16}H_{16}FN_3O$:	67.35%C	5.65%H	14.73%N
Found:	67.45%C	5.67%H	14.72%N

Example 1d

4-(3-Methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine

To a suspension of NaH (0.34 g) in 5 ml dimethylformamide was added N-(3-fluoro-pyridin-4-yl)-N-(3-methyl-1H-indol-1-yl)-2-aminoethanol (2.0 g) in 50 ml dimethylformamide. The reaction was heated to 70°C and stirred for four hours. The mixture was poured into water and extracted with ethyl acetate. The organic layer was washed with water and dried (sat. NaCl, $MgSO_4$). After filtering, the solvent was evaporated to yield an oil (2.8 g), which was eluted with 50% ethyl

acetate/dichloromethane on a silica gel column via HPLC. The desired fractions were evaporated to yield 1.0g of a solid, m.p. 139-141°C.

Analysis:

Calculated for C ₁₆ H ₁₅ N ₃ O:	72.43%C	5.70%H	15.48%N
Found:	72.37%C	5.74%H	15.76%N

Example 2a

N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol

To a solution of N-(3-fluoro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)glycine ethyl ester (18.7 g) in 100 ml of tetrahydrofuran cooled to ice bath temperature, was added lithium aluminum hydride (89.16 ml) dropwise to the cool solution. The solution was stirred for 0.5 hour, then quenched with ammonium chloride and extracted with ethyl acetate. The organic layer was washed with water and dried (sat. NaCl, MgSO₄). After filtering, the solvent was evaporated to yield a solid (12.5 g) which was eluted with 50% ethyl acetate/dichloromethane on a silica gel column via HPLC. The desired fractions were evaporated to yield 9.65 g of a solid, m.p. 130-132°C.

Analysis:

Calculated for C ₂₂ H ₂₀ FN ₃ O ₂ :	70.01%C	5.34%H	11.13%N
Found:	69.98%C	5.28%H	11.04%N

Example 2b

4-(5-Benzyloxy-1H-indol-1-yl)-pyrido-[3,4-b]-1,4-oxazine

Sodium hydride (1.0 g) was suspended in dimethylformamide (10 ml) and this mixture cooled to ice bath temperature. A solution of N-(3-fluoro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol (8.25 g) in 100 ml of dimethylformamide was added dropwise, and the reaction mixture was then heated to 70°C and stirred for three hours. The mixture was cooled, poured into water and extracted with ethyl acetate. The organic layer was washed with water and dried (sat. NaCl, anhy. MgSO₄). After filtering, the solvent was evaporated to yield a solid (12.2 g) which was eluted with 50% ethyl

acetate/dichloromethane on a silica gel column via HPLC. The desired fractions were evaporated to yield 7.4 g of a solid, which was triturated with ether to yield 4.04 g of a solid, m.p. 181-183°C.

Analysis:

Calculated for $C_{22}H_{19}N_3O_2$:	73.93%C	5.36%H	11.75%N
Found:	73.67%C	5.39%H	11.68%N

Example 3

1-(Pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol

4-(5-benzyloxy-1H-indol-1-yl)-pyrido-[3,4-b]-1,4-oxazine (5.0 g) in 240 ml of ethanol was added to a suspension of 10% Pd/C (0.6 g) in 10 ml of ethanol. This mixture was hydrogenated on a Parr apparatus for two hours at 50°C. The mixture was then cooled, filtered, and the filtrate evaporated to yield a solid (3.5 g). This material was eluted with 5% methanol/dichloromethane on a silica gel column via HPLC. The desired fractions were evaporated to yield 2.7 g of a solid. Of this material, 0.9 g was recrystallized from acetonitrile to yield 0.62 g of a solid, m.p. 221-222°C.

Analysis:

Calculated for $C_{15}H_{13}N_3O_2$:	67.40%C	4.90%H	15.72%N
Found:	67.38%C	4.85%H	15.68%N

Example 4

1-(Pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methylcarbamate

Potassium carbonate (1.3 g) was added to a solution of 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol (2.0g) in 100 ml of tetrahydrofuran. After stirring at room temperature for 10 minutes, methyl isocyanate (0.46 g) was added dropwise. The reaction was allowed to proceed for 1 hour at room temperature. The mixture was then filtered and the filtrate evaporated to yield a solid (2.8 g). This material was eluted with 5% methanol/dichloromethane on a silica gel column via HPLC. The desired fractions were evaporated to yield 3.2 g of a solid, which was recrystallized from acetonitrile to yield 1.5

g of a solid, m.p. 196-198°C.

Analysis:

Calculated for $C_{17}H_{16}N_4O_3$:	62.95%C	4.97%H	17.28%N
Found:	62.95%C	4.91%H	17.30%N

Example 5a

N-(3-Fluoro-4-pyridinyl)-N-
(1H-indol-1-yl)glycine ethyl ester

To a suspension of sodium hydride (3.6 g) in 20 ml dimethylformamide at 0°C was added a solution of N-(3-fluoro-4-pyridinyl)-1H-indol-1-amine (19 g) in 120 ml dimethylformamide over fifteen minutes, and the resultant mixture stirred at 0°C for twenty minutes. After cooling the mixture to -20°C, a solution of ethyl chloroacetate (9.6 ml) in 25 ml dimethylformamide was added over fifteen minutes, and the resultant mixture stirred at -20°C for one hour.

The mixture was poured into 400 ml water, stirred for five minutes, then extracted with ethyl acetate. The organic layer was washed with water and saturated NaCl solution, then dried over anhydrous $MgSO_4$.

After filtering, the solvent was evaporated to an oil (26 g) which was eluted on a silica gel column with 10% ethyl acetate/dichloromethane via HPLC. The desired fractions were combined, then evaporated to yield 13.3 g of N-(3-fluoro-4-pyridinyl)-N-(1H-indol-1-yl)glycine ethyl ester, as a solid, m.p. 86-7°C.

Analysis:

Calculated for $C_{17}H_{16}FN_3O_2$:	65.16%C	5.15%H	13.41%N
Found:	65.00%C	5.14%H	13.19%N

Example 5b

N-(3-Fluoropyridin-4-yl)-N-
(1H-indol-1-yl)-2-aminoethanol

To a solution of lithium aluminum hydride (1 M solution, 70 ml) cooled to 0°C,

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was added a solution of N-(3-fluoro-4-pyridinyl)-N-(1H-indol-1-yl)glycine ethyl ester (11.4 g) in 125 ml tetrahydrofuran in thirty minutes. After stirring at 0°C for one hour, a solution of ammonium chloride was added, followed by 300 ml ethyl ether. The mixture was filtered, and the filtrate evaporated to a solid 10 g; which was eluted on a silica gel column with ethyl acetate/dichloromethane (1:1) via HPLC. The desired fractions were combined, then evaporated to yield 6.1 g of N-(3-fluoropyridin-4-yl)-N-(1H-indol-1-yl)-2-aminoethanol, as a solid, m.p. 133-5°C.

Analysis:

Calculated for C ₁₅ H ₁₄ FN ₃ O:	66.41%C	5.20%H	15.49%N
Found:	66.33%C	5.22%H	15.41%N

Example 5c

4-(1H-Indol-1-yl)-pyrido[3,4-b]-1,4-oxazine

To a suspension of sodium hydride (0.8 g) in 10 ml dimethylformamide, was added a solution of N-(3-fluoropyridin-4-yl)-N-(1H-indol-1-yl)-2-aminoethanol (4.8 g) in 100 ml dimethylformamide. After stirring at 70°C for four hours, the mixture was poured into 300 ml ice-water, stirred for five minutes, then extracted with ethyl acetate. The organic layer was washed with water, then saturated NaCl solution and then dried over anhydrous MgSO₄.

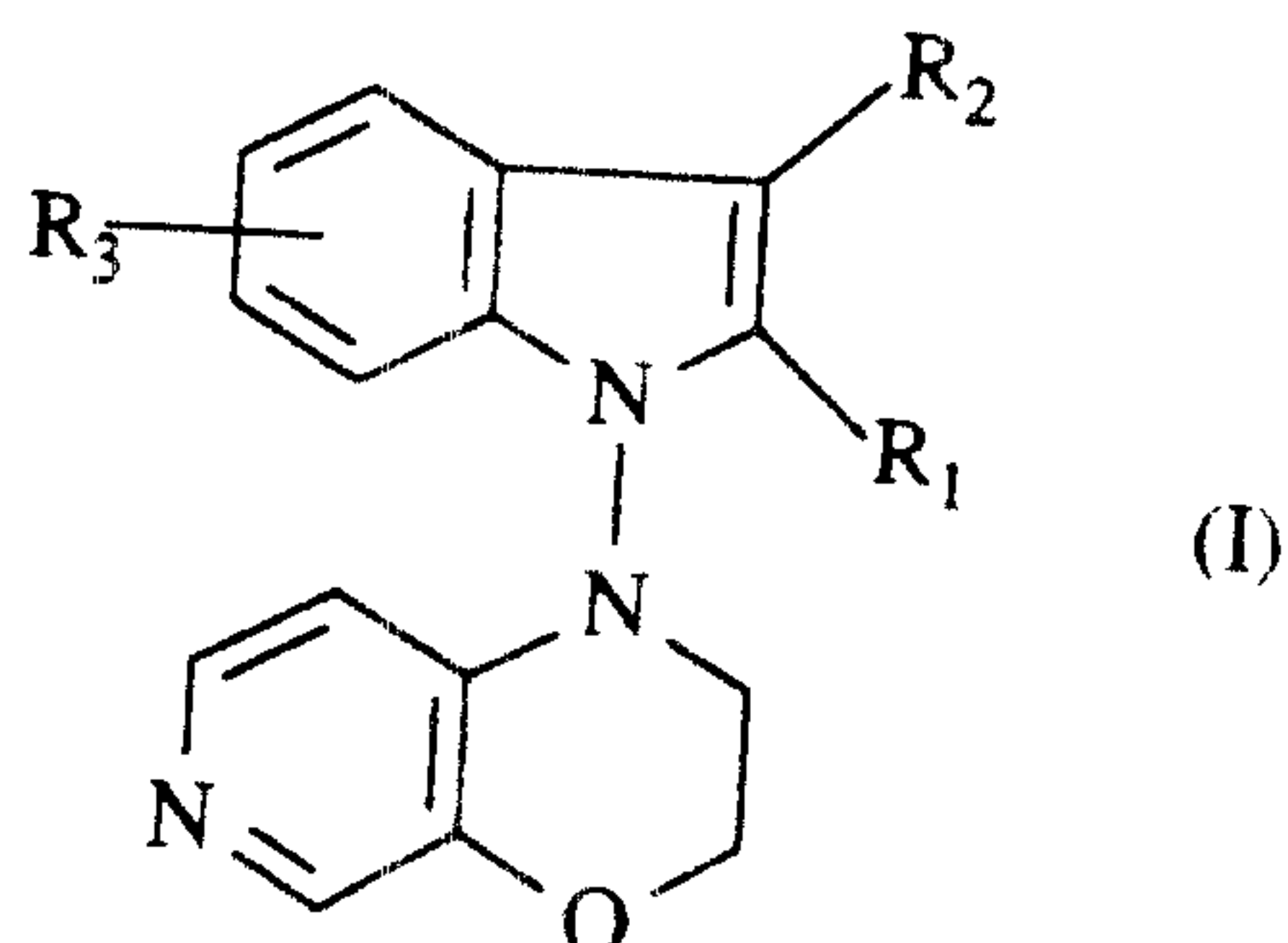
After filtering, the solvent was evaporated to an oil, which was eluted on a silica gel column with ethyl acetate/dichloromethane (1:2) via HPLC. The desired fractions were combined then evaporated to a thick oil, which solidified on standing to yield 3.4 g of 4-(1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine, as a solid, m.p. 108-110°C.

Analysis:

Calculated for C ₁₅ H ₁₃ N ₃ O:	71.70%C	5.21%H	16.72%N
Found:	71.38%C	4.91%H	16.52%N

CLAIMS:

1. A compound of the formula I

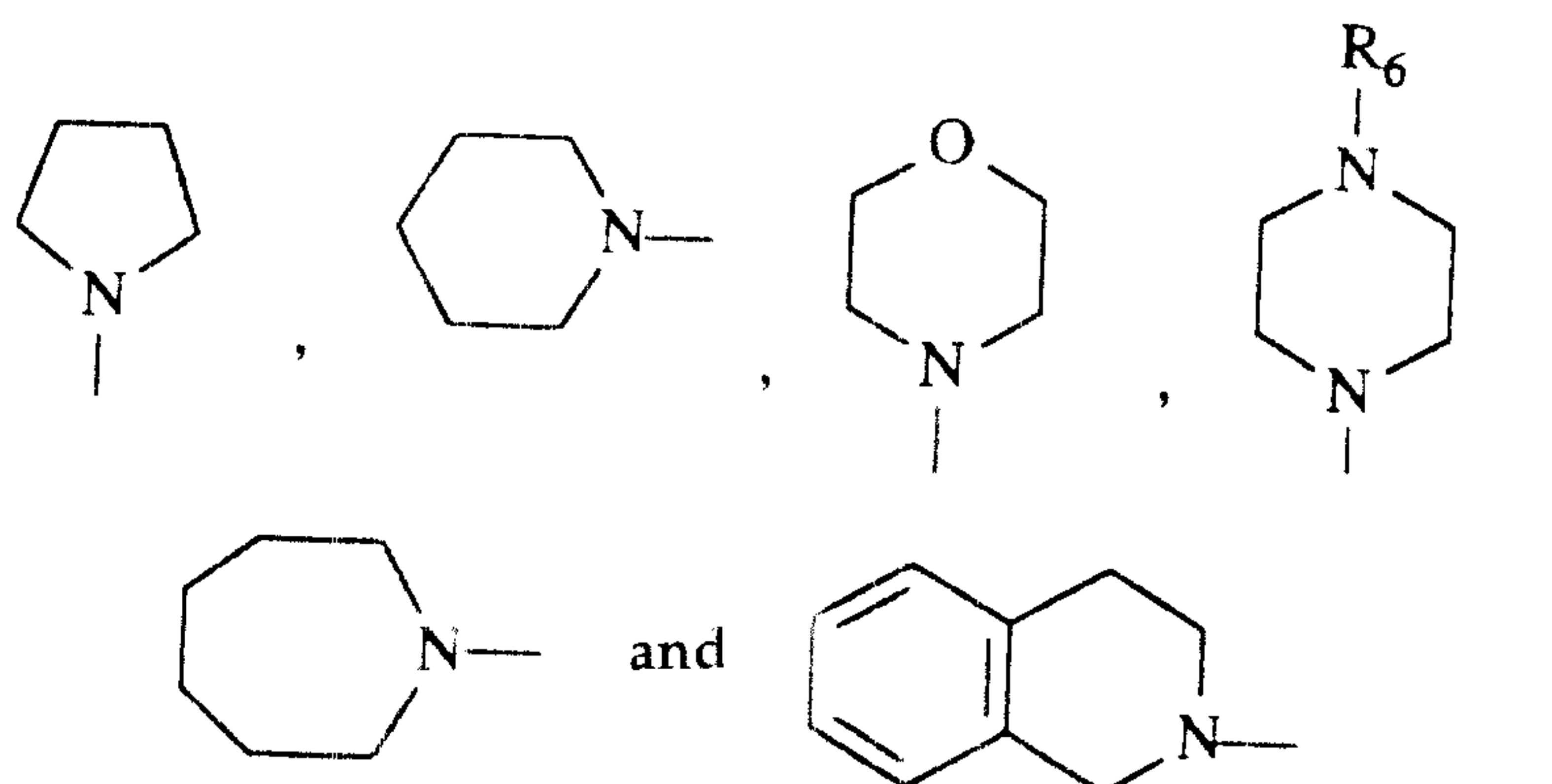


wherein

R₁ is hydrogen or (C₁-C₇)alkyl;

R₂ is hydrogen or (C₁-C₇)alkyl; and

R₃ is hydrogen, (C₁-C₇)alkyl, halogen, nitro, amino, hydroxy, (C₁-C₇)alkoxy, benzyloxy or -O-C(O)-NR₄R₅ where R₄ is hydrogen or (C₁-C₇)alkyl and R₅ is (C₁-C₇)alkyl, aryl or aryl(C₁-C₇)alkyl, or R₄ and R₅ taken together form a heterocyclic ring selected from the group consisting of



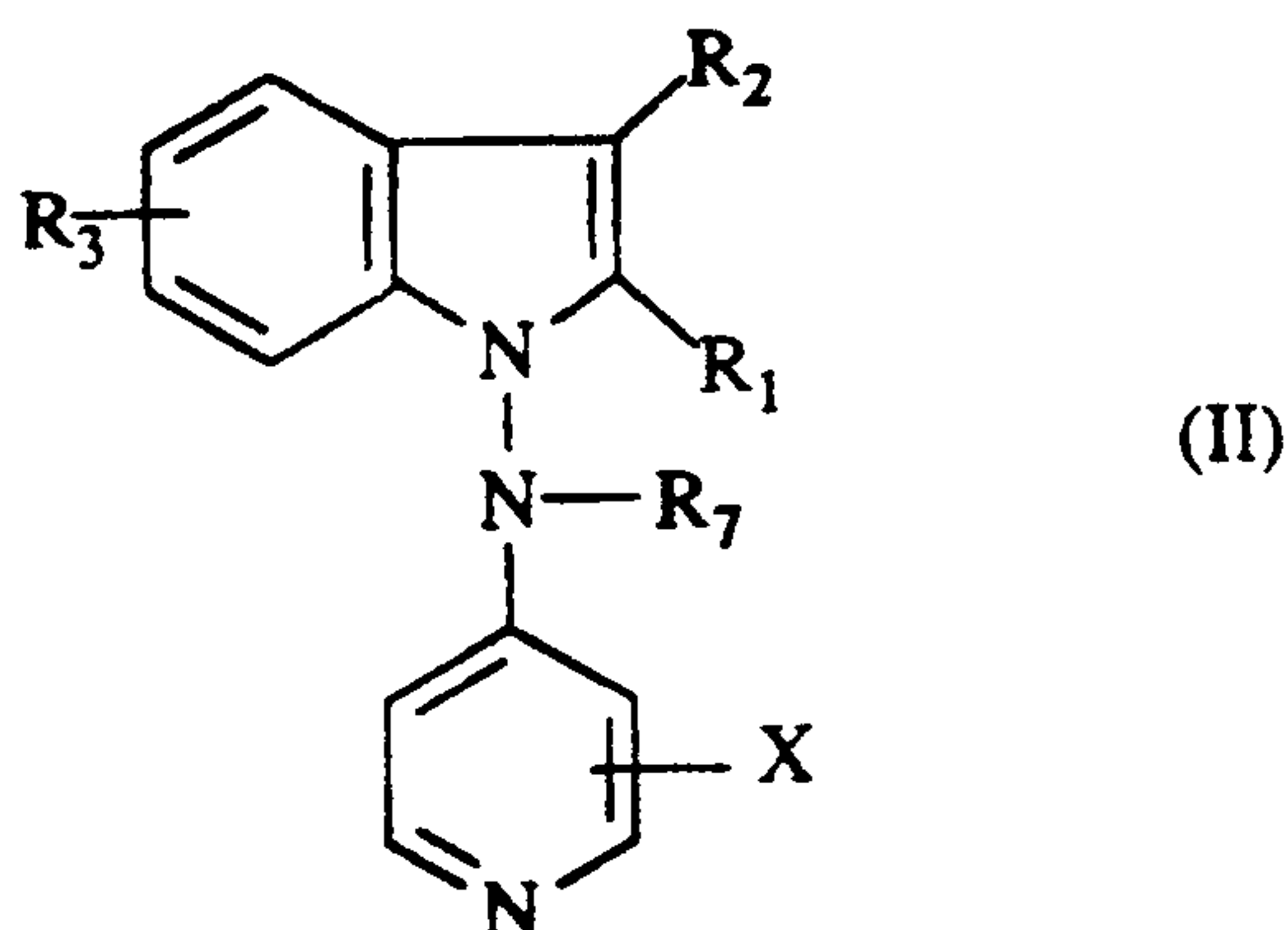
wherein R₆ is hydrogen, (C₁-C₇)alkyl, aryl or aryl(C₁-C₇)alkyl, and each occurrence of the term aryl is taken to mean a phenyl group substituted with 0, 1 or 2 substituents each of which being independently (C₁-C₇)alkyl, (C₁-C₇)alkoxy, halogen or trifluoromethyl, or a pharmaceutically acceptable acid addition salt thereof.

2. The compound as claimed in claim 1 wherein R_3 is hydrogen.
3. The compound as claimed in claim 1, wherein R_3 is hydrogen, hydroxy, benzyloxy or $-O-C(O)-NR_4R_5$ where R_5 is (C_1-C_7) alkyl.
4. The compound as claimed in claim 1 which is 1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methylcarbamate.
5. The compound as claimed in claim 1 which is 4-(3-methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
6. The compound as claimed in claim 1 which is 4-(1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
7. The compound as claimed in claim 1 which is 4-(5-benzyloxy-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
8. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol.
9. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-2,3-dimethyl-1H-indol-5-yl heptylcarbamate.
10. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 1,2,3,4-tetrahydroisoquinolylcarbamate.
11. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl isopropylcarbamate.
12. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl phenylmethylcarbamate.
13. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-3-ethyl-1H-indol-5-yl piperidinylcarbamate.

14. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl morpholinylcarbamate.
15. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 4-methylpiperazinylcarbamate.
16. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl 4-phenylmethylpiperazinylcarbamate.
17. The compound as claimed in claim 1 which is 4-(1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
18. The compound as claimed in claim 1 which is 4-(5-Benzyloxy-2-methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
19. The compound as claimed in claim 1 which is 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol.
20. The compound as claimed in claim 1 which is 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl methylcarbamate.
21. The compound as claimed in claim 1 which is 2-Methyl-1-(pyrido[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-yl phenylmethylcarbamate.
22. The compound as claimed in claim 1 which is 4-(5-Methoxy-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
23. The compound as claimed in claim 1 which is 4-(3-Methyl-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.
24. The compound as claimed in claim 1 which is 4-(6-Chloro-1H-indol-1-yl)-pyrido[3,4-b]-1,4-oxazine.

25. The compound as claimed in claim 1 which is 1-(pyrido-[3,4-b]-1,4-oxazin-4-yl)-1H-indol-5-ol.
26. A pharmaceutical composition which comprises a compound as defined in any one of claims 1-25 as the active ingredient and a suitable carrier therefor.
27. Use of a compound as defined in any one of claims 1-25 for the preparation of a medicament having memory dysfunction alleviating and/or antidepressant activity.
28. Use of a compound as defined in any one of claims 1-25 for alleviating memory dysfunction and/or antidepressant activity.
29. A process for the preparation of a compound of formula I as defined in claim 1, which comprises

- a) cyclizing a compound of the formula (II)

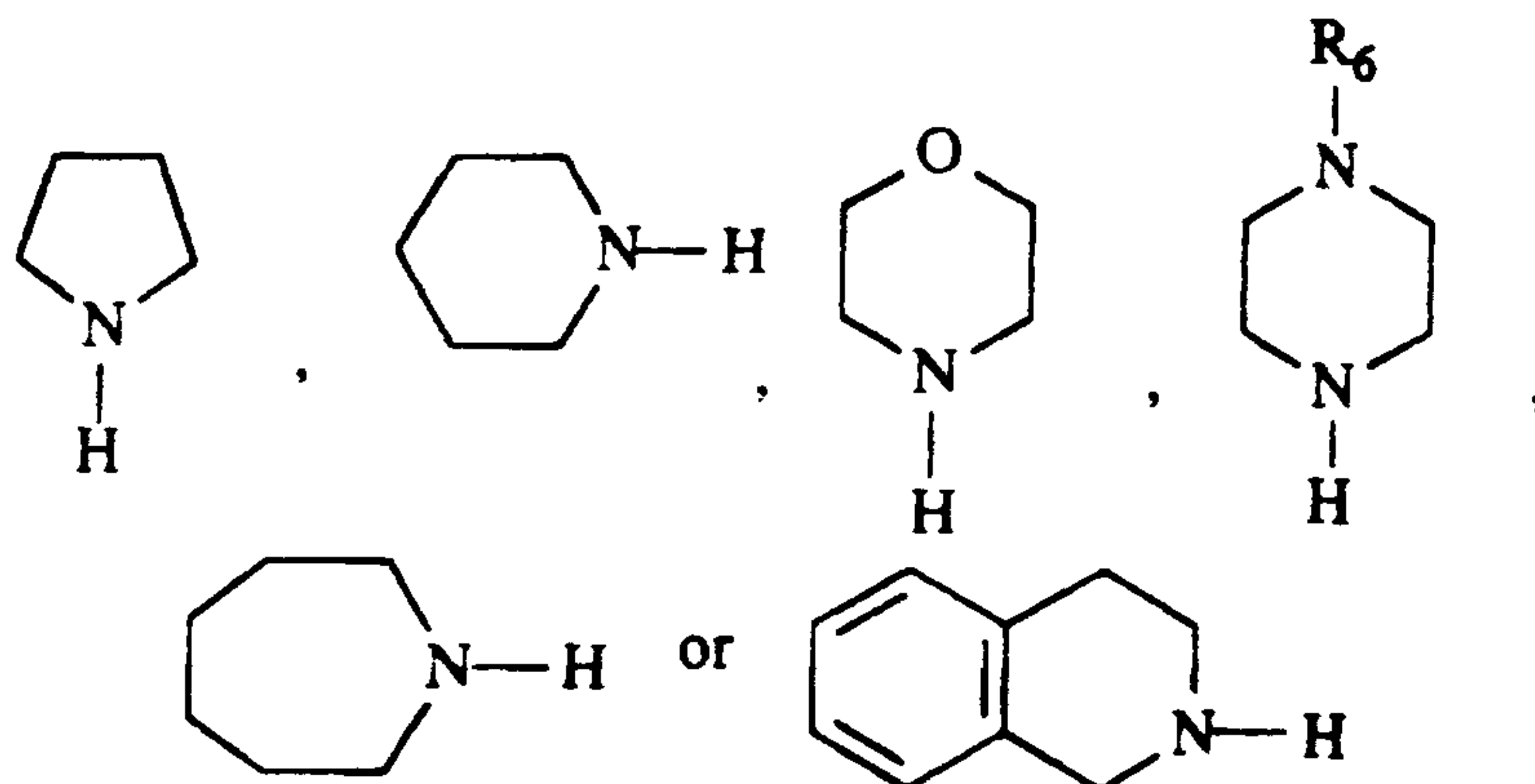


where R_1 , R_2 , and R_3 are as defined in claim 1, X is a fluorine atom in the meta position with respect to the nitrogen atom of the pyridyl ring and R_7 is $(CH_2)_2OH$, in the presence of a strong base, to form a compound of the formula I, where R_1 , R_2 and R_3 are as defined in claim 1,

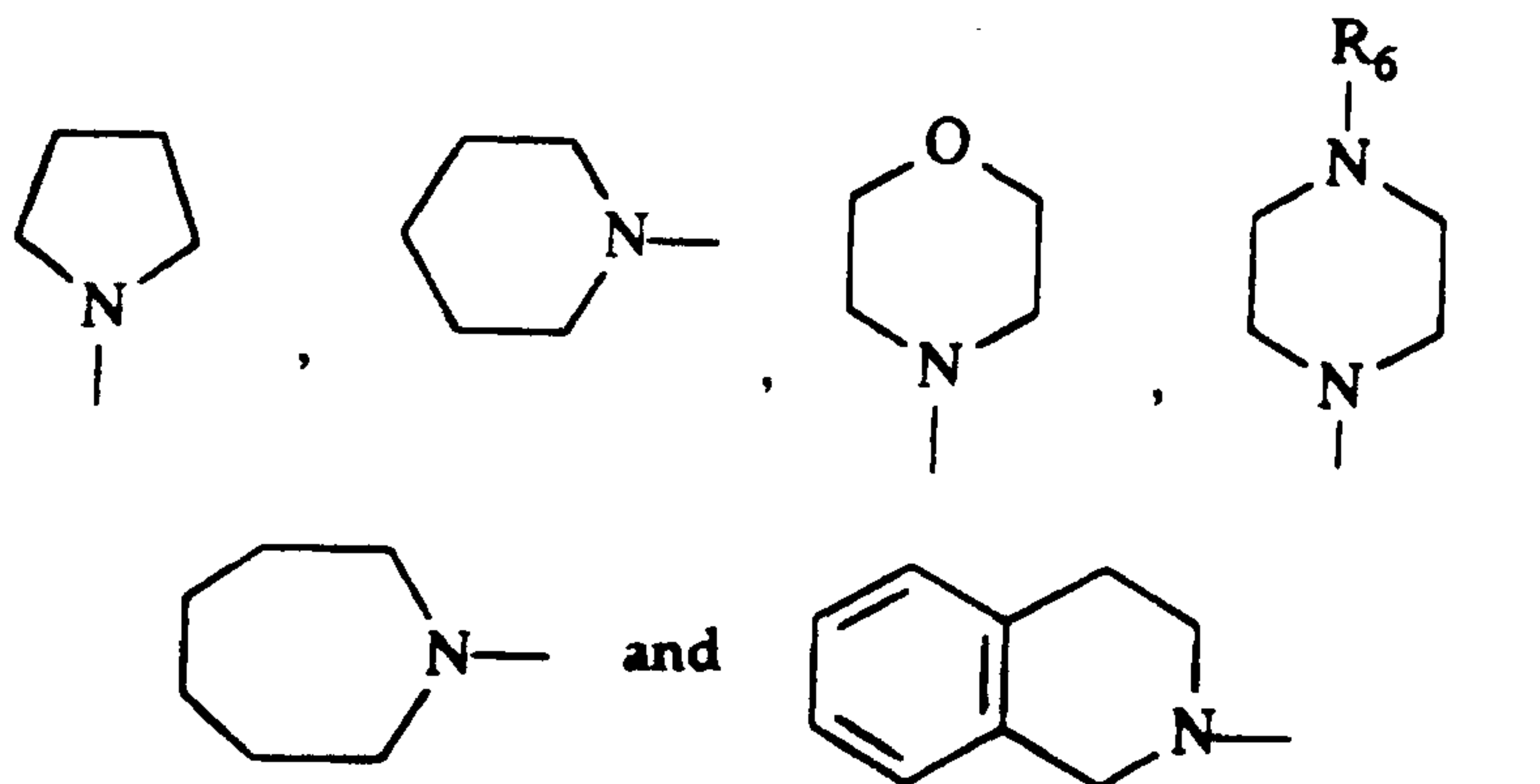
- b) optionally subjecting a compound of the formula I, wherein R_1 and R_2 are hydrogen and R_3 is benzyloxy, to catalytic hydrogenolysis, to

form a compound of the formula I, wherein R_1 and R_2 are hydrogen and R_3 is hydroxy,

- c) optionally reacting a compound of the formula I, wherein R_1 and R_2 are hydrogen, and R_3 is hydroxy, with an isocyanate of the formula $R_5\text{-NCO}$, wherein R_5 is $(C_1\text{-}C_7)$ alkyl, aryl or aryl $(C_1\text{-}C_7)$ alkyl, to form a compound of the formula I, wherein R_3 is the group $-\text{OC(O)-NH-}R_5$ where R_5 is as defined, or
- d) optionally reacting a compound of the formula I, wherein R_1 and R_2 are hydrogen and R_3 is hydroxy, with a compound of the formula

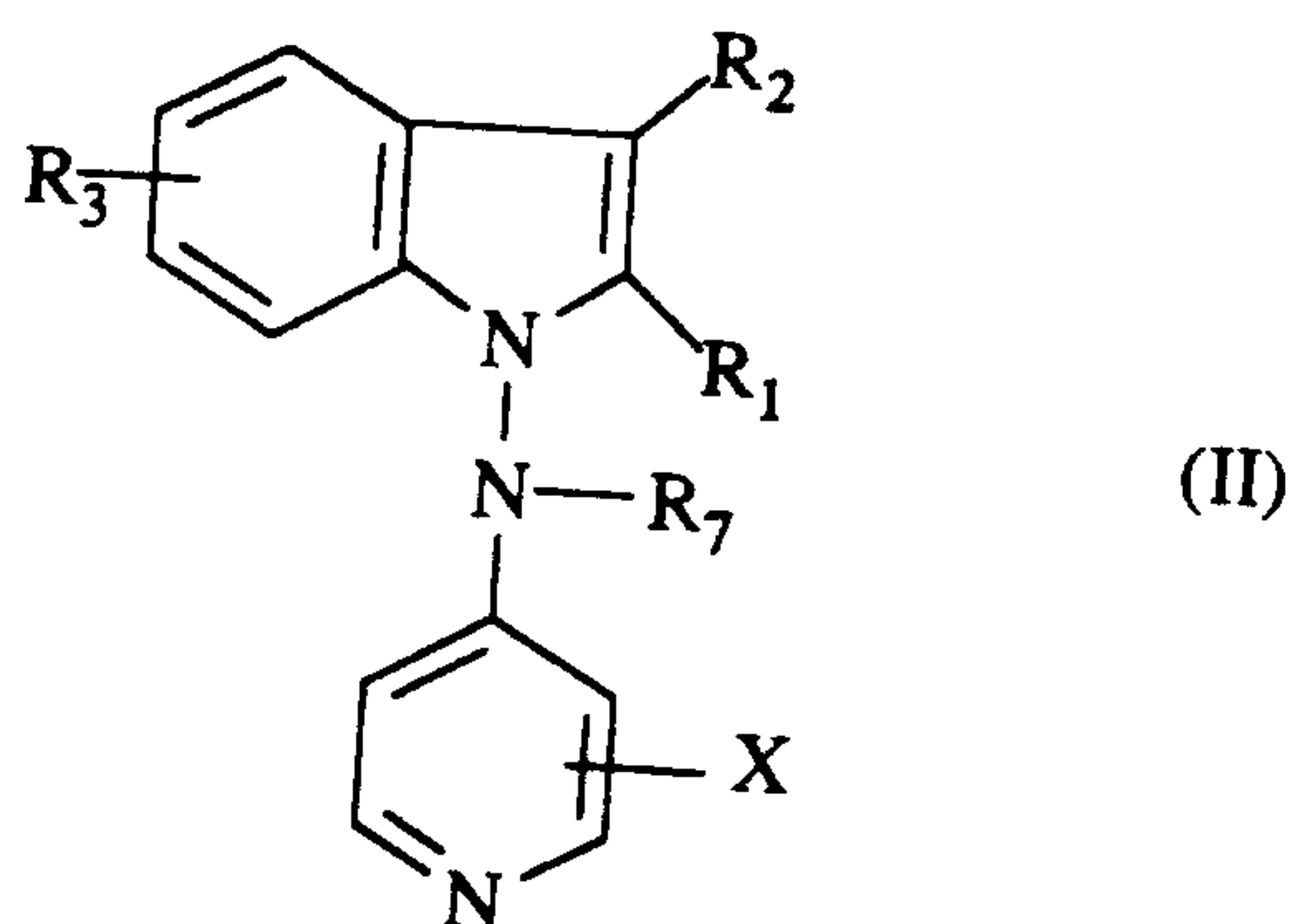


where R_6 is as defined in claim 1, in the presence of carbonyldiimidazole to afford a compound of the formula I wherein R_1 and R_2 are hydrogen and R_3 is the group $-\text{O-C(O)-NR}_4\text{R}_5$ where R_4 and R_5 taken together with the nitrogen atom form a heterocyclic ring selected from the group consisting of



where R_6 is as defined in claim 1.

30. A compound of the formula II

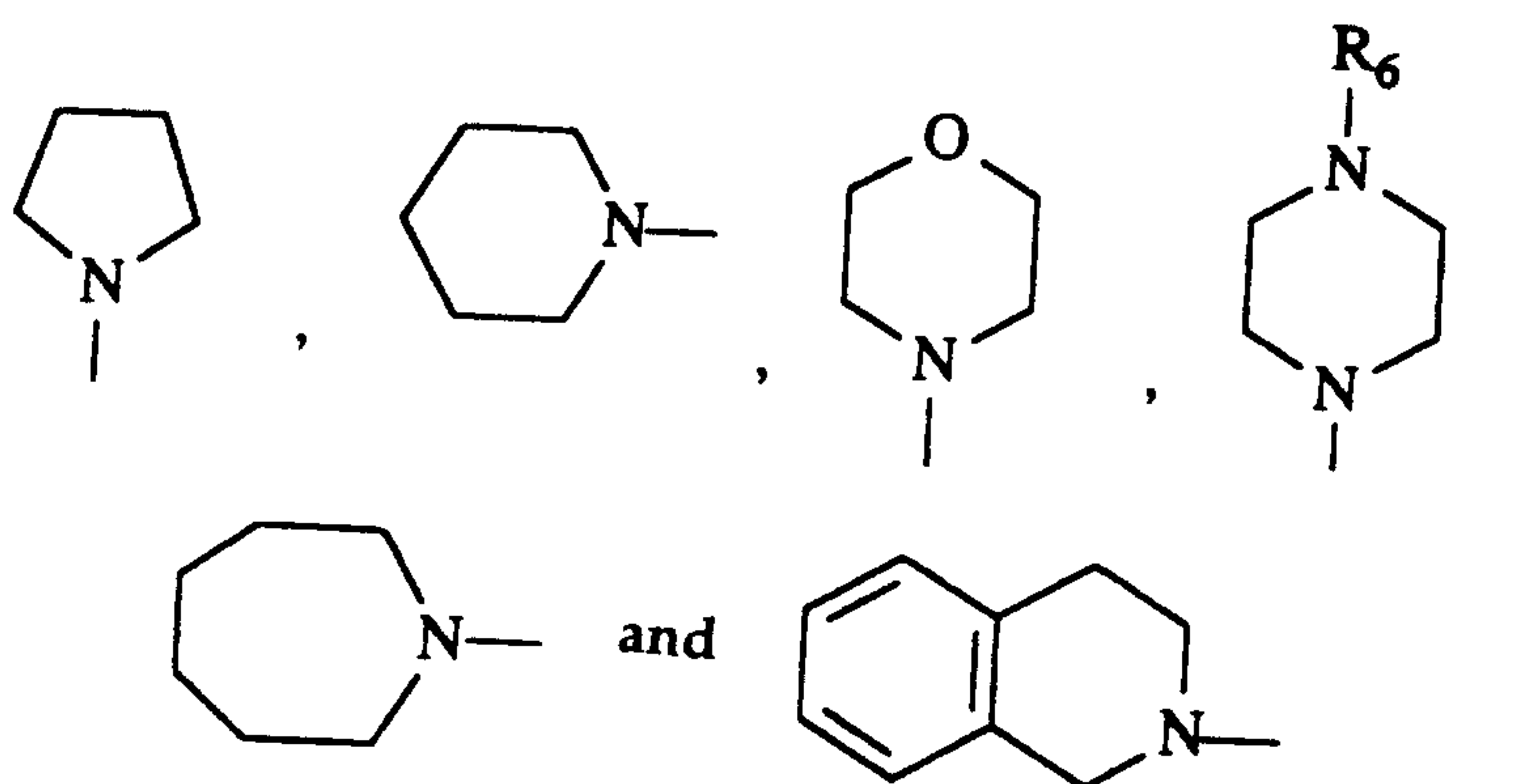


wherein

R_1 is hydrogen or (C_1-C_7) alkyl;

R_2 is hydrogen or (C_1-C_7) alkyl,

R_3 is hydrogen, (C_1-C_7) alkyl, halogen, nitro, amino, hydroxy, (C_1-C_7) alkoxy, benzyloxy or $-O-C(O)-NR_4R_5$ where R_4 is hydrogen or (C_1-C_7) alkyl and R_5 is (C_1-C_7) alkyl, aryl or aryl (C_1-C_7) alkyl, or R_4 and R_5 taken together form a heterocyclic ring selected from the group consisting of

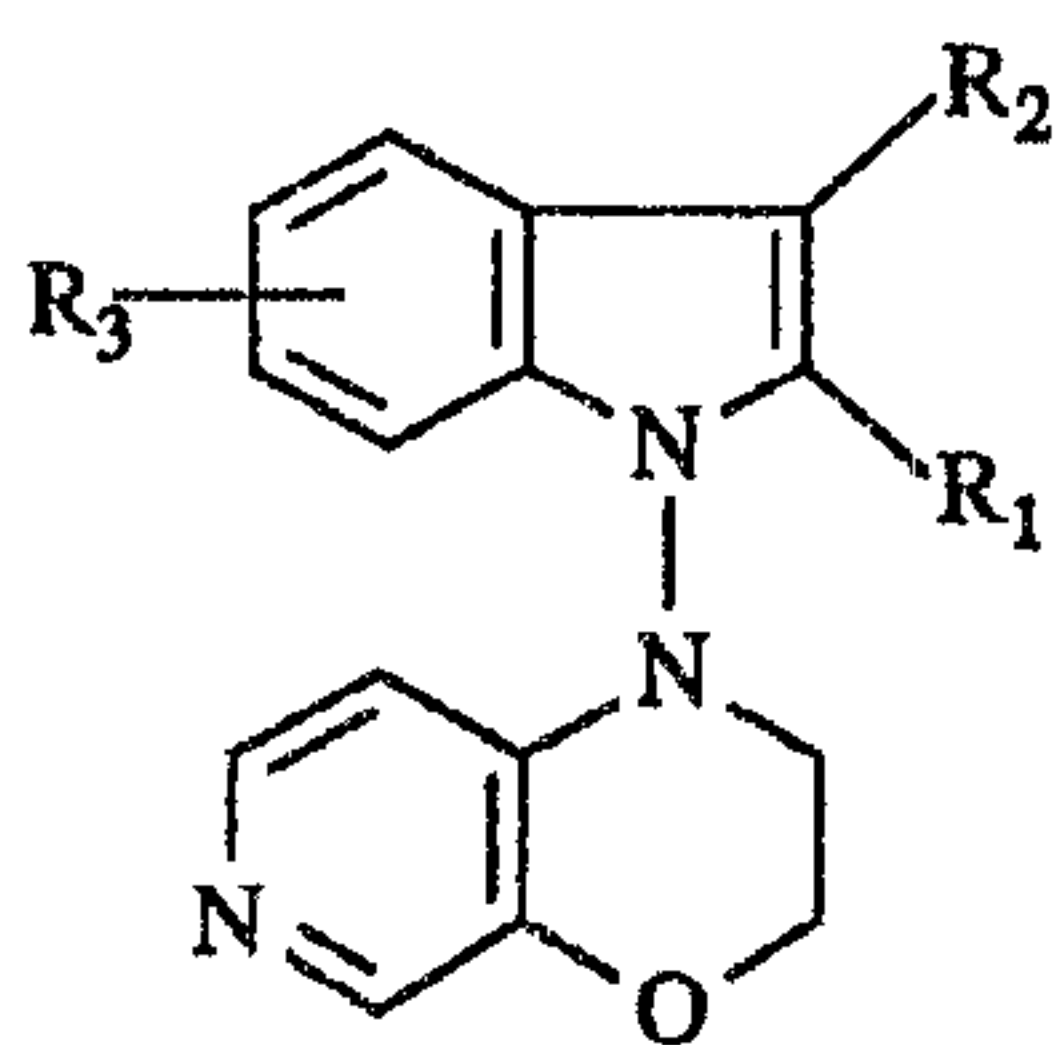


wherein R_6 is hydrogen, (C_1-C_7) alkyl, aryl or aryl (C_1-C_7) alkyl; X is halogen, and R_7 is $(CH_2)_2OH$, $CH_2CO_2R_8$ or $CH_2C(O)H$ wherein R_8 is hydrogen or (C_1-C_7) alkyl,

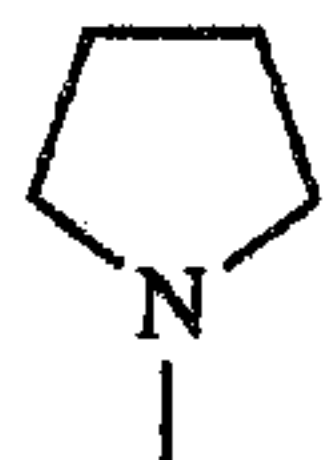
and each occurrence of the term "aryl" is taken to mean a phenyl group substituted with 0, 1 or 2 substituents each of which being independently (C₁-C₇)alkyl, (C₁-C₇)alkoxy, halogen or trifluoromethyl, or a pharmaceutically acceptable addition salt thereof.

31. The compound as claimed in claim 30 which is N-(3-fluoropyridin-4-yl)-N-(3-methyl-1H-indol-1-yl)-2-aminoethanol.
32. The compound as claimed in claim 30 which is N-(3-fluoropyridin-4-yl)-N-(1H-indol-1-yl)-2-aminoethanol.
33. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol.
34. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(1H-indol-1-yl)glycine ethyl ester.
35. The compound as claimed in claim 30 which is N-(3-Fluoropyridin-4-yl)-N-(1H indol-1-yl)-2-aminoethanol.
36. The compound as claimed in claim 30 which is N-(3-Chloro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)glycine ethyl ester.
37. The compound as claimed in claim 30 which is N-(3-Chloro-4-pyridinyl)-N-(5-benzyloxy-1H-indol-1-yl)-2-aminoethanol.
38. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-2-methyl-1H-indol-1-yl)glycine ethyl ester.
39. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(5-benzyloxy-2-methyl-1H-indol-1-yl)-2-aminoethanol.
40. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(5-methoxy-1H-indol-1-yl)-2-aminoethanol.

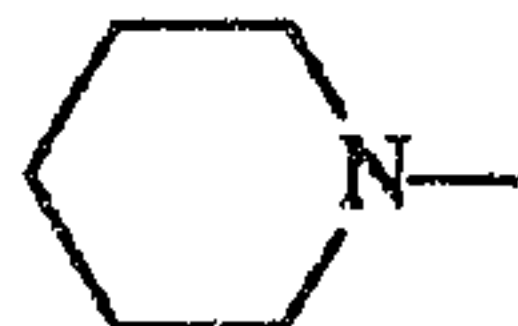
41. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(5-methyl-1H-indol-1-yl)-2-aminoethanol.
42. The compound as claimed in claim 30 which is N-(3-Fluoro-4-pyridinyl)-N-(6-chloro-1H-indol-1-yl)-2-aminoethanol.



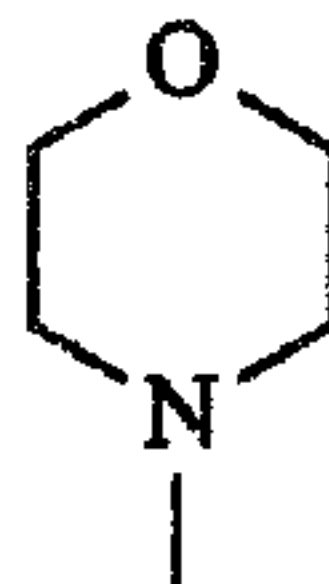
(I)



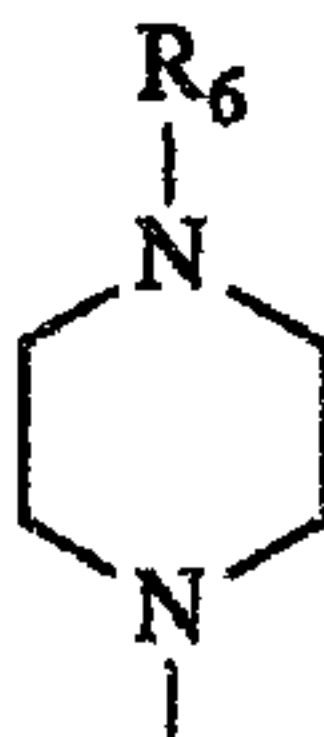
(II)



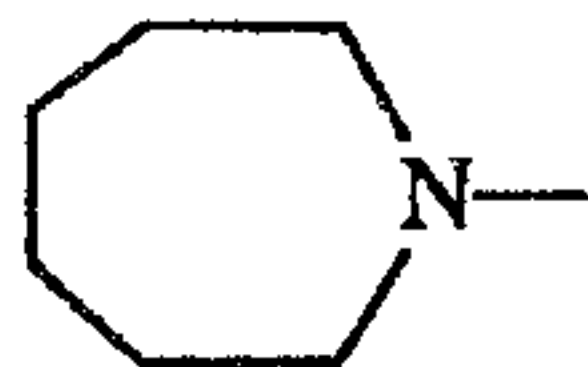
(III)



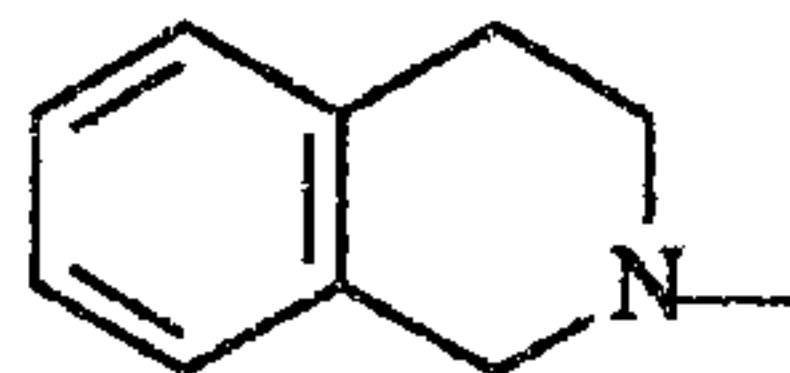
(IV)



(V)



(VI)



(VII)