

[54] STEREOSELECTIVE PREPARATION OF 3-SUBSTITUTED-4-ANILINO-PIPERIDINE COMPOUNDS AND DERIVATIVES

3,907,813 9/1975 Janssen et al. 260/293.79
3,998,834 12/1976 Janssen et al. 546/213
4,196,210 4/1980 Sanczuk et al. 546/213
4,584,303 4/1986 Huang et al. 546/210

[75] Inventors: Linas V. Kudzma, North Bergen; H. Kenneth Spencer, Chatham; Sherry A. Savernak, Plainfield, all of N.J.

FOREIGN PATENT DOCUMENTS

0119558 9/1984 European Pat. Off. 211/44

[73] Assignee: BOC, Inc., Murray Hill, N.J.

OTHER PUBLICATIONS

[21] Appl. No.: 413,427

D. B. Collum et al., "Substituent Effects on the Stereo--Chemistry, etc", 2/13/84, 4 pages, J. Am. Chem. Soc. 106, (4864-4869).

[22] Filed: Sep. 27, 1989

T. R. Burke et al., "Probes for Narcotic Receptor Mediated Phenomena, etc.", J. Med. Chem., 1986, 29, 1087-1093 (7 pages).

"Drugs for the Future", vol. 9, No. 4, 1984, pp. 197-198 and 262-263.

Related U.S. Patent Documents

Reissue of:

[64] Patent No.: 4,849,521
Issued: Jul. 18, 1989
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[51] Int. Cl.⁵ C07D 417/06

[52] U.S. Cl. 546/209; 546/194; 546/210; 546/211; 546/213; 546/223; 546/193; 546/244

[58] Field of Search 546/193, 194, 209, 210, 546/211, 213, 223, 244

[57] ABSTRACT

The present invention is directed to an improved stereoselective tandem substitution and reduction of an imine precursor to the cis form of [3-substituted-4-(phenylamino)piperidine] 3-substituted-4-anilino piperidine compounds or their substituted derivatives.

[56] References Cited

U.S. PATENT DOCUMENTS

3,161,637 12/1964 Janssen et al. 546/213
3,164,600 1/1965 Janssen et al. 546/213
3,907,811 9/1975 Janssen et al. 260/293.77

17 Claims, No Drawings

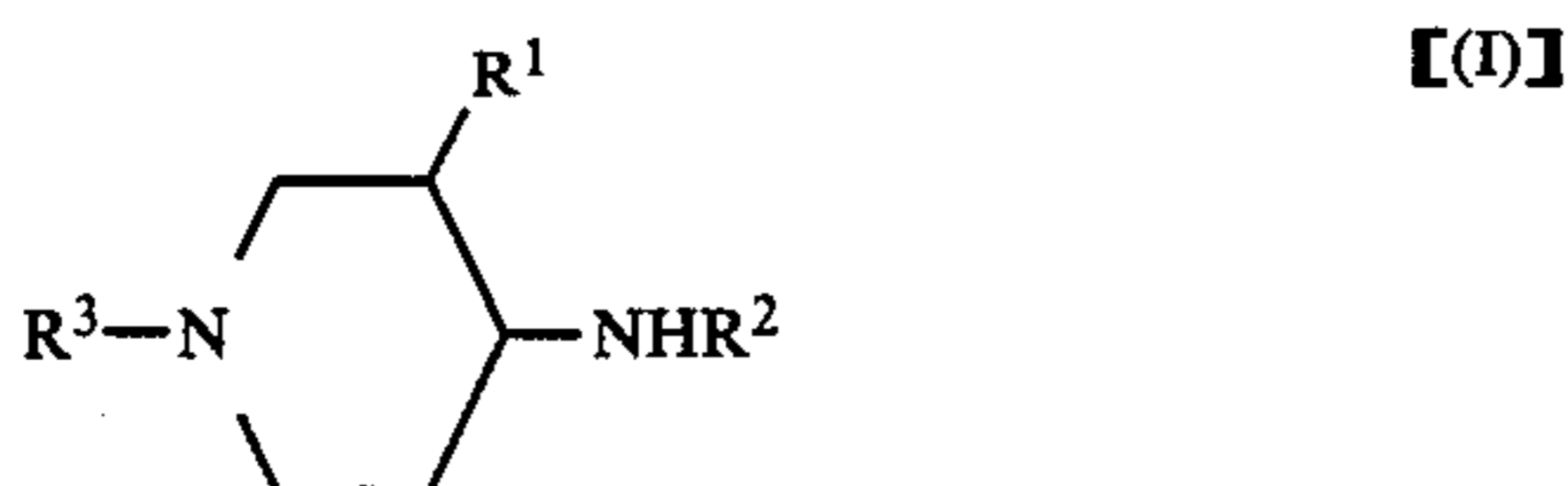
STERESELECTIVE PREPARATION OF 3-SUBSTITUTED-4-ANILINO-PIPERIDINE COMPOUNDS AND DERIVATIVES

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

BACKGROUND OF THE INVENTION

The present invention relates to a stereoselective tandem substitution and reduction reaction of [4-(cinalino) piperidine] 4-anilino-piperidine derivatives. The resulting 3,4-cis compounds are useful intermediates leading to intravenous analgesics.

U.S. Pat. No. 4,584,303 discloses a method of preparing compounds of the following formula:



wherein R¹ is [a lower alkyl, lower cyclic alkyl, lower alkyl lower cyclic alkyl, lower alkenyl, lower alkyl phenyl] *hydrogen or methyl*; R² is phenyl or [aromatic heterocycle ring either of which may be] *phenyl* substituted; and R³ may be a variety of groups including [alkyl phenyl] *phenyl alkyl*. With respect to the R¹ and NHR² substituents, it is desirable to obtain the more pharmacologically active cis isomer.

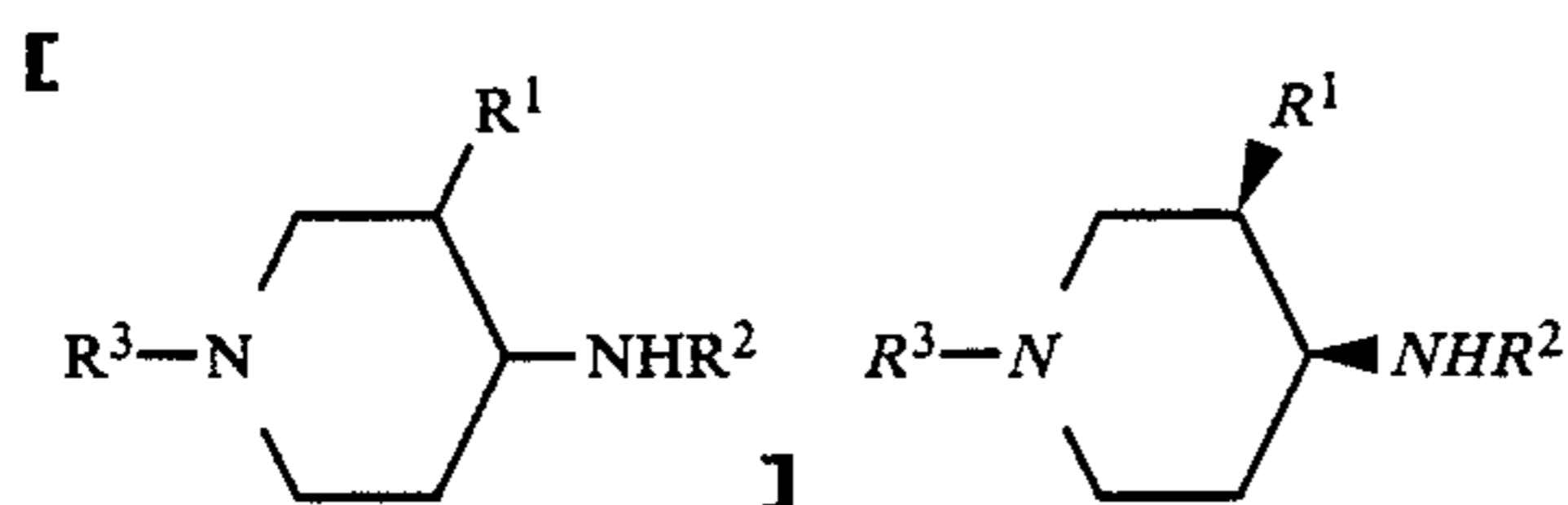
The method taught in U.S. Pat. No. [3,584,303] 4,584,303 for preparing compounds of the above formula (I) requires a multi-step synthetic route involving the preparation of cis isomers at an advanced stage of the synthetic route. Furthermore, a cis:trans ratio of not greater than 70:30 can be achieved.

J. Burke, Jr. et al., J. Med. Chem., Vol. 29, No. 6, pp 1087-1093 (1986), discloses a method to prepare piperidine derivatives, which method suffers the same disadvantages of the above-mentioned prior art method. Furthermore, the multi-step method of Burke et al. requires expensive starting materials and protection of the piperidine nitrogen.

The deprotonation of aliphatic imines followed by alkylation is generally known as, for example, shown by Collum et al., J. Am. Chem. Soc., Vol. 106, pp 4865-4869 (1984). The reduction of an imine is in itself also conventional.

SUMMARY OF THE INVENTION

The invention is directed to a method of preparing a compound of the following formula:



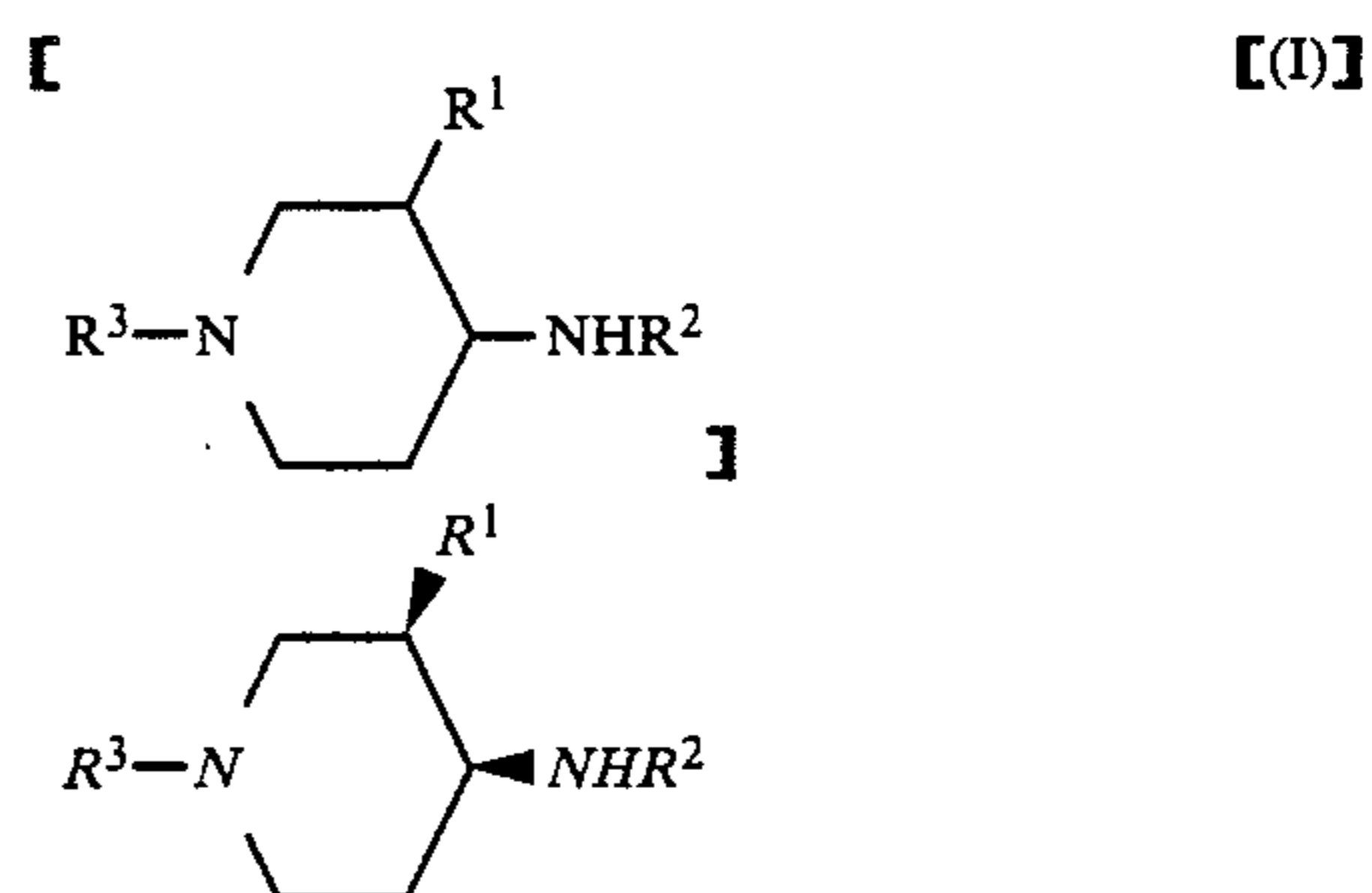
wherein R¹ is lower alkyl, lower [cyclic] *cyclic* alkyl, [lower alkyl] lower cyclic alkyl *lower alkyl*, lower alkenyl, or *phenyl* lower alkyl [phenyl]; R² is a phenyl or aromatic heterocycle ring either of which may be

substituted with one or more groups selected from the group consisting of lower alkoxy, lower alkyl, halogen, or combinations thereof; and R³ can be a wide variety of groups, for example, selected from phenyl lower alkyl, thiazolyl lower alkyl, which can be substituted in the 4-position with a lower alkyl group, (4,5-dihydro-5-oxo-1H-tetrazol-1-yl) lower alkyl, which can be substituted in the 4-position with a lower alkyl, and substituted phenyl lower alkyl in which the substituents on the phenyl ring are selected from halogen, lower alkoxy, lower alkyl or combinations thereof.

According to the method of the present invention, an aryl imine precursor is capable of being stereoselectively substituted in a single reactor without requiring intermediate separations or purifications. Readily available starting materials are utilized and no special protection of the piperidine nitrogen is necessary. Very high selectivity of the cis isomer (typically 96%) can be achieved, resulting in an easier purification at an early stage of the overall synthetic route leading to the final product. Production of the nonrecyclable trans isomer is minimized.

DETAILED DESCRIPTION OF THE INVENTION

Applicants have found an improved method for the efficient and economical preparation of compounds according to formula (I) below:



wherein R¹ is lower alkyl, lower cyclic alkyl, [lower alkyl] lower cyclic alkyl *lower alkyl*, lower alkenyl, or *phenyl* lower alkyl [phenyl]; R² is a phenyl or aromatic heterocycle ring either of which may be substituted with one or more groups selected from the group consisting of lower alkoxy, lower alkyl, halogen, or combinations thereof; and R³ is selected from a wide variety of groups, including phenyl lower alkyl, thiazolyl lower alkyl, which can be substituted in the 4-position with a lower alkyl group, (4,5-dihydro-5-oxo-1H-tetrazol-1-yl) lower alkyl, which can be substituted in the 4-position with a lower alkyl, and substituted phenyl lower alkyl in which the substituents on the phenyl ring are selected from halogen, lower alkoxy, lower alkyl or combinations thereof.

By the term lower alkyl, lower alkoxy, lower cyclic alkyl, or lower alkenyl are meant branched or unbranched chain groups with seven or less carbon atoms and preferably 5 or less carbons. By aromatic heterocycle ring is meant a fully unsaturated ring having 5 or 6 members including 0-3 nitrogen atoms and 0-2 oxygen or sulfur atoms. The term halogen is meant to include fluoro, chloro, bromo, or iodo substituents.

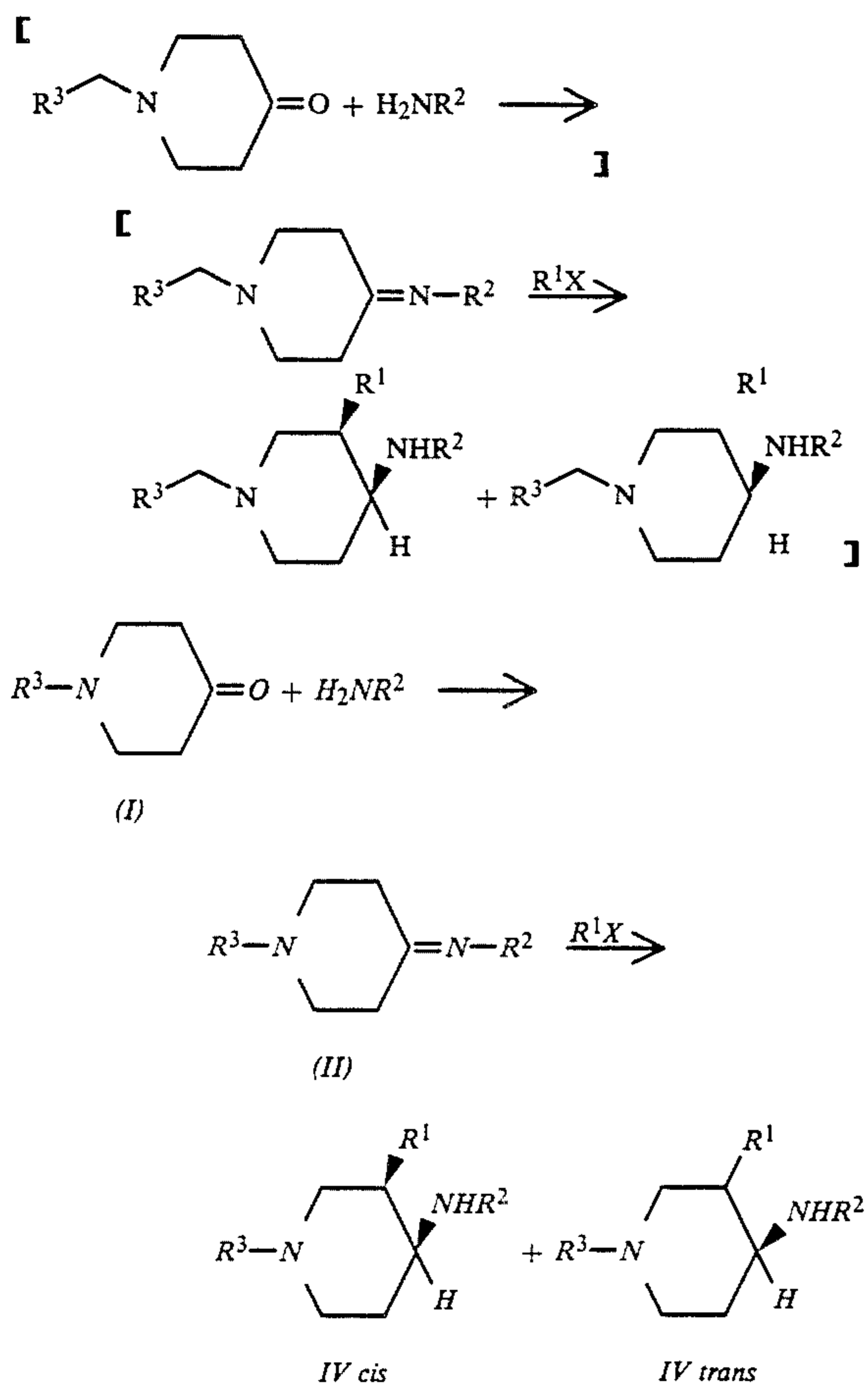
Examples of suitable R¹ groups include methyl, ethyl, cyclopropyl, cyclopropylmethyl, allyl and benzyl.

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Examples of suitable R^2 groups include phenyl, 2-fluorophenyl, 2-methylphenyl, 2-methoxyphenyl, pyrazolyl, or thienyl.

Examples of suitable R^3 groups include phenyl ethyl, benzyl, 2-(4-ethyl-4,4,5-dihydro-5-oxo-1H-tetrazol-1-yl)ethyl, and 2-(4-methyl-thiazoyl)ethyl.

The route to compounds of the [formula (I)] invention proceeds as follows:



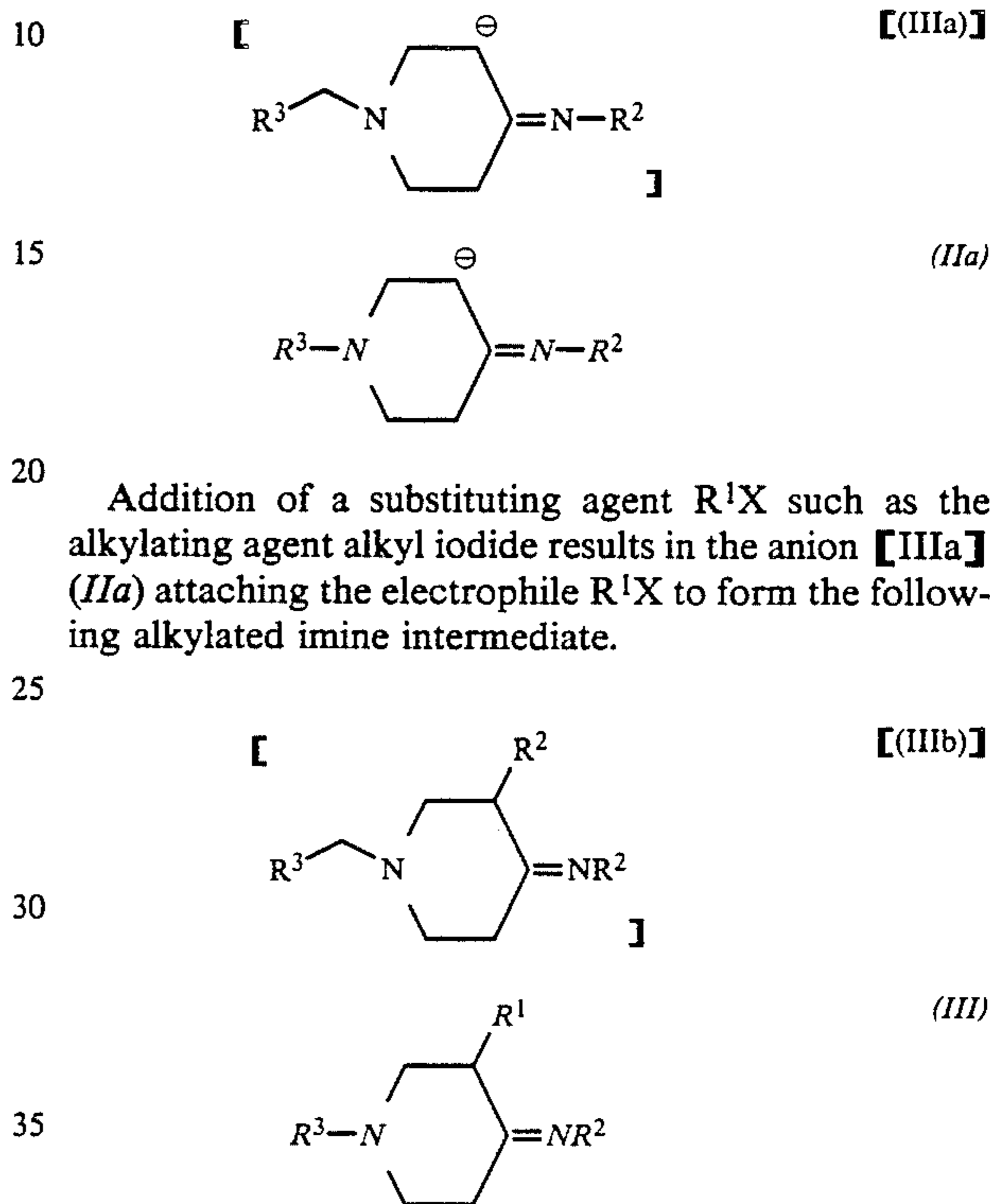
wherein R^1 , R^2 and R^3 are as defined above and R^1X is a reagent capable of adding the R^1 group to the 3 position of the piperidine ring, for example, a lower alkyl iodide alkylating agent.

It is noted that the present invention does not involve the N-substituted-3-substituted-4-piperidone intermediate compound conventionally employed, for example, in the prior art synthetic route of U.S. Pat. No. 4,584,303. This latter compound is difficult to make. Instead, Applicants' above described reaction scheme begins with the intermediate compound N-substituted-4-piperidone, which is commercially available from Aldrich Chemical Co. (Milwaukee, Wis.) or Chemical Dynamics Corp. (So. Plainfield, N.J.) or else easily made by a Mannich condensation, as will be readily appreciated by those skilled in the art. The latter piperidone compound is then reacted with a substituted or unsubstituted phenyl amine or aromatic heterocyclic amine to form the imine precursor [(III)] (II) above. This reaction is suitably carried out in the presence of p-toluene sulfonic acid and refluxed while collecting water. The imine precursor [(III)] (II) is then stirred at a low temperature with a non-nucleophilic base such as freshly prepared lithium diisopropyl amide in order

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to deprotonate the imine. Other suitable non-nucleophilic bases include LDC (lithium dicyclohexylamide), LIC (lithium isopropylcyclohexylamide), LTP (tetramethylpiperamide) and LHS [lithium bis(trimethylsilyl)]amide.

By removal of the alpha (to the schiff base) proton, the following anion is generated:



Addition of a substituting agent R^1X such as the alkylating agent alkyl iodide results in the anion [(IIIa)] (IIa) attaching the electrophile R^1X to form the following alkylated imine intermediate.

The most preferred substituting agents are iodides, bromides and chlorides. Tosylates and mesylates and other substituting agents known to those skilled in the art are also suitable.

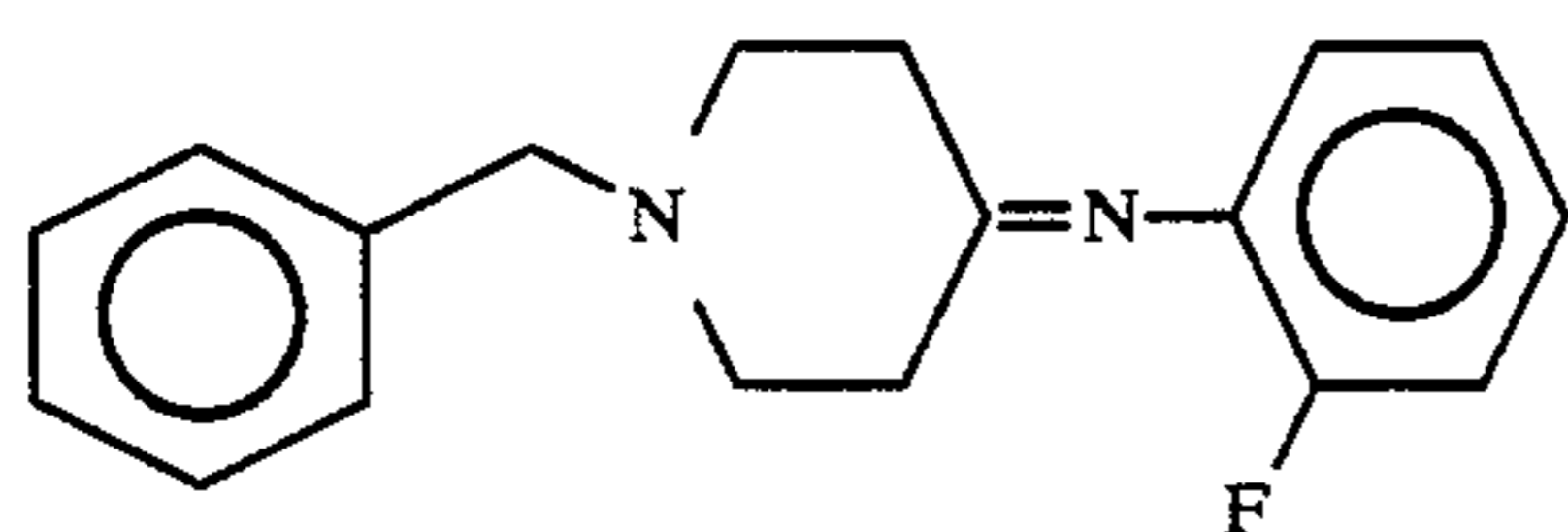
Finally, without the necessity of isolating [(IIIb)], the alkylated imine compound (III) a very selective reduction to the desired valuable intermediate (IV) above is carried out. This reduction is a steric approach control reaction wherein the least crowded side of the [intermediate (IIIb)] alkylated imine compound (III) is preferably [attached] attacked by a relatively highly hindered reducing agent such as the hindered borohydride reducing agents.

The most preferred reducing agent is "Super-Hydride", i.e. lithium triethylborohydride, because of its superior combination of cis selectivity and speed. Other preferred hindered borohydride reducing agents include L-selectride (lithium tri-sec-butylborohydride, 1.0 molar in THF) and N β -Enantride (lithium hydride, a 9- β N-nopolbenzyl ether adduct, 0.5 molar in THF). A cis:trans selectivity of greater than 90 percent and typically 96 percent is thereby obtainable. Other suitable reducing agents include Red-Al (sodium bis(2-methoxy-ethoxy)aluminum hydride, 3.4 molar in toluene, and $LiAlH_4$. Typically, a selectivity of only about 60-70 percent cis:trans is obtained with the latter reducing agents. All of the above named reducing agents are commercially available from Aldrich Chemical Co. (Milwaukee, Wis.).

A major advantage of the above described synthetic route is that the reactions occur in a single vessel by the sequential introduction of the necessary reactants. Consequently, successive isolations and purifications are obviated, thereby greatly simplifying the overall route to a variety of therapeutic agents, notably of the fentanyl type, which are used in humans for inducing anesthesia or analgesia, for example **[A-3331]** *cis-1*[2-(4-ethyl-4,5-dihydro-5-oxo-1H-tetrazol-1-yl)ethyl]-3-methyl-4-[N-2(2-fluorophenyl methoxyacetamido) piperidine hydrochloride]. The remaining steps in the overall synthesis to such compounds are disclosed in detail in U.S. Pat. No. 4,584,303 to Huang et al., which hereby is incorporated by reference. Other compounds which may be prepared by a synthetic route within the scope of the present invention include β -hydroxyl-3-methylfentanyl and *cis*-3-methyl fentanyl (known in the chemical and pharmaceutical literature as F-7302 and R 26,800, respectively) which have demonstrated potent analgesic activity.

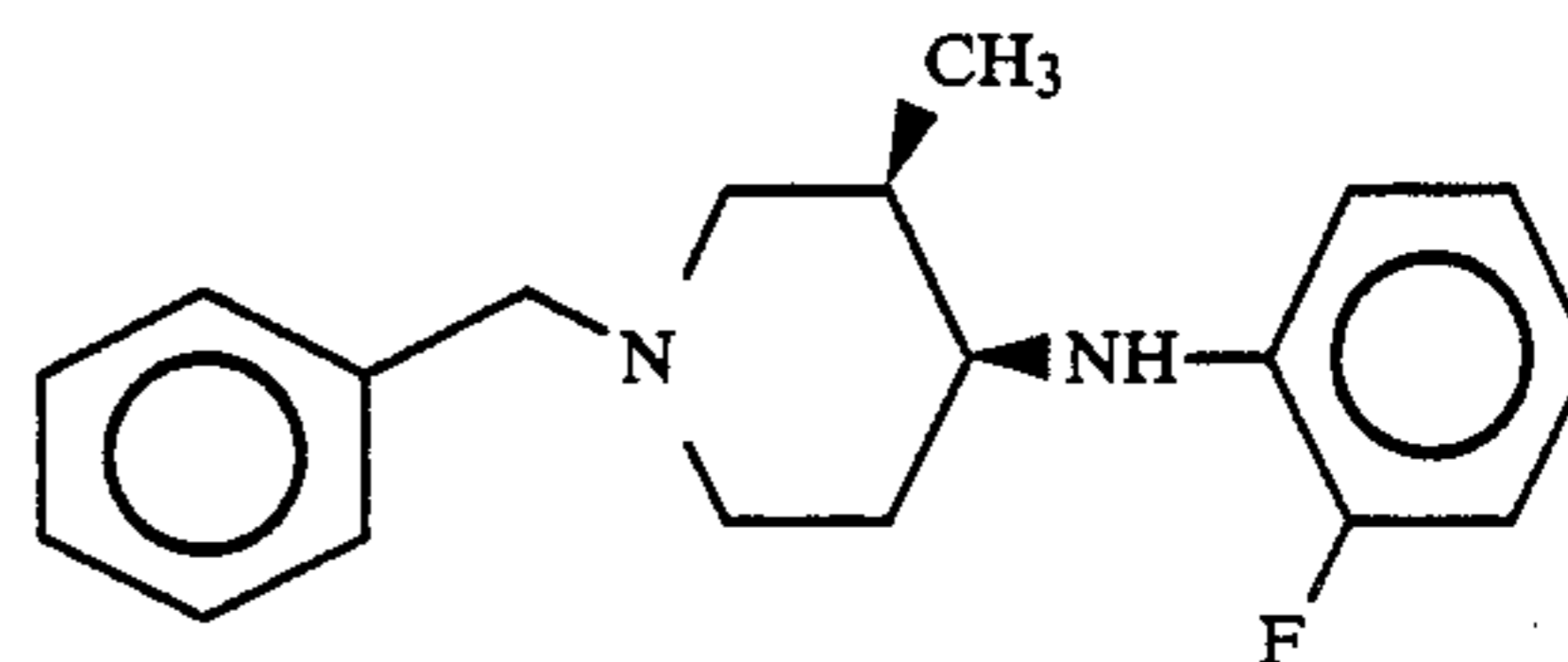
EXAMPLE 1

This example illustrates the preparation of **[1-benzyl-3-(*cis*-methyl)-4-[N-(2-fluorophenyl)amino]piperidine]** *1-benzyl-3-(*cis*-methyl)-4-(2-fluorophenyl) amino piperidine*. A solution of 1-benzyl-4-piperidone, 15.20 gms (80.31 mmol), 2-fluoroaniline, 9.02 gms (81.17 mmol) and p-toluenesulfonic acid monohydrate, 0.48 gms in 200 ml of toluene was refluxed overnight under argon collecting water in a Dean-Stark trap. After 18 hours the theoretical amount of water had separated and the trap was drained several times to distill off 100 mls of toluene. The reaction was cooled under argon and diluted with 40 mls anhydrous THF. The deep orange solution of crude imine **[1]** was used "as is" for next step.



LDA was prepared under an atmosphere of argon by adding freshly distilled diisopropyl amine, 15 ml (107 mmol) dropwise to a cold (0° C.) solution of 55 mls of 1.6M n-butyllithium (88 mmol) in hexane in 60 mls of anhydrous THF. After 15 minutes at 0° C. the LDA solution was cooled to -78° C. in an isopropanol-dry ice slush bath. The solution of imine **[1]** (80.31 mmol) was added dropwise with stirring. The reaction was stirred at -78° C. for 1 hour followed by rapid addition of methyl iodide, 12.9 gms (90.88 mmol). The reaction was stirred at -78° C. for 15 minutes followed by warming to room temperature. After 10 minutes at -78° C. a precipitate formed which redissolved as the reaction warmed up. After stirring at room temperature for 2 hours the reaction was cooled to 0° C. in an ice bath and 120 mls. 1.0M **[Lithium triethylborohydride]** *lithium triethylborohydride* in THF was added dropwise via syringe. The reaction was stirred overnight (16 hours) warming to room temperature. The reaction was then cooled back down to 0° C. and 50 mls of water was added slowly dropwise (exotherm and vigorous gas evolution). The quenched reaction mixture was concentrated to a pasty oil which was dissolved in 200 mls toluene and washed with 100 mls of water. The toluene layer was separated, dried over anhydrous sodium sul-

fate and concentrated to give a crude mixture of *cis* and *trans* diamine. Analytical LC showed the *cis*/*trans* diamine ratio to be 92.2:7.8. This crude oil was flash chromatographed on Silica 60, 230-444 mesh (444 gms) eluting with 1:10 EtOAc/Hex with 0.1% ammonium hydroxide added to give 9.74 gms pure *cis* diamine (40.6%) shown below and 1.57 gms *cis* and *trans* **[diammine]** *diamine* mixture. Total isolated yield of *cis* and *trans* **[diammine]** *diamine* was 47.2%.

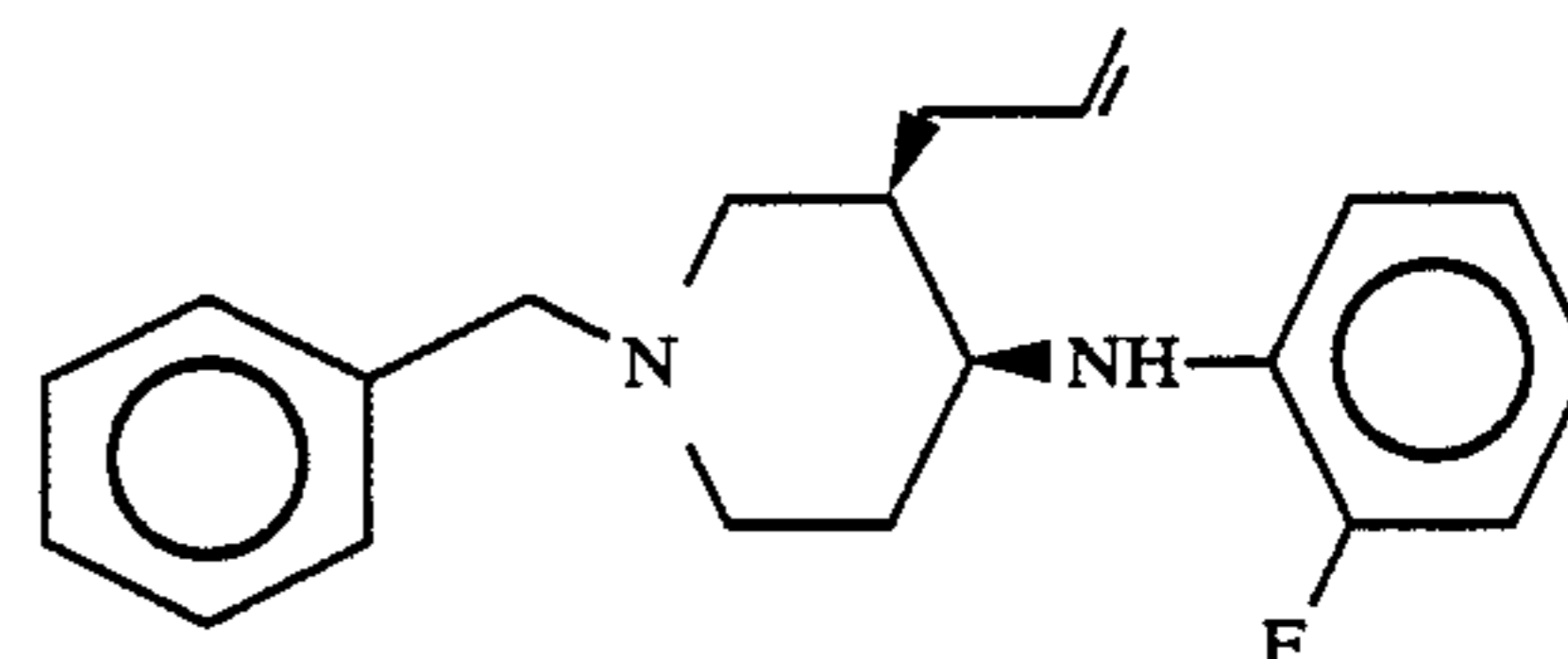


M.P.: 55°-56° C.

NMR: 7.40(s,5H), 7.20-6.35(m,4H), 3.90(br s,1H), 3.40(br s,2H), 3.00-1.30(complex,8H), 0.95(d,3H)

EXAMPLE 2

In an analogous manner to the synthesis of Example 1, except using allyl bromide as the substituting agent, the compound **[1-benzyl-3-(*cis*-allyl)-4-[N-(2-fluorophenyl)amino]piperidine]** *1-benzyl-3-(*cis*-allyl)-4-(2-fluorophenyl)amino piperidine* was prepared having the following formula:

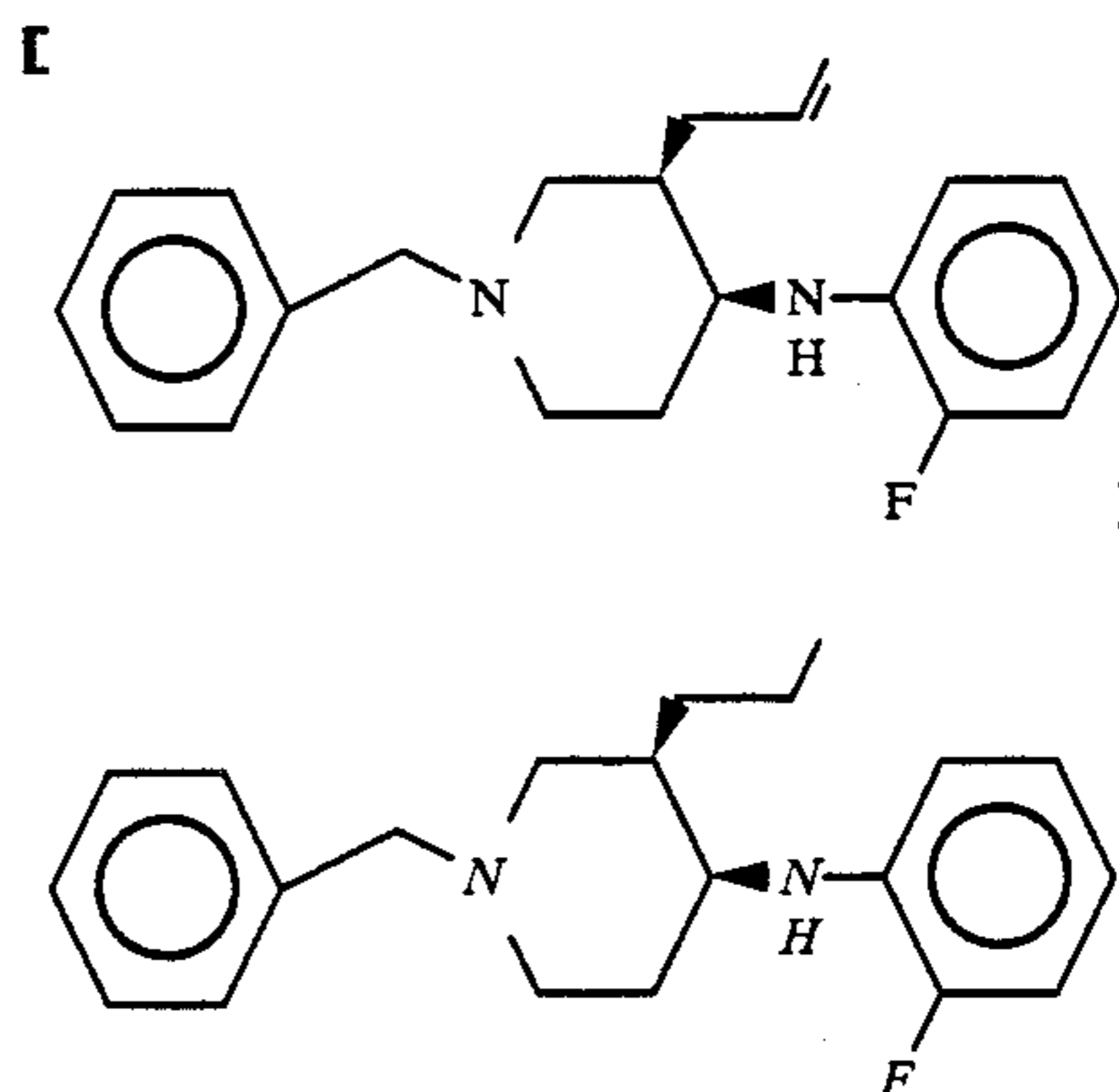


oil at room temperature

NMR: 7.30 (m,5H), 6.95(m,2H), 6.60(m,2H), 5.65(m,1H), 4.45(m,2H), 3.95(br 2,1H), 3.60(m,1H), 3.50 (ABq,2H), 2.60-1.65(complex,9H)

EXAMPLES 3-5

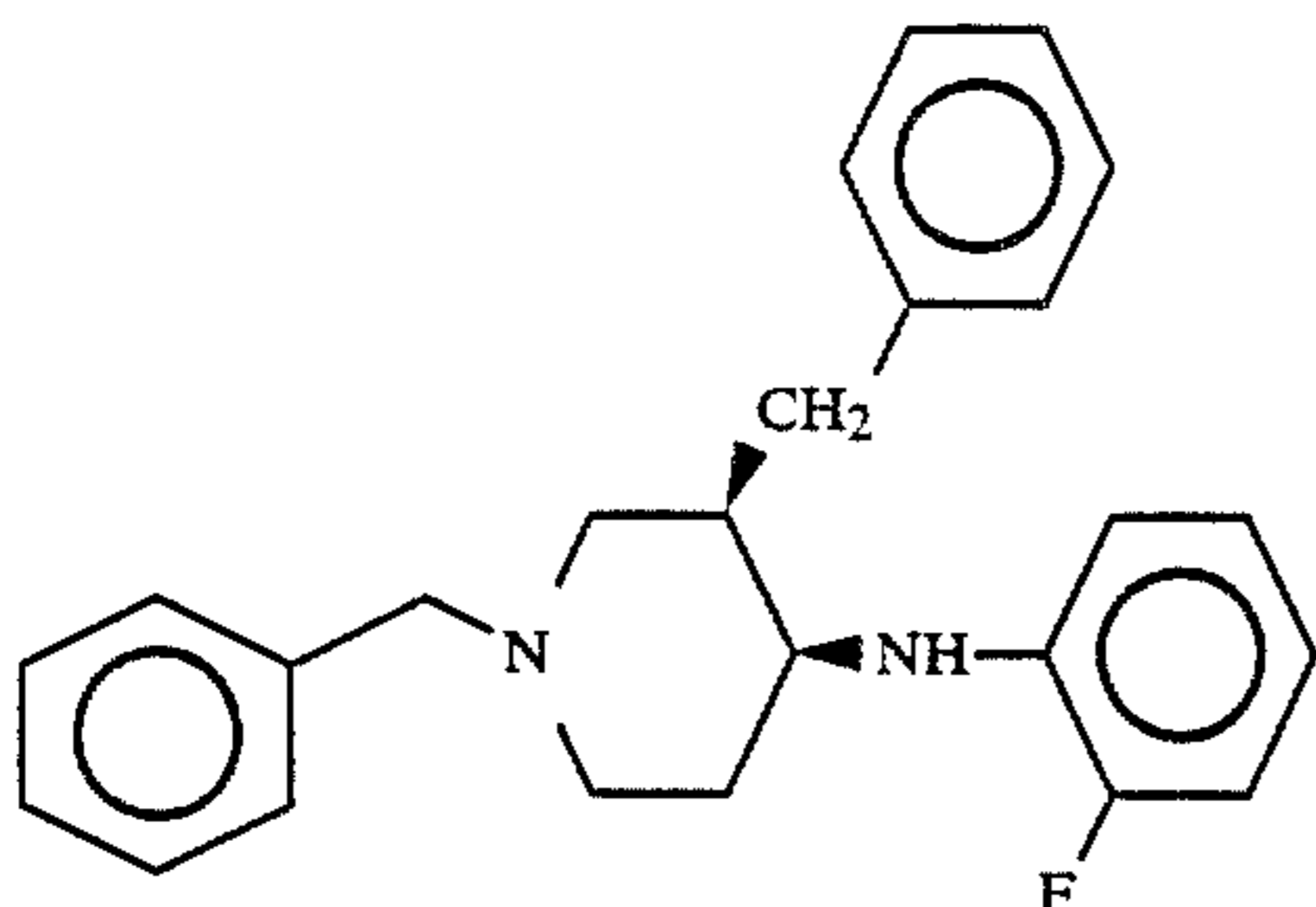
In an analogous manner to the synthesis of Example 1, except using 1-iodopropane, benzyl bromide, and (bromomethyl)-cyclopropane, respectively as the substituting agent, the following compounds were prepared:



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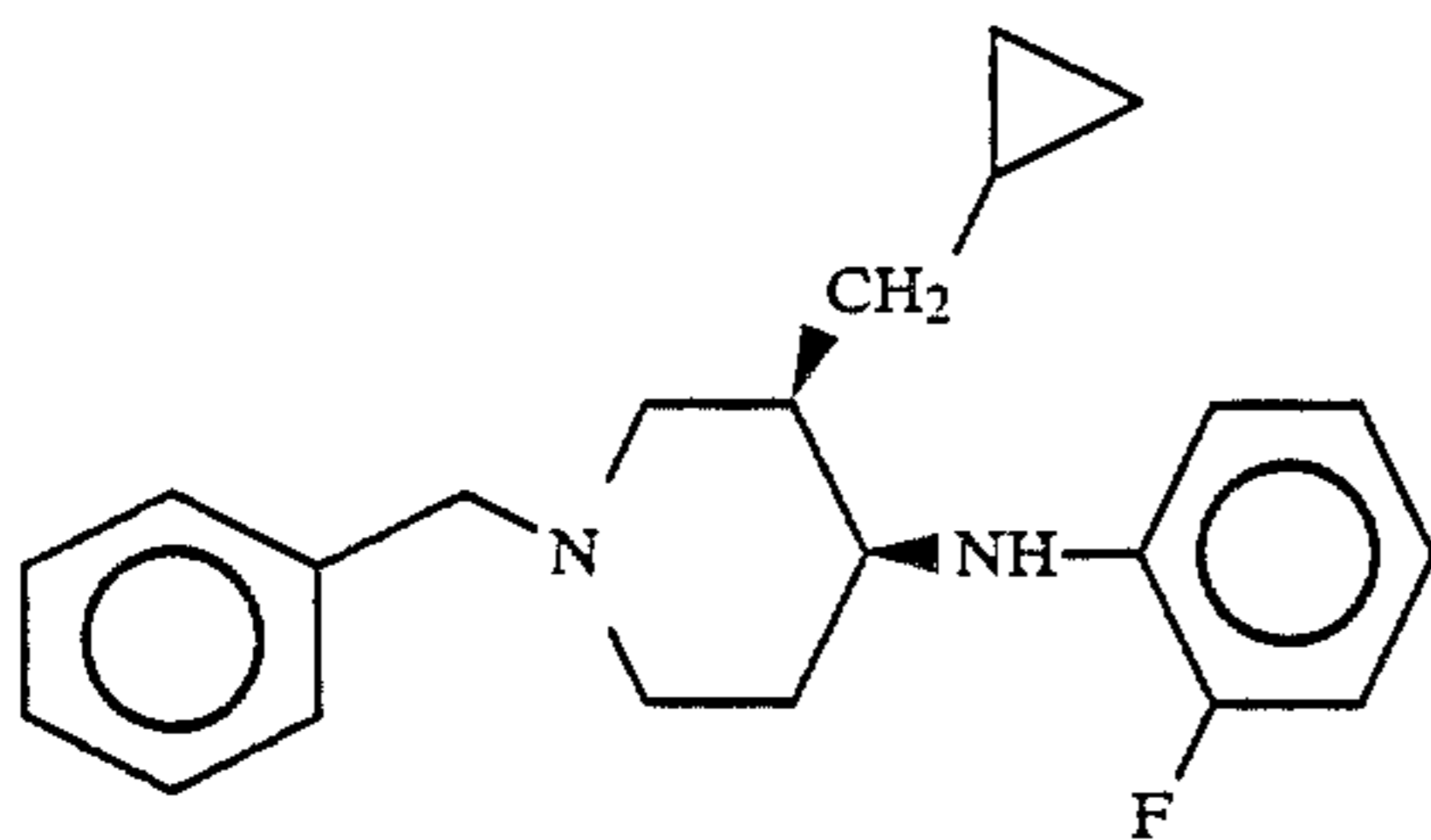
[1-benzyl-3-[cis-(n-propyl)]-4-[N-(2-fluorophenyl)amino]-N piperidine] *1-benzyl-3-[cis-(n-propyl)]-4-2-fluorophenylamino piperidine* oil at R.T.

NMR: 7.40(s,5H), 7.40-6.50(m,4H), 3.95(br s, 1H), 3.60(m,1H), 3.50(ABq,2H), 2.60-0.30(complex,14H)



[1-benzyl-3-(cis-benzyl)-4-[N-(2-fluorophenylamino)]-piperidine] *1-benzyl-3-(cis-benzyl)-4-(2-fluorophenyl)amino piperidine* oil at R.T.

NMR: 7.40-6.40(complex,14H), 4.05(m,1H), 3.50(br s,2H), 3.85-1.45(complex,10H).



[1-benzyl-3-[cis-(cyclopropyl)methyl]-4-[N-(2-fluorophenylamino)]piperidine] *1-benzyl-3-[cis-(cyclopropyl)methyl]-4-(2-fluorophenyl)amino piperidine* oil at R.T.

NMR: 7.50-6.50(m,9H), 4.35(m,1H), 3.40(br s,2H) 3.35-0.80(complex,10H), 0.60-0.05(m,5H)

It will be understood that the embodiments described herein are merely exemplary and that a person skilled in the art may make variations and modifications without departing from the spirit and scope of the invention. All such modifications and variations are intended to be included within the scope of the invention as defined in the appended claims.

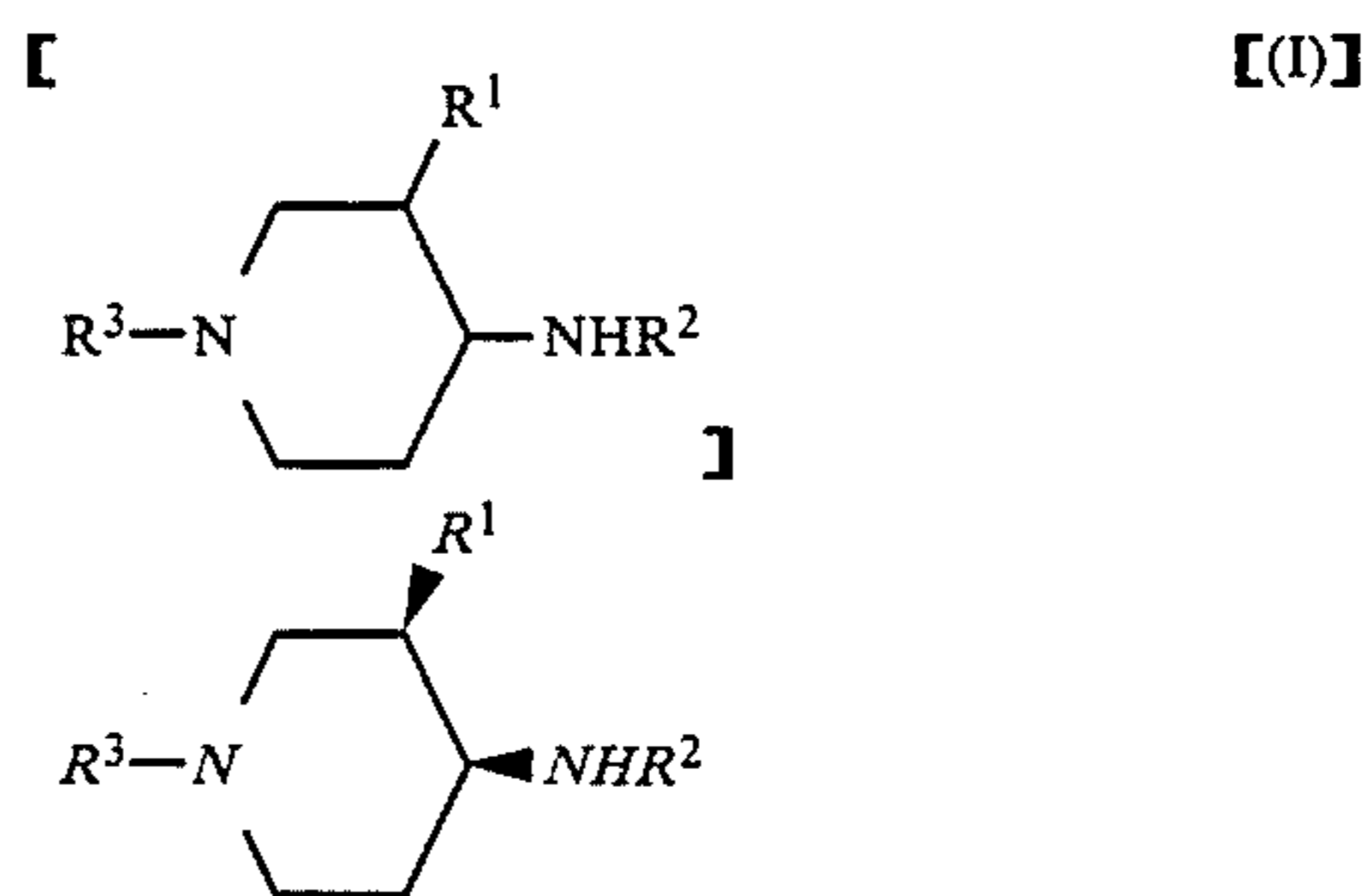
We claim:

1. A method of preparing the cis isomer of a 4-anilino-3-R¹-piperidine, wherein R¹ is lower alkyl, lower cyclic alkyl, [lower alkyl] lower cyclic alkyl lower alkyl, phenyl lower alkyl [phenyl], or lower alkenyl, said method comprising:

- (i) deprotonating a 4-imine piperidine with a non-nucleophilic base to form a deprotonated anion at the 3-position of the piperidine ring;
- (ii) reacting said deprotonated anion with a substituting agent to introduce an R¹ group in said 3-position; and
- (iii) reducing the compound resulting from step (ii) to produce the cis isomer thereof, whereby a cis:trans selectivity of greater than about 90 percent is obtainable.

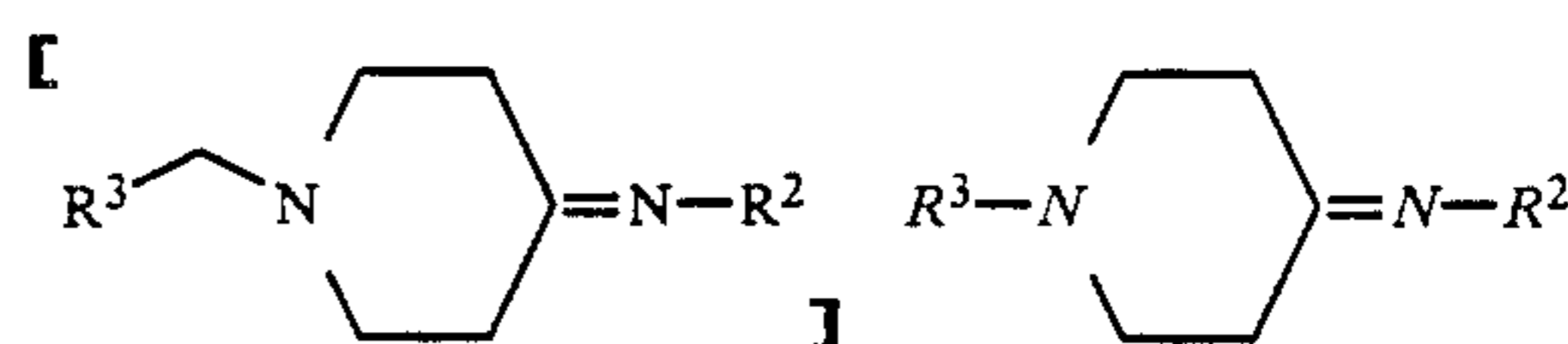
2. A method of preparing a cis compound of the formula:

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wherein R¹ is a lower alkyl, lower [cyclic] cyclic alkyl, [lower alkyl] lower cyclic alkyl lower alkyl, lower alkenyl or phenyl lower alkyl [phenyl]; R² is a phenyl which may be substituted with one or more substituents selected from the group consisting of lower alkoxy, lower alkyl, halogen or combinations thereof, and R³ is selected from the group consisting of phenyl-lower-alkyl, thiazoyl lower alkyl which can be substituted in the 4-position with a lower alkyl group, (4,5-dihydro-4-oxo-1H-tetrazol-1-yl) lower alkyl which can be substituted in the 4-position with a lower alkyl, and substituted phenyl lower alkyl in which the substituents on the phenyl ring are selected from halogen, lower alkoxy, lower alkyl, or combinations thereof; said method comprising:

- (i) deprotonating a compound of the following formula:



with a non-nucleophilic base to form a deprotonated anion at the 3-position of the piperidine ring;

- (ii) reacting said anion with a substituting agent to introduce said [Rgroup] R¹group in said 3-position; and
- (iii) reducing the compound resulting from step (ii) to produce the cis compound [(1)] above, [thereby obtaining the cis isomer thereof,] whereby a cis:trans selectivity of greater than about 90 percent is obtainable.

3. The method of claim 1 or 2, wherein said non-nucleophilic base is a lithium lower alkyl amide.

4. The method of claim 3, wherein said lithium lower alkyl amide is selected from the group consisting of lithium diisopropylamide, lithium dicyclohexylamide, lithium isopropylcyclohexylamide, lithium tetramethylpiperamide and lithium bis(trimethylsilyl)amide.

5. The method of claim 1 or 2 wherein said substituting agent is an alkylating agent.

6. The method of claim 1 or 2 wherein said deprotonating is carried out in a solvent comprising tetrahydrofuran.

7. The method of claim 5, wherein said alkylating agent is an iodide or tosylate.

8. The method of claim 7, wherein said iodide is an alkyl iodide.

9. The method of claim 1 or 2, wherein said reducing is by means of a hindered borohydride reducing agent.

10. The method of claim 9, wherein said hindered borohydride reducing agent is selected from the group

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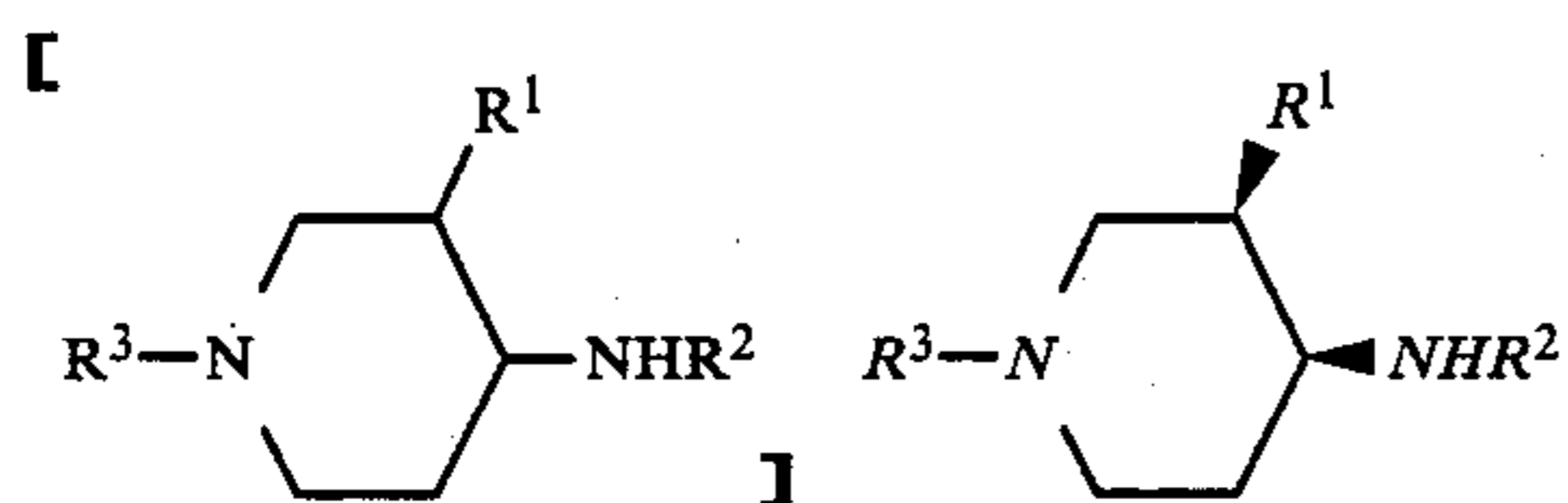
consisting of lithium triethylborohydride, lithium tri-sec-butylborohydride, [or] and lithium hydride 9-ββN-nopolbenzylether adduct.

11. The method of claim 1 or 2, wherein the steps (i) through (iii) are carried out continuously without purification or isolation of intermediates.

12. The method of claim 11, wherein the said steps (i) through (iii) are continuously carried out in the same reactor means.

13. The method of claim 1 or 2, wherein said cis isomer is purified from minor amounts of the trans isomer.

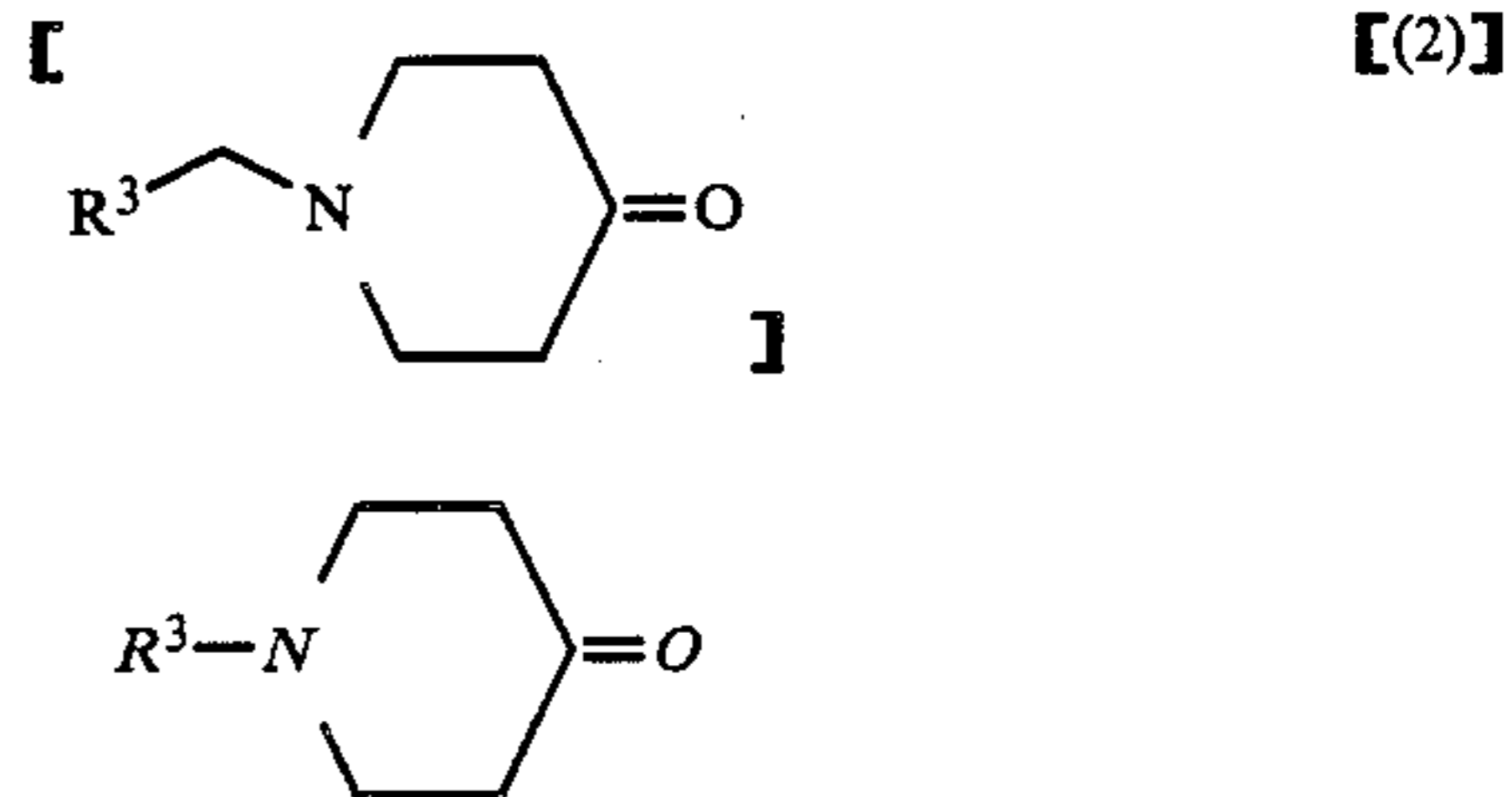
14. A method for preparing a cis compound of the formula:



wherein R¹ is a lower alkyl, lower [cyclic] cyclic alkyl, lower [alkyl lower cyclic alkyl,] cyclic alkyl lower alkyl, lower alkenyl, or phenyl lower alkyl [phenyl]; R² is a phenyl, which may be substituted with one or more substituents selected from the group consisting of lower alkoxy, lower alkyl, halogen or combinations thereof, and R³ is selected from the group consisting of phenyl-lower-alkyl, thiazoyl lower alkyl which can be substituted in the 4-position with a lower alkyl group, (4,5-dihydro-4-oxo-1H-tetrazol-1-yl) lower alkyl which can be substituted in the 4-position with a lower alkyl, and substituted phenyl lower alkyl in which the substituents on the phenyl ring are selected from halogen, lower alkoxy, lower alkyl, halogen or combinations thereof; said method comprising:

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(i) reacting H₂NR² with a compound of the following formula:



(ii) deprotonating the compound [of formula (2)] with a non-nucleophilic base to form a deprotonated anion at the 3-position of the piperidine ring;

(iii) reacting said anion with a substituting agent to introduce an R¹ group in said 3-position; and

(iv) reducing the compound of step [(ii)] (iii) to produce the cis compound [(1)] above, thereby obtaining the cis isomer thereof, whereby a cis:trans selectivity of greater than about 90 percent is obtainable.

15. The method of claim 14, wherein said substituting agent is an alkylating agent.

16. The method of claim 15, wherein said non-nucleophilic base is a lithium lower alkyl amide.

17. The method of claim 14 wherein said compound is reduced by introducing a hindered borohydride reducing agent.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : Re. 33,495
DATED : Dec. 18, 1990
INVENTOR(S) : Kudzma et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Cover page, inventor designation:

Sherry A. Savernak should be -- Sherry A. Severnak -- .

**Signed and Sealed this
Twelfth Day of May, 1992**

Attest:

DOUGLAS B. COMER

Attesting Officer

Acting Commissioner of Patents and Trademarks