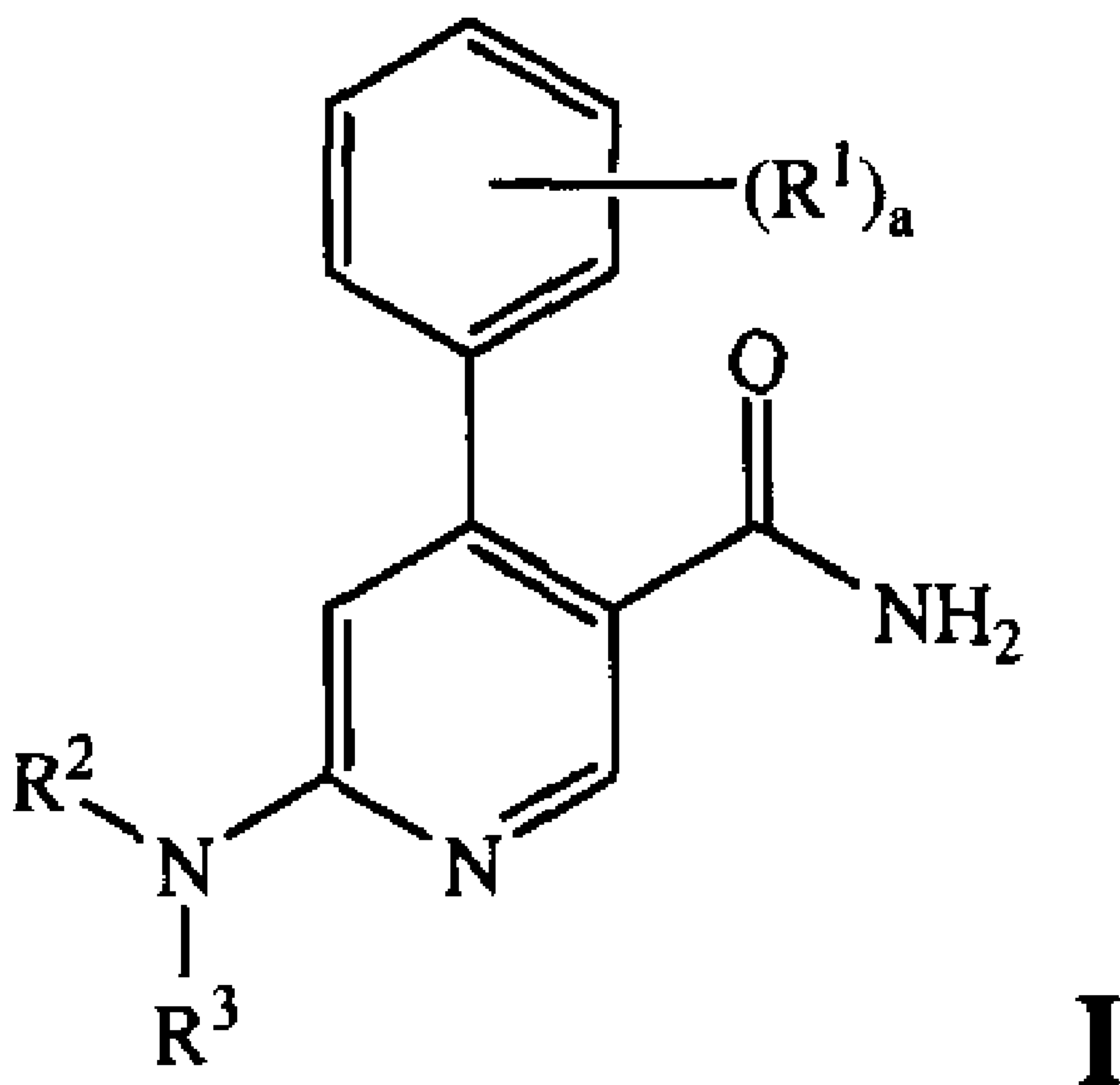




(86) Date de dépôt PCT/PCT Filing Date: 2005/06/28
(87) Date publication PCT/PCT Publication Date: 2006/01/12
(45) Date de délivrance/Issue Date: 2011/01/18
(85) Entrée phase nationale/National Entry: 2007/01/03
(86) N° demande PCT/PCT Application No.: EP 2005/006919
(87) N° publication PCT/PCT Publication No.: 2006/002860
(30) Priorités/Priorities: 2004/07/06 (US60/585,779);
2005/02/23 (US60/655,731)

(51) Cl.Int./Int.Cl. *C07D 213/82* (2006.01),
C07D 213/64 (2006.01), *C07D 213/85* (2006.01)
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(54) Titre : PROCEDE POUR LA PREPARATION DE DERIVES PYRIDINES CARBOXAMIDE UTILISES COMME
INTERMEDIAIRES DANS LA SYNTHSE D'ANTAGONISTES DE RECEPTEURS NK-1
(54) Title: PROCESS FOR PREPARING CARBOXAMIDE DERIVATIVES USED AS INTERMEDIATES IN THE
SYNTHESIS OF NK-1 RECEPTOR ANTAGONISTS



(57) Abrégé/Abstract:

The present invention provides a process for preparing a pyridine compound of formula (I), where R^1 , R^2 , R^3 and a are those defined herein. These compounds may be used as intermediates for the preparation of pharmaceutically active NK-1 receptor antagonists.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 January 2006 (12.01.2006)

PCT

(10) International Publication Number
WO 2006/002860 A1

(51) International Patent Classification⁷: **C07D 213/82**,
213/85, 213/64

(21) International Application Number:
PCT/EP2005/006919

(22) International Filing Date: 28 June 2005 (28.06.2005)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/585,779 6 July 2004 (06.07.2004) US
60/655,731 23 February 2005 (23.02.2005) US

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KM, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA,
MD, MG, MK, MN, MW, MX, MZ, NA, NG, NI, NO, NZ,
OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL,
SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC,
VN, YU, ZA, ZM, ZW.

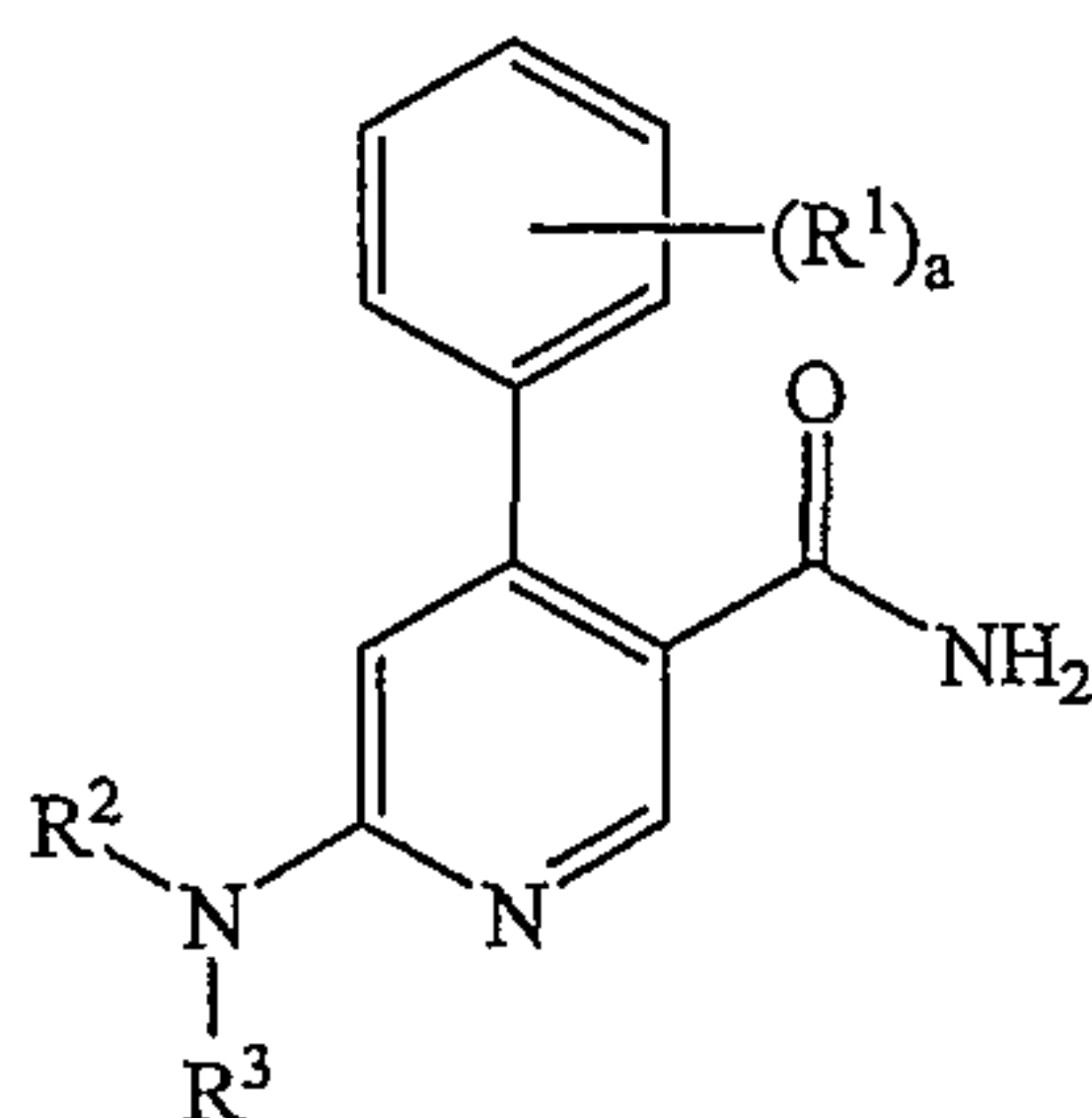
(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO,
SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

- with international search report
- before the expiration of the time limit for amending the
claims and to be republished in the event of receipt of
amendments

For two-letter codes and other abbreviations, refer to the "Guid-
ance Notes on Codes and Abbreviations" appearing at the begin-
ning of each regular issue of the PCT Gazette.

(54) Title: PROCESS FOR PREPARING CARBOXAMIDE PYRIDINE DERIVATIVES USED AS INTERMEDIATES IN THE
SYNTHESIS OF NK-1 RECEPTOR ANTAGONISTS



(I)

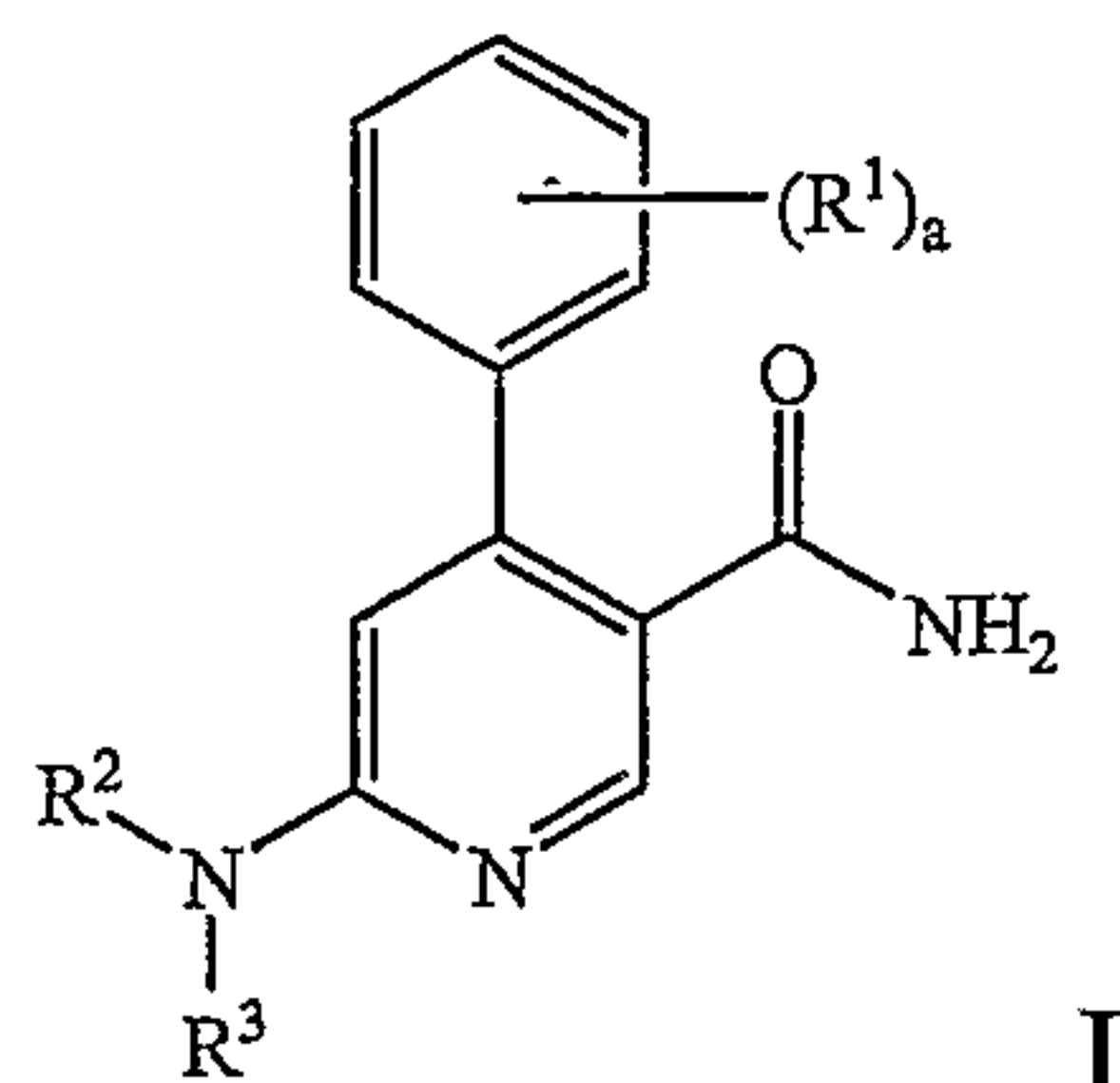
(57) Abstract: The present invention provides a process for preparing a pyridine compound of formula (I), where R^1 , R^2 , R^3 and a are those defined herein. These compounds may be used as intermediates for the preparation of pharmaceutically active NK-1 receptor antagonists.



WO 2006/002860 A1

PROCESS FOR PREPARING CARBOXAMIDE DERIVATIVES USED AS INTERMEDIATES IN THE SYNTHESIS OF NK-1 RECEPTOR ANTAGONISTS

The present invention provides a process for preparing a carboxamide pyridine compound of the formula:



where

each R^1 is independently lower alkyl, lower alkoxy, halogen, cyano or alkylamino;

a is an integer from 0 to 2;

R^2 is hydrogen, C_{3-6} cycloalkyl, aralkyl, lower alkyl, hydroxylalkyl, $-S(O)_2$ -lower alkyl, $-S(O)_2$ - Ar^1 , optionally substituted N-heterocyclyl)alkyl, $-C(=O)R^3$, where Ar^1 is aryl;

R^3 is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl;

or R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl;

or R^2 and R^3 together form $=C(R^5)-R^6-NR^7R^8$;

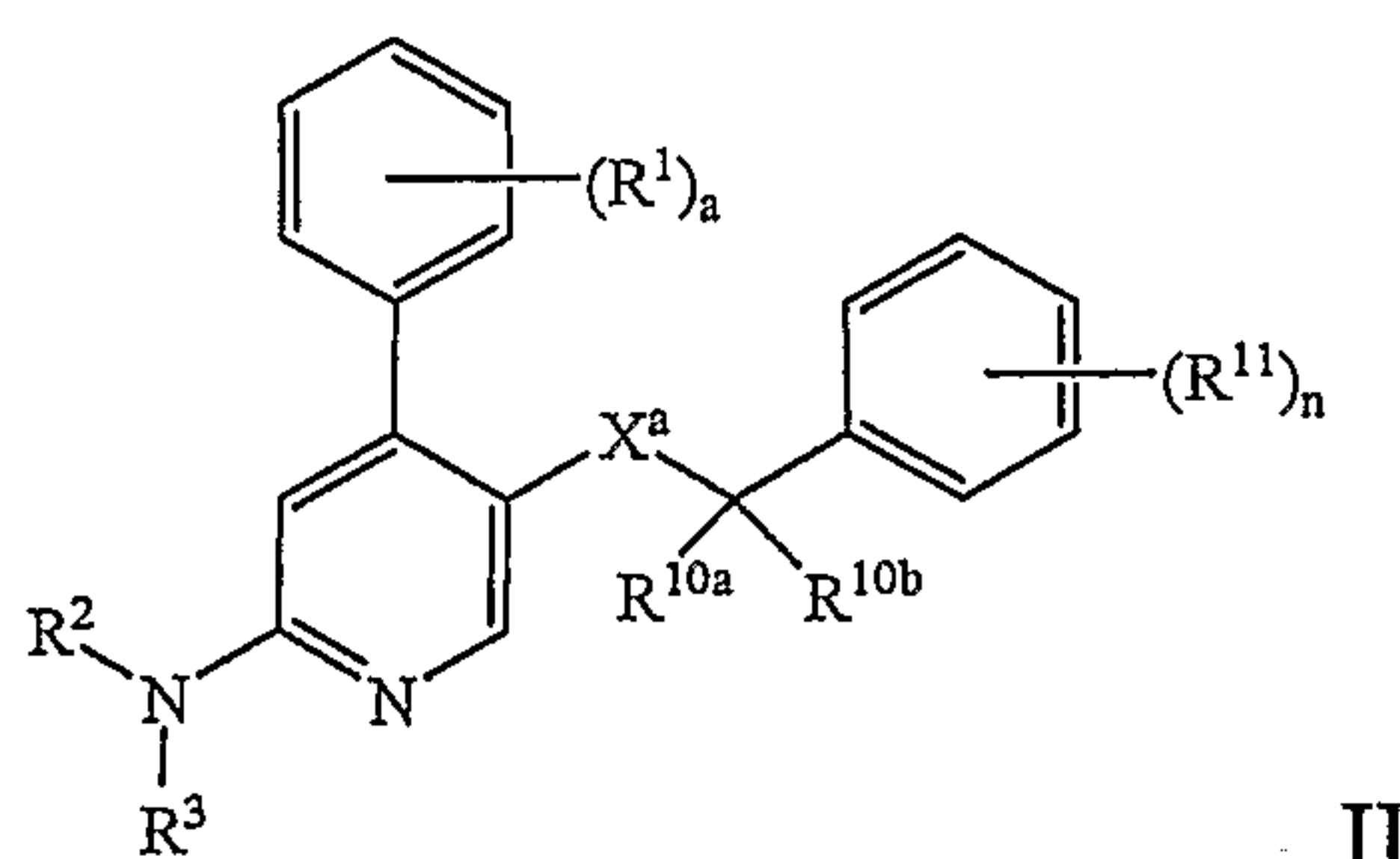
where

R^5 is lower alkyl or hydrogen;

R^6 is alkylene or a bond and

each of R^7 and R^8 is independently hydrogen, C_{3-6} cycloalkyl, aralkyl, or lower alkyl.

The carboxamide pyridine compounds of Formula I are useful intermediates in the preparation of Neurokinin-1 receptor antagonists, encompassed by Formula II.



where

a, R^1 , R^2 , and R^3 are those defined herein,

each of R^{10a} and R^{10b} is independently hydrogen or lower alkyl, or R^{10a} and R^{10b} together with the carbon atom to which they are attached to form a cycloalkyl group;

5 each R^{11} is independently halide, trifluoromethyl, lower alkoxy, or cyano, or two R^{11} moieties together form $-CR^w=CR^x-CR^y=CR^z-$, where each of R^w , R^x , R^y , and R^z is independently selected from the group consisting of hydrogen, lower alkyl or lower alkoxy, provided that at least two of R^w , R^x , R^y , and R^z are hydrogen;

n is an integer from 0 to 5; and

10 X^a is $-C(=O)N(R^{14})-$, $-R^{16}-O-$, $-R^{16}-N(R^{14})-$, $-N(R^{14})C(=O)-$, or $-N(R^{14})-R^{16}-$, where

R^{14} is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl; and

R^{16} is alkylene, preferably methylene or ethylene.

These compounds are not novel and have been described for example in

15 EP 1 035 115 A1.

The tachykinin neuropeptide substance P is a naturally occurring undecapeptide that stimulates contractile action on extravascular smooth muscle tissue upon binding with the receptor Neurokinin 1 (NK-1). NK-1 receptors inhibit the central nervous system (CNS) and peripheral tissues of humans. The interactions of substance P and NK-1 are frequently
20 associated with inflammatory conditions, such as migraine, rheumatoid arthritis, asthma and inflammatory bowel disease. In addition, the modulation of Parkinson's disease and other disorders of the CNS and mediation of the emetic reflex are attributed to substance P/NK-1 contact.

NK-1 antagonists inhibit the interaction of substance P and NK-1 receptor site.
25 These antagonists have previously been utilized for treatment of pain, headache, migraine, Alzheimer's disease, multiple sclerosis, attenuation of morphine withdrawal, cardiovascular changes, edema, chronic inflammatory disease, asthma/bronchial hyperactivity, allergic rhinitis, inflammatory diseases of the gut, ocular injuries and ocular inflammatory disease. Such compounds are also believed to be useful in the treatment of various psychological disorders,
30 including disorders of the CNS, as well as treatment of motion sickness, inducement of vomiting and reduction of cisplatin-induced emesis. See Stout, S.C., et al. *Annu. Rev. Pharmacol. Toxicol.* (2001) 41,877.

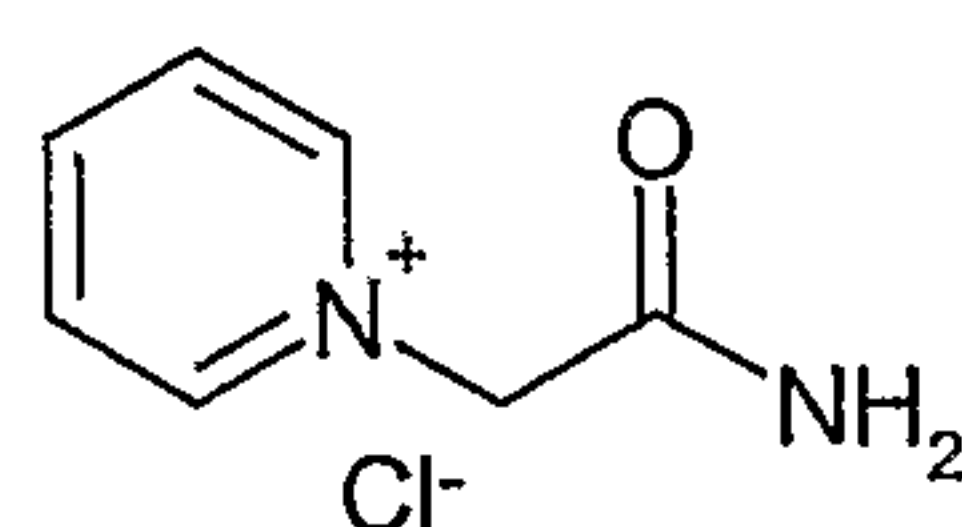
The conventional processes for synthesis of the pyridine ring structure of NK-1 antagonists of formula II require functionalization of a 2,5-disubstituted pyridine. One of the current methods for producing N-[6-(4-morpholinyl)-3-pyridinyl]pivalamide from 2-chloro-5-nitropyridine involves displacement of the chloro group with morpholine, reduction of the nitro group and acylation of the resulting amine by a pivaloyl group, such as pivaloyl chloride or pivaloyl anhydride. Regioselective lithiation of N-[6-(4-morpholinyl)-3-pyridinyl]pivalamide followed by reaction with an iodide source (such as iodine) then provides a 4-iodopyridine compound, which is used in a Suzuki coupling with an arylboronic acid. The coupled product is then hydrolyzed to remove the pivaloyl group. N-Methylation and acylation of the resulting aminopyridine compound then provides a 2,4,5-tri-substituted pyridine compound, as described in EP 1,103,545 (Ballard, T.M. et al.). The cost of this process is relatively high due to the need for lithiation. In addition, this process requires production of nitropyridine, which presents a safety hazard.

Another process for producing pyridine ring system based NK-1 receptor agonist utilizes Hoffman rearrangement reaction of a nicotinamide compound. In this process, microbial oxidation of nicotinic acid is used to produce 6-hydroxynicotinic acid, which is then converted to 6-chloronicotinic acid. The carboxylic acid group is then converted to a *tert*-butylamide group by converting the carboxylic acid to an acid chloride and reacting the acid chloride with *tert*-butylamine. The resulting pyridine compound is then reacted with *o*-tolylmagnesium chloride, followed by an oxidation of the resulting product to produce a 4-(*o*-tolyl)substituted pyridine compound. The overall yield of this process is often low, and requires an excess amount of *o*-tolylmagnesium chloride. In addition, an oxidation reaction is required to regenerate the pyridine ring system. Removal of the *tert*-butyl group followed by Hoffman rearrangement of the amide group results in a formation of an isocyanate which is then trapped with methanol to yield a carbamate. The overall production cost of this process is high due to use of expensive starting materials. And furthermore, the overall production efficiency of this process is low due to variability in the success of the Grignard reaction.

Additional known methods for producing pyridine compounds include the Hantzsch, Kröhnke and Guareschi-Thorpe syntheses. Preparation of pyridine compounds via the Guareschi-Thorpe synthesis uses cyanoacetamide and an arylacetate (e.g., ethyl benzoylacetate) as starting materials, described in US 4,182,887. This process results in a low yield (42%) of 2,6-dihydroxy-3-cyano-4-phenylpyridine with bezoylacetate and still a lower yield when an aryl group is ortho-substituted.

Trans-4-Aryl-3-cyano-6-ox-5-pyridino-1,4,5,6-tetrahydropyridin-2-olates can also be prepared by reaction of a pyridinium salt, an aromatic aldehyde and ethyl cyanoacetate in the presence of a base, described in Shestopalov, A.M., et al. *Synthesis* (1991) 402; Shestopalov, A.M., et al. *Khim. Geterotsikl. Soedin.* (1990) 363; and Litvinov, V.P., Shestopalov, A.M. *Zh. Org. Khim.* (1997) 33, 975.

Another suitable starting material for the production of the NK-1 antagonist pyridine derivative of formula II is an amide of the formula:



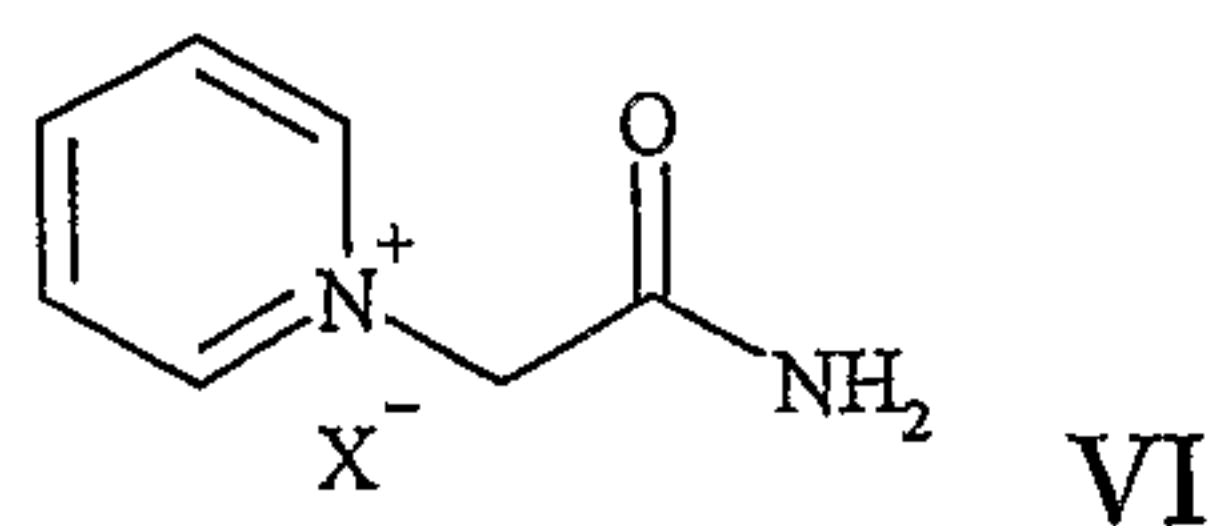
This acetamide compound can be obtained in good yield by the reaction of 2-chloroacetamide with pyridine, described in Katritzky, A.F., et al. *J.C.S. Perkins I* (1981) 1180-1185.

Regioselective displacement of chloride from the 2,6-dichloro-3-cyanopyridine by an amine and the conversion of the nicotinonitrile to a nicotinamide are well known to one skilled in the art. In general, unhindered primary amines attack at the 2-position, while hindered primary and secondary amines attack at the 6-position, described in US 4,061,642, and US 3,853,895. Hydrolysis of a nicotinonitrile to a nicotinamide compound can be achieved using a variety of reagents, including sulfuric acid, aqueous hydroxide, basic hydrogen peroxide or potassium trimethylsilanolate, as described in Miyamoto, T., et al. *Het. Chem.* (1987) 24, 1333; Salem, M., et al. *Heterocycles* (2000) 53, 1129; Humphries, M., Ramsden, C., *Synthesis* (1999) 985; Merchant, K., *Tet. Lett.* (2000) 41, 3747.

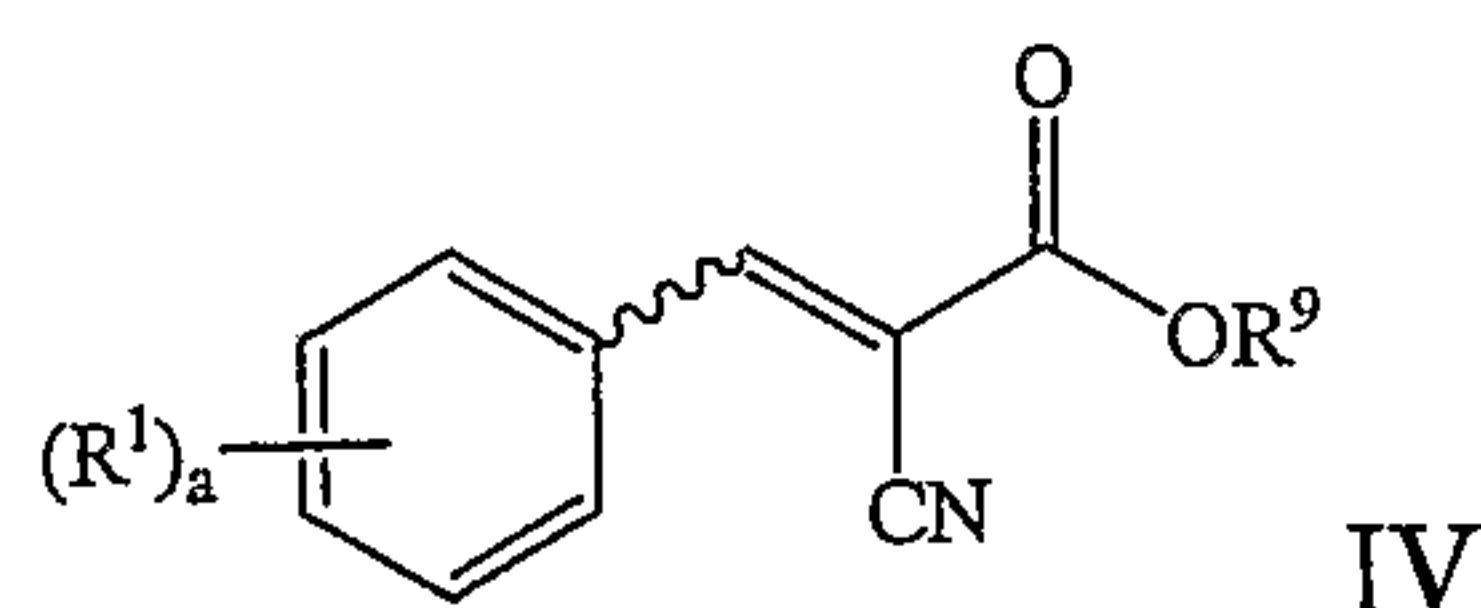
While methods are available for the production of pyridine derivatives, there exists a need for a pyridine compound production process that utilizes low cost starting materials. There is also a need for a process that avoids the shortcoming of the Grignard reaction's variability.

The present invention provides processes for preparing a variety of intermediates that can be used to synthesize carboxamide pyridine compounds of Formula I.

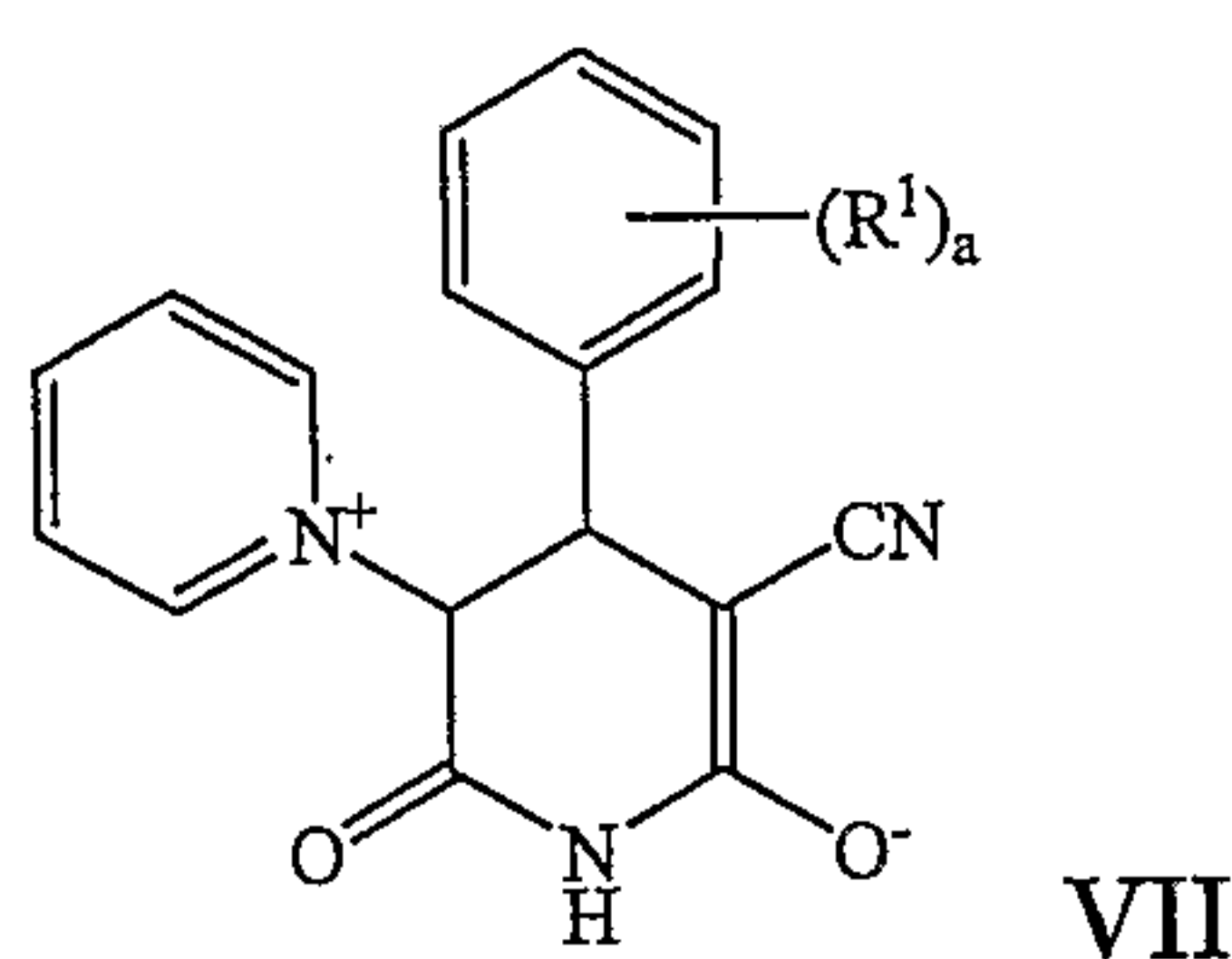
In one embodiment, methods of the present invention include reacting a pyridinium salt of the formula:



with an α -cyano- β -aryl acrylate compound of the formula:

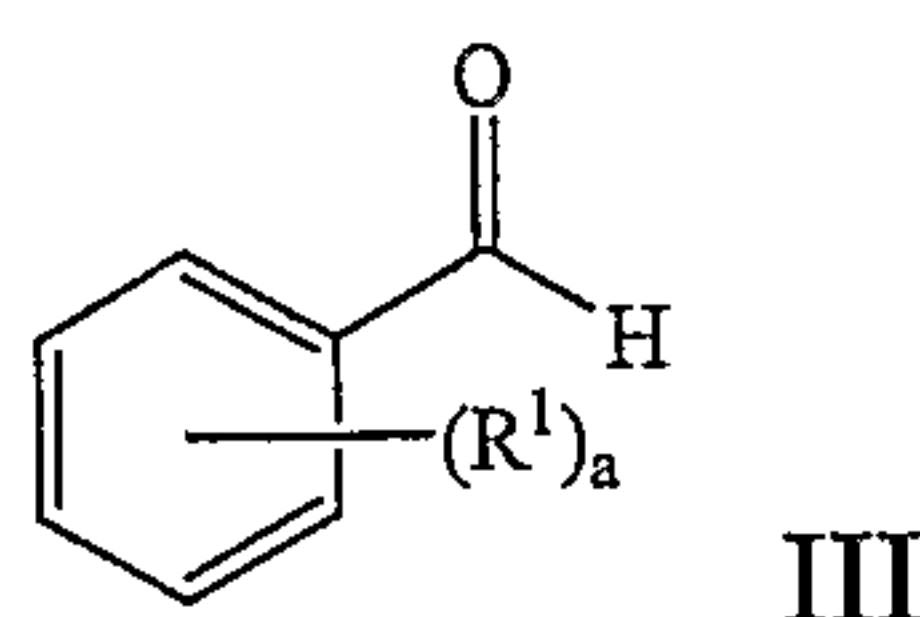


5 to produce a pyridinium zwitter ionic compound of the formula:

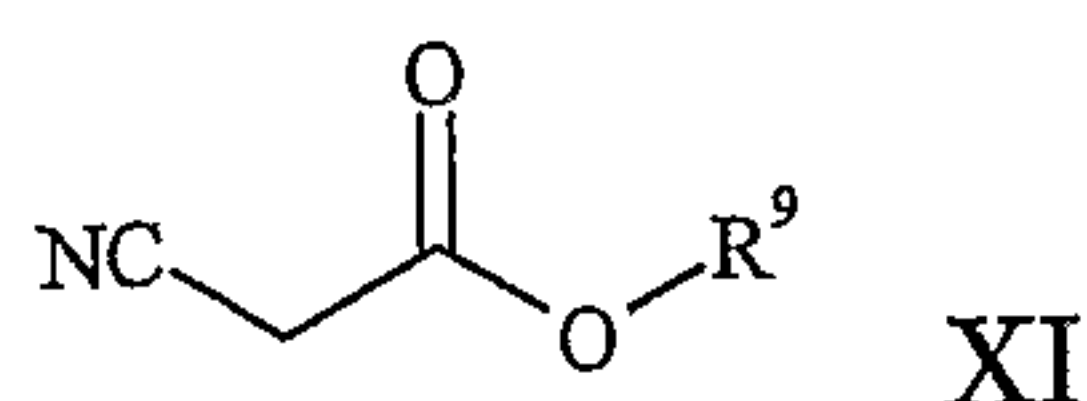


where X is halide, R⁹ is lower alkyl, a, and R¹ are those defined herein.

The α -cyano- β -aryl acrylate compound of Formula IV can be prepared by reacting a benzaldehyde compound of the formula:



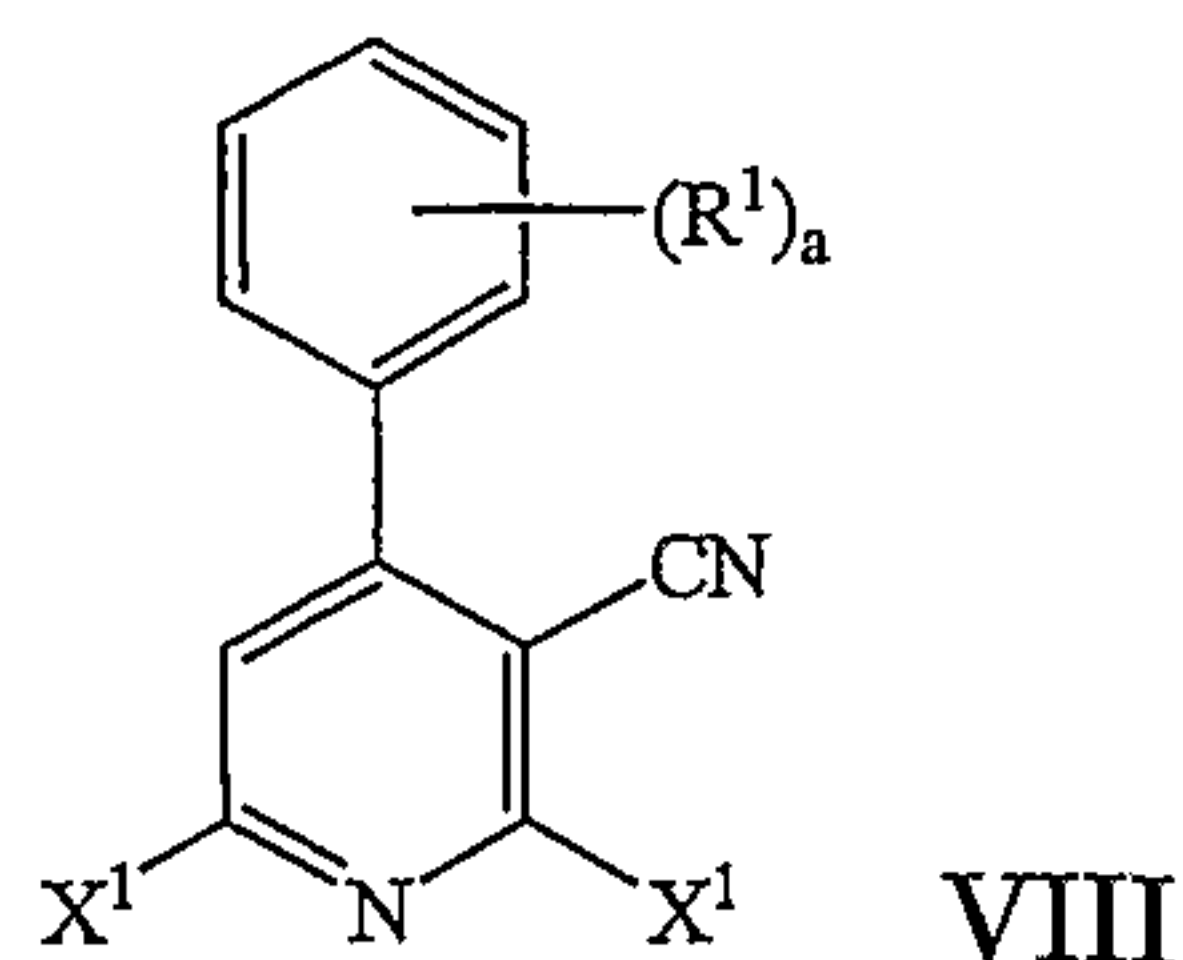
10 with an α -cyanoester compound of the formula:



in the presence of a base, where a, R¹, R⁹ are those defined herein.

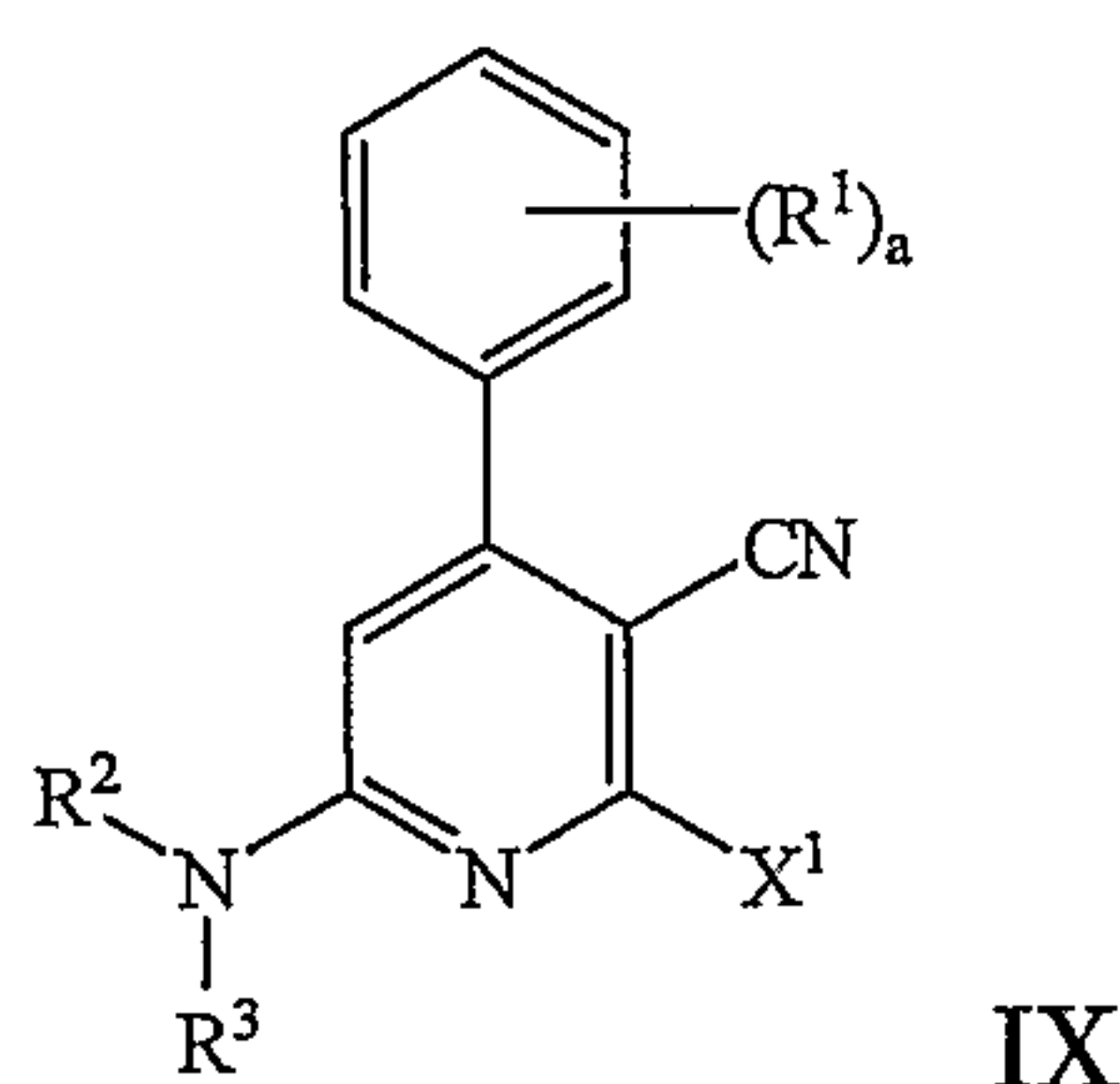
15 The α -cyano- β -aryl acrylate compound of Formula IV can be prepared separately (i.e., in a separate step or process) or it can be prepared *in situ*.

In another aspect of the present invention, the pyridinium zwitter ionic compound of Formula VII is treated with a reagent selected from POCl₃, PBr₃, and (F₃CSO₂)₂O to form a cyanopyridine compound of formula:



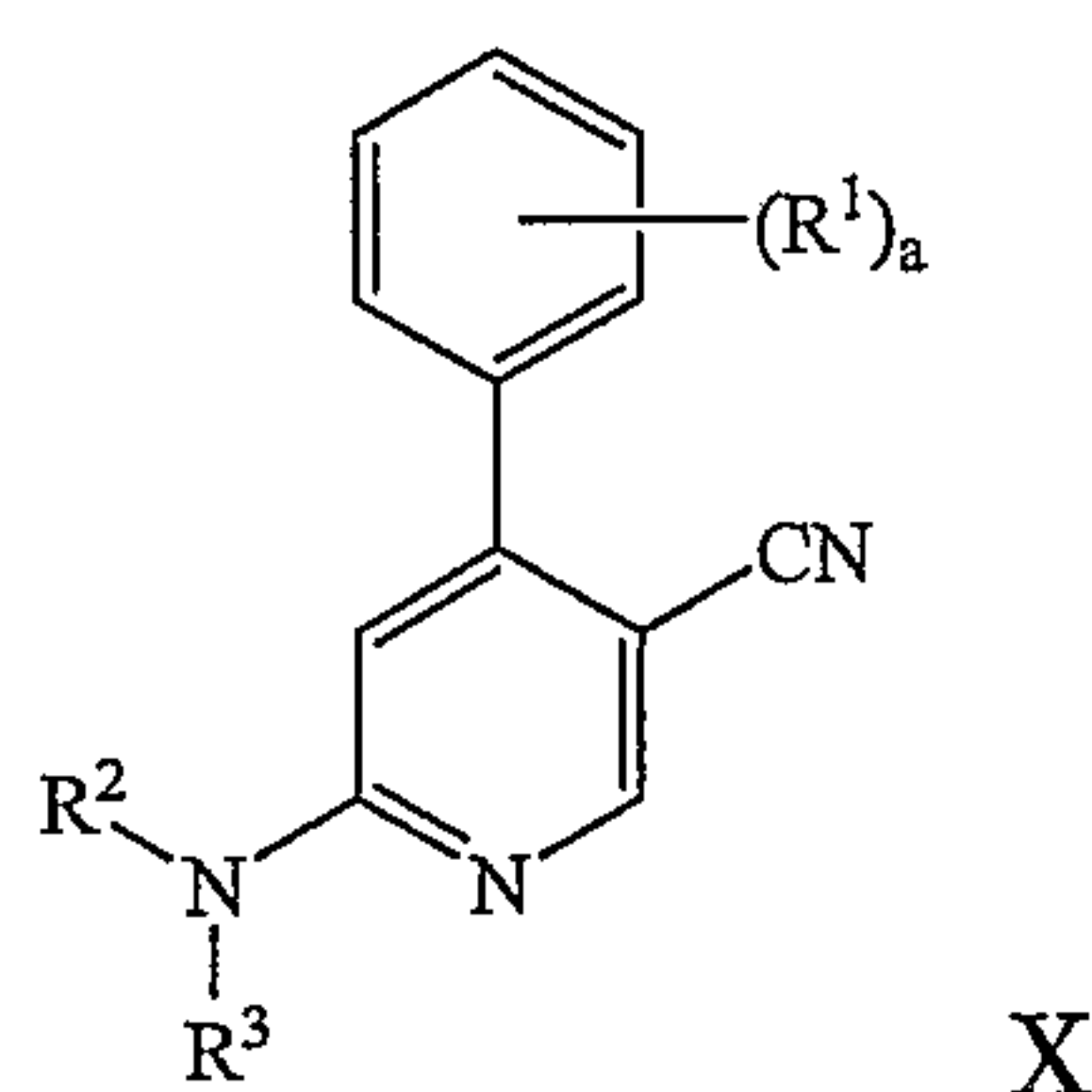
where X^1 is halogen or trifluoromethanesulfonate; and R^1 and a are those defined herein.

Regioselective amination of the cyanopyridine compound of formula VIII with an amine
 5 compound of the formula HNR^2R^3 then provides a tetra-substituted pyridine compound of the formula:



where a , R^1 , R^2 , R^3 and X^1 are those defined herein.

Methods of the present invention can also include hydrogenating the tetra-
 10 substituted pyridine compound of Formula IX in the presence of a hydrogenation catalyst to form a tri-substituted pyridine compound of the formula:



where a , R^1 , R^2 , and R^3 are those defined herein.

In addition, methods of the present invention can further include hydrolyzing the
 15 tri-substituted pyridine compound of Formula X to form the carboxamide compound of Formula I.

The following definitions apply generally to terms used in this description regardless of whether the term appears alone or in conjunction.

“Acyl activating group” refers to a group which facilitates transfer of an acyl group
 20 to an amine or a hydroxy functional group. Exemplary acyl activation groups include, but are

not limited to, halides (such as chlorides as in acid chlorides), anhydrides, and thioesters. Other acyl activating groups are well known to one skilled in the art and can be found, among others, in Smith and March, *Advanced Organic Chemistry*, 5th ed., John Wiley & Sons, New York, NY, 2001 and Harrison and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8 (John Wiley and Sons, 1971-1996).

“Alkylene” means a saturated linear saturated divalent hydrocarbon moiety of one to twelve carbon atoms or a branched saturated divalent hydrocarbon moiety of three to twelve carbon atoms. Exemplary alkylene groups include, but are not limited to, methylene, ethylene, propylene, butylene, pentylene, and the like.

“Aralkyl” means a moiety of the formula $-R^bR^c$ where R^b is an alkylene group and R^c is an aryl group. Exemplary aralkyl groups include, but are not limited to, benzyl, phenylethyl, 3-(3-chlorophenyl)-2-methylpentyl, and the like, with benzyl being the preferred aralkyl group.

The term “lower alkyl” means a straight- or branched-chain alkyl group containing from 1-7 carbon atoms, for example, methyl, ethyl, propyl, isopropyl, n-butyl, i-butyl, t-butyl, and the like. Preferred lower alkyl groups are groups with 1-4 carbon atoms.

The term “lower alkoxy” means a group wherein the alkyl residues are as defined above, and which is attached via oxygen atom.

The terms “halogen” and “halide” are used interchangeably herein and means chlorine, iodine, fluorine or bromine.

The term “cycloalkyl” means a saturated carbocyclic group, containing 3-6 carbon atoms.

The term “aryl” means an unsaturated aromatic ring, preferably phenyl.

“Heterocyclyl” means an aromatic or non-aromatic cyclic moiety having one or more ring heteroatoms, preferably one or two, each of which is independently selected from N, O, $S(O)_m$ (where m is 0, 1 or 2) with the remaining ring atoms being C. Exemplary heterocyclyl groups include, but are not limited to, morpholinyl, thiomorpholinyl, 1,1-dioxo-1 λ^6 -thiomorpholinyl, piperidinyl, piperazinyl and the like.

“Heterocyclalkyl” means a moiety of the formula $-R^d-R^e$, where R^d is alkylene and R^e is heterocycl as defined herein.

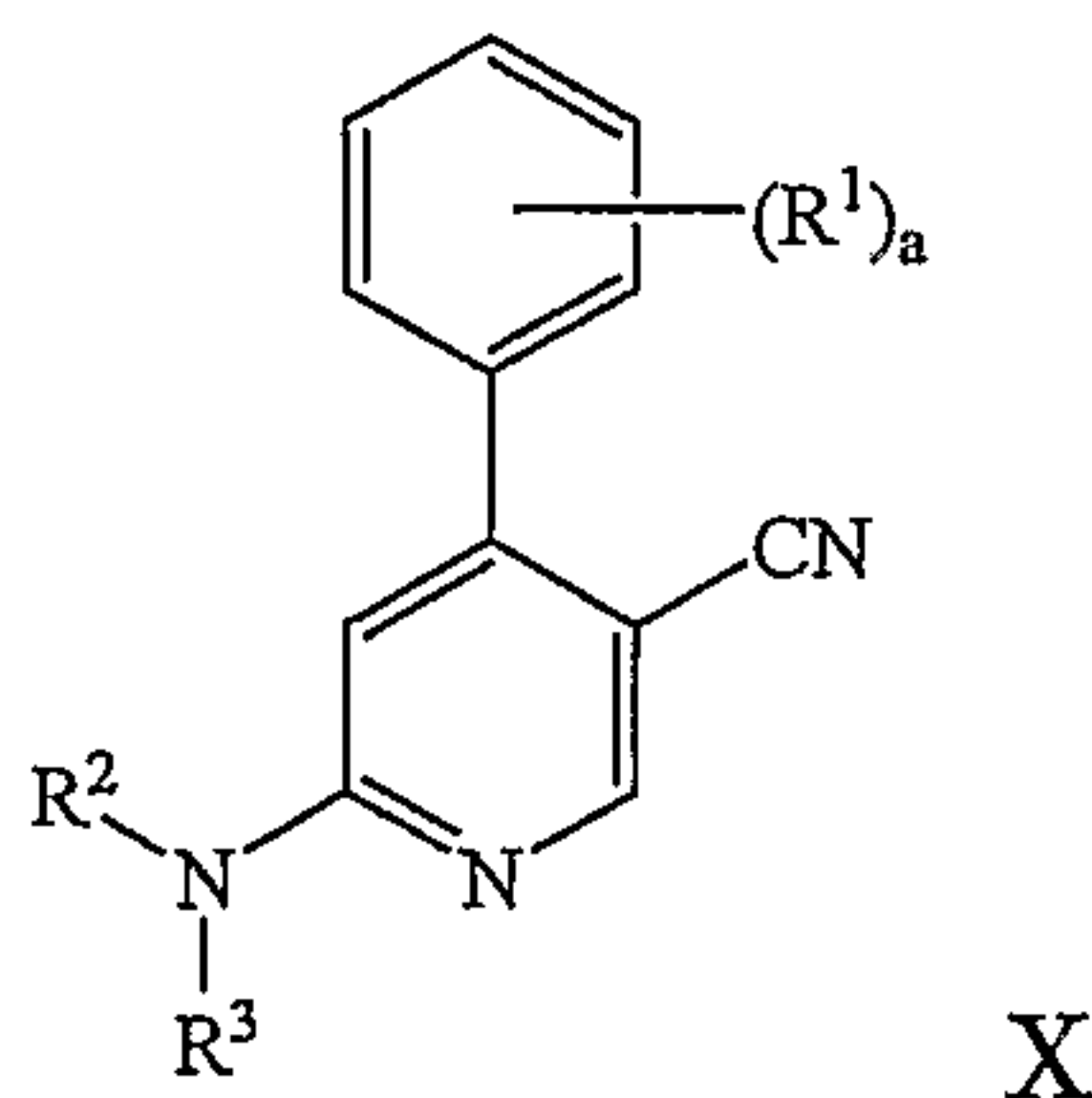
The term “N-heterocycl” refers to a heterocycl moiety as defined above,
 5 comprising at least one nitrogen ring atom with the understanding that the point of attachment of N-heterocycl moiety is through the ring nitrogen atom. N-Heterocycl may optionally be substituted with hydroxy, lower alkyl, $-R^a-COO-R^b$ (where R^a is a bond or alkylene, and R^b is lower alkyl), $-N(R^c)C(=O)-$ lower alkyl (where R^c is hydrogen, C₃₋₆ cycloalkyl, aralkyl or lower alkyl), hydroxylalkyl, cyano, $-R^e-O-R^f$ (where R^e is alkylene and R^f
 10 is hydroxylalkyl), $-CHO$, 5- and 6- membered heterocycl, or 5- or 6-membered heterocyclalkyl.

The term “5 or 6 membered heterocycl” refers to a heterocycl moiety having 5 or 6 ring atoms. Exemplary 5 or 6 membered heterocycl moieties include pyridinyl, pyridimidinyl, oxadiazolyl, triazolyl, tetrazolyl, thiazolyl, thienyl, furyl, pyranyl, pyrrolyl,
 15 imidazolyl, pyrazolyl, isothiazolyl, piperazinyl, or piperidyl.

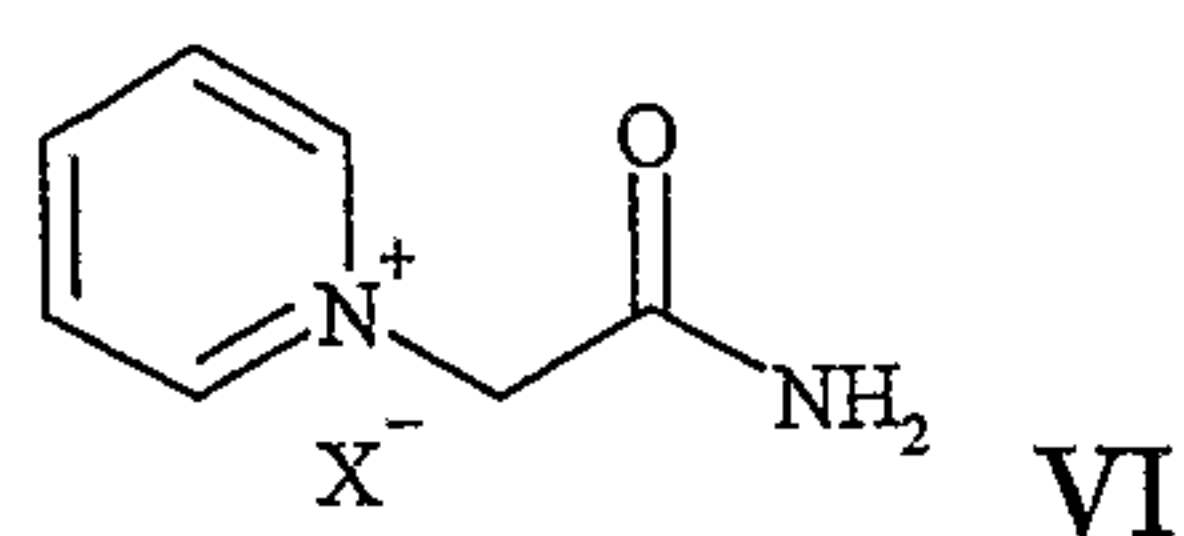
“Hydroxylalkyl” refers to an alkyl, preferably lower alkyl, moiety as defined herein that is substituted with one or more hydroxyl group, provided that no two carbon atom contains more than one hydroxyl group. Preferably, a hydroxylalkyl moiety is of the formula $-R^g-OH$ (where R^g is alkylene, i.e., where the hydroxyl group is attached to the
 20 terminal carbon atom).

Process for Preparing Compounds of Formula I

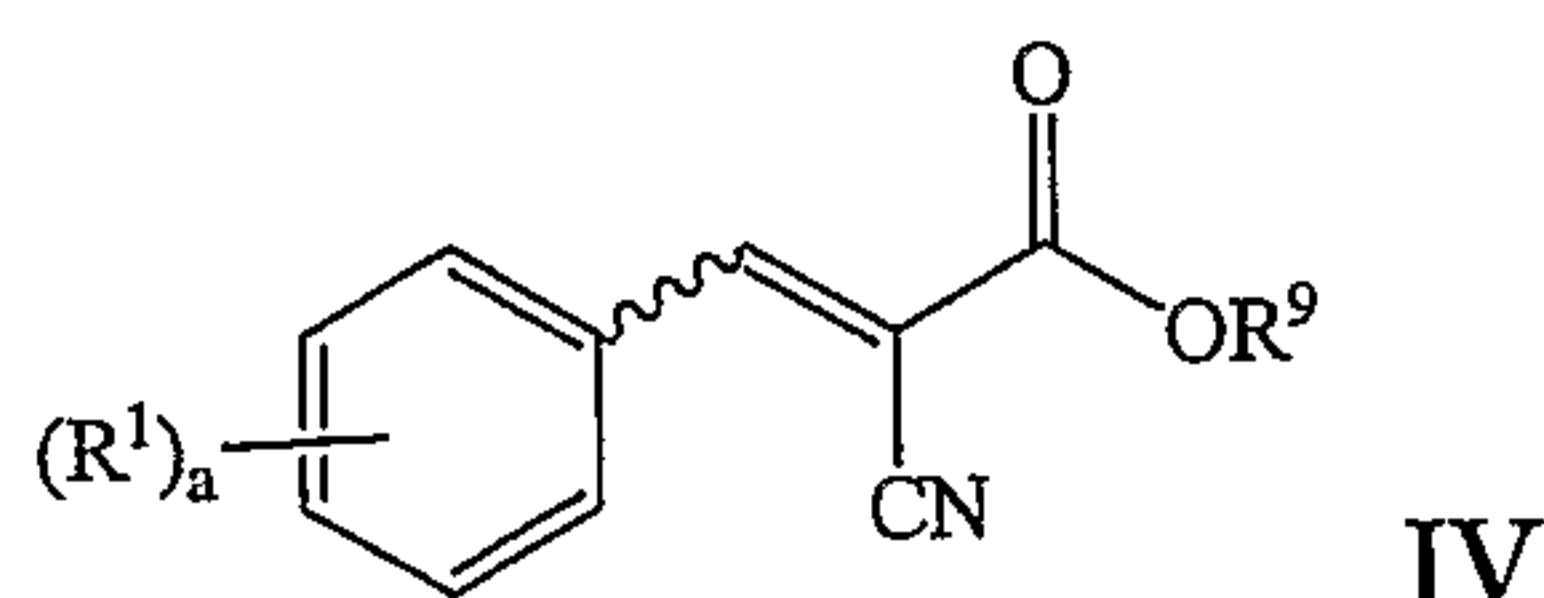
One aspect of the present invention provides a process for preparing an amino-substituted cyanopyridine compound of the formula:



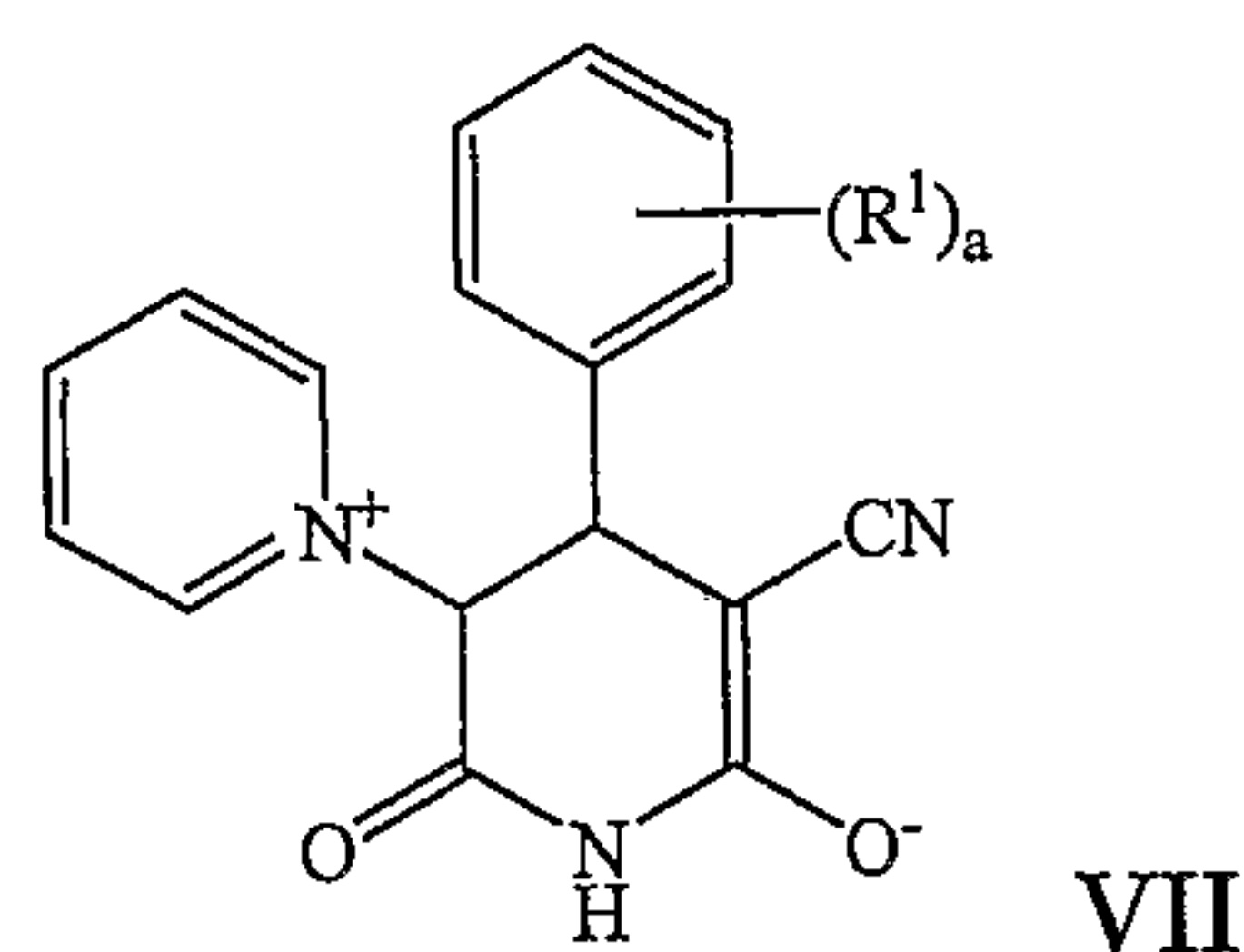
25 by reacting a pyridinium salt of the formula:



with an α -cyano- β -aryl acrylate compound of the formula:



5 to produce a pyridinium zwitter ionic compound of the formula:



where

each R^1 is independently lower alkyl, lower alkoxy, halogen, cyano or alkylamino;

a is an integer from 0 to 2;

10 R^2 is hydrogen, C_{3-6} cycloalkyl, aralkyl, lower alkyl, hydroxylalkyl, $-S(O)_2$ -lower alkyl, $-S(O)_2-Ar^1$, optionally substituted N-heterocyclyl)alkyl, $-C(=O)R^3$, where Ar^1 is aryl;

R^3 is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl;

or R^2 and R^3 together with the nitrogen atom to which they are attached to form

15 optionally substituted N-heterocyclyl;

or R^2 and R^3 together form $=C(R^5)-R^6-NR^7R^8$;

where

R^5 is lower alkyl, or preferably hydrogen;

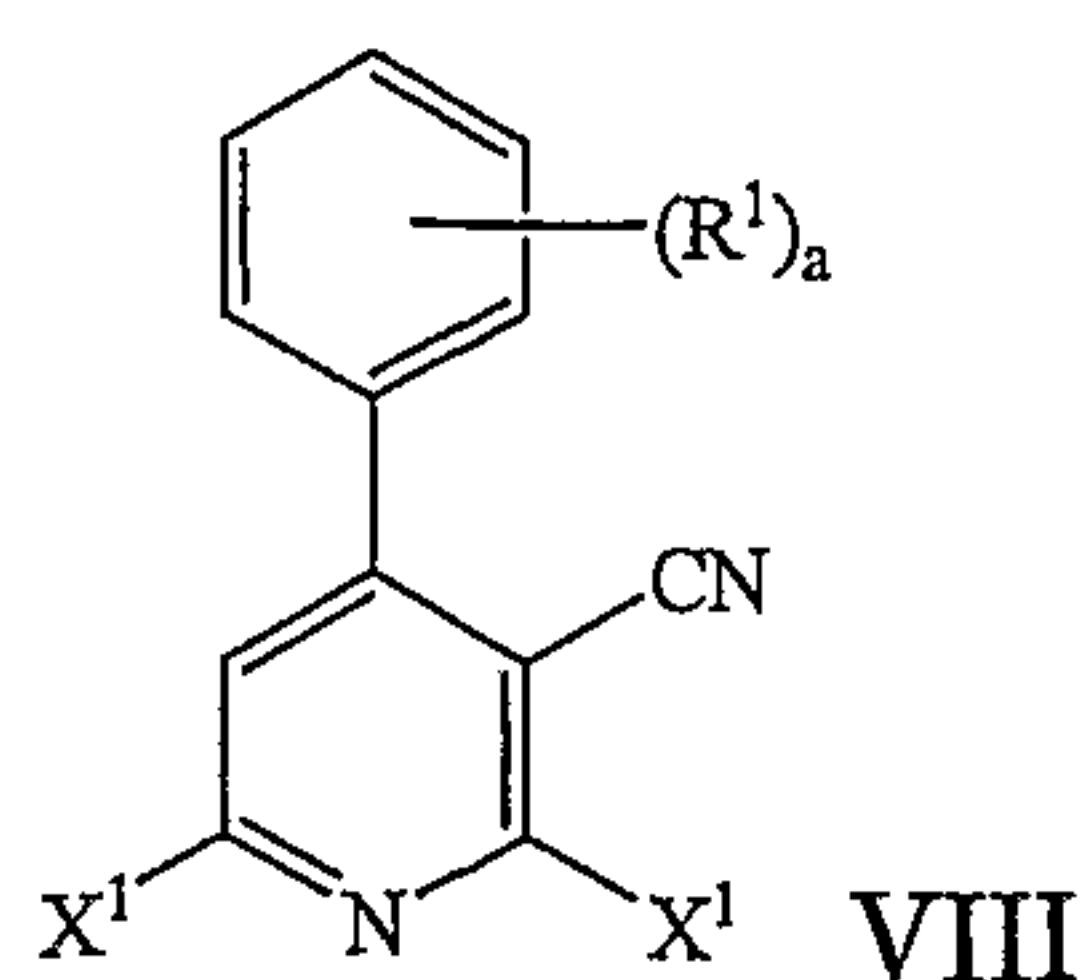
R^6 is alkylene or preferably a bond; and

20 each of R^7 and R^8 is independently hydrogen, C_{3-6} cycloalkyl, aralkyl, or lower alkyl;

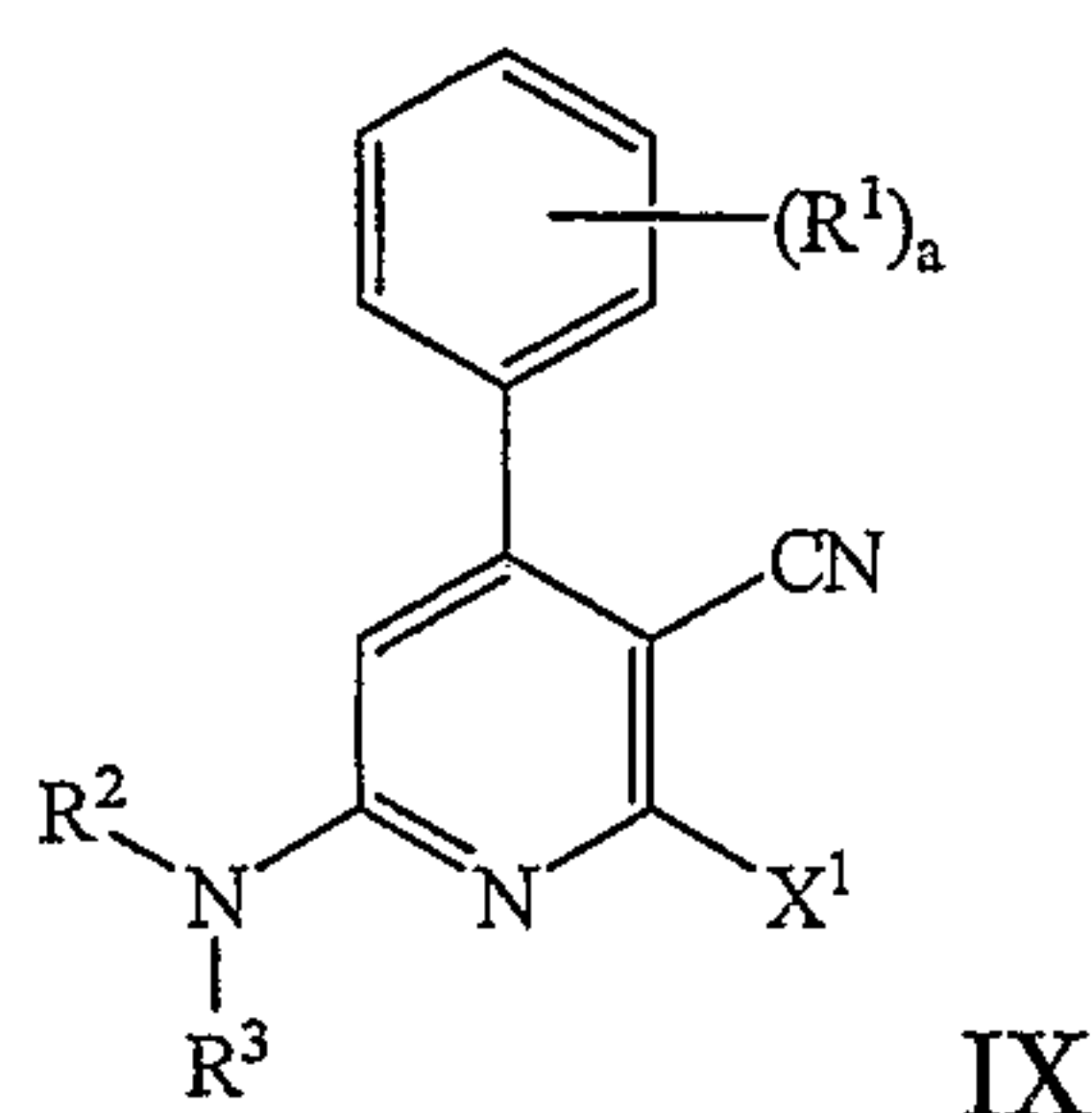
R^9 is lower alkyl; and

X is halide.

The pyridinium zwitter ionic compound of Formula VII is then reacted with a reagent
25 selected from $POCl_3$, PBr_3 , $(F_3CSO_2)_2O$, and other similar reagents known to one skilled in the art, to form a cyanopyridine compound of the formula:

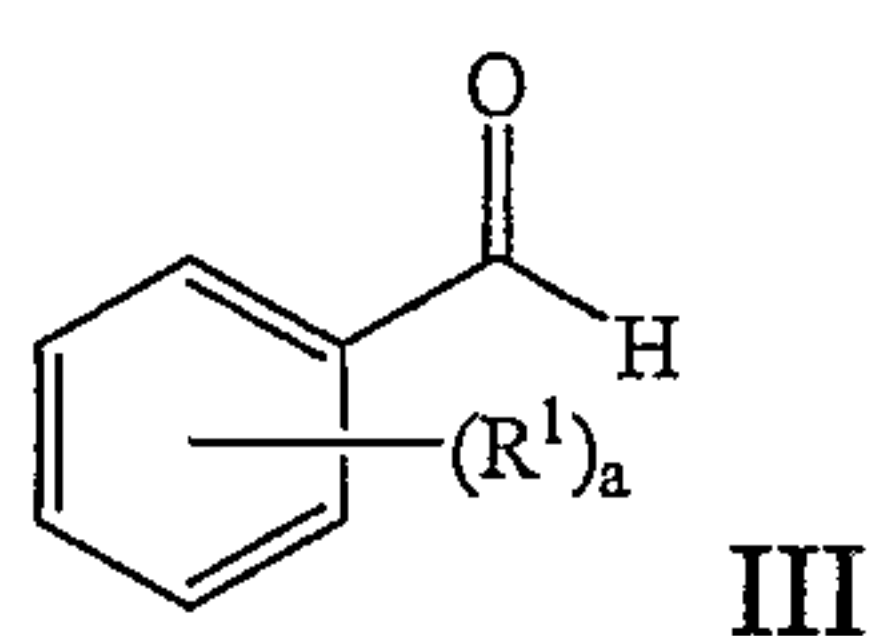


and the cyanopyridine compound of formula VIII is reacted with an amine compound of the formula HNR^2R^3 to form a tetra-substituted pyridine compound of the formula:

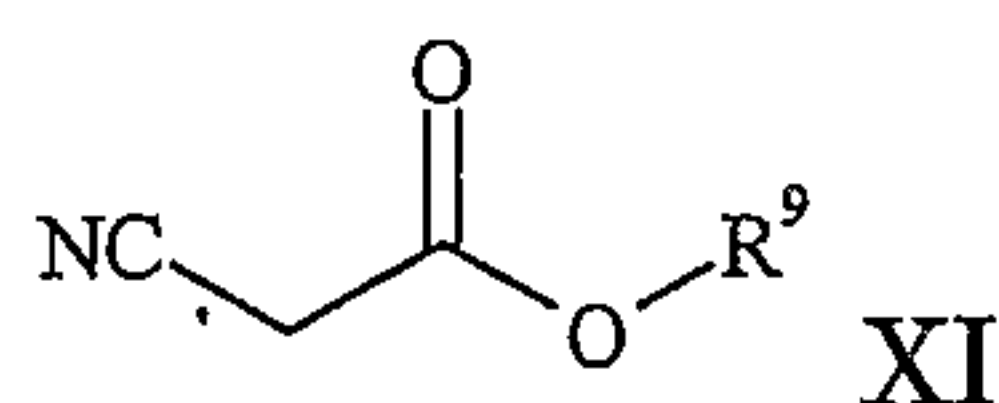


which is then hydrogenated in the presence of a hydrogenation catalyst to form the amino-substituted cyanopyridine compound of the Formula X, where a, R^1 , R^2 , and R^3 are those defined herein, and each X^1 is independently halide or trifluoromethanesulfonate. Preferably, both X^1 are of the same moiety.

The α -cyano- β -aryl acrylate compound of Formula IV can be prepared by reacting a benzaldehyde compound of the formula:

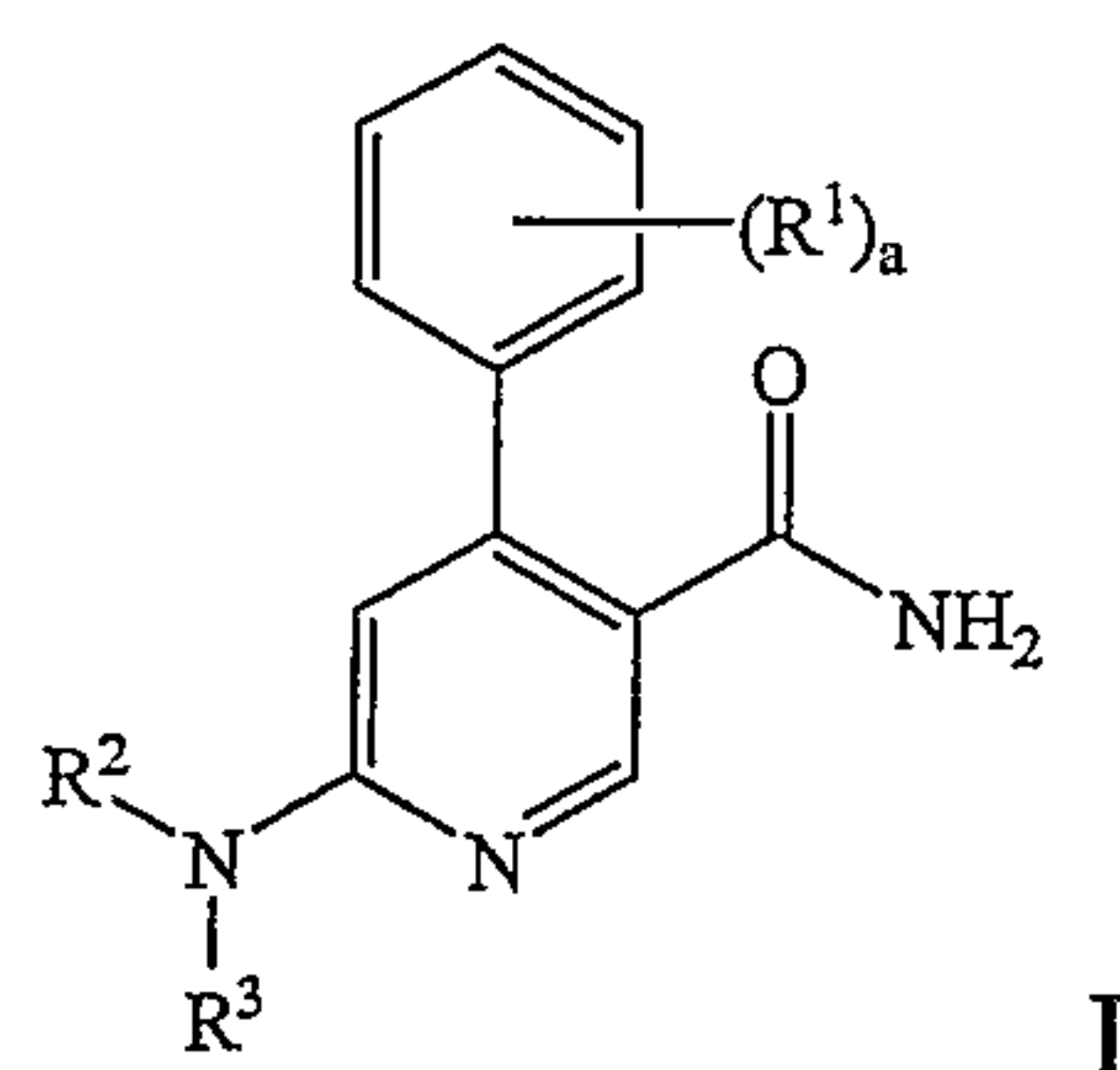


with an α -cyanoester compound of the formula:



in the presence of a base, wherein a, R^1 , and R^9 are those defined herein. Moreover, the α -cyano- β -aryl acrylate compound of Formula IV can be prepared and separated prior to use or it can be prepared and used *in situ*.

Hydrolyzing the amino-substituted cyanopyridine compound of the Formula X provides a carboxamide pyridine compound of the formula:

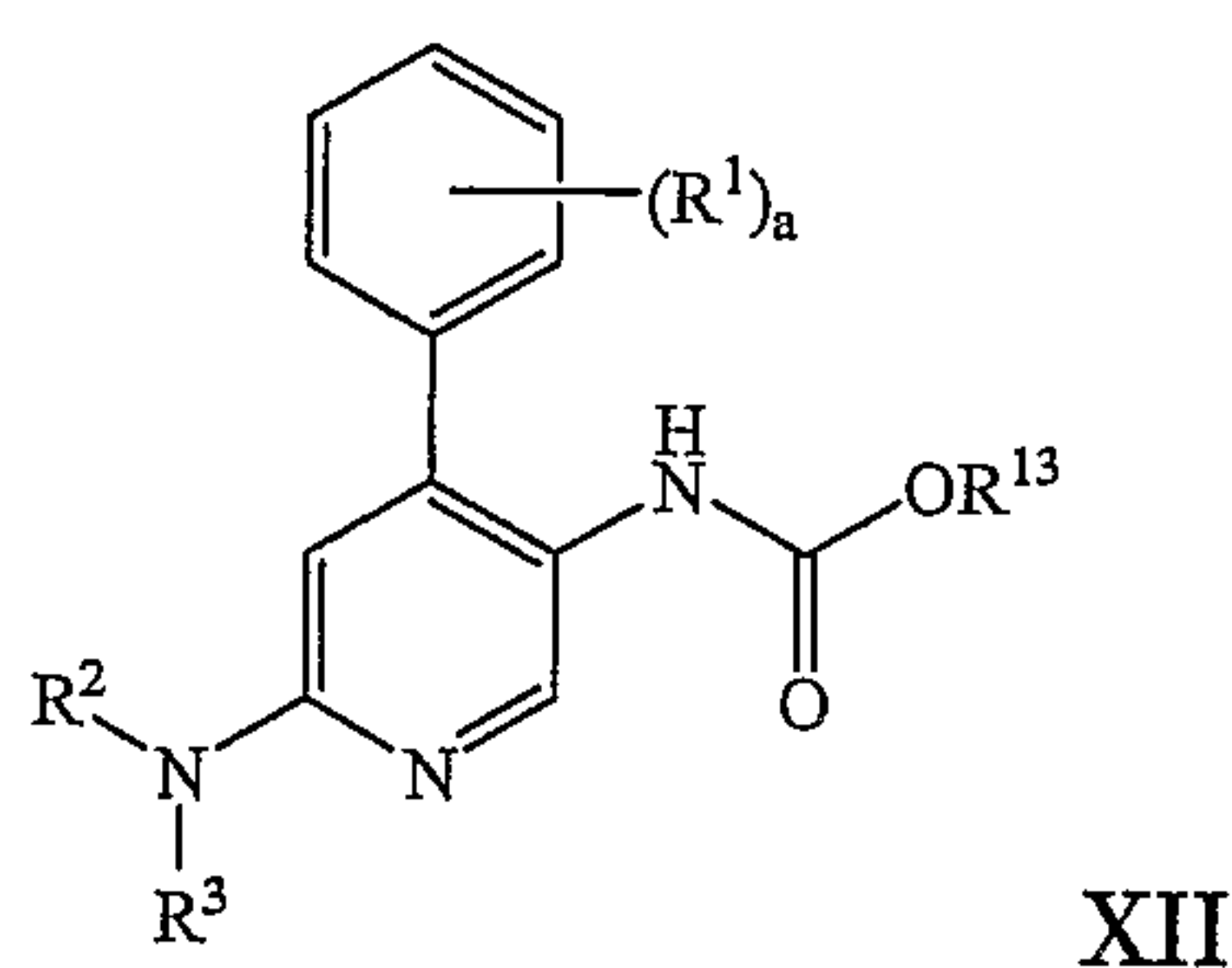


where a , R^1 , R^2 , and R^3 are those defined herein. As stated above, the carboxamide pyridine compound of Formula I is useful as a valuable intermediate in the synthesis of Neurokinin-1
 5 receptor antagonists, such as those disclosed in WO 02/085458.

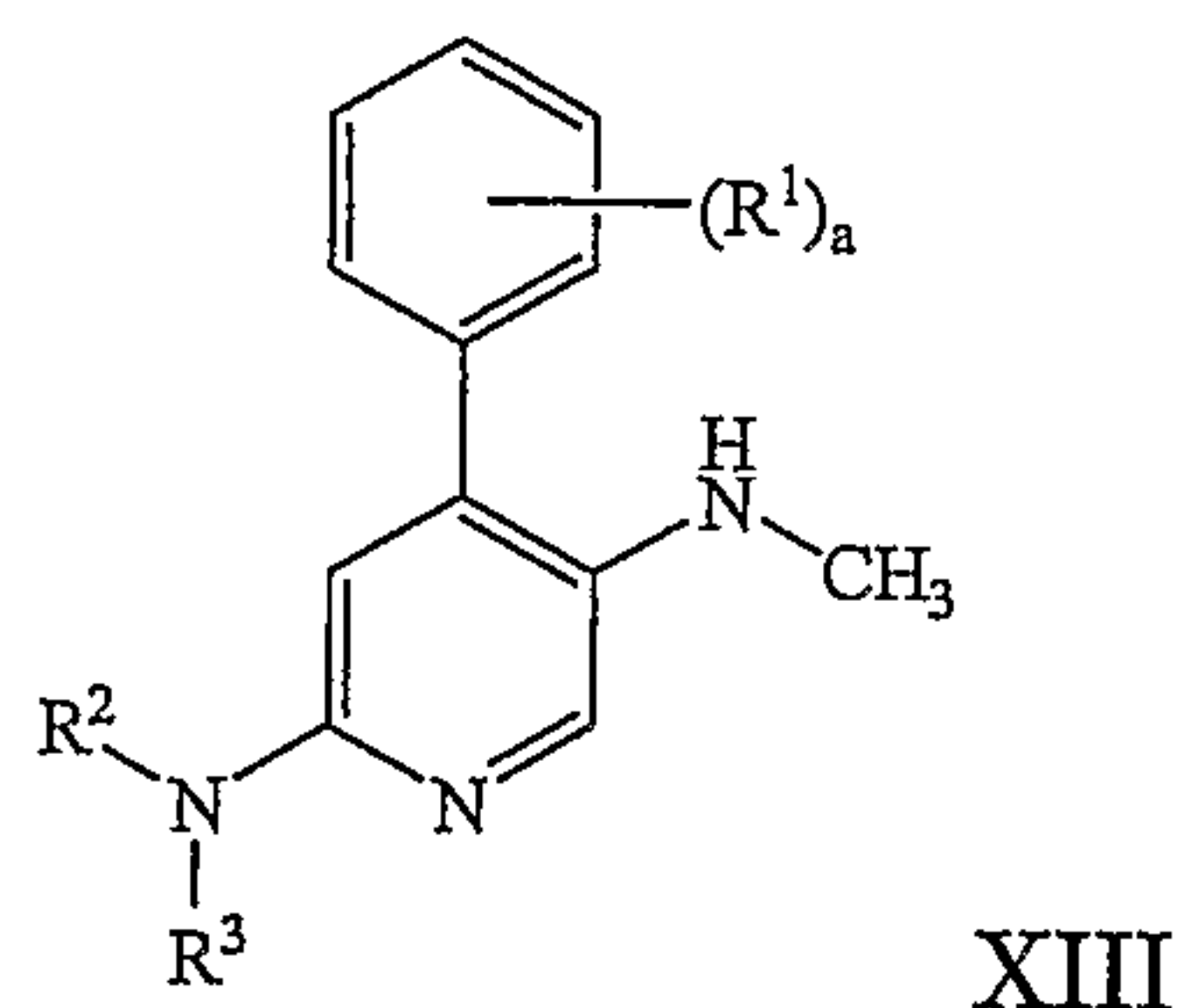
Preparation of the aminopyridine compounds of Formula II, which are known Neurokinin-1 receptor antagonist, can be achieved by one of several processes illustrated below. It should be appreciated that the preparation of the aminopyridine compounds of Formula II from the carboxamide pyridine compound of Formula I discussed below are only
 10 illustrative and the scope of the present invention is not limited to such processes.

In one particular embodiment, the aminopyridine compounds of Formula II can be prepared from the carboxamide pyridine compound of Formula I by:

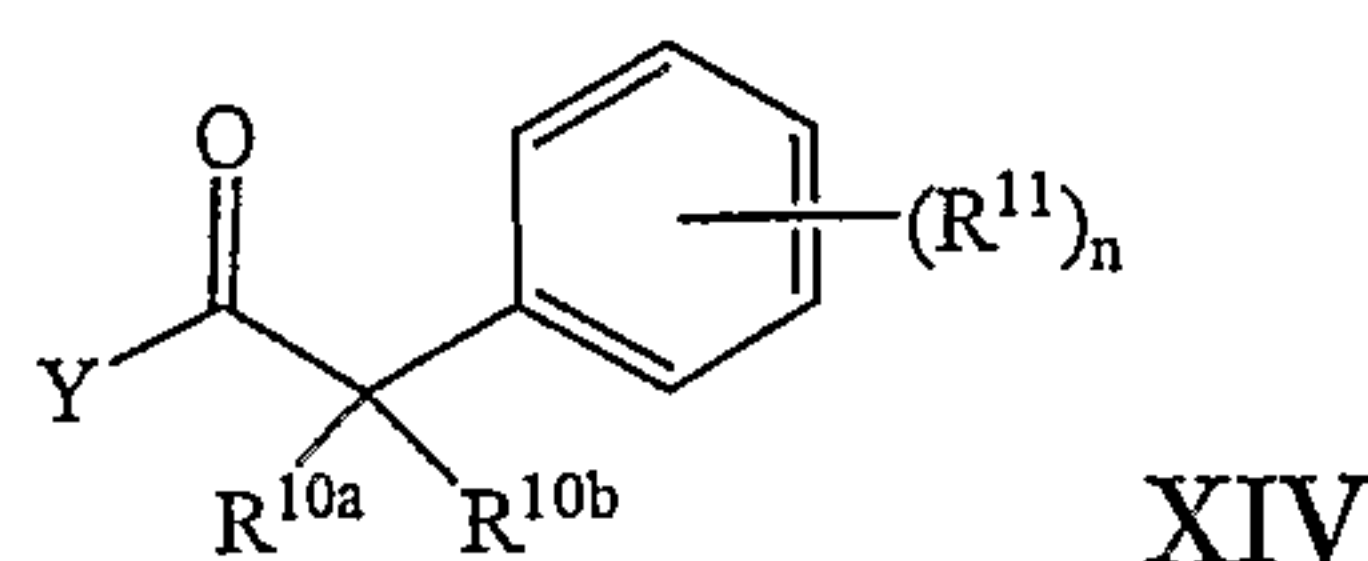
- (a) reacting the carboxamide pyridine compound of Formula I with an oxidizing agent in the presence of an alcohol of the formula $R^{13}-OH$ to produce a carbamate pyridine
 15 compound of the formula:



- (b) reducing the carbamate pyridine compound of Formula XII with a reducing agent to produce a diaminopyridine compound of the formula:



(c) reacting the diaminopyridine compound of Formula XIII with a carbonyl compound of the formula:



5 to form the aminopyridine compound of Formula II, where X^a is $-N(CH_3)C(=O)-$; and

(d) optionally reacting the aminopyridine compound of Formula II, where X^a is $-N(CH_3)C(=O)-$, with a second reducing agent to produce the aminopyridine compound of Formula II (where X^a is $-N(CH_3)-CH_2-$),

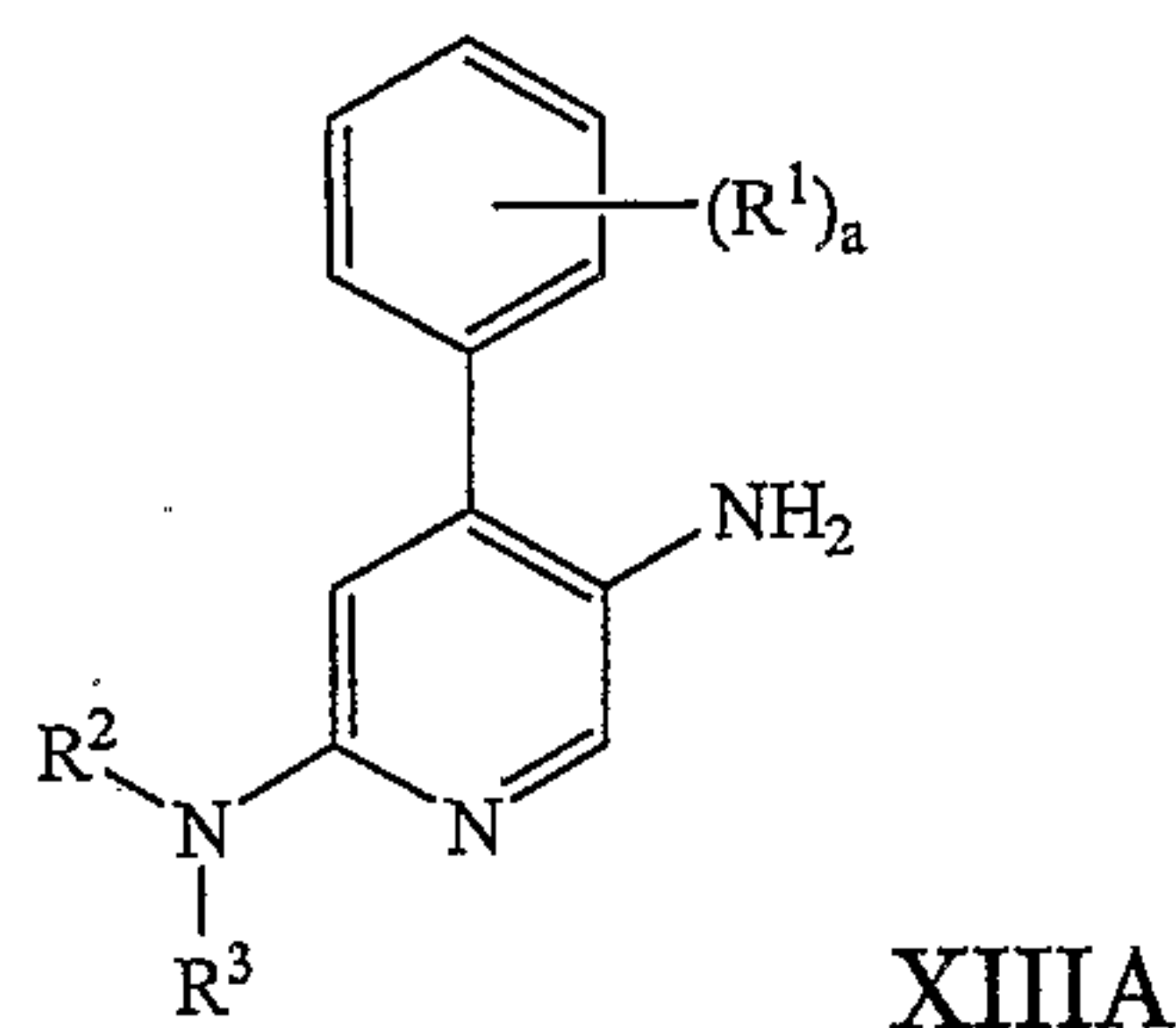
where

10 a, n, R^1 , R^2 , R^3 , R^{10a} , R^{10b} , and R^{11} are those defined herein;

R^{13} is lower alkyl; and

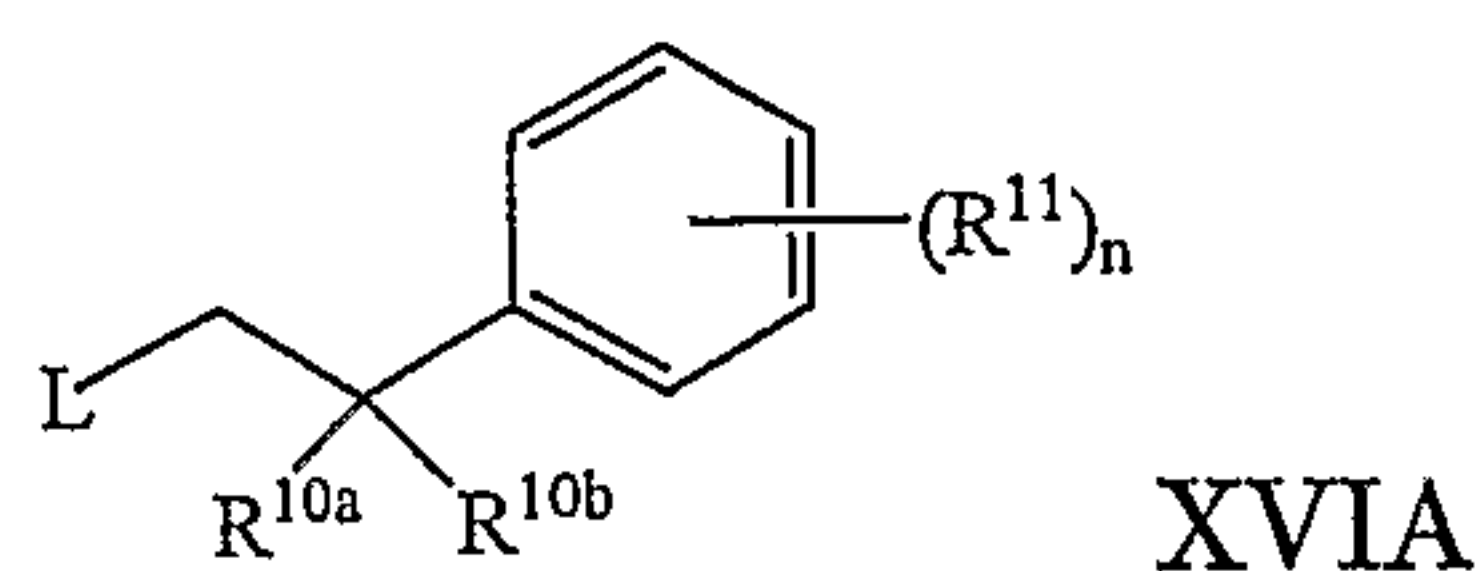
Y is alkoxide or an acyl activating group.

It should be appreciated that a compound of Formula I can be reacted with an oxidizing agent and hydrolyzed with water rather than $R^{13}-OH$ to produce a diaminopyridine compound of the formula:



This diaminopyridine of Formula XIII A can then be further derivatized using similar processes and/or reactions as those described in reference to compounds of Formula XIII to produce corresponding compounds of Formula II.

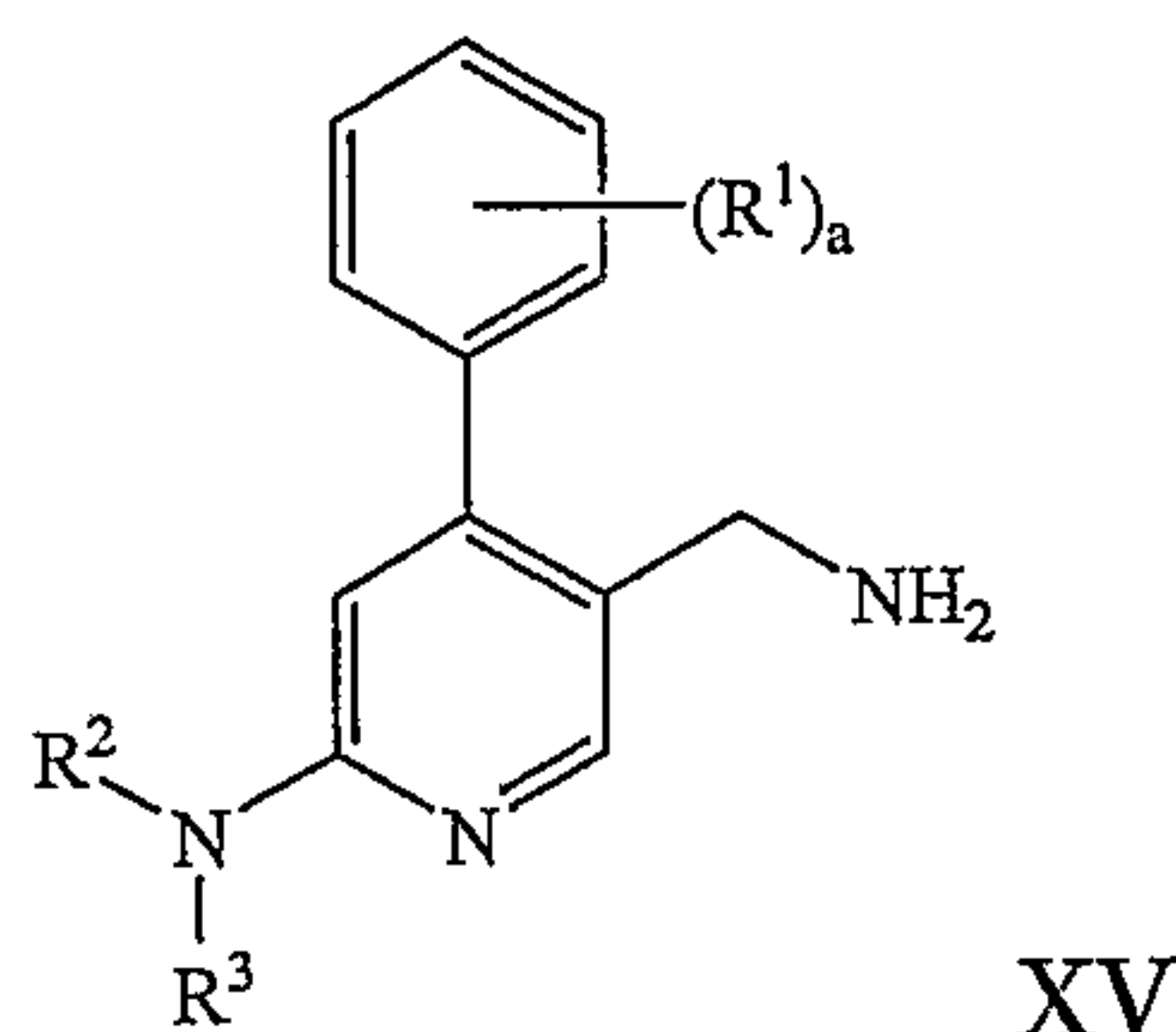
20 Some aminopyridine compounds of formulas II can be prepared from the diaminopyridine compound of Formula XIII A by alkylating with an aralkyl compound of the formula:



to produce the aminopyridine compounds of formulas II where X^a is $-N(H)-CH_2-$, L is a leaving group, and R^{10a} , R^{10b} , R^{11} , and n are those defined herein.

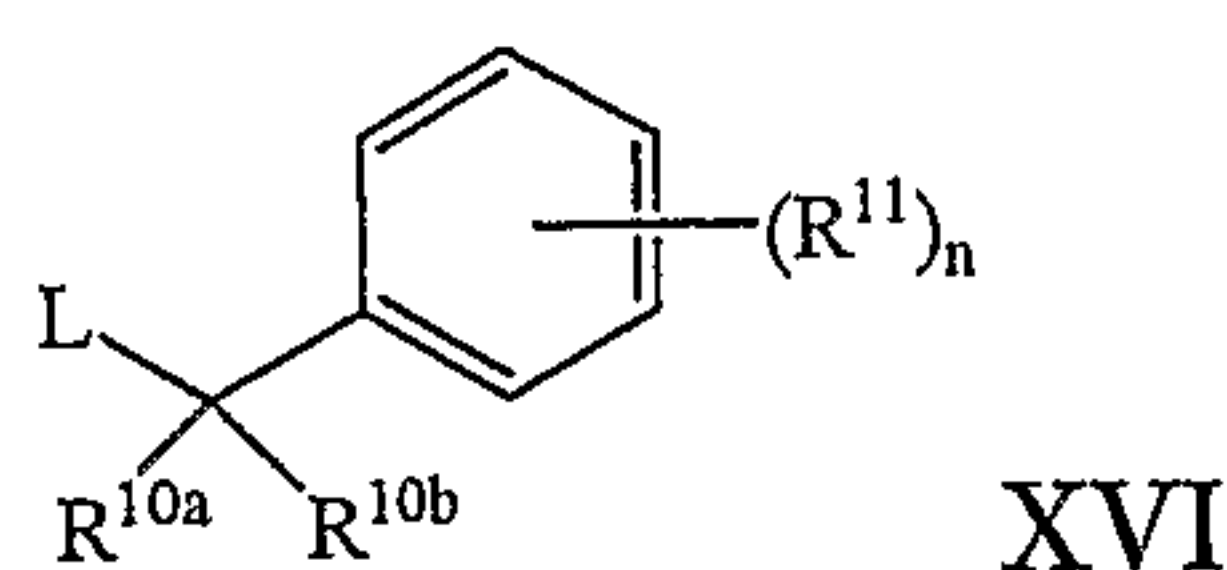
In another embodiment, the aminopyridine compounds of Formula II can be prepared from the carboxamide pyridine compound of Formula I by:

- (a) contacting the carboxamide pyridine compound of Formula I with a reducing agent to produce an alkylamino-substituted pyridine compound of the formula:



and

- (b) reacting the alkylamino-substituted pyridine compound of Formula XV with an aralkyl compound of the formula:



to produce the aminopyridine compound of Formula II,
where

a, n, R¹, R², R³, R^{10a}, R^{10b}, and R¹¹ are those defined herein;

L is a leaving group; and

X^a is -CH₂N(H)-.

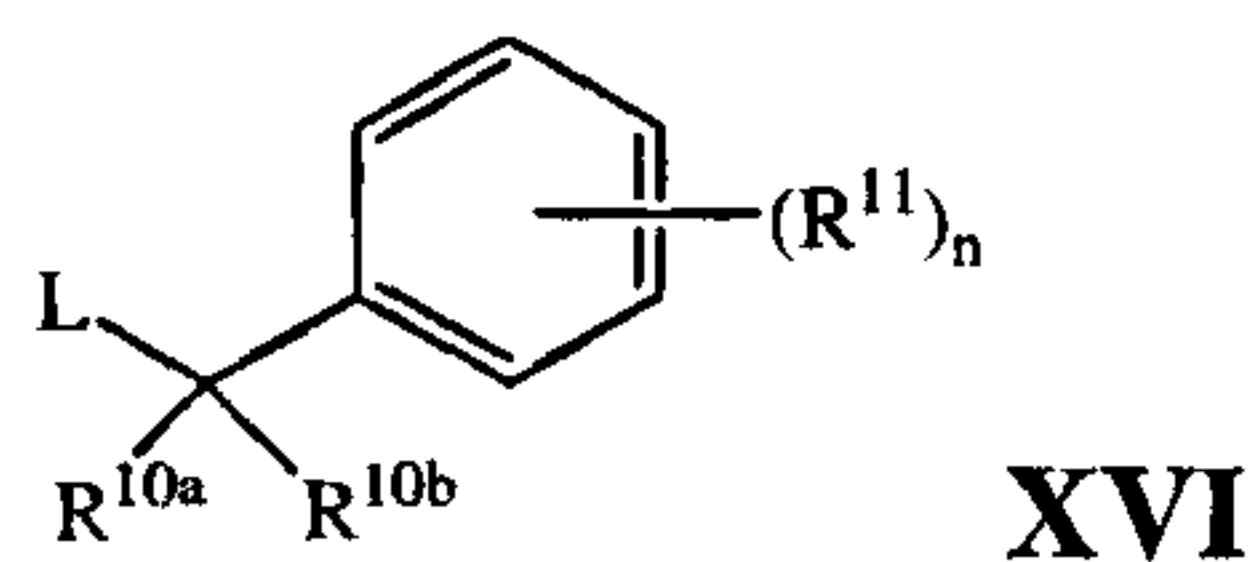
It should be appreciated that when X^a is -CH₂N(H)- or -N(H)-CH₂- in compounds of Formula II, the amino group of X^a can be further alkylated to produce a substituted X^a group, where X^a is -CH₂N(R^{14a})- or -N(R^{14a})-CH₂-, where R^{14a} is C₃₋₆ cycloalkyl, aralkyl or lower alkyl. Typically this alkylation can be achieved with a corresponding R^{14a}-X^b, where R^{14a} those defined above and X^b is a leaving group. Such alkylation reactions are well known to one of ordinary skill in the art, described for example in Smith and March, *Advanced Organic Chemistry*, 5th ed. and Harrison and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8, all.

Alternatively, rather than by an alkylation reaction, a reductive amination reaction can also be used to substitute the amino group with R^{14a} group. Briefly, a reductive amination

involves reacting the amino group X^a (where X^a is $-\text{CH}_2\text{N}(\text{H})-$ or $-\text{N}(\text{H})-\text{CH}_2-$) with an R^{14a} group having a carbonyl group (i.e., a corresponding R^{14a} carbonyl compound) in the presence of a reducing agent, such as sodium borohydride or other similar reducing agent. For example, when R^{14a} is an ethyl group, the corresponding R^{14a} carbonyl compound is $\text{HC}(=\text{O})\text{CH}_3$, when R^{14a} is benzyl group, the corresponding R^{14a} carbonyl compound is $\text{HC}(=\text{O})\text{Ph}$, and when R^{14a} is cyclohexane, the corresponding R^{14a} carbonyl compound is cyclohexanone. Thus, the corresponding R^{14a} carbonyl compound refers to a compound having a carbonyl group within the R^{14a} moiety such that the reductive amination provided substitution of R^{14a} group. Reductive amination reaction is also disclosed in Smith and March, *Advanced Organic Chemistry*, 5th ed., and Harrison and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8.

Still alternatively, synthesis of compounds where R^{14a} is an aralkyl or a lower alkyl can involve acylation of the X^a moiety (where the initial X^a moiety is $-\text{CH}_2\text{N}(\text{H})-$ or $-\text{N}(\text{H})-\text{CH}_2-$) with a $\text{R}^{15}-\text{C}(=\text{O})-\text{X}^c$, where X^c is an acyl activating group such as halide or ester (i.e., $-\text{OR}^{16}$, where R^{16} is an alkyl or other hydrocarbon moiety) and reduction with a suitable reducing agent such as LiAlBH_4 . Other suitable reducing agents are well known to one skilled in the art as disclosed by Smith and March in *Advanced Organic Chemistry*, 5th ed. and Harrison and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8. Thus, an R^{14a} group is incorporated by using the acylating agent $\text{R}^{15}-\text{C}(=\text{O})-\text{X}^c$, where $\text{R}^{15}-\text{CH}_2-$ group represents R^{14a} moiety. Accordingly, in these instances, R^{14a} is a methylene homolog of R^{15} moiety.

Yet in another embodiment, some aminopyridine compounds of Formula II can be prepared from the carboxamide pyridine compound of Formula I by reacting the carboxamide pyridine compound of Formula I with an aralkyl compound of the formula:



in the presence of a base to produce the aminopyridine compound of Formula II, where n , R^{10a} , R^{10b} , R^{11} , and L are those defined herein.

Using processes of the present invention, a wide variety of aminopyridine compounds of Formula II can be prepared including, but not limited to:

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-[methyl-(2-morpholin-4-yl-ethyl)-amino]-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-morpholin-4-yl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-thiomorpholin-4-yl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-(1-oxo-1 λ^6 -4-thiomorpholin-4-yl)-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-6-(1,1-dioxo-1 λ^6 -6-thiomorpholin-4-yl)-N-methyl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-piperazin-1-yl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-6-[4-(2-hydroxyethyl)-piperazin-1-yl]-N-methyl-4-o-tolyl-nicotinamide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(4-methyl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-N-methyl-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(4-fluoro-2-methyl-phenyl)-6-(4-methyl-piperazin-1-yl)-pyridin-3-yl]-N-methyl-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chloro-phenyl)pyridin-3-yl]-N-methyl-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(4-o-tolyl-pyridin-3-yl)-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-[6-(4-pyridin-2-yl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide;

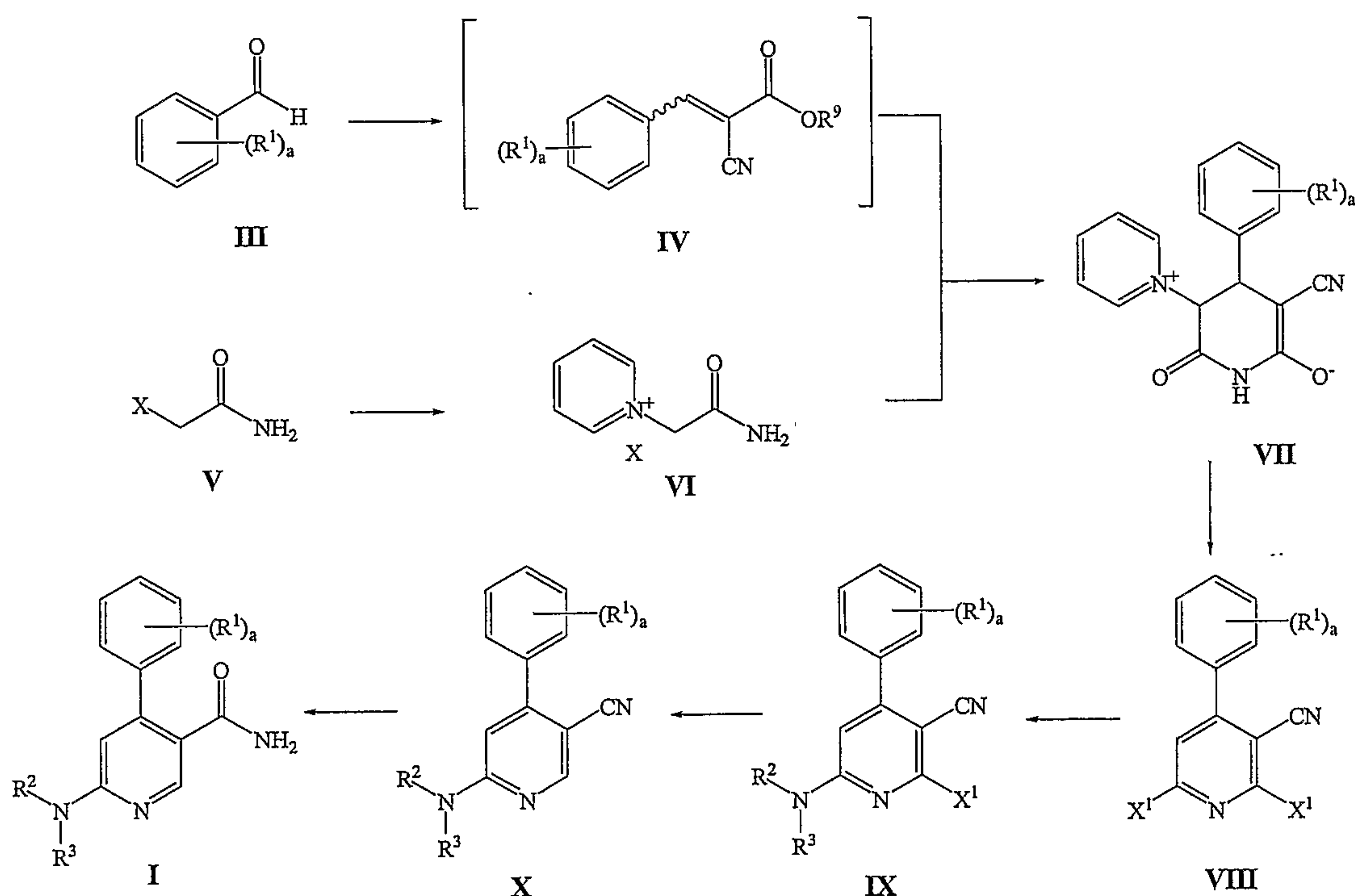
2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chlorophenyl)-6-dimethylamino-pyridin-3-yl]-isobutyramide;

2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(6-piperazin-1-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide; or

2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(1,1-dioxo-1 λ^6 -thiomorpholin-4-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide.

Processes of the present invention overcome many of the disadvantages of the conventional synthetic methods by eliminating the need for expensive starting materials and avoiding use of a Grignard reaction. The overall process for preparation of compounds of formula I is shown in Scheme I.

Scheme I



Throughout this specification, some synthetic processes for producing compounds of Formula I are often indicated by exact structures; however, it should be appreciated that processes of the present invention can be applied widely to analogous compounds of Formula I, given an appropriate consideration to protection and deprotection of reactive functional groups by methods standard to the art of organic chemistry. For example, hydroxy groups, in order to prevent unwanted side reactions, sometimes need to be converted to ethers or esters during chemical reactions at other sites in the molecule. The hydroxy protecting group is then removed to provide the free hydroxy group. Similarly, amino groups and carboxylic acid groups can be derivatized to protect them against unwanted side reactions. Typical protecting groups, and methods for attaching and cleaving

them, are described in the above references by T.W. Greene and P.G.M. Wuts, *Protective Groups in Organic Synthesis*, 3rd edition, John Wiley & Sons, New York, 1999, and Harrison and Harrison et al., *Compendium of Synthetic Organic Methods*, Vols. 1-8 (John Wiley and Sons, 1971-1996).

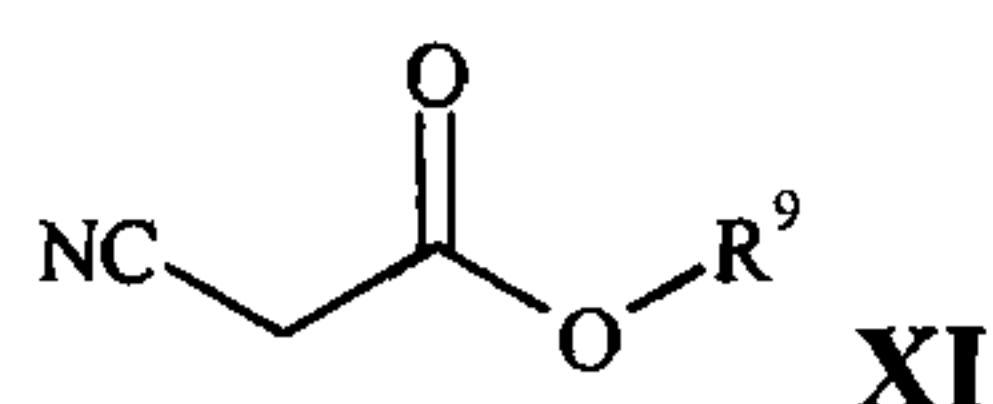
5

Referring to Scheme I, reacting a compound of formula VI with a compound of formula IV is typically carried out in the presence of an organic solvent, such as ether, ketone, toluene or alcohol, preferably methanol. Often the reaction is carried out in the presence of a base, preferably an organic base, such as triethylamine. Typical reaction conditions include refluxing the reaction mixture for about one minute, then allowing the mixture to cool to about 20 °C to about 50 °C, preferably about 25 °C. After cooling, the reaction mixture is stirred for about 1 to 100 hours, typically about 66 hours. Filtration of the reaction mixture and air drying the solid then affords a pyridinium zwitter ionic compound of Formula VII.

15

Compound of Formula IV can be generated separated prior to its reaction with the pyridinium salt of formula VI or it can be generated *in situ*. In this manner, the pyridinium zwitter ionic compound of Formula VII can be produced by reacting a pyridinium salt of formula VI with a benzaldehyde compound of formula III in the presence of an α -cyanoester compound of the formula:

20



25

where R^9 is as defined herein. Generally the reaction is carried out in the presence of an alcohol, such as a lower alkyl alcohol, cycloalkyl alcohol, preferably isopropanol. In one aspect, the solvent is isopropanol, methanol, or a mixture thereof. Typically, the reaction is carried out in an organic solvent such as ether, ketone, toluene, alcohol (preferably methanol), or a mixture thereof. Often the reaction mixture includes an organic base, such as triethylamine. The base may also be morpholine. Typical reaction time is about 2 to 48 hours, generally about 24 hours. Suitable reaction temperature ranges from about 20 °C to 33 °C, often about 25 °C to 30 °C.

30

Referring again to Scheme I above, reacting the pyridinium zwitter ionic compound of formula VII with a reagent selected from POCl_3 , PBr_3 , and $(\text{F}_3\text{CSO}_2)_2\text{O}$ yields a cyanopyridine compound of formula VIII. Typical reaction conditions include heating the mixture to about 105 °C for approximately 72 hours. The mixture is then cooled to approximately 20 °C to 33 °C, preferably 20 °C to 25 °C and diluted with an organic solvent,

such as methylene chloride. The resulting mixture is then placed in an ice bath and stirred for about 10 minutes. Aqueous work up followed by concentration of the organic layer then affords the cyanopyridine compound of formula VIII.

5 The cyanopyridine compound of formula VIII is then reacted with an amine compound of the formula HNR^2R^3 to form a tetra-substituted pyridine compound of formula IX. Displacement of one of the X^1 moiety with the amine compound of the formula HNR^2R^3 is typically preformed in an alcoholic solvent, such as methanol. The reaction temperature is generally kept at about 0 °C to 25 °C, preferably 18 °C. If necessary, an ice-water bath can be
10 used to control the reaction temperature. In one particular embodiment, the amine compound of the formula HNR^2R^3 is morpholine, which is added to the reaction mixture at a temperature of about 18 °C to 33 °C, preferably 18 °C to 22 °C. Morpholine is typically added slowly to the reaction mixture, e.g., addition time of about 10 to 60 minutes, preferably 45 minutes. The resulting mixture is stirred at about 20 °C to 33 °C, preferably 20 °C to 25 °C,
15 for approximately 48 hours.

Hydrogenation of the tetra-substituted pyridine compound of formula IX in the presence of a hydrogenation catalyst then affords an amino-substituted cyanopyridine compound of formula X. Typically, the hydrogenation reaction is carried out in the presence of a base, preferably an organic base, such as triethylamine. The hydrogenation reaction
20 temperature generally ranges from about 25 °C to 45 °C, preferably 20 °C to 25 °C. A variety of hydrogenation catalysts are suitable for reducing the tetra-substituted pyridine compound of formula IX. Preferred hydrogenation catalysts are transition metal based, preferably palladium metal based. A particularly useful hydrogenation catalyst is $\text{Pd}(\text{OH})_2$ or 20% palladium hydroxide on carbon (Pearlman's catalyst). The hydrogenation reaction mixture
25 includes an organic solvent, such as methanol. The reaction mixture is typically stirred under a high pressure of hydrogen atmosphere, typically at about 30 psi of hydrogen or higher, more generally about 40 psi of hydrogen or higher. In one particular embodiment, the hydrogenation reaction is carried out at about 48.0 to 48.3 psi of hydrogen. Generally, the reaction time ranges from about 2 to 42 hours, often about 21 hours.

30 The amino-substituted cyanopyridine compound of formula X is then hydrolyzed to provide a carboxamide pyridine compound of formula I. Hydrolysis of the nitrile function group of formula X can be achieved in a basic or, preferably, in an acidic medium. Exemplary

acids that are useful in hydrolysis of the nitrile function group include, but are not limited to, H_2SO_4 , HCl and acetic acid, with H_2SO_4 being the typical acid used in hydrolysis. Hydrolysis can be carried out in the presence or absence of an organic solvent. Typical hydrolysis
5 reaction is carried out at a temperature in the range of about 50°C to 140°C , preferably about 60°C to 90°C . The reaction time generally ranges from approximately 2 to 22 hours, preferably 12 hours.

While Scheme I shows various reactions in a particular sequence, it should be appreciated that Scheme I is only an illustrative example. One skilled in the art having the
10 present disclosure can readily recognize that some of the reaction sequences can be changed, eliminated or combined. Therefore, the scope of present invention includes all suitable variations to Scheme I reaction sequences. For example, Scheme I illustrates a reaction sequence involving substitution of one of the X^1 moiety of compound of formula VIII with an amine compound of the formula HNR^2R^3 , followed by hydrogenation of compound of
15 formula IX, then hydrolysis of the cyano group of compound of formula X to produce the carboxamide pyridine compound of formula I. However, variations of reaction sequences illustrated in Scheme I are also readily apparent to those skilled in the art having the disclosure of the present invention. For example, hydrolysis of the cyano group can be achieved prior to the reduction, i.e., hydrogenolysis, reaction.

20 In one particular embodiment of the present invention, each R^1 is independently lower alkyl, alkoxy, halogen, cyano, or alkylamino; X^1 is halogen; and R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl.

In another embodiment of the present invention, each R^1 is independently lower alkyl, alkoxy, halogen, cyano and alkylamino; X^1 is chloro; and R^2 and R^3 together with the
25 nitrogen atom to which they are attached to form morpholin-4-yl, 4-methyl-piperazin-1-yl, or 1,1-dioxothiomorpholin-4-yl.

Another embodiment of the present invention provides various compounds that can be produced by one or more reaction disclosed herein, such compounds include, but are not limited to, methyl 2-cyano-3- (2-methylphenyl) -2-propenoate, 1-(2-amino)-2-
30 oxoethylpyridinium chloride, 5'-cyano-1'-2',3',4'-tetrahydro-6'-hydroxy-4'-(2-methylphenyl)-2'-oxo-1,3'-bipyridium, zwitter ion, 3-cyano-2,-6-dichloro-4-(2-methylphenyl)pyridine, 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-morpholinyl)pyridine, 5-

cyano-4-(2-methylphenyl)-2-(4-morpholinyl)pyridine, 4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide, 2-chloro-4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamine, 2,6-dichloro-4-(2-methylphenyl)-3-pyridinecarboxamide, 3-cyano-2,6-dichloro-4-(4-fluoro-2-methylphenyl)pyridine, 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-thiomorpholino)pyridine, 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine, 4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine-3-carboxamide, 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-methylpiperazinyl)pyridine, 5-cyano-4-(2-methylphenyl)-2-(4-methylpiperazinyl)pyridine, and 4-(2-methylphenyl)-6-(4-methylpiperazinyl)-3-pyridinecarboxamide.

Another aspect of the present invention provides aminopyridine compound of Formula II including, but not limited to: N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-[methyl-(2-morpholin-4-yl-ethyl)-amino]-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-morpholin-4-yl-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-thiomorpholin-4-yl-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-(1-oxo-1 λ^6 -4-thiomorpholin-4-yl)-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-6-(1,1-dioxo-1 λ^6 -6-thiomorpholin-4-yl)-N-methyl-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-piperazin-1-yl-4-o-tolyl-nicotinamide, N-(3,5-bis-trifluoromethyl-benzyl)-6-[4-(2-hydroxy-ethyl)-piperazin-1-yl]-N-methyl-4-o-tolyl-nicotinamide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(4-methyl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-N-methyl-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(4-fluoro-2-methyl-phenyl)-6-(4-methyl-piperazin-1-yl)-pyridin-3-yl]-N-methyl-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chloro-phenyl)-pyridin-3-yl]-N-methyl-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(4-o-tolyl-pyridin-3-yl)-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-[6-(4-pyridin-2-yl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chloro-phenyl)-6-dimethylamino-pyridin-3-yl]-isobutyramide, 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(6-piperazin-1-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide, and 2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(1,1-dioxo-1 λ^6 -thiomorpholin-4-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide.

Additional objects, advantages, and novel features of this invention will become apparent to those skilled in the art upon examination of the following examples thereof, which are not intended to be limiting.

5

Example 1

Process for preparing 4-fluoro-2-methylbenzaldehyde (Fig. III, Scheme I)

2-Bromo-5-fluorotoluene (37.5 mL, 56.1 g, 297 mmol) was dissolved in 500 mL of dry THF and the solution was cooled to -78°C . Butyllithium in hexanes (2.5 M) (119 mL, 297 mmol, 1.0 equiv) was added at -75 to -78°C over 35 minutes, and the resulting mixture was stirred
10 at -78°C for 20 minutes. Dry N,N-dimethylformamide (27.6 mL, 26.0 g, 356 mmol, 1.2 equiv) was added over 26 minutes at -75 to -78°C . The resulting solution was stirred at -78°C for 60 minutes then allowed to warm to 15°C over 2 hours.

Ammonium chloride (100 g of 15.9% aqueous solution) was added over 5 minutes at 15 - 20°C . The solution was concentrated by fractional distillation (597 mL collected at 50 - 61°C).
15 The distillation pot layers were separated. The aqueous layer was extracted three times with 25 mL of methyl tert-butyl ether (i.e., MTBE). The organic layers were combined, washed with 50 mL of brine, dried (MgSO_4), filtered, and fractionally distilled (b.p. 54 - 62°C) to yield 59.3 g of yellow oil. The oil was fractionally distilled (b.p. 60 - 62°C at 1.6 - 2.0 mmHg of pressure) to afford 28.041 g (68.4%) of a colorless oil.

20

Example 2

Process for preparing methyl 2-cyano-3-(2-methylphenyl)-2-propenoate (Fig. IV, Scheme I)

A 100-mL, 1-necked round bottom flask (with magnetic stir-bar and dry N_2 adaptor) was charged with 11.6 mL (12.0 g, 100 mmol) of *o*-tolualdehyde, 8.8 mL (9.9g, 100 mmol) of methyl cyanoacetate, and 50 mL of isopropanol. Morpholine (0.50 mL, 0.55 g, 6.3 mmol, 6.3
25 mol%) was added and the mixture was stirred at 20 - 33°C for 60 minutes. This mixture was diluted with 25 mL of isopropanol. The precipitate was filtered, washed with 10 mL of isopropanol, and dried to afford 17.37 g (86.3%) of methyl 2-cyano-3-(2-methylphenyl)-2-propenoate as a colorless solid.

Example 3

Process for preparing 1-(2-amino)-2-oxoethylpyridinium chloride (Fig. VI, Scheme I)

5 A 3-L, 4-necked round bottom flask (with reflux condenser/dry N₂ adaptor, perforated Teflon paddle stirrer with glass shaft, septum with Teflon-coated thermocouple, and Teflon stopper) was charged with 190.76 g (2.04 mol) of 2-chloroacetamide, 2.0 L of *n*-butyl acetate and 192 mL (187.8 g, 2.37 mol) of dry pyridine. The resulting mixture was refluxed for 24 hours, and then cooled to 25 °C. The precipitate was filtered, washed with 500 mL of *n*-butyl acetate and twice with 500 mL of hexanes, and dried to afford 324.05 g (92.0%) of 1-(2-amino)-2-oxoethylpyridinium chloride as a beige colored solid.

Example 4

Process for preparing 1-(2-amino)-2-oxoethylpyridinium chloride (Fig. VI, Scheme I), alternatively

15 A 2000-mL pressure bottle with paddle stirrer was charged with 93.51 g (1.00 mol) of 2-chloroacetamide, 300 mL of isopropanol, and 82.4 mL (80.7 g, 1.02 mol) of pyridine. The resultant mixture was refluxed for 18 hours, and then cooled to 25 °C, and the title compound was isolated as described in Example 3.

Example 5

20 Process for preparing 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion (Fig. VII, Scheme I)

A 100-mL, 2-necked round bottom flask equipped with a reflux condenser was charged with 1.726 g (10.0 mmol) of the pyridinium salt (i.e., 1-(2-amino)-2-oxoethylpyridinium chloride, see Example 3 or 4), 2.012 g (10.0 mmol) of methyl 2-cyano-3-(2-methylphenyl)-2-propenoate (see Example 2), 20 mL of methanol, and triethylamine (1.55 mL, 1.11 g, 1.10 equiv). The mixture was refluxed for 1 minute then allowed to cool to 25 °C and stirred for 66 hours. The precipitate was filtered, washed successively with 10 mL of methanol, 10 mL of toluene and 10 mL of hexanes, and dried to afford 2.734 g (89.5%) of 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion as a bright yellow solid.

Example 6

Process for preparing 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion (Fig. VII, Scheme I), alternatively

- 5 A 3000-mL, 4-necked flask (with a 250-mL pressure equilibrating addition funnel/dry N₂ adapter, septum with Teflon-coated thermocouple, Teflon paddle stirrer/glass shaft, and stopper) was charged with 115.6 mL (120.15 g, 1.0 mol) of *o*-tolualdehyde, 87.9 mL (90.09 g, 1.0 mol) of methyl cyanoacetate, 172.61 g (1.0 mol) of the pyridinium salt of Example 3 and 2.0 L of methanol. The addition funnel was charged with 153.3 mL (111.3 g, 1.1 mol) of
- 10 triethylamine and was added to the reaction mixture over a period of 20 minutes at 20-25 °C. The resulting mixture was stirred at 25-30 °C for 24 hours. The precipitate was filtered, washed successively with 500 mL of methanol, 500 mL of toluene and 500 mL of hexanes, and dried to afford 285.10 g (93.4%) of 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion as a bright yellow solid.

15

Example 7

Process for preparing 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion (Fig. VII, Scheme I), alternatively

- A 3000-mL, 4-necked flask (equipped with a 250 mL pressure equilibrating addition funnel/dry N₂ adapter, septum with Teflon-coated thermocouple, Teflon paddle stirrer/glass
- 20 shaft, and stopper) was charged with 115.6 mL (120.15 g, 1.0 mol) of *o*-tolualdehyde, 87.9 mL (99.09 g, 1.0 mol) of methyl cyanoacetate, 172.61 g (1.0 mol) of pyridinium salt of Example 3, 300 mL of isopropanol, and 1.7 L of methanol. The addition funnel was charged with 153.3 mL (111.3 g, 1.1 mol) of triethylamine and was added to the reaction mixture over a period of 24 minutes at 20-25 °C. The resulting mixture was stirred at 25-30 °C for 24 hours.
- 25 The precipitate was filtered, washed successively with 500 mL of methanol, 500 mL of toluene and 500 mL of hexanes, and dried to afford 284.69 g (93.2%) of 1',2',3',4'-tetrahydro-5'-cyano-6'-hydroxy-4'(2-methylphenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion as a bright yellow solid. An analytical sample tested revealed: m.p. 232-233 °C (dec); ¹H NMR (DMSO-
- 30 d₆) δ 9.82 (s, 1H), 8.98 (d, 2H), 8.50 (t, 1H), 8.04 (t, 2H), 7.45 (br, 1H), 7.12 (t, J = 7.0 Hz, 1H), 6.99 (t, J = 7.0 Hz, 1H), 6.93 (d, J = 8.0 Hz, 1H), 6.13 (d, J = 13 Hz, 1H), 6.82 (d, J = 13

Hz, 1H), 2.08 (s, 3H); ^{13}C NMR (DMSO- d_6) δ 166.4, 163.8, 147.3, 145.8, 137.2, 137.0, 128.3, 128.1, 127.5, 126.9, 126.0, 75.3, 53.6, 19.8; IR (KBr) 3625-3300, 3162, 3135, 3045, 2956, 2929, 2168, 1701, 1634 1600 cm^{-1} . Analytically calculated for $\text{C}_{18}\text{H}_{15}\text{N}_2\text{O}_2$: C, 70.81; H, 4.95; N, 13.76; Cl, 26.95. Found: C, 70.66; H, 5.10; N, 13.80.

Example 8

Process for preparing 5'-cyano-1',2',3',4'-tetrahydro-6'-hydroxy-4'(2-methyl-4-fluorophenyl)-2'-oxo-1,3'-bipyridinium, zwitter ion (Fig. VII, Scheme I).

A 1000 mL, 4-necked flask (with 50 mL pressure equilibrating addition funnel/dry N_2 adapter, septum with teflon-coated thermocouple, teflon paddle stirrer/glass shaft, and stopper) was charged with 28.01 g (203 mmol) of 4-fluoro-2-methylbenzaldehyde, 17.8 mL (20.1 g, 203 mmol) of methyl cyanoacetate, 35.00 g (203 mmol) of N-(carbamoylmethyl)-pyridinium chloride, and 400 mL of methanol. The addition funnel was charged with 31.1 mL (22.6 g, 223 mmol) triethylamine and was added to the reaction mixture over 11 min at 170 rpm and 20-25 °C (intermittent ice-water bath). The resulting mixture was stirred at 25-30 °C for 24 h.

The precipitate was suction filtered using a 600 mL coarse sintered glass funnel. The precipitate was washed successively with 100 mL of 25 °C methanol, 100 mL of 25 °C toluene, and 100 mL of 25 °C hexanes. The solid was then air dried 3.5 h at 25 °C to afford 60.69 g (92.6%) of bright yellow solid, m.p. 236-237 °C (dec); ^1H NMR (DMSO d_6) δ 9.84 (s, 1H), 8.98 (d, $J = 6.0\text{ Hz}$, 2H), 8.52 (t, $J = 7.5\text{ Hz}$, 1H), 8.07 (dd, 2H), 7.50 (br, 1H), 6.97 (br t, 7.0 Hz, 1H), 6.80 (dd, $J = 1.5\text{ Hz}$, $J = 10\text{ Hz}$, 1H), 6.26 (d, $J = 13\text{ Hz}$, 1H), 4.81 (d, $J = 13\text{ Hz}$, 1H), 2.08 (br, 3H); ^{13}C NMR (DMSO d_6) δ 166.3, 163.7, 161.2 (d, $J = 241.9\text{ Hz}$), 147.4, 145.8, 139.9, 133.4, 130.3, 128.5, 126.0, 117.4, 113.7, 75.2, 53.6, 31.4, 19.7; IR (KBr) 3170, 3130, 3045, 2168, 1703, 1633, 1602, 1577 cm^{-1} . Elem. Anal. Calcd for $\text{C}_{18}\text{H}_{14}\text{FN}_3\text{O}_2$: C, 66.87; H, 4.36; F, 5.88; N, 13.00. Found: C, 66.31; H, 4.29; F, 6.05; N, 12.72.

Example 9

Process for preparing 3-cyano-2,6-dichloro-4-(2-methylphenyl)pyridine (Fig. VIII, Scheme I)

A mixture of 40.00 g (131.0 mmol) of the appropriate pyridinium zwitter ion (prepared according to Example 5, 6 or 7) and 50.0 mL (82.3 g, 536 mmol) of phosphorus oxychloride was heated in a 300-mL Parr bottle at 135 °C for 10 hours.

5 The reaction mixture was cooled to 25 °C and diluted with 75 mL of methylene chloride. The solution was transferred onto 350 g of ice. Additional methylene chloride (25 mL) was used to aid the transfer. The resulting mixture was stirred for 1 hour. The layers were separated, and the aqueous layer was extracted twice with 25 mL of methylene chloride and twice with 50 mL of toluene. The extracts were combined, dried (5.0 g Na₂SO₄), and
10 filtered through 15 g of Filtrol[®] on a 60-mL coarse sintered glass funnel. The flask and the solid were washed with 50 mL of toluene. The combined mother liquors were concentrated to afford 28.70 g (83.3%) of 3-cyano-2,6-dichloro-4-(2-methylphenyl)pyridine as a near colorless solid (LC assay 100.7 wt %).

An analytical sample was prepared by recrystallization from isopropanol and
15 revealed: m.p. 129-131 °C; ¹H NMR (CDCl₃) δ 7.43 (dt, J = 1.5 Hz, J = 7 Hz, 1H), 7.37-7.31 (m, 2H), 7.33 (s, 1H), 7.18 (dd, J = 1.5 Hz, 8 Hz, 1H), 2.25 (s, 3H); ¹³C NMR (CDCl₃) δ 159.1, 153.9, 153.3, 135.3, 134.1, 131.3, 130.7, 128.8, 126.7, 124.5, 113.7, 110.3, 20.0; IR (KBr) 3087, 2227, 1603, 1569, 1520, 1340 cm⁻¹. Analytically calculated for C₁₃H₈Cl₂N₂: C, 59.34; H, 3.06; N, 10.65; Cl, 26.95. Found: C, 59.00; H, 3.05; N, 10.64; Cl, 27.76.

20

Example 10

Process for preparing 3-cyano-2,6-dichloro-4-(4-fluoro-2-methylphenyl)pyridine (Fig. VIII, Scheme I)

A mixture of 55.00 g (170.1 mmol) of the appropriate pyridinium zwitter ion (prepared according to Example 5, 6 or 7) and 65 mL (106.9 g, 697 mmol, 4.1 equiv) of
25 phosphorus oxychloride was heated in a 300-mL Parr bottle at 135 °C for 12 hours.

The reaction mixture was cooled to 25 °C, diluted with 200 mL of methylene chloride, transferred using additional 25 mL of methylene chloride onto 450 g of ice, and stirred until all the ice melted. The layers were separated, and the aqueous layer was extracted successively twice with 25 mL of methylene chloride and twice with 125 mL of toluene. The
30 combined extracts were filtered through 15 g of Filtrol[®] on a 60-mL coarse sintered glass

funnel. The flask and the solid were washed with 100 mL of toluene. The combined mother liquors were concentrated to afford 39.70 g (83.0%) of near colorless solid.

An analytical sample was prepared by recrystallization from isopropanol and revealed: m.p. 161.5-162.5 °C; ¹H NMR (CDCl₃) δ 7.32 (s, 1H), 7.18 (dd, J = 5.5 Hz, J = 8.5 Hz, 1H), 7.08 (dd, J = 2.5 Hz, J = 9.5 Hz, 1H), 7.04 (dt, J = 2.5 Hz, J = 8-8.5 Hz, 1H), 2.26 (s, 3H); ¹³C NMR (CDCl₃) δ 163.9 (d, J = 250 Hz), 158.0, 154.0, 153.4, 138.4 (d, J = 8.4 Hz), 130.8 (d, J = 8.8 Hz), 130.1 (d, J = 3.6 Hz), 124.6, 118.2 (d, J = 21.6 Hz), 114.0 (d, J = 21.6 Hz), 113.6, 110.4, 20.2 (d, J = 1.6 Hz); IR (KBr) 3100, 2920, 2230, 1590, 1578, 1566, 1521, 1496 cm⁻¹. Analytically calculated for C₁₃H₇Cl₂FN₂: C, 55.54; H, 2.51; F, 6.76; N, 9.97. Found: C, 55.32; H, 2.55; F, 7.02; N, 9.78.

Example 11

Process for preparing 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-morpholinyl)pyridine (Fig. VIII, Scheme I)

The crude dichloride, 3-cyano-2,6-dichloro-4-(2-methylphenyl)pyridine, (194.8 g, 0.740 mol, see Example 8) and 1100 mL of methanol were added to a 2000-mL, 3-necked flask (equipped with a 125-mL pressure-equilibrating addition funnel/dry N₂ adapter, septum with teflon-coated thermocouple, and teflon paddle stirrer/glass shaft). The mixture was cooled to 18 °C. Morpholine (132.3 mL, 132.2 g, 1.52 mol) was charged to the addition funnel and added dropwise to the reaction mixture over a period of 45 minutes. The resulting mixture was stirred at 20-25 °C for 18 hours.

The precipitate was filtered, washed successively with 150 mL of methanol and 1000 mL of water, and dried to afford 182.04 g (78.4%) of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-morpholinyl)pyridine as a colorless solid.

An analytical sample was prepared by recrystallization from isopropanol and revealed: m.p. 152-154 °C; ¹H NMR (CDCl₃) δ 7.35 (dt, J = 1.5 Hz, J = 7.5 Hz, 1H), 7.31-7.28 (m, 1H), 7.26 (dd, J = 1.5 Hz, J = 7.5 Hz, 1H), 6.37 (s, 1H), 3.81-3.79 (m, 4H), 3.68-3.66 (m, 4H), 2.25 (s, 3H); ¹³C NMR (CDCl₃) δ 158.3, 156.9, 153.0, 136.4, 135.1, 130.6, 129.5, 128.4, 126.1, 115.8, 104.7, 97.8, 66.4, 44.8, 19.7; IR (KBr) 2966-2843, 2216, 1597, 1490 cm⁻¹.

Analytically calculated for $C_{17}H_{16}ClN_3O$: C, 65.07; H, 5.14; N, 13.39; Cl, 11.30.
Found: C, 65.38; H, 5.28; N, 13.36; Cl, 11.65.

Example 12

5 Process for preparing 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-methylpiperazinyl)pyridine (Fig. IX, Scheme I).

Crude dichloride, 3-cyano-2,6-dichloro-4-(2-methylphenyl)pyridine, (78.00 g, 0.296 mol) and 330 mL of methanol were added to a 1000-mL, 3-necked flask (equipped with a 125 mL pressure-equilibrating addition funnel/dry N_2 adapter, septum with teflon-coated thermocouple, and teflon paddle stirrer/glass shaft), and the mixture was cooled to 18 °C. 1-Methylpiperazine (67.3 mL, 60.78 g, 0.607 mol) was charged to the addition funnel and added dropwise to the reaction mixture at 18-22 °C over a period of 15 minutes. Seed crystals of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-methylpiperazinyl)pyridine were added after 2 hours and the suspension was stirred at 20-25 °C for an additional 18 hours.

15 Water (165 mL) was added dropwise over 1 hour and the resulting mixture was stirred at 25 °C for 3 hours. The precipitate was filtered, washed successively with 90 mL of 2:1 methanol- H_2O and 100 mL of water, and dried to afford 74.19 g (76.6%) of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-methylpiperazinyl)pyridine as a beige solid.

An analytical sample was prepared by recrystallization from isopropanol and revealed: m.p. 116-123 °C; ^1H NMR ($CDCl_3$) δ 7.34 (dt, $J = 7.5$ Hz, $J = 1.5$ Hz, 1H), 7.3-7.25 (m, 2H), 7.14 (dd, $J = 7.5$ Hz, $J = 1.5$ Hz, 1H), 6.37 (s, 1H), 3.71 (br m, 4H), 2.49 (br t, 4H), 2.35 (s, 3H), 2.25 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 158.4, 156.9, 153.2, 136.8, 135.4, 130.9, 129.6, 128.7, 126.3, 116.2, 105.0, 97.3, 54.7, 46.3, 44.8, 20.0; IR (KBr) 2966, 2936, 2846, 2797, 2215, 1592, 1498 cm^{-1} . Analytically calculated for $C_{18}H_{19}ClN_4$: C, 66.15; H, 5.86; N, 17.14; Cl, 10.85.
25 Found: C, 66.04; H, 6.04; N, 17.11; Cl, 10.94.

Example 13

Process for preparing 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(thiomorpholino)pyridine (Fig. IX, Scheme I).

Crude 3-cyano-2,6-dichloro-4-(4-fluoro-2-methylphenyl)pyridine, (32.44 g, 115.4 mmol) and 300 mL of methanol were added to a 500-mL, 3-necked flask (equipped with a 25-mL pressure-equilibrating addition funnel/dry N₂ adapter, septum with teflon-coated thermocouple, and teflon paddle stirrer/glass shaft). Thiomorpholine (23.0 mL, 25.0 g, 242 mmol, 2.10 equiv) was added dropwise over a period of 22 minutes via the addition funnel, and the resulting mixture was stirred at 20-25 °C for 18 hours. The precipitate was filtered, washed with 30 mL of methanol, and dried to afford 35.47 g (88.4%) of 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(thiomorpholino)pyridine as a beige solid.

An analytical sample was prepared by recrystallization from ethanol and revealed: m.p. 195.3-197.3 °C; ¹H NMR (CDCl₃) δ 7.13 (dd, J = 5.5 Hz, J = 8.5 Hz, 1H), 7.01 (dd, J = 3.0 Hz, J = 10 Hz, 1H), 6.97 (dt, J = 3.0 Hz, J = 8.5 Hz, 1H), 6.33 (s, 1H), 4.04 (br, 4H), 2.70 (br t, J = 5.0 Hz, 4H), 2.25 (s, 3H); ¹³C NMR (CDCl₃) δ 163.3 (d, J = 247 Hz), 157.7, 156.2, 153.4, 138.3 (d, J = 8.5 Hz), 132.7 (d, J = 3.1 Hz), 130.5 (d, J = 8.5 Hz), 117.7 (d, J = 21.3 Hz), 116.0, 113.4 (d, J = 21.6 Hz), 105.3, 97.5, 48.1, 27.0, 20.2 (d, J = 1.6 Hz); IR (KBr) 2219, 1594, 1581, 1502, 1489, 1448, 1432 cm⁻¹. Analytically calculated for C₁₇H₁₅ClFN₃S: C, 58.70; H, 4.35; N, 12.08. Found: C, 58.76; H, 4.43; N, 12.04.

Example 14

Process for preparing 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine (Fig. IX, Scheme I).

Oxone® (56.18 g, 91.4 mmol) was added to a solution of 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(thiomorpholino)pyridine (26.54 g, 76.3 mmol) in 200 mL of NMP in a 1000-mL, 3-necked flask (equipped with a teflon paddle stirrer, septum with teflon-coated thermocouple, dry N₂ adapter). The mixture was stirred at 25 °C for 20 hours, and diluted with 800 mL of water. The resulting mixture was stirred at 25 °C for 30 minutes. The precipitate was filtered, washed several times with H₂O, and dried to afford 29.30 g (101.1%) of 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine as a colorless solid.

An analytical sample was prepared by recrystallization from acetonitrile and revealed: m.p. 264-267 °C ¹H NMR (DMSO-d₆) δ 7.30 (dd, J = 5.5-6 Hz, J = 8.8 Hz, 1 H), 7.26 (dd, J = 2.5 Hz, J = 10 Hz, 1H), 7.17 (dd, J = 2.5 Hz, J = 8.5-9.0 Hz, 1H), 7.07 (s, 1H),

4.15 (m, 4H), 3.22 (br, 4H), 2.22 (s, 3H); ^{13}C NMR (DMSO- d_6) δ 163.1 (d, J = 244 Hz), 158.2, 155.8, 152.1, 139.1 (d, J = 8.4 Hz), 133.3 (d, J = 2.9 Hz), 131.6 (d, J = 8.8 Hz), 117.6 (d, J = 21.3 Hz), 116.4, 113.6 (d, J = 21.3 Hz), 107.9, 97.5, 51.2, 44.1, 20.1; IR (KBr) 2930, 2223, 1588, 1522, 1500, 1494, 1474, 1429, 1125 cm^{-1} . Analytically calculated for $\text{C}_{17}\text{H}_{15}\text{ClFN}_3\text{O}_2\text{S}$: C, 53.76; H, 3.98; N, 11.06. Found: C, 53.76; H, 3.94; N, 11.06.

Example 15

Process for preparing 5-cyano-4-(2-methylphenyl)-2-(4-morpholinyl)pyridine (Fig. X, Scheme I).

10 A mixture of 20.00 g (63.74 mmol) of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-morpholinyl)pyridine, 9.77 mL (7.10 g, 70.11 mmol, 1.1 equiv) of triethylamine, 33.9 mg $\text{Pd}(\text{OH})_2$ or 249 mg (0.242 mmol, 0.379 mol%) of 20% palladium hydroxide on carbon [Pearlman's catalyst, 32.2% LOD], and 80 mL of methanol was stirred in a 300-mL Parr bottle at 25 °C and 48.0-41.3 psi of hydrogen for 21 hours.

15 The pressure was vented and the mixture diluted with 40 mL of H_2O . The mixture was transferred to a round bottom flask using 40 mL of methanol. The mixture was concentrated and the residue was diluted with 80 mL of toluene and filtered through 2.0 g Celite®. Celite® was washed three times with 10 mL of toluene. A solution of 2.80 g (70.1 mmol) sodium hydroxide in 5 mL of H_2O was added to the combined mother liquors. The 20 layers were separated and the aqueous layer (pH = 13-14) was extracted three times with 20 mL of toluene. The organic layers were combined and concentrated to afford 17.95 g of 5-cyano-4-(2-methylphenyl)-2-(4-morpholinyl)pyridine as a colorless solid (LC assay 91.8-93.9 wt%) (yield 92.6-94.7%).

An analytical sample was prepared by radial chromatography on silica gel 25 followed by recrystallization from isopropanol and revealed: m.p. 128.5-129.7 °C; ^1H NMR (CDCl_3) δ 8.48 (s, 1H), 7.35 (dt, J = 1.5 Hz, J = 7.5 Hz, 1H), 7.31-7.29 (m, 1H), 7.28-7.26 (M, 1H), 7.16 (dd, J = 1.5 Hz, J = 7.5 Hz, 1H), 6.48, (d, 1H), 3.82-3.80 (m, 4H), 3.68-3.66 (m, 4H), 2.25 (s, 3H); ^{13}C NMR (CDCl_3) δ 159.6, 154.0, 153.1, 136.8, 135.2, 130.6, 129.2, 128.7, 126.0, 117.9, 106.3, 98.4, 66.5, 44.8, 19.7; IR (KBr) 2967, 2892, 2853, 2210, 1593, 1503, 1444 30 cm^{-1} . Analytically calculated for $\text{C}_{17}\text{H}_{17}\text{N}_3\text{O}$: C, 73.10; H, 6.13; N, 15.04. Found: C, 73.40; H, 6.18; N, 15.03.

Example 16

Process for preparing 5-cyano-4-(2-methylphenyl)-2-(4-methylpiperazinyl)pyridine (Fig. X, Scheme I).

5 A mixture of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-methylpiperazinyl)-pyridine (20.00 g, 61.19 mmol), 9.38 mL (6.81 g, 67.3 mmol, 1.1 equiv) of triethylamine, 25.8 mg Pd(OH)₂ or 190 mg (0.184 mmol, 0.300 mol%) of 20% palladium hydroxide on carbon [Pearlman's catalyst, 32.2% LOD], and 80 mL of methanol was stirred in a 300-mL Parr bottle at 25 °C and 48.3-43.0 psi hydrogen for 10 hours.

10 The pressure was vented and the mixture was diluted with 40 mL of H₂O. The mixture was transferred to a round bottom flask using 40 mL of methanol. Volatiles were removed on a rotary evaporator at 35 °C and 60-30 mm Hg. The resulting residue was diluted with 80 mL of toluene, and filtered through a pad of 2.0 g of Celite[®]. The Celite[®] was washed three times with 10 mL of toluene. A solution of 2.80 g (70.1 mmol) sodium
15 hydroxide in 5 mL of H₂O was added to the combined mother liquors. The layers were separated and the aqueous layer (pH = 13-14) was extracted three times with 20 mL of toluene. The combined organic layers were concentrated *in vacuo* (rotary evaporator at 35 °C and 30 mm Hg). The residual yellow syrup was taken up in 100 mL of toluene, washed with dilute HCl (20.5 mL, 20 mL H₂O with 0.5 mL 12 N HCl), washed with 20 mL of H₂O, then
20 concentrated to afford 16.85 g (94.2%) of 5-cyano-4-(2-methylphenyl)-2-(4-methylpiperazinyl)pyridine as a near-colorless solid.

An analytical sample was prepared by recrystallization from isopropanol and revealed: m.p. 109.5-110.4 °C; ¹H NMR (CDCl₃) δ 8.46 (s, 1H), 7.34 (t, J = 7 Hz, 1H), 7.30 (d, J = 7 Hz, 1H), 7.26 (t, J = 7.5 Hz, 1H), 7.16 (dd, J = 7.5 Hz, 1H), 6.49 (s, 1H), 3.72 (br t, 4H),
25 2.50 (t, J = 5 Hz, 4H), 2.35 (s, 3H), 2.25 (s, 3H); ¹³C NMR (CDCl₃) δ 159.7, 154.0, 153.4, 137.2, 135.5, 130.8, 129.3, 128.9, 126.2, 118.3, 106.6, 98.0, 54.9, 46.4, 44.7, 20.0; IR (KBr) 3019, 2936, 2884, 2848, 2793, 2210, 1607, 1590, 1504 cm⁻¹. Analytically calculated for C₁₈H₂₀N₄: C, 73.94; H, 6.90; N, 19.16. Found: C, 74.04; H, 7.03; N, 18.98.

Example 17

Process for preparing 5-cyano-4-(4-fluoro-2-methylphenyl)-2-(1,1-dioxo-thiomorphlin-4-yl)pyridine (Fig. X, Scheme I).

5 A 300-mL Parr bottle charged with crude 2-chloro-3-cyano-4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine (19.86 g, 52.29 mmol), 10.9 mL (7.94 g, 78.4 mmol, 1.50 equiv) of triethylamine, 220 mg Pd(OH)₂ or 1.62 g (1.57 mmol, 3.0 mol%) of 20% palladium hydroxide on carbon [Pearlman's catalyst, 32.2% LOD] and 100 mL of dry DMF. The mixture was stirred at 25 °C and 48.9-43.2 psi of H₂ for 25.5 hours. The
10 pressure was vented, and the mixture was filtered through a 5.0 g pad of cellulose. The cellulose pad was washed with 10 mL of DMF. Water (400 mL) was added to the filtrate and the resulting mixture was stirred for 30 minutes. The precipitate was filtered, washed several times with H₂O, and dried to afford 17.52 g (97.0%) of 5-cyano-4-(4-fluoro-2-methylphenyl)-2-(1,1-dioxo-thiomorphlin-4-yl)pyridine as a slightly grey solid (97%
15 conversion).

A 300-mL Parr bottle was charged with 17.31 g of crude 5-cyano-4-(4-fluoro-2-methylphenyl)-2-(1,1-dioxo-thiomorphlin-4-yl)pyridine, 7.3 mL (5.30 g, 52.4 mmol) of triethylamine, 148 mg Pd(OH)₂ or 1.09 g (1.05 mmol) of 20% palladium hydroxide on carbon [Pearlman's catalyst, 32.2% LOD] and 100 mL of dry DMF. The mixture was stirred
20 at 25 °C and 42.5-28.2 psi hydrogen for 23 hours. The pressure was vented and the mixture was filtered through a 5.0 g pad of cellulose. The cellulose pad was washed with 10 mL of DMF. Water (400 mL) was added to the filtrate and the resulting mixture was stirred at 25 °C for 30 minutes. The precipitate was filtered, washed several times with H₂O, and dried to afford 17.04 g (95.5%) of 5-cyano-4-(4-fluoro-2-methylphenyl)-2-(1,1-dioxo-thiomorphlin-
25 4-yl)pyridine as a colorless solid (100% conversion).

An analytical sample was prepared by recrystallization from acetonitrile and revealed: m.p. 219.5-220.5 °C; ¹H NMR (CDCl₃) δ 8.52 (d, J = 1 Hz, 1H), 7.14 (dd, J = 5.5 Hz, J = 8.5 Hz, 1H), 7.04 (dd, J = 2.5 Hz, J = 9.5 Hz, 1H), 7.00 (dd, J = 2.5 Hz, J = 8.5 Hz, 1H), 6.61 (d, J = 1 Hz, 1H), 4.27 (br t, 4H), 3.10 (br t, 4H), 2.24 (s, 3H); ¹³C NMR (CDCl₃) δ 163.4
30 (d, J = 248 Hz), 157.9, 154.4, 153.6, 138.2 (d, J = 8.0 Hz), 132.5 (d, J = 3.3 Hz), 130.7 (d, J = 8.8 Hz), 117.8 (d, J = 21.6 Hz), 117.2, 113.5 (d, J = 21.6 Hz), 107.2, 100.6, 51.6, 43.8, 20.2; IR

(KBr) 2930, 2217, 1599, 1531, 1494, 1432, 1123, 1117 cm^{-1} . Analytically calculated for $\text{C}_{17}\text{H}_{16}\text{FN}_3\text{O}_2\text{S}$: C, 59.12; H, 4.67; N, 12.17. Found: C, 59.19; H, 4.69; N, 12.17.

Example 18

5 Process for preparing 4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide (Fig. I, Scheme I).

10 A mixture of 5-cyano-4-(2-methylphenyl)-2-(4-morpholinyl)pyridine (17.71 g), 18 mL of toluene, and 17.0 mL (33.1 g, 319 mmol) of concentrated sulfuric acid was heated at 70 °C for 12 hours, cooled to room temperature, and quenched by addition of 100 mL of cold H_2O . Ethyl acetate (100 mL) was added followed by a solution of 25.5 g (638 mmol) of sodium hydroxide in 50 mL of H_2O . The aqueous layer was separated and extracted three times with 50 mL of ethyl acetate. The organic layers were combined and concentrated to afford 19.14 g of 4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide as a colorless solid (LC assay 87.7 wt%) (yield 94.9-97%).

15 An analytical sample was prepared by filtration through a plug of silica gel and recrystallization from ethyl acetate and revealed: m.p. 144-145.5 °C; ^1H NMR (CDCl_3) δ 8.93 (s, 1H), 7.36 (dt, $J = 1.5$ Hz, $J = 7.5$ Hz, 1H), 7.32-7.29 (m, 2H), 7.21-7.20 (m, 1H), 6.30 (s, 1H), 5.6 (br, 1H), 5.1 (br, 1H), 3.82-3.80 (m, 4H), 3.64-3.62 (m, 4H), 2.15 (s, 3H); ^{13}C NMR (CDCl_3) δ 168.0, 160.1, 151.8, 149.5, 139.0, 135.8, 130.7, 129.0, 128.2, 126.5, 117.6, 106.2, 20 66.6, 45.0, 19.8; IR (KBr) 3462, 3300-3000, 2959, 2854, 1660, 1584, 1491, 1391 cm^{-1} . Analytically calculated for $\text{C}_{17}\text{H}_{19}\text{N}_3\text{O}_2$: C, 68.67; H, 6.44; N, 14.13. Found: C, 68.78; H, 6.48; N, 14.11.

Example 19

25 Process for preparing 4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide (Fig. I, Scheme I).

30 A mixture of 2-chloro-4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide (5.00 g, 15.1 mmol), 2.31 mL (1.68 g, 16.5 mmol, 1.1 equiv) of triethylamine, 6.4 mg $\text{Pd}(\text{OH})_2$ or 47 mg (0.0453 mmol, 0.30 mol%) of 20% palladium hydroxide on carbon [Pearlman's catalyst, 32.2% LOD], and 50 mL of methanol was stirred in a 300-mL Parr bottle at 25 °C and 40.2-31.2 psi hydrogen for 21 hours.

The pressure was vented and the mixture was filtered through a 2.0 g pad of Celite[®] on a coarse sintered glass funnel. The pad of Celite[®] was washed twice with 10 mL of methanol. Filtrate was concentrated and the resulting residue was taken up in 25 mL of toluene and 10 mL of H₂O. A solution of 660 mg (16.5 mmol) sodium hydroxide in 2 mL of H₂O was added. The layers were separated and the aqueous layer was extracted three times with 10 mL toluene. The organic layers were combined, dried (MgSO₄), filtered, and concentrated to afford 4.24 g of 4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide as a (94.6%) of colorless solid.

Example 20

Process for preparing 4-(2-methylphenyl)-6-(4-methylpiperazinyl)-3-pyridinecarboxamide (Fig. I, Scheme I).

A mixture of crude 5-cyano-4-(2-methylphenyl)-2-(4-methylpiperazinyl)pyridine (16.85 g, 57.6 mmol), 18 mL of toluene, and 27 mL (49.7 g, 507 mmol) of concentrated sulfuric acid was heated at 70 °C for 12 hours. The mixture was cooled and quenched with 200 mL of cold H₂O. Ethyl acetate was added followed by a solution of 45.6 g (1.14 mol) of sodium hydroxide in 200 mL of H₂O. Water (200 mL) was added and the layers were separated. The aqueous layer was extracted several times with 100 mL of ethyl. The organic layers were combined and concentrated to afford 17.55 g (98.1%) of 4-(2-methylphenyl)-6-(4-methylpiperazinyl)-3-pyridinecarboxamide as a colorless solid.

[An analytical sample was prepared by recrystallization from isopropanol and final recrystallization from toluene-hexanes and revealed: m.p. 127.5-128.5 °C; ¹H NMR (CDCl₃) δ 8.92 (s, 1H), 7.35 (m, J = 1.5 Hz, J = 7-8 Hz, 1H), 7.31-7.28 (m, 2H), 7.21 (m, 1H), 6.31 (s, 1H), 3.68 (br t, J = 5 Hz, 4H), 2.51 (t, J = 5 Hz, 4H), 2.35 (s, 3H), 2.15 (s, 3H); ¹³C NMR (CDCl₃) δ 168.4, 160.2, 152.1, 149.7, 139.4, 136.0, 130.9, 129.2, 128.4, 126.7, 117.3, 106.5, 55.0, 46.4, 44.8, 20.0; IR (KBr) 3459, 3324, 3273, 3168, 2967, 2935, 2849, 2795, 1665, 1581 cm⁻¹. Analytically calculated for C₁₈H₂₂N₄O: C, 69.65; H, 7.14; N, 18.05. Found: C, 69.76; H, 7.33; N, 17.92.

Example 21

Process for preparing 4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine-3-carboxamide (Fig. I, Scheme I).

5 A mixture of 5-cyano-4-(4-fluoro-2-methylphenyl)-2-(1,1-dioxo-thiomorpholin-4-yl)pyridine (14.80 g, 42.85 mmol), 15 mL of toluene, and 15 mL (27.6 g, 281 mmol) of concentrated sulfuric acid was heated in a 500-mL flask at 70 °C for 12 hours. The mixture was cooled and quenched with 150 mL cold H₂O. A solution of 22.8 g (570 mmol) of sodium hydroxide in 200 mL of H₂O was added dropwise at 25-30 °C over 15 minutes. The
10 precipitate was filtered, washed with H₂O, and dried to afford 15.68 g (100.7%) of 4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine-3-carboxamide as a colorless solid (2 wt% toluene remains).

An analytical sample was prepared by recrystallization from acetonitrile and revealed: m.p. 235-236 °C; ¹H NMR (DMSO-d₆) δ 8.38 (s, 1H), 7.36 (br, 1H), 7.13 (dd, J = 6
15 Hz, J = 8.5 Hz, 1H), 7.09-7.07 (m, 2H), 7.02 (dt, J = 2.5 Hz, J = 8.5 Hz, 1H), 6.78 (s, 1H), 4.11 (br, 4H), 3.11 (br, 4H), 2.10 (s, 3H); ¹³C NMR (DMSO-d₆) δ 166.9, 160.3 (d, J = 241 Hz), 155.8, 148.2, 146.3, 136.7 (d, J = 8.0 Hz), 134.6 (d, J = 2.8 Hz), 129.1 (d, J = 8.4 Hz), 121.3, 114.8 (d, J = 20.8 Hz), 110.8 (d, J = 20.8 Hz), 107.2, 49.3, 42.1, 18.7; IR (KBr) 3446, 3324, 1372, 3147, 1663, 1608, 1575, 1496, 1399, 1121 cm⁻¹. Analytically calculated for
20 C₁₇H₁₈FN₃O₃S: C, 56.19; H, 4.99; N, 11.56. Found: C, 56.14; H, 4.99; N, 11.88.

Example 22

Process for preparing 2,6-dichloro-4-(2-methylphenyl)-3-pyridinecarboxamide

A mixture of 3-cyano-2,6-dichloro-4-(2-methylphenyl)pyridine (15.00 g, 57.0 mmol), and 15 mL of concentrated sulfuric acid was heated at 100 °C for 3 hours. The
25 mixture was cooled and quenched with 150 mL of H₂O. The mixture was then extracted three times with ethyl acetate. The organic layers were combined, washed twice with 50 mL of H₂O, dried (MgSO₄), filtered, and concentrated to afford 11.99 g of near-colorless solid.

An analytical sample was prepared by recrystallization from toluene and revealed: m.p. 154-156 °C; ¹H NMR (CDCl₃) δ 7.34 (dt, J = 1.5 Hz, J = 7.5 Hz, 1H), 7.27 (d, J = 7.5 Hz,

1H), 7.23 (t, J = 8 Hz, 1H), 7.20 (s, 1H), 7.12 (dd, J = 1 Hz, J = 7.5 Hz, 1H), 5.76 (br, 1H), 5.53 (br, 1H), 2.18 (s, 3H); ¹³C NMR (CDCl₃) δ 166.0, 153.4, 150.6, 147.4, 135.4, 135.3, 130.9, 129.7, 128.5, 126.1, 124.5, 95.0, 20.4; IR (KBr) 3391, 3303, 3167, 2360, 2350-
5 2340, 1685, 1565, 1525 cm⁻¹. Elemental analytically calculated for C₁₃H₁₀Cl₂N₂O: C, 55.54; H, 3.59; N, 9.96. Found: C, 55.51; H, 3.57; N, 9.81.

Example 23

Process for preparing 2-chloro-4-(2-methylphenyl)-6-(4-morpholinyl)-3-pyridinecarboxamide

10 A mixture of 2-chloro-3-cyano-4-(2-methylphenyl)-6-(4-morpholinyl)pyridine (16.80 g, 53.5 mmol), 15 mL of toluene, and 14.3 mL (26.2 g, 268 mmol) of concentrated sulfuric acid was heated at 70 °C for 120 hours. The mixture was cooled and then quenched by addition of 160 mL of cold H₂O. Isopropyl acetate (150 mL) was added followed by a solution of 24.46 g (612 mmol) of sodium hydroxide in 120 mL of H₂O at 20-25 °C. The
15 precipitate was filtered and dried to afford 16.83 g (94.8%) of colorless solid.

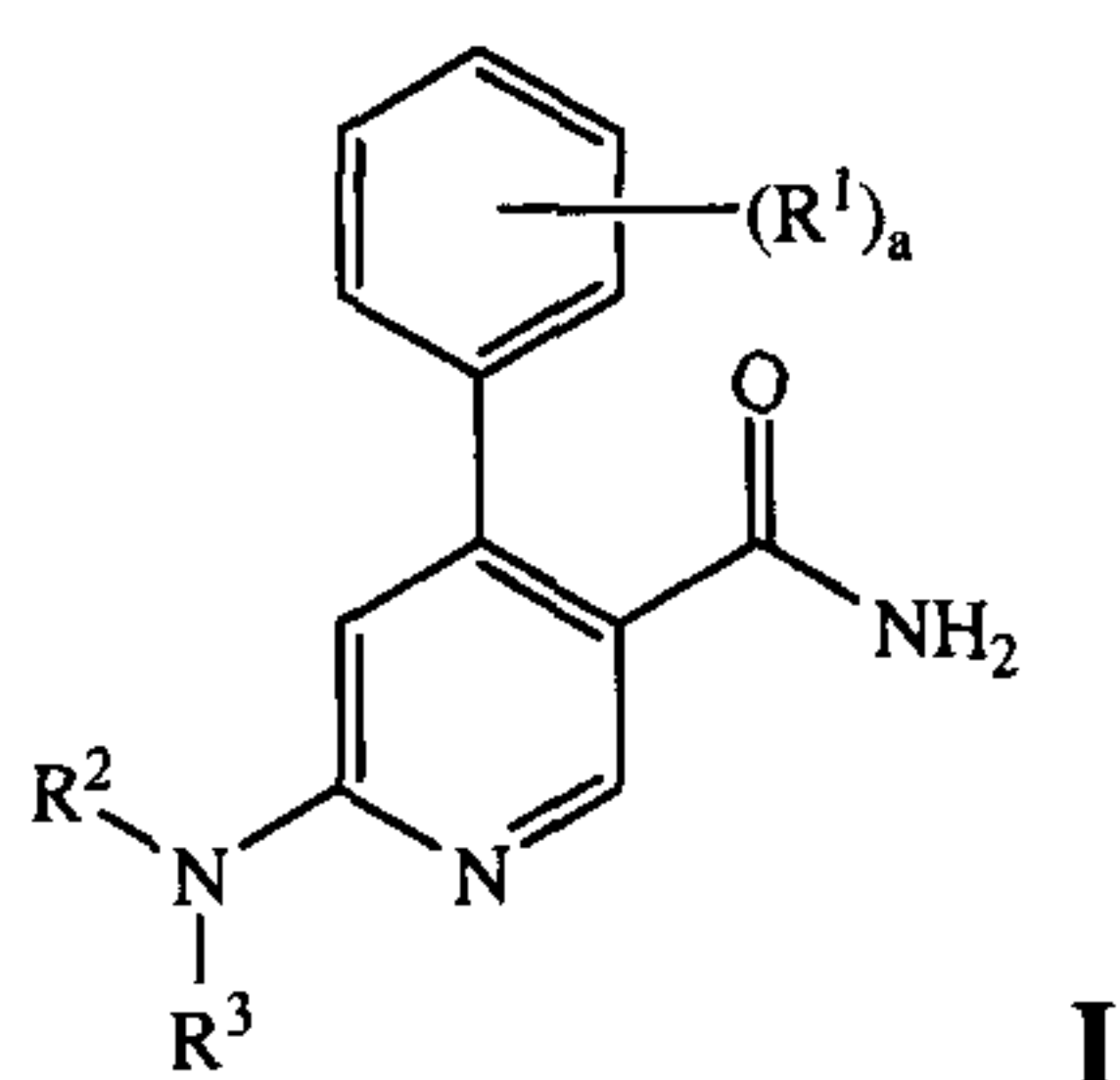
An analytical sample was prepared by recrystallization from toluene to afford shiny colorless needles and revealed: m.p. 217-219 °C; ¹H NMR (CDCl₃) δ 7.28 (dd, 1H), 7.23 (d, J = 7.0 Hz, 1H), 7.19 (dd, 1H), 7.12 (d, J = 7.5 Hz, 1H), 6.32 (s, 1H), 5.72 (br, 1H), 5.43 (br, 1H), 3.79 (m, 4H), 3.55 (m, 4H), 2.20 (s, 3H); ¹³C NMR (CDCl₃) δ 167.9, 158.2, 152.4,
20 146.6, 138.0, 135.5, 130.6, 128.8, 128.5, 125.8, 120.8, 105.7, 66.7, 45.3, 20.3; IR (KBr) 3393, 3197, 2970, 2920, 2900, 2861, 1666, 1607, 1594, 1525 cm⁻¹. Elemental analytically calculated for C₁₇H₁₈ClN₃O₂: C, 61.54; H, 5.47; N, 12.66. Found: C, 61.65; H, 5.44; N, 12.56.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form
25 or forms disclosed herein. Although the description of the invention has included description of one or more embodiments and certain variations and modifications, other variations and modifications are within the scope of the invention, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments to the extent permitted, including
30 alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures,

functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

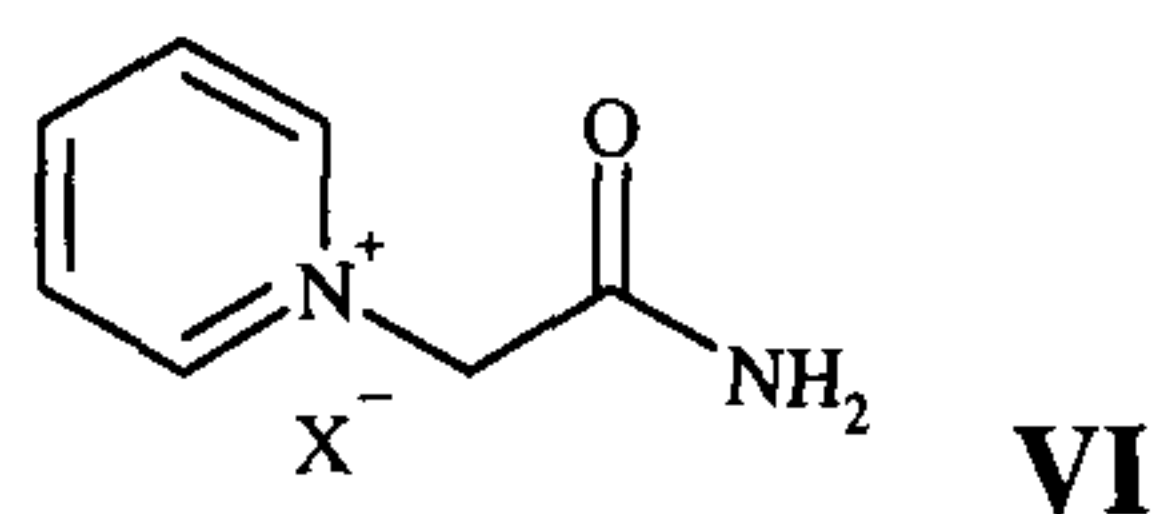
CLAIMS

1. A process for producing a carboxamide pyridine compound of the formula:

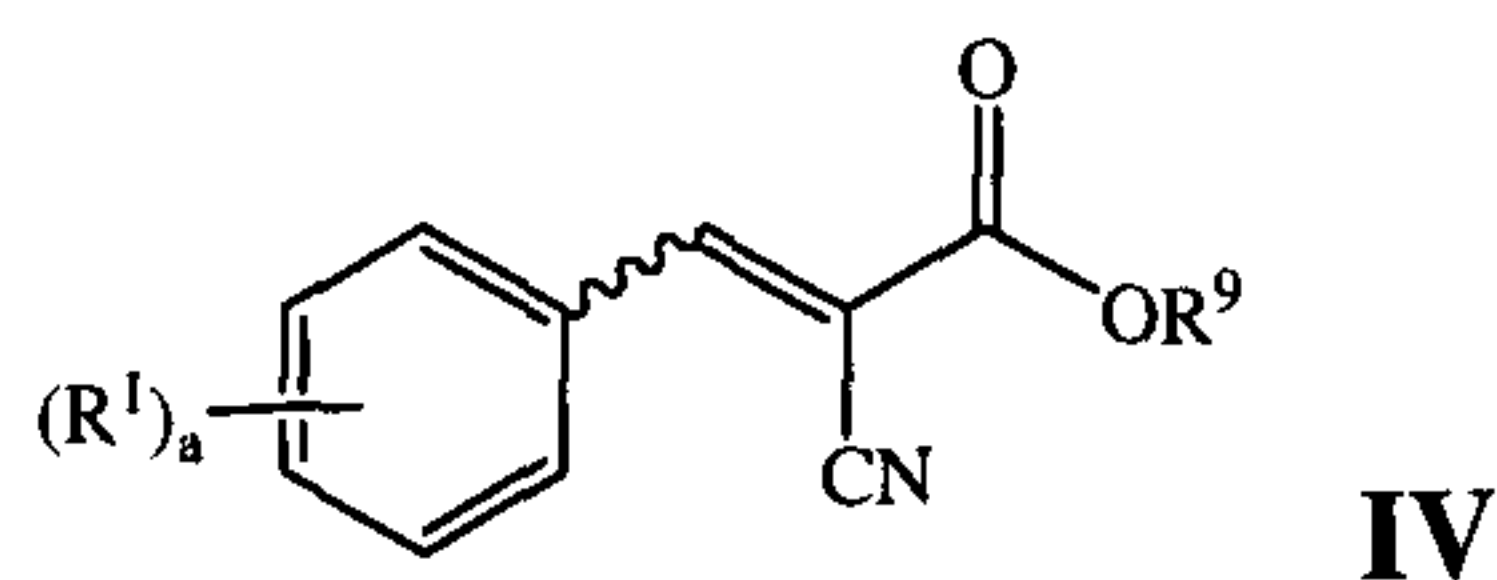


comprising:

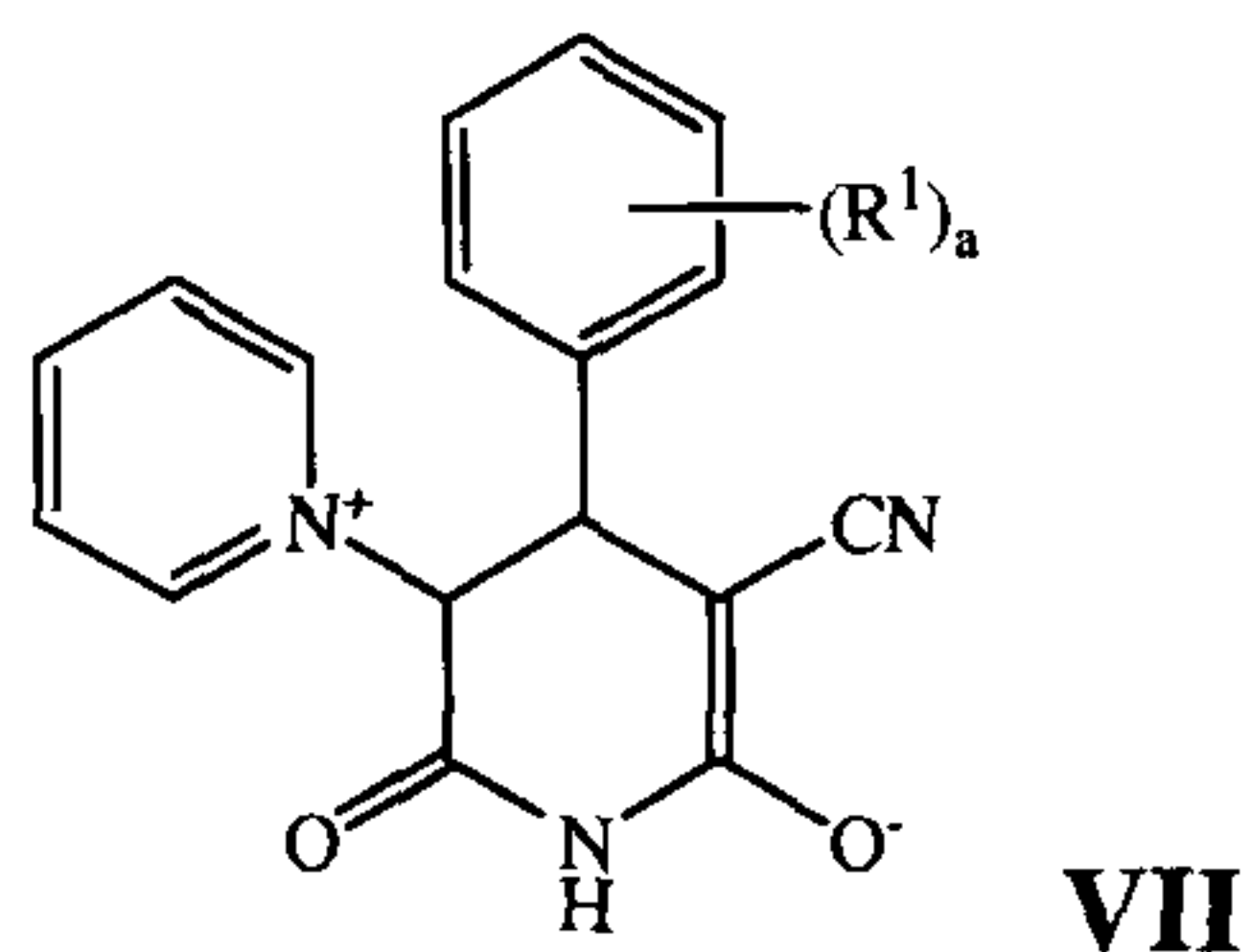
- (a) reacting a pyridinium salt of the formula:



with an α -cyano- β -aryl acrylate compound of the formula:

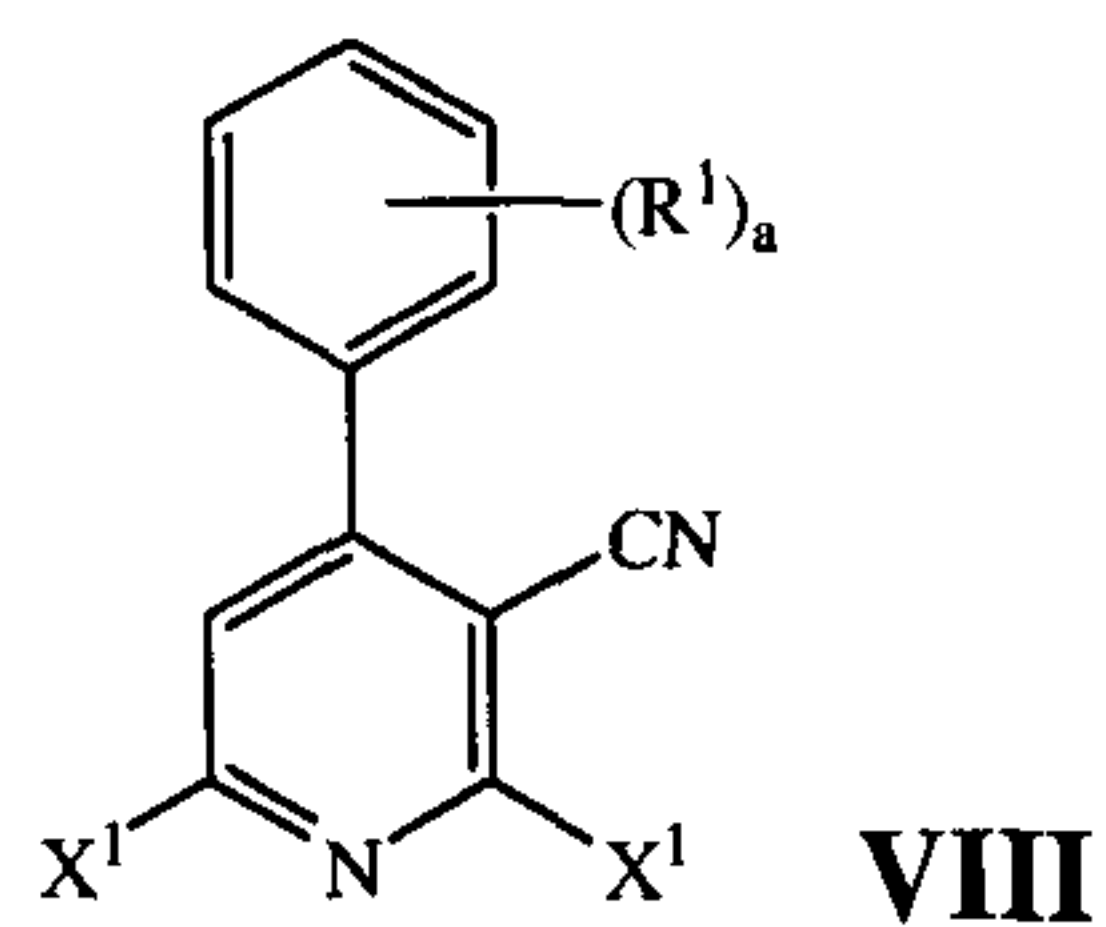


to produce a pyridinium zwitter ionic compound of the formula:

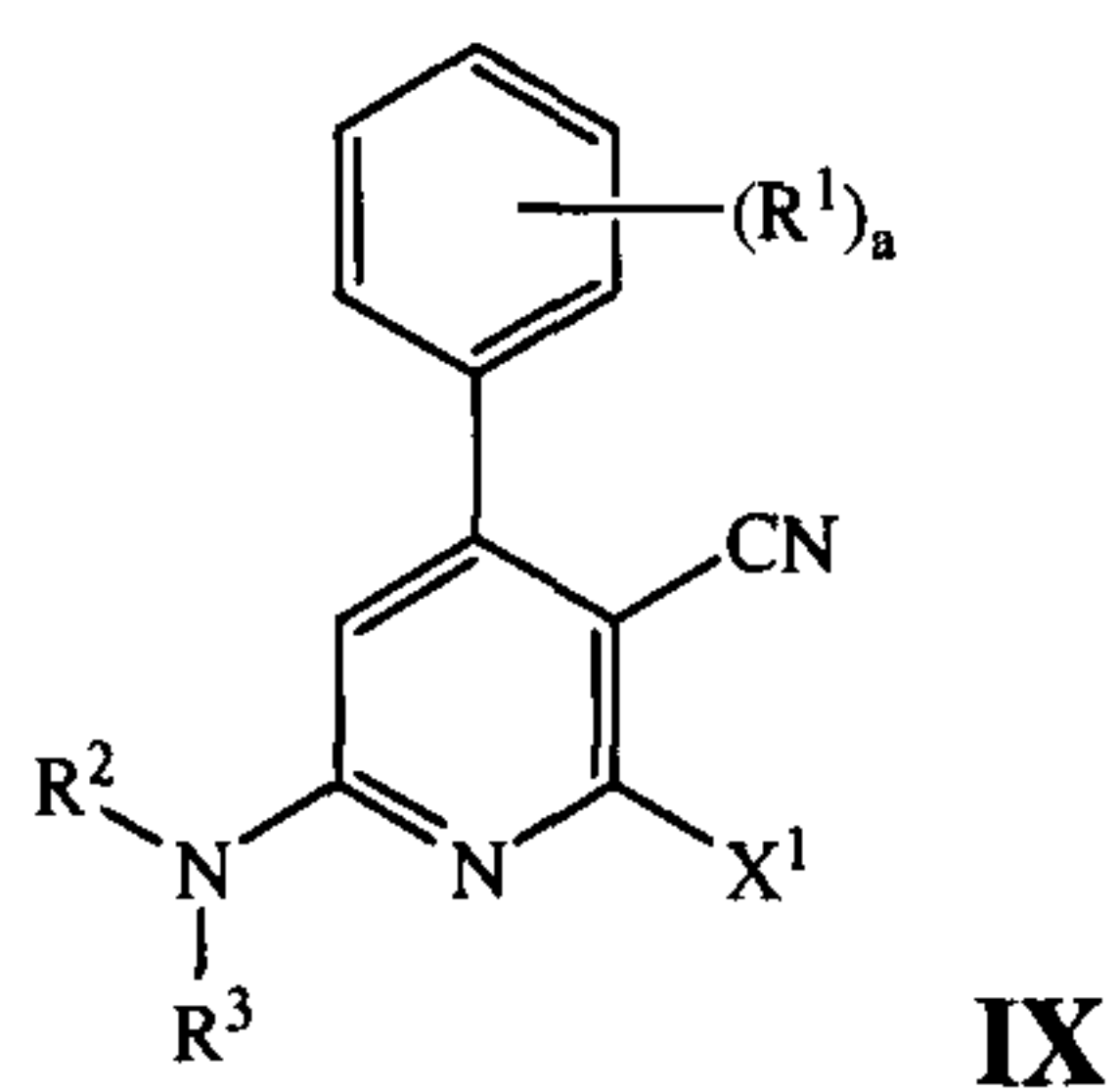


- (b) reacting the pyridinium zwitter ionic compound with a reagent selected from the group consisting of POCl_3 , PBr_3 , and $(\text{F}_3\text{CSO}_2)_2\text{O}$, to form a cyanopyridine compound of formula:

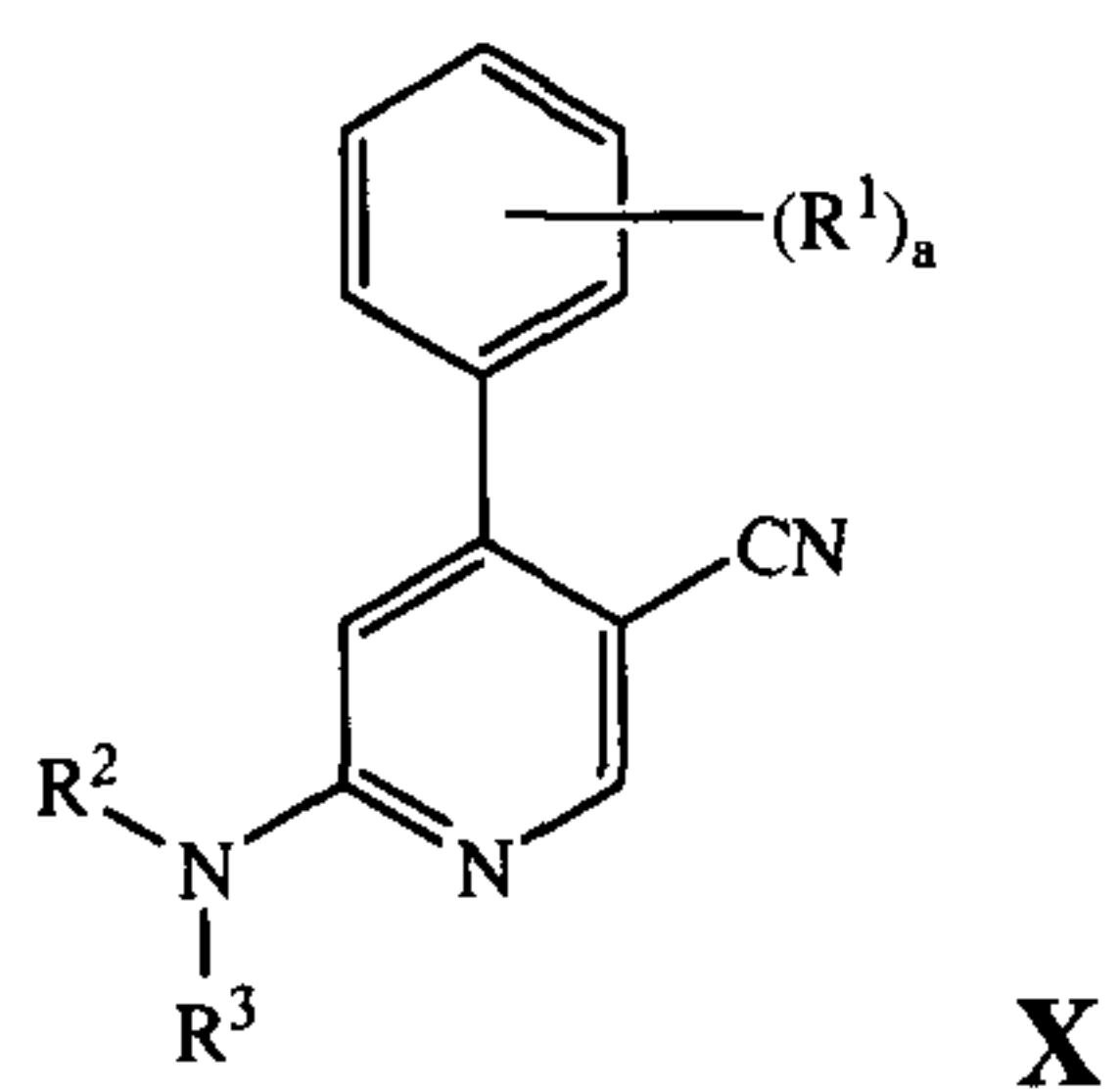
38



- (c) reacting the cyanopyridine compound of formula **VIII** with an amine compound of the formula HNR^2R^3 to form a tetra-substituted pyridine compound of the formula:



- (d) hydrogenating the tetra-substituted pyridine compound formula **IX** in the presence of a hydrogenation catalyst to form a tri-substituted pyridine compound of the formula:



and

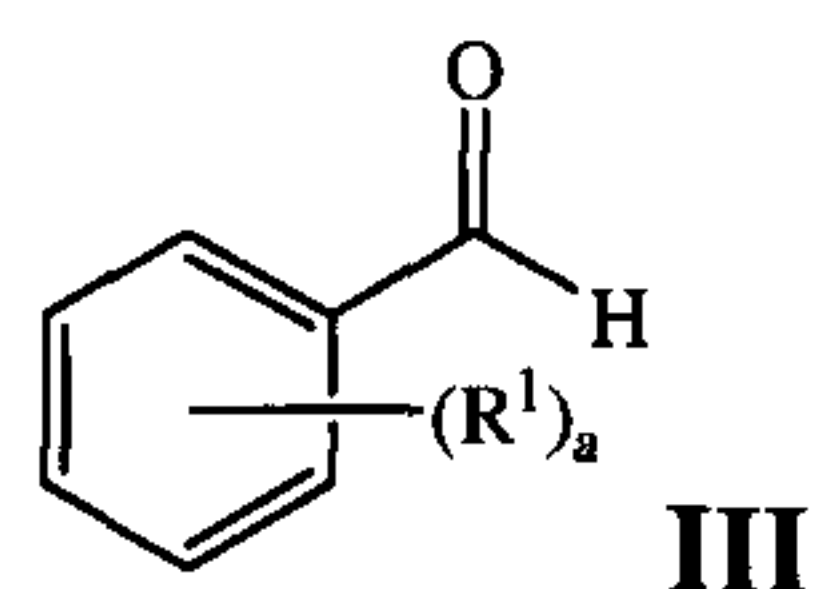
- (e) hydrolyzing the tri-substituted pyridine compound to form the carboxamide compound of Formula **I**,

where

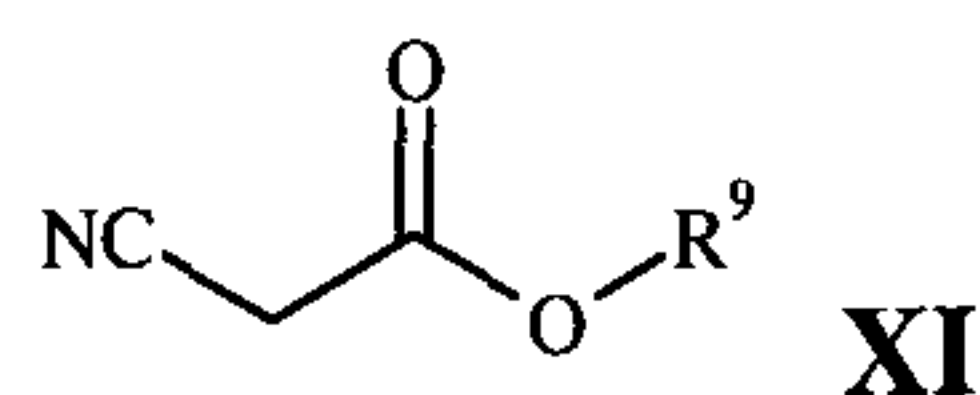
- each R^1 is independently lower alkyl, lower alkoxy, halogen, cyano or alkylamino;
 a is an integer from 0 to 2;

- R^2 is hydrogen, C_{3-6} cycloalkyl, aralkyl, lower alkyl, hydroxylalkyl, $-S(O)_2$ -lower alkyl, $-S(O)_2-Ar^1$, optionally substituted N-heterocyclyl)alkyl, $-C(=O)R^3$, where Ar^1 is aryl;
- R^3 is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl;
- or R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl;
- or R^2 and R^3 together form $=C(R^5)-R^6-NR^7R^8$;
- where
- R^5 is lower alkyl or hydrogen;
- R^6 is alkylene or a bond and
- each of R^7 and R^8 is independently hydrogen, C_{3-6} cycloalkyl, aralkyl, or lower alkyl;
- R^9 is lower alkyl;
- X^1 is halide or trifluoromethanesulfonate; and
- X is halide.

2. The process according to claim 1, wherein the α -cyano- β -aryl acrylate compound of Formula IV is prepared by reacting a benzaldehyde compound of the formula:



with an α -cyanoester compound of the formula:



in the presence of a base, wherein R^1 , a , and R^9 are those defined in Claim 1.

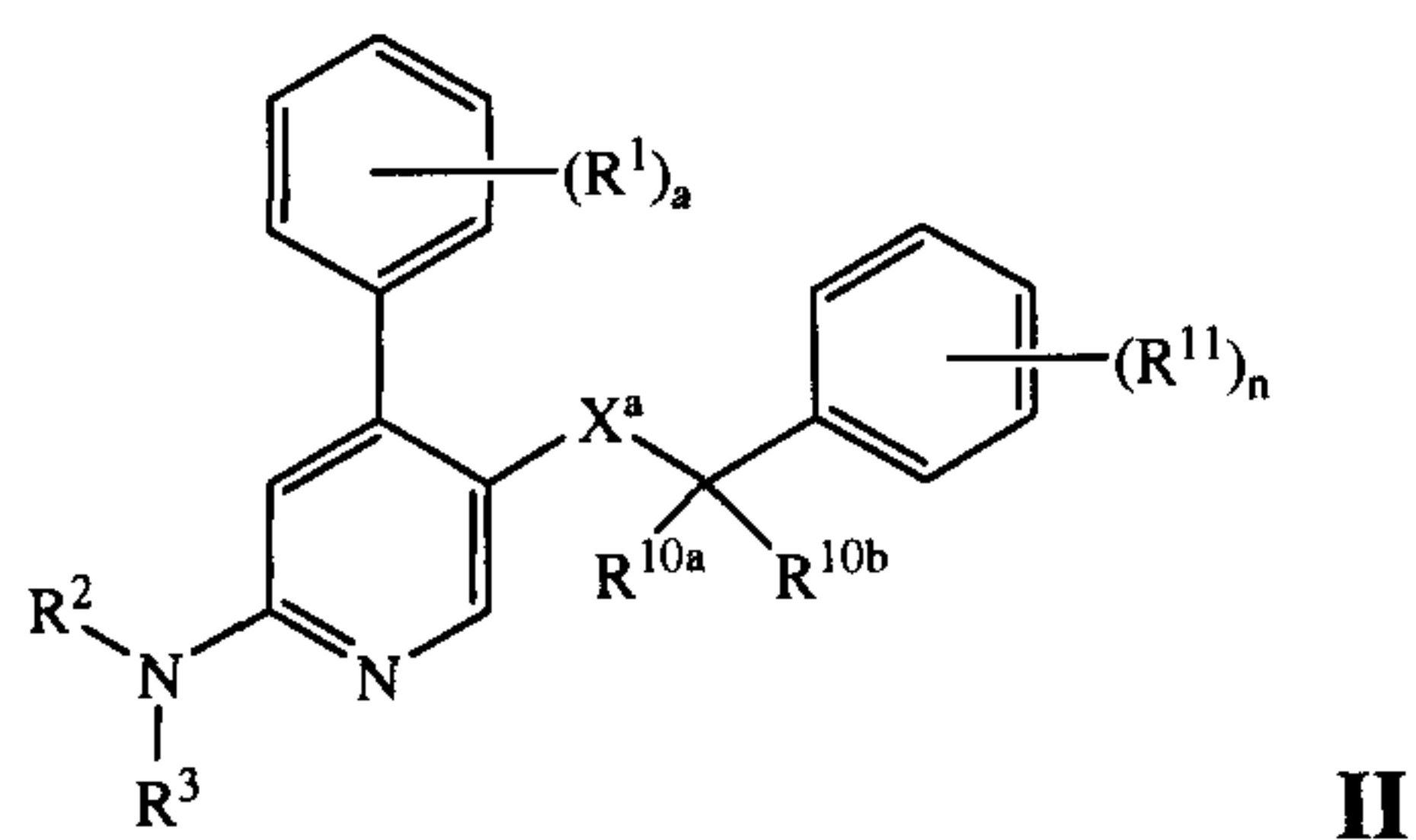
3. The process according to Claim 2, wherein the α -cyano- β -aryl acrylate compound of Formula IV is prepared *in situ*.

4. The process according to Claim 2, wherein the base is morpholine.

5. The process according to claim 2, wherein said step of producing the α -cyano- β -aryl acrylate compound of formula (IV) comprises conducting the reaction in an alcoholic solvent.
6. The process according to claim 5, wherein the alcoholic solvent comprises isopropanol, methanol, or a mixture thereof.
7. The process according to claim 2, wherein the reaction temperature of said α -cyano- β -aryl acrylate compound of formula (IV) producing step is in the range of 20 °C to 33 °C.
8. The process according to claim 1, wherein the reaction conditions for said step of producing the pyridinium zwitter ionic compound comprises a reaction solvent and the presence of an organic base.
9. The process according to claim 8, wherein the reaction solvent comprises ether, ketone, toluene, an alcohol, or a mixture thereof.
10. The process according to claim 9, wherein the alcohol is methanol.
11. The process according to claim 8, wherein the organic base is triethylamine.
12. The process according to Claim 1, wherein X^1 is chloride.
13. The process according to claim 12, wherein the reagent for producing the cyano pyridine compound is phosphorous oxychloride.
14. The process according to claim 1, wherein the amine compound is selected from the group consisting of morpholine, 1-methylpiperazine, and thiomorpholine.
15. The process according to claim 14, wherein the amine compound is morpholine.

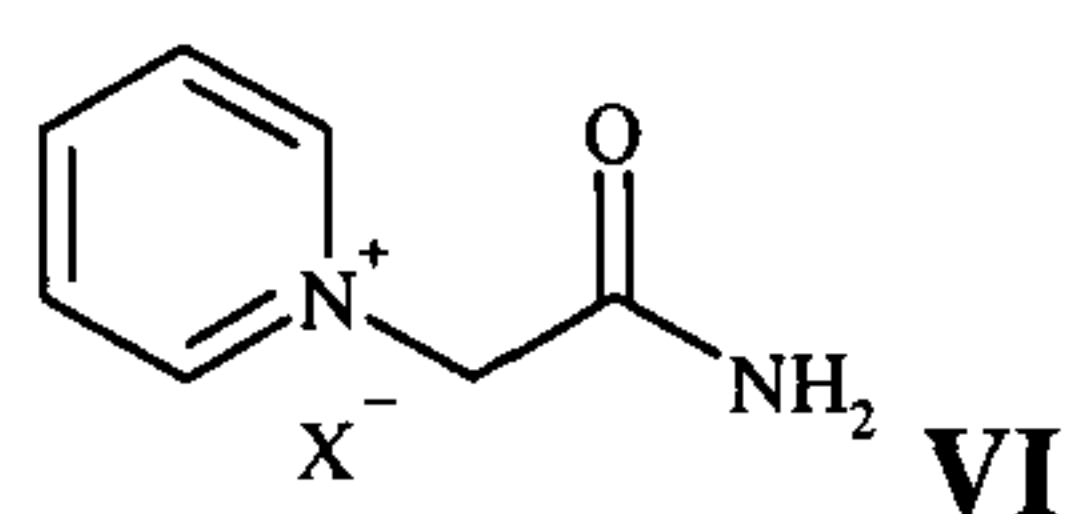
16. The process according to claim 1, wherein the hydrogenation catalyst is $\text{Pd}(\text{OH})_2$.
17. The process according to claim 1, wherein said hydrolyzing step comprises contacting the tri-substituted pyridine compound with an acid.
18. The process according to Claim 17, wherein the acid is selected from the group consisting of H_2SO_4 , HCl , and acetic acid.
19. The process according to claim 18, wherein the acid is H_2SO_4 .
20. The process according to claim 1, wherein each of R^1 is independently lower alkyl, alkoxy, halogen, cyano, or alkyamino.
21. The process according to Claim 20, wherein R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl.
22. The process according to Claim 21, wherein R^2 and R^3 together with the nitrogen atom to which they are attached to form morpholin-4-yl, 4-methy-piperazine-1-yl or 1,1-dioxothiomorpholin-4-yl.
23. The process according to claim 1, wherein the carboxamide pyridine compound is:
4-(2-methylphenyl)-6- (4-morpholinyl)-3-pyridinecarboxamide;
4-(4-fluoro-2-methylphenyl)-6-(1,1-dioxo-thiomorpholin-4-yl)pyridine-3-carboxamide;
or
4-(2-methylphenyl)-6-(4-methylpiperazinyl)-3-pyridinecaboxamide.
24. A process for preparing an aminopyridine compound of the formula:

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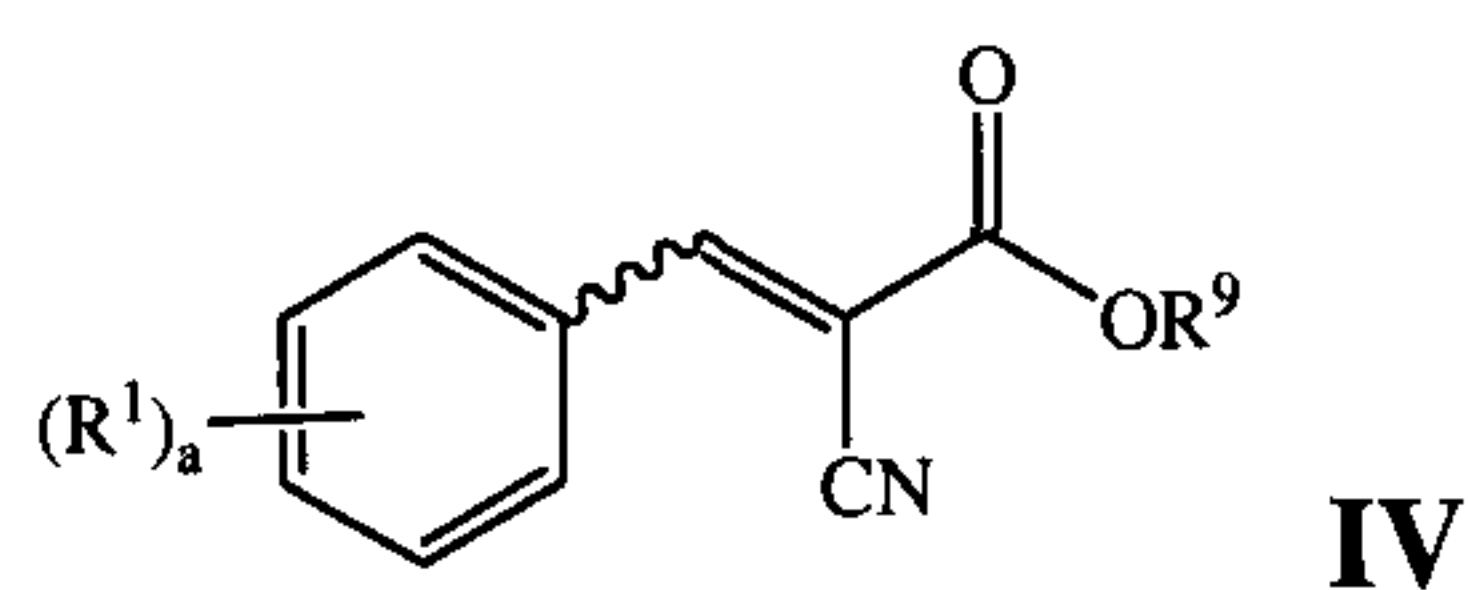


said process comprising:

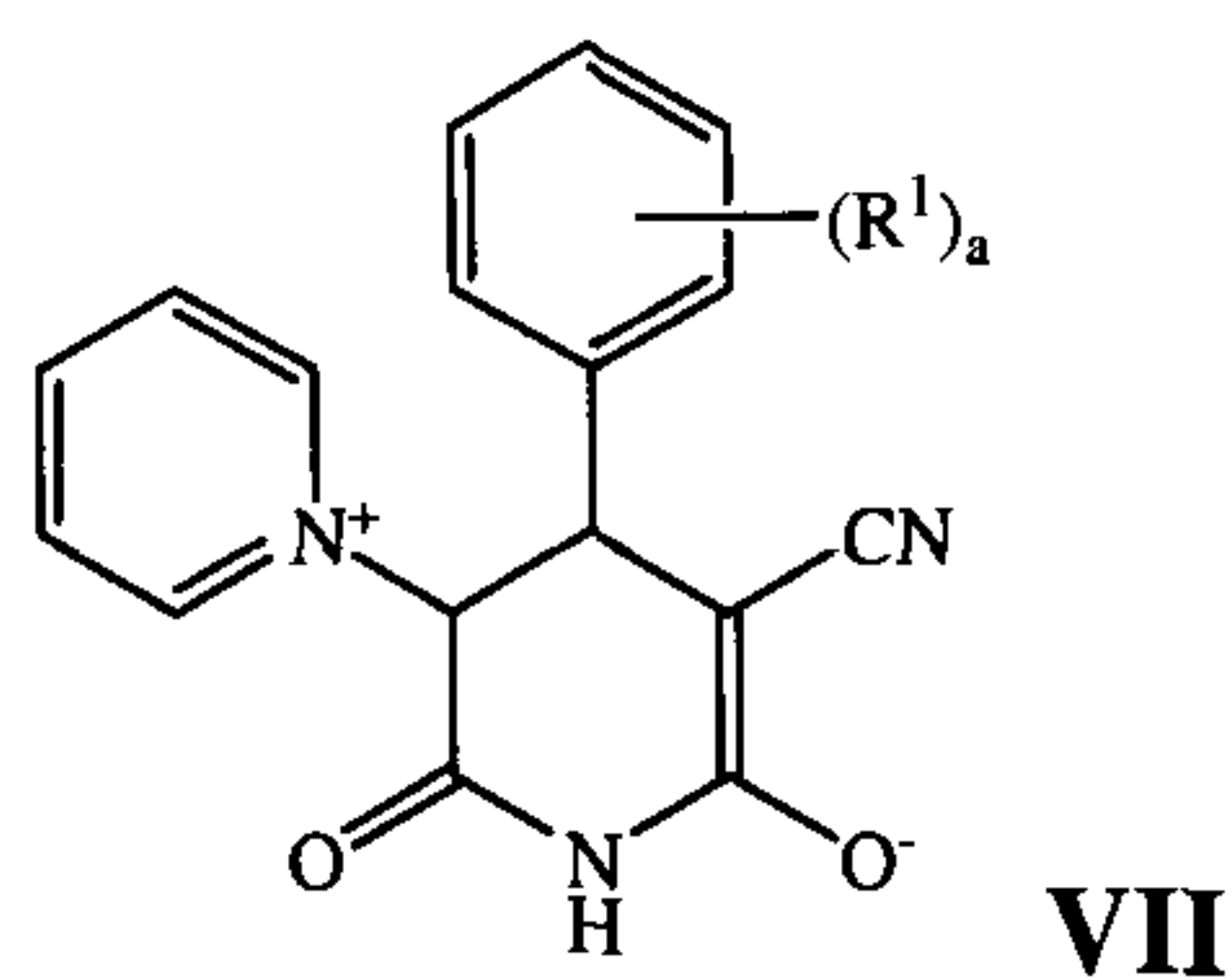
- (a) reacting a pyridinium salt of the formula:



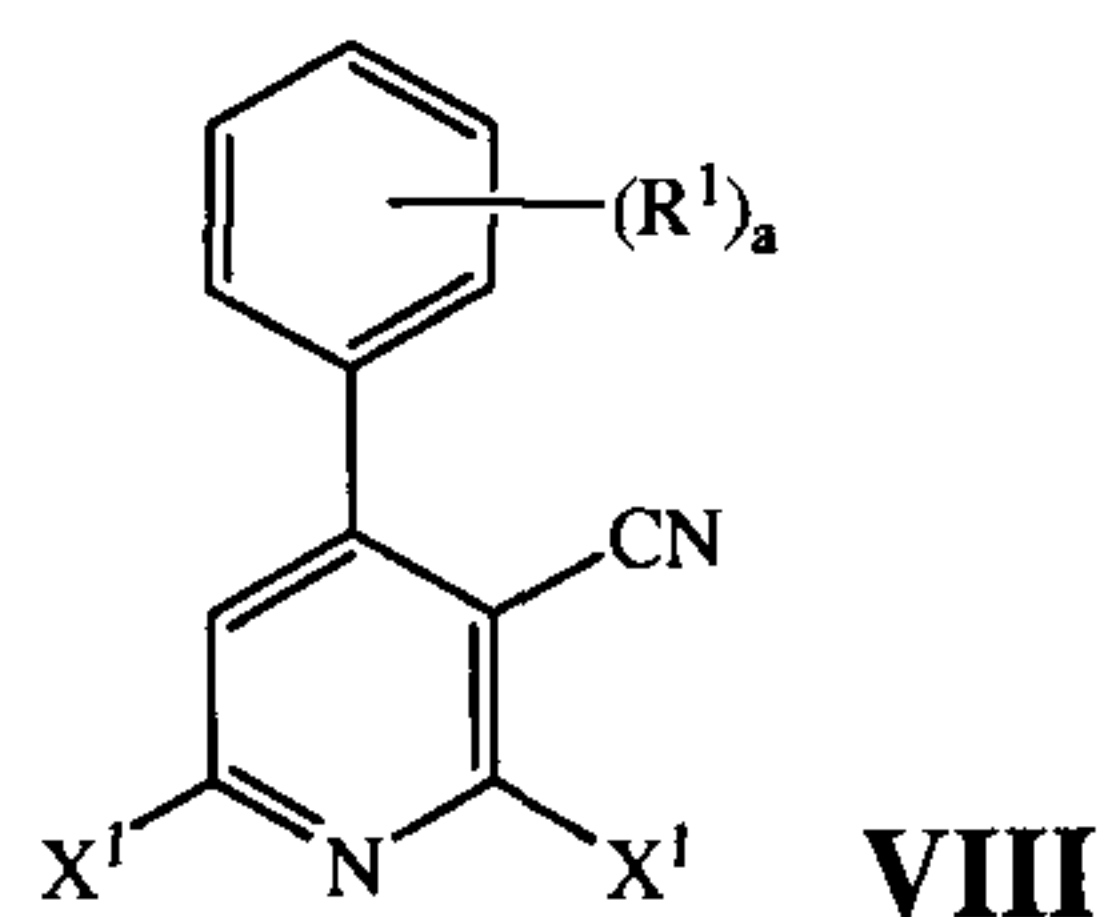
with an α -cyano- β -aryl acrylate compound of the formula:



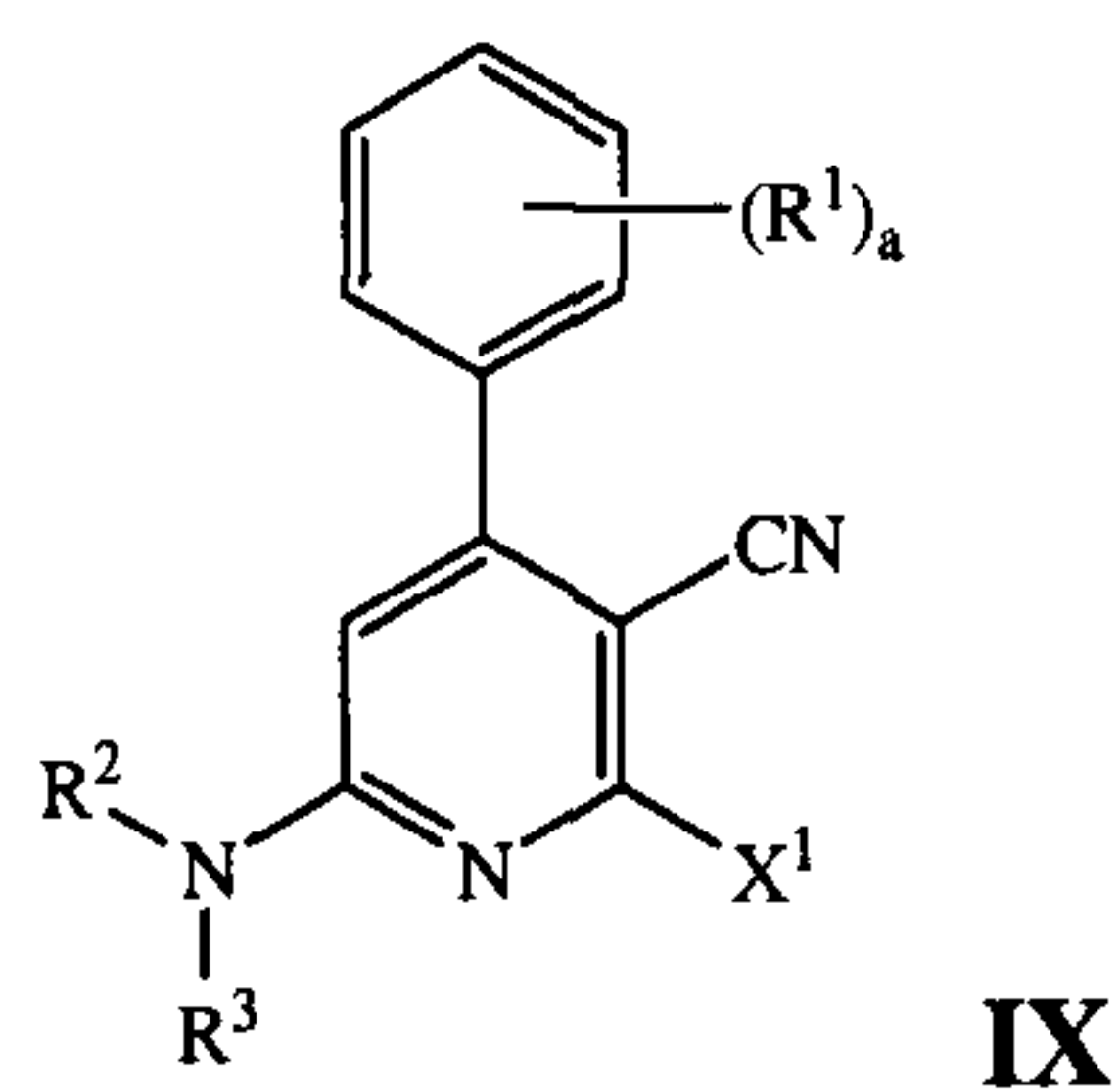
to produce a pyridinium zwitter ionic compound of the formula:



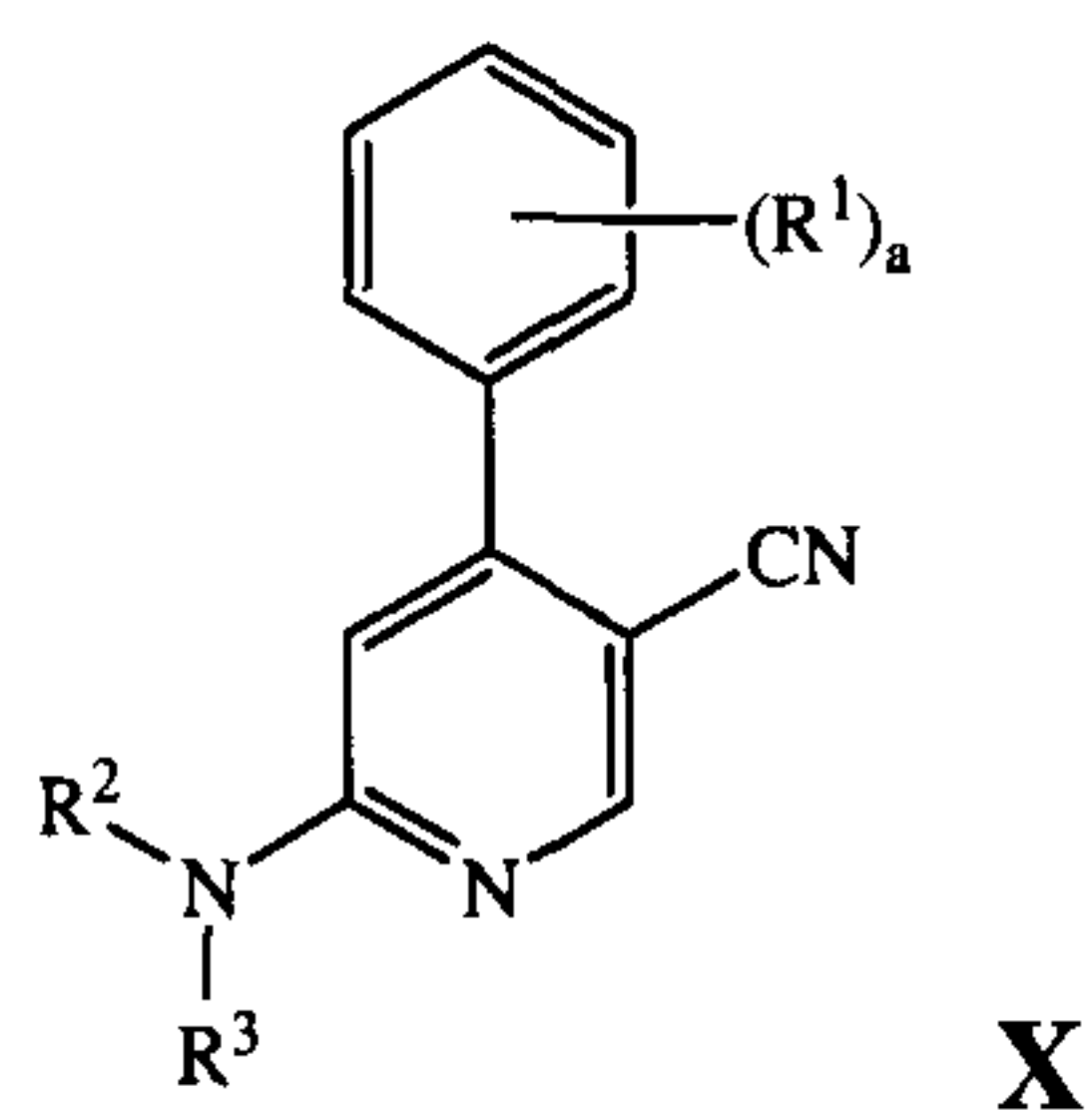
- (b) reacting the pyridinium zwitter ionic compound with a reagent selected from the group consisting of POCl₃, PBr₃, and (F₃CSO₂)₂O, to form a cyanopyridine compound of formula:



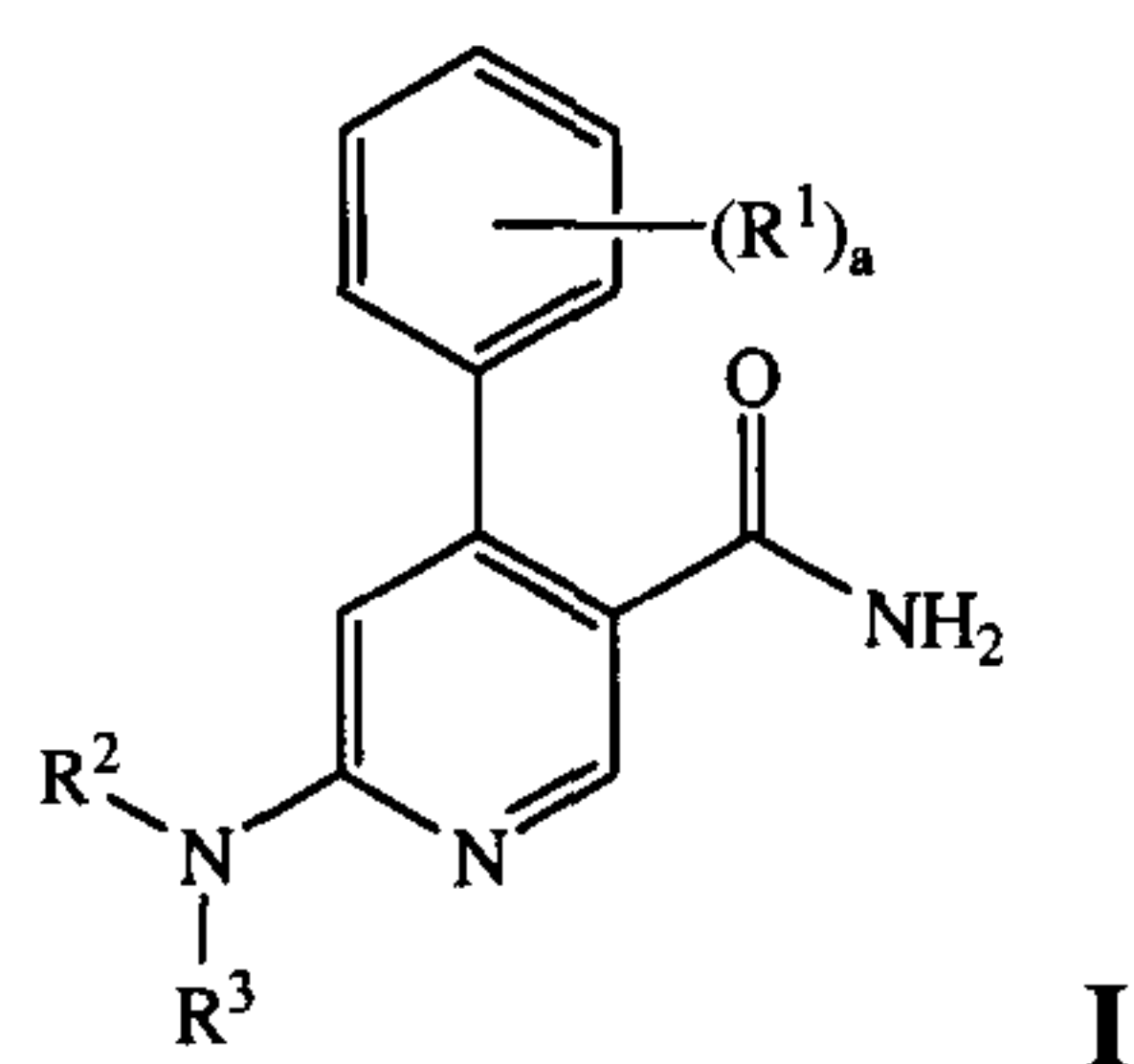
- (c) reacting the cyanopyridine compound of formula **VIII** with an amine compound of the formula HNR^2R^3 to form a tetra-substituted pyridine compound of the formula:



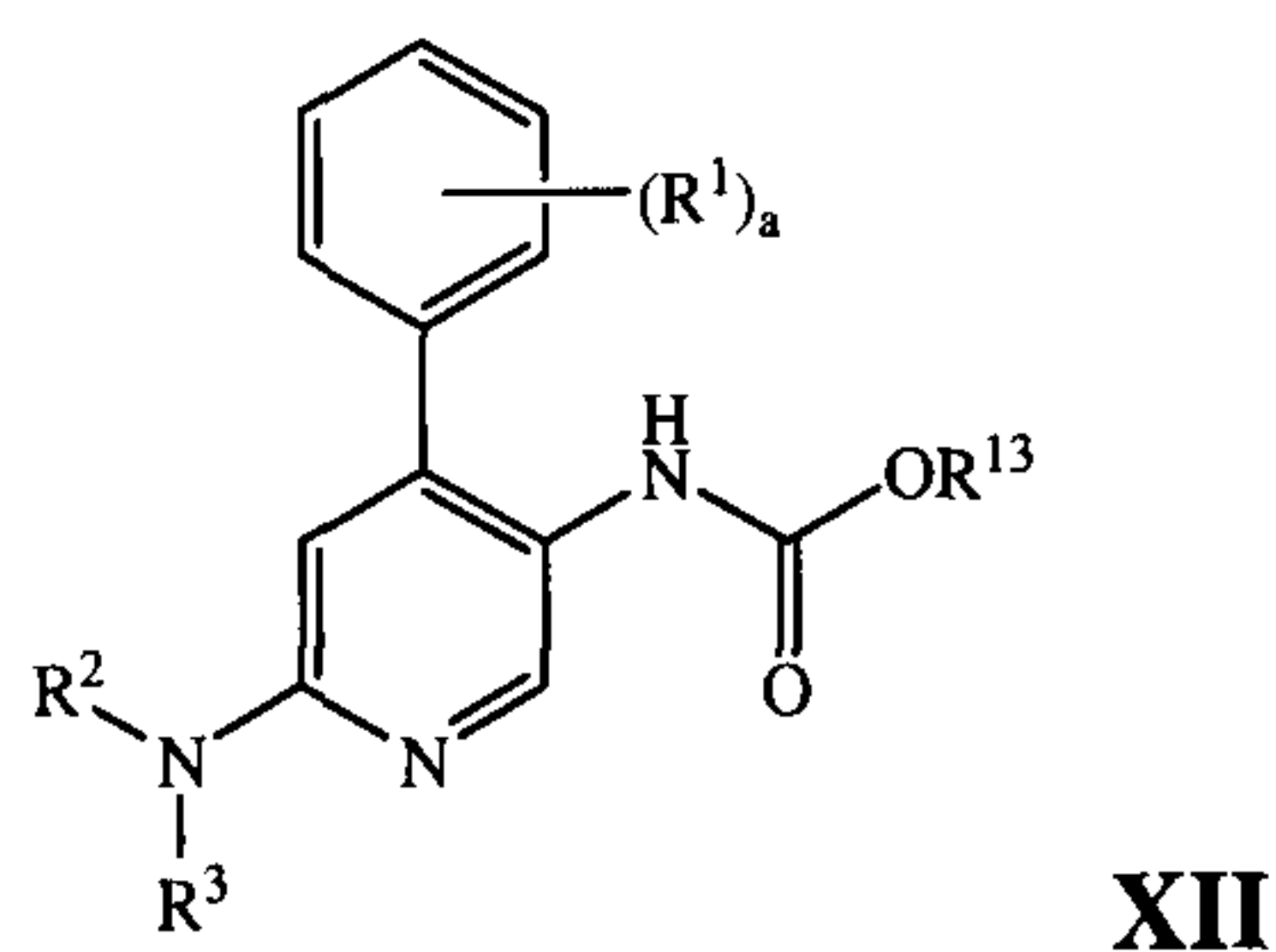
- (d) hydrogenating the tetra-substituted pyridine compound of formula **IX** in the presence of a hydrogenation catalyst to form a tri-substituted pyridine compound of the formula:



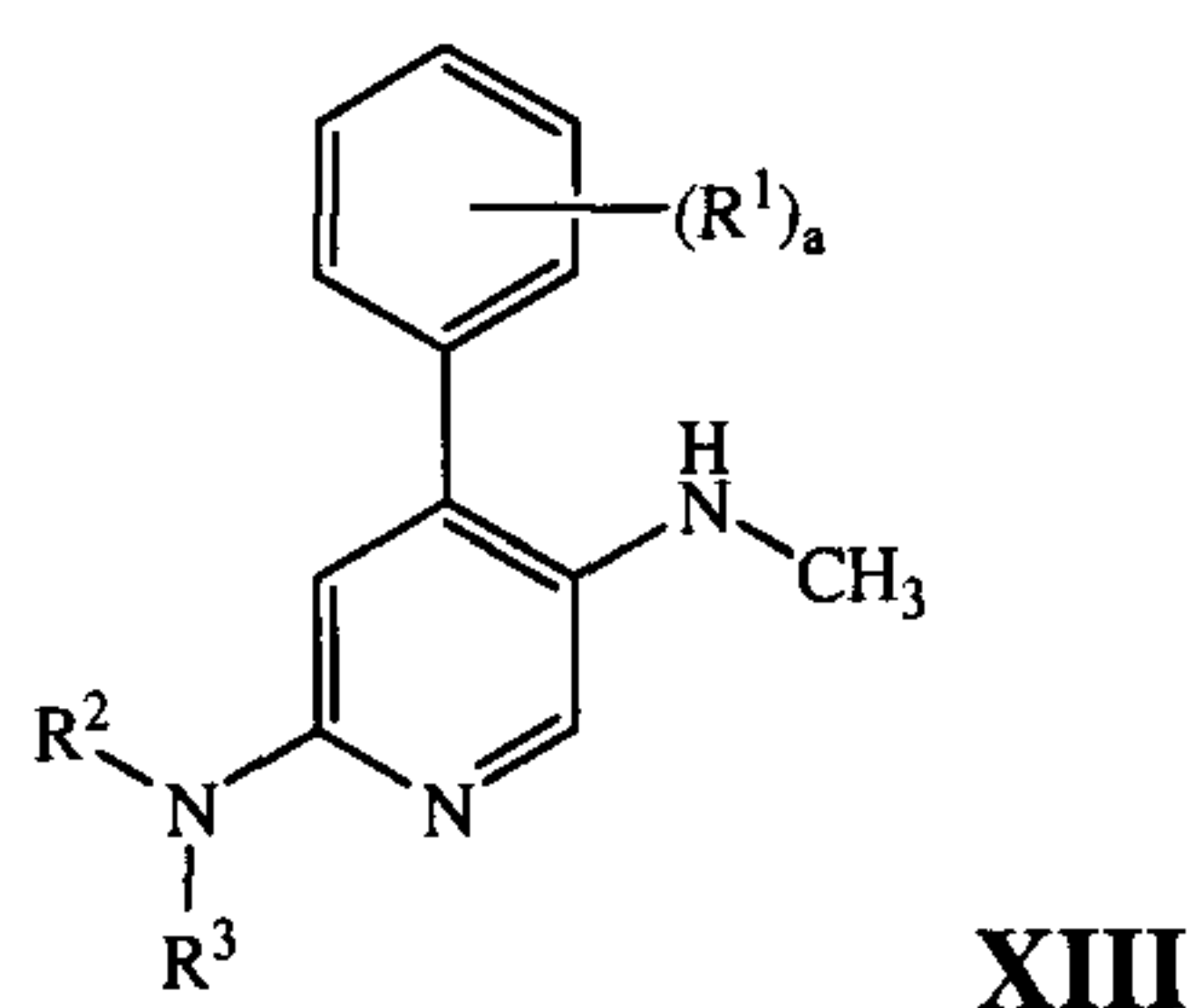
- (e) hydrolyzing the tri-substituted pyridine compound to form the carboxamide pyridine compound of the formula:



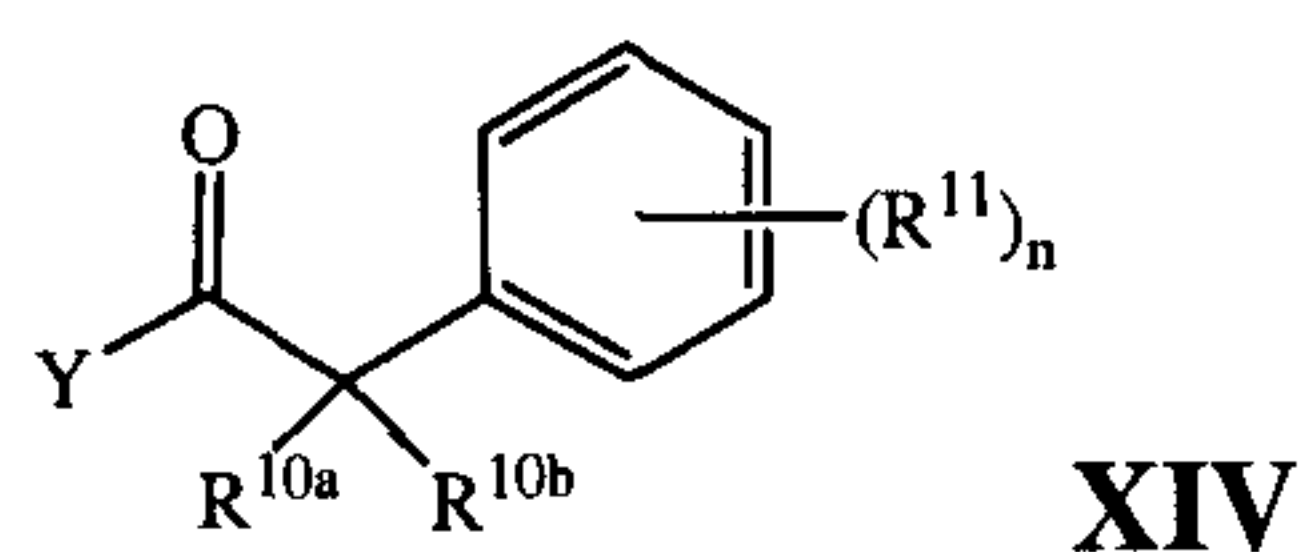
- (f) (i) (a) contacting the carboxamide pyridine compound of Formula **I** with an oxidizing agent in the presence of an alcohol of the formula $\text{R}^{13}\text{-OH}$ to produce a carbamate pyridine compound of the formula:



(b) reducing the carbamate pyridine compound of Formula **XII** with a reducing agent to produce a diaminopyridine compound of the formula:

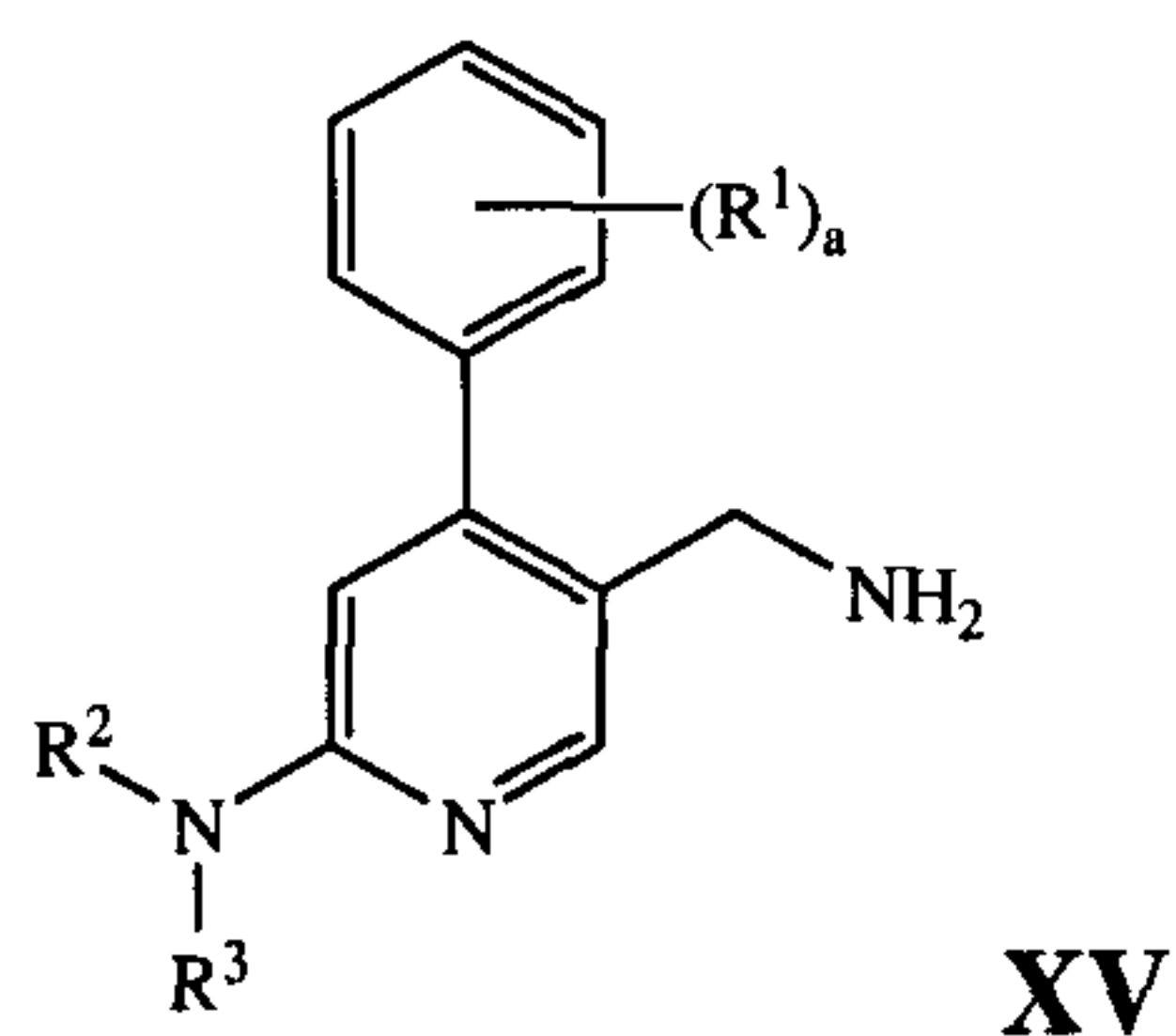


(c) reacting the diaminopyridine compound of Formula **XIII** with a carbonyl compound of the formula:

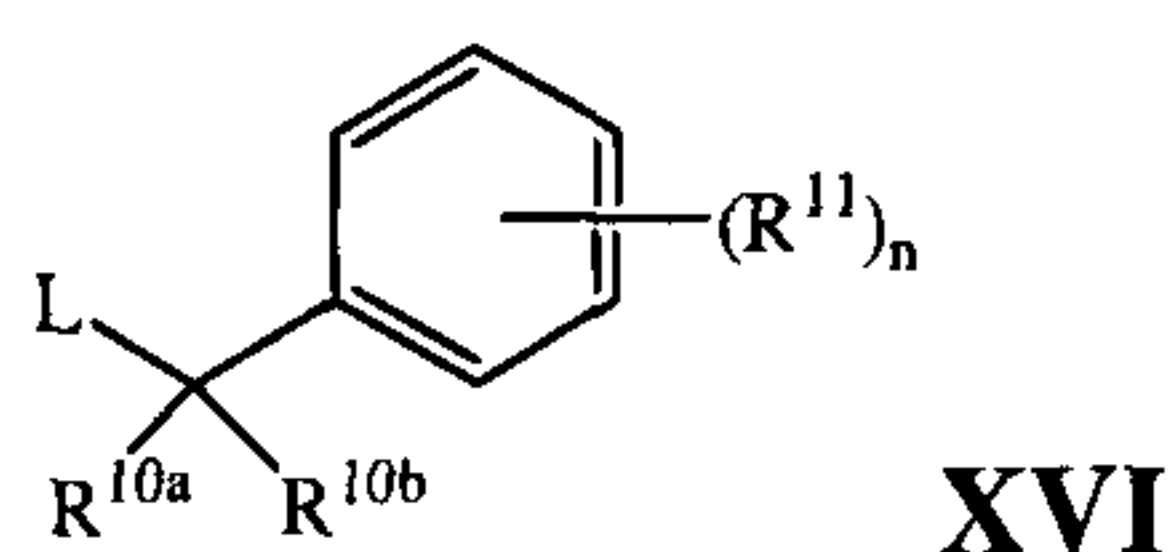


to form the aminopyridine compound of Formula **II**, where X^a is $-N(CH_3)C(=O)-$;

- (d) optionally reacting the aminopyridine compound of Formula **II**, where X^a is $-N(CH_3)C(=O)-$, with a second reducing agent to produce the aminopyridine compound of Formula **II**, where X^a is $-N(CH_3)-CH_2-$; or
- (ii) (a) contacting the carboxamide pyridine compound of Formula **I** with a reducing agent to produce an alkylamino-substituted pyridine compound of the formula:

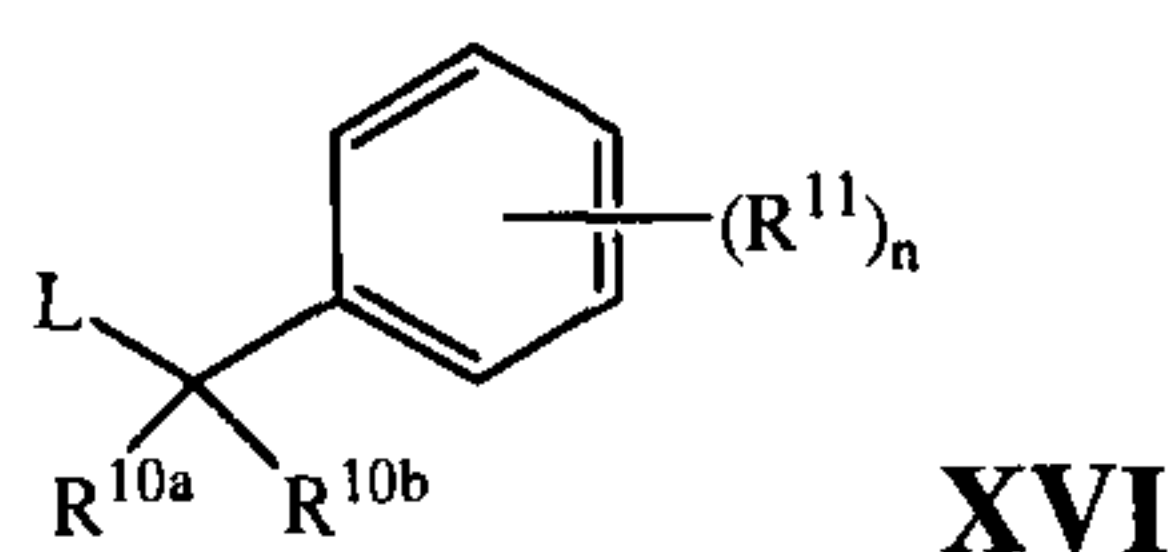


(b) reacting the alkylamino-substituted pyridine compound of Formula **XV** with an aralkyl compound of the formula:



to produce the aminopyridine compound of Formula II, where X^a is $-\text{CH}_2\text{N}(\text{H})-$; or

- (iii) reacting the carboxamide pyridine compound of Formula I with an aralkyl compound of the formula:



in the presence of a base to produce the aminopyridine compound of Formula II, where X^a is $-\text{C}(=\text{O})\text{N}(\text{H})-$,

wherein

- each R^1 is independently lower alkyl, lower alkoxy, halogen, cyano or alkylamino;
- a is an integer from 0 to 2;
- R^2 is hydrogen, C_{3-6} cycloalkyl, aralkyl, lower alkyl, hydroxylalkyl, $-\text{S}(\text{O})_2$ -lower alkyl, $-\text{S}(\text{O})_2$ - Ar^1 , optionally substituted N-heterocyclyl)alkyl, $-\text{C}(=\text{O})\text{R}^3$, where Ar^1 is aryl;
- R^3 is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl;
- or R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl;
- or R^2 and R^3 together form $=\text{C}(\text{R}^5)-\text{R}^6-\text{NR}^7\text{R}^8$;
 where
 R^5 is lower alkyl or hydrogen;
 R^6 is alkylene or a bond; and
 each of R^7 and R^8 is independently hydrogen, C_{3-6} cycloalkyl, aralkyl, or lower alkyl;
- R^9 is lower alkyl;

- each of R^{10a} and R^{10b} is independently hydrogen or lower alkyl, or R^{10a} and R^{10b} together with the carbon atom to which they are attached to form a cycloalkyl group;
- L is a leaving group;
- each R^{11} is independently halide, trifluoromethyl, lower alkoxy, or cyano, or two R^{11} moieties when adjacent to each other form a moiety of the formula $-CR^w=CR^x-CR^y=CR^z-$, wherein each of R^w , R^x , R^y , and R^z is independently hydrogen, lower alkyl or lower alkoxy, provided that at least two of R^w , R^x , R^y , and R^z are hydrogen;
- R^{13} is lower alkyl;
- n is an integer from 0 to 5;
- Y is lower alkoxide or an acyl activating group;
- X^a is $-C(=O)N(R^{14})-$, $-R^{16}-N(R^{14})-$, $-N(R^{14})C(=O)-$ or, where
- R^{14} is hydrogen or lower alkyl; and
- R^{16} is alkylene; and
- X^1 is halide or trifluoromethanesulfonate; and
- X is halide.

25. The process according to claim 24, wherein the aminopyridine compound of Formula II is:

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-[methyl-(2-morpholin-4-yl-ethyl)-amino]-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-morpholin-4-yl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-thiomorpholin-4-yl-4-o-tolyl-nicotinamide;

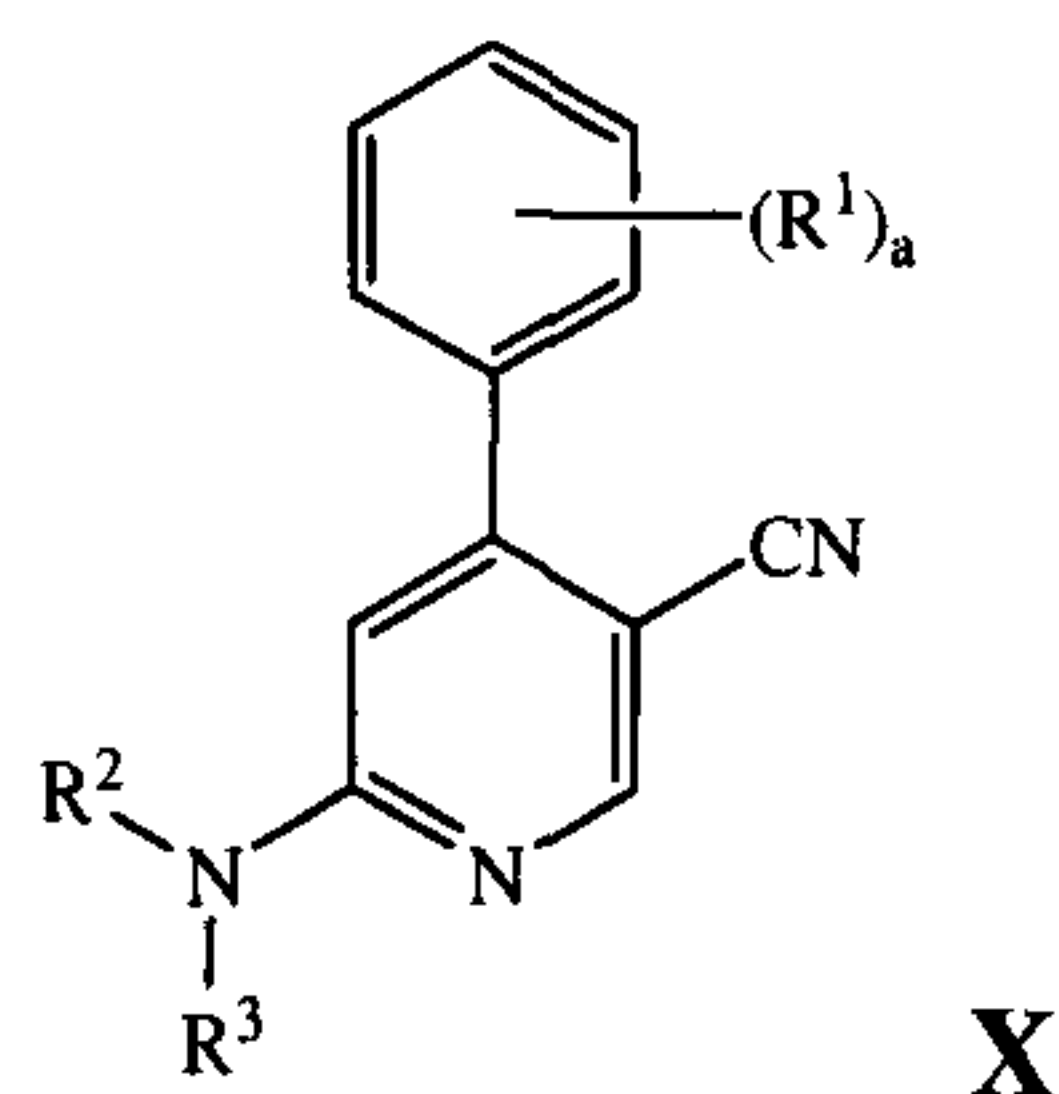
N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-(1-oxo-1 λ^6 -4-thiomorpholin-4-yl)-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-6-(1,1-dioxo-1 λ^6 -6-thiomorpholin-4-yl)-N-methyl-4-o-tolyl-nicotinamide;

N-(3,5-bis-trifluoromethyl-benzyl)-N-methyl-6-piperazin-1-yl-4-o-tolyl-nicotinamide;

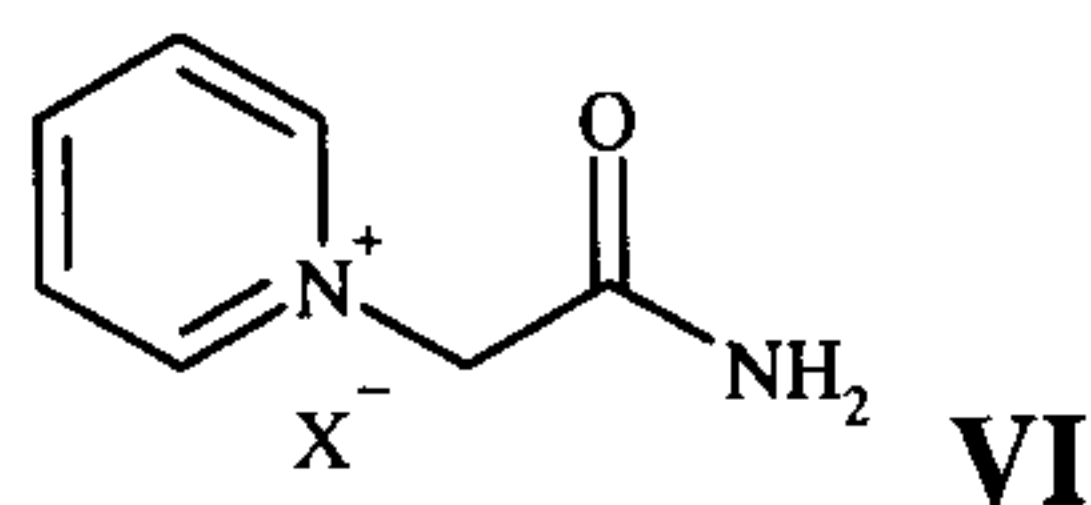
N-(3,5-bis-trifluoromethyl-benzyl)-6-[4-(2-hydroxy-ethyl)-piperazin-1-yl]-N-methyl-4-o-tolyl-nicotinamide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(4-methyl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-N-methyl-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(4-fluoro-2-methyl-phenyl)-6-(4-methyl-piperazin-1-yl)-pyridin-3-yl]-N-methyl-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chloro-phenyl)-pyridin-3-yl]-N-methyl-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(4-o-tolyl-pyridin-3-yl)-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-[6-(4-pyridin-2-yl-piperazin-1-yl)-4-o-tolyl-pyridin-3-yl]-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-(6-morpholin-4-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-[4-(2-chloro-phenyl)-6-dimethylamino-pyridin-3-yl]-isobutyramide;
 2-(3,5-bis-trifluoromethyl-phenyl)-N-methyl-N-(6-piperazin-1-yl-4-o-tolyl-pyridin-3-yl)-isobutyramide; or
 2-(3,5-bis-trifluoromethyl-phenyl)-N-[6-(1,1-dioxo-1 λ^6 -thiomorpholin-4-yl)-4-o-tolyl-pyridin-3-yl]-N-methyl-isobutyramide.

26. A process for preparing an amino-substituted cyanopyridine compound of the formula:

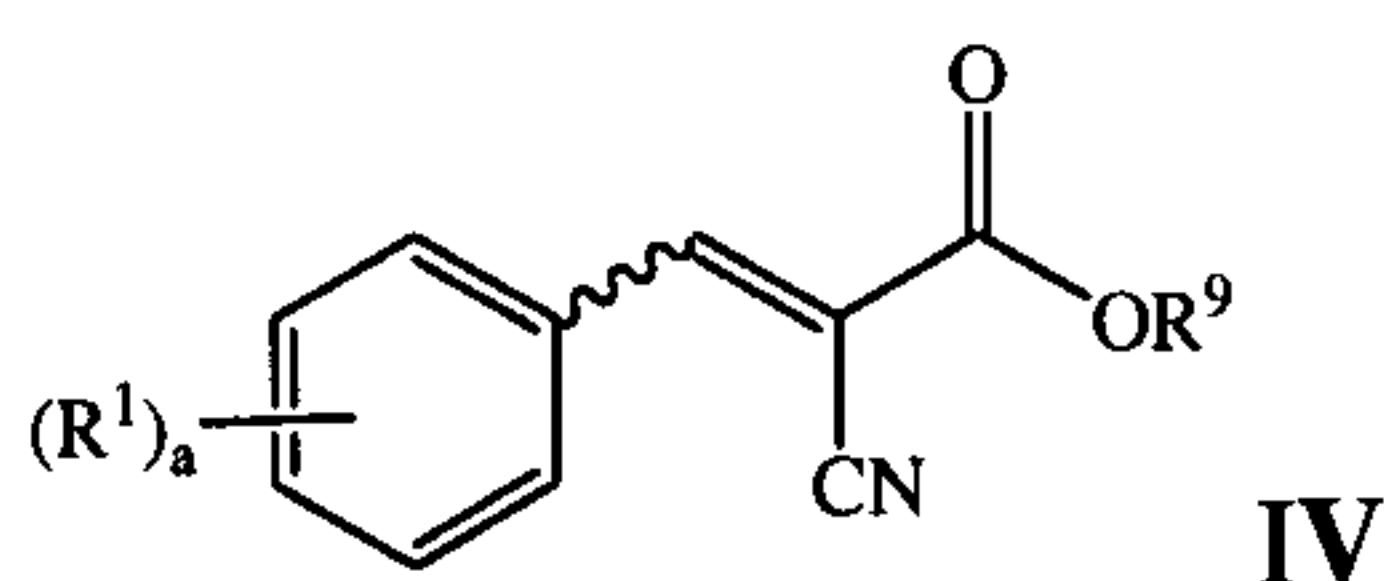


said method comprising:

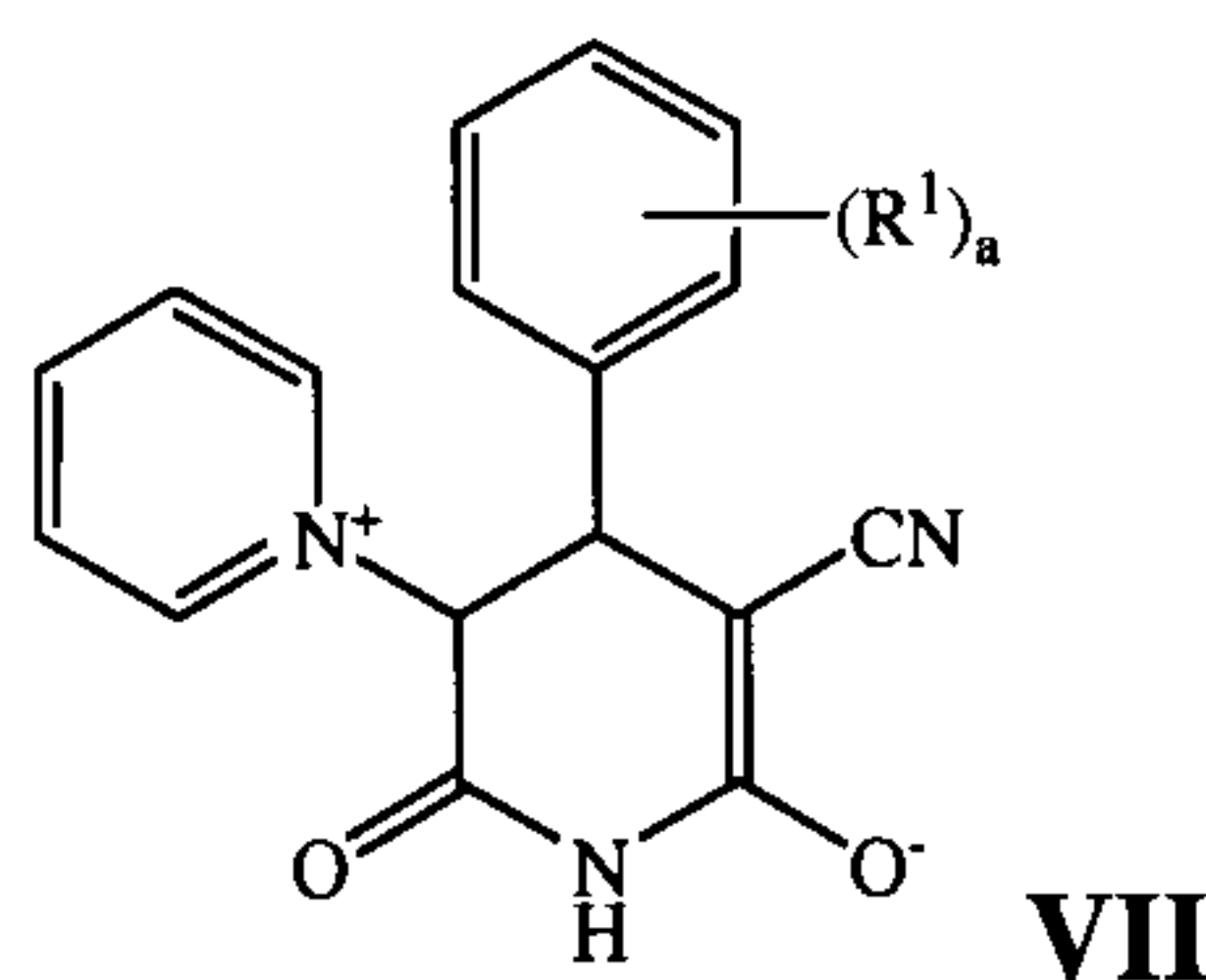
- (a) reacting a pyridinium salt of the formula:



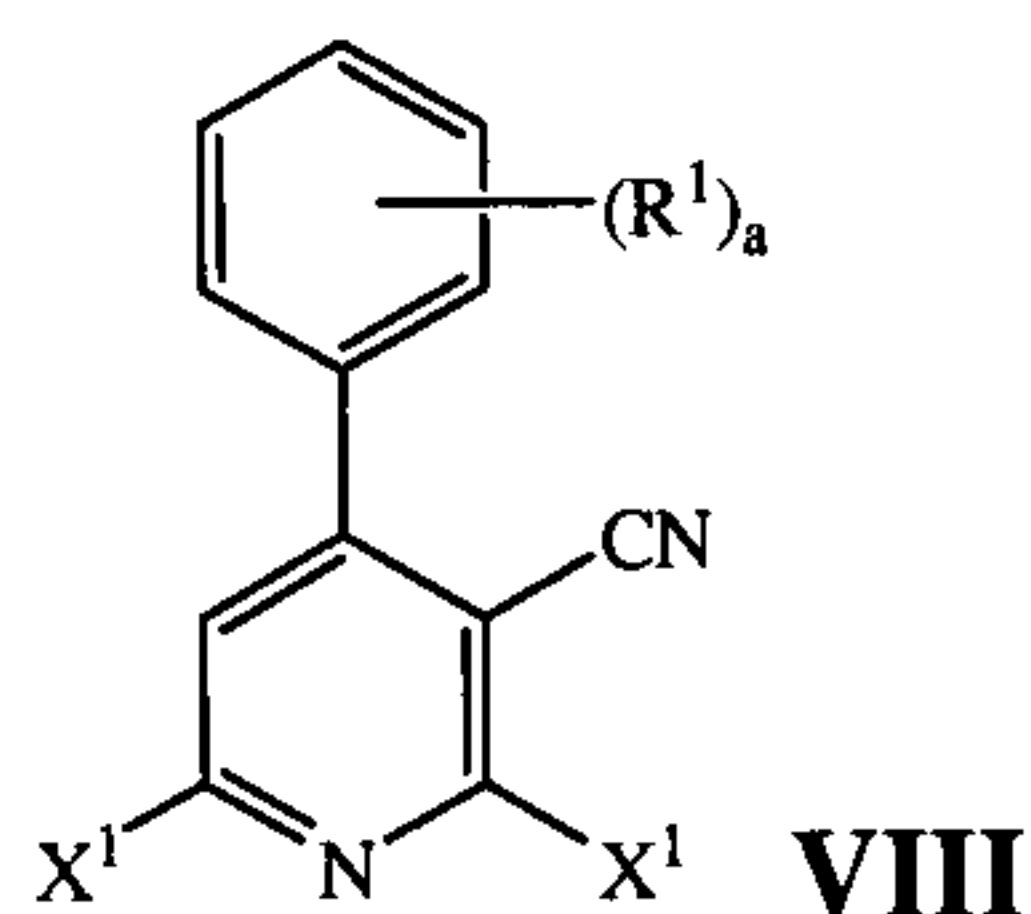
with an α -cyano- β -aryl acrylate compound of the formula:



to produce a pyridinium zwitter ionic compound of the formula

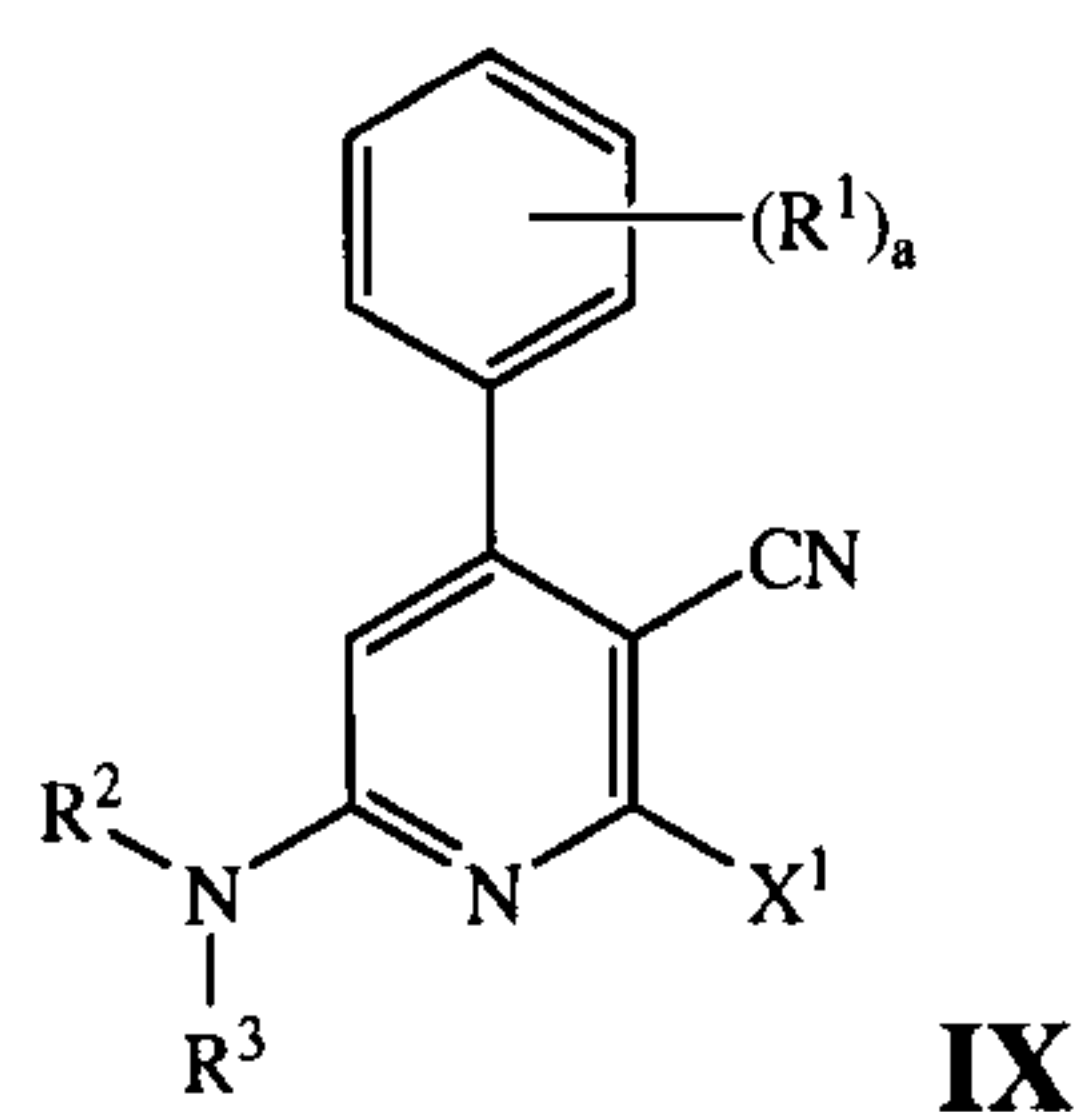


- (b) reacting the pyridinium zwitter ionic compound with a reagent selected from the group consisting of POCl_3 , PBr_3 , and $(\text{F}_3\text{CSO}_2)_2\text{O}$, to form a cyanopyridine compound of formula:



- (c) reacting the cyanopyridine compound of formula **VIII** with an amine compound of the formula HNR^2R^3 to form a tetra-substituted pyridine compound of the formula:

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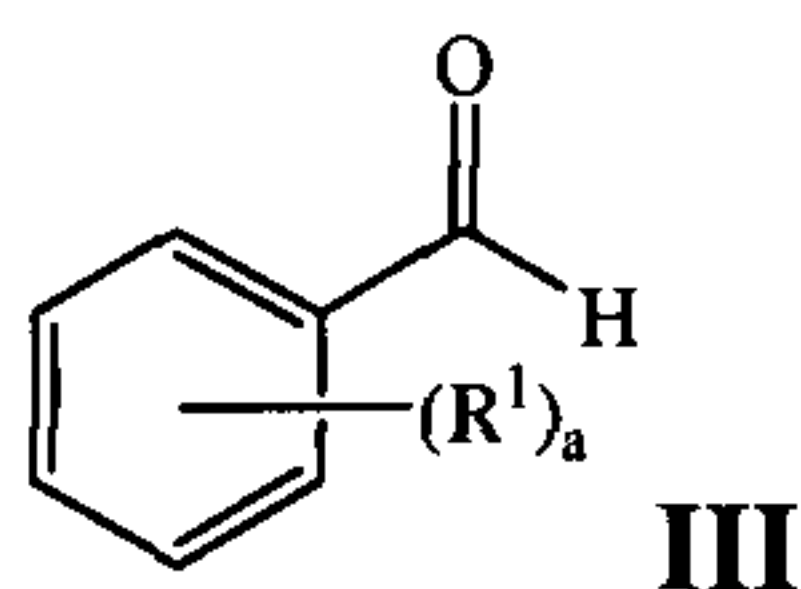
and

- (d) hydrogenating the tetra-substituted pyridine compound formula **IX** in the presence of a hydrogenation catalyst to form the amino-substituted cyanopyridine compound,

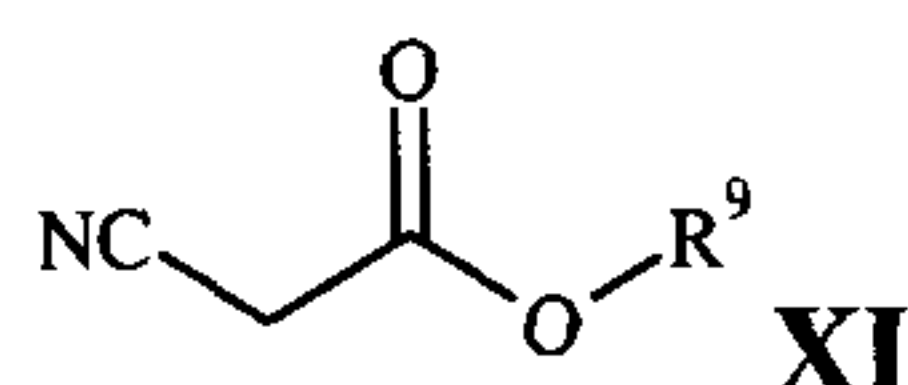
wherein

- each R^1 is independently lower alkyl, lower alkoxy, halogen, cyano or alkylamino;
- a is an integer from 0 to 2;
- R^2 is hydrogen, C_{3-6} cycloalkyl, aralkyl, lower alkyl, hydroxylalkyl, $-S(O)_2$ -lower alkyl, $-S(O)_2-Ar^1$, optionally substituted N-heterocyclyl)alkyl, $-C(=O)R^3$, where Ar^1 is aryl;
- R^3 is hydrogen, C_{3-6} cycloalkyl, aralkyl or lower alkyl;
- or R^2 and R^3 together with the nitrogen atom to which they are attached to form optionally substituted N-heterocyclyl;
- or R^2 and R^3 together form $=C(R^5)-R^6-NR^7R^8$;
- where
- R^5 is lower alkyl or hydrogen;
- R^6 is alkylene or a bond; and
- each of R^7 and R^8 is independently hydrogen, C_{3-6} cycloalkyl, aralkyl, or lower alkyl;
- R^9 is lower alkyl;
- X is halide; and
- X^1 is halide or trifluoromethanesulfonate.

27. The process according to Claim 26, wherein the α -cyano- β -aryl acrylate compound of Formula IV is prepared by reacting a benzaldehyde compound of the formula:



with an α -cyanoester compound of the formula:



in the presence of a base, wherein R^1 , a , and R^9 are those defined in Claim 26.

28. The process according to Claim 27, wherein the α -cyano- β -aryl acrylate compound of Formula IV is prepared *in situ*.

29. The process according to Claim 27, wherein said step of producing the α -cyano- β -aryl acrylate compound of formula (IV) comprises conducting the reaction in an alcoholic solvent.

30. The process according to Claim 29, wherein the alcoholic solvent comprises isopropanol, methanol, or a mixture thereof.

31. The process according to Claim 26, wherein the amino-substituted cyanopyridine compound is:

5-cyano-4-(2-methylphenyl)-2-(4-morpholinyl)pyridine; or

5-cyano-4-(2-methylphenyl)-2-(4-methylpiperazinyl)pyridine.

