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(71) Applicant *(for all designated States except US)*: THE REGENTS OF THE UNIVERSITY OF CALIFORNIA [US/US]; 22nd floor, 300 Lakeside Drive, Oakland, CA 94612-3550 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: MITCHELL, Alexander, R. [US/US]; 5577 Bridgeport Circle, Livermore, CA 94550 (US). PAGORIA, Phillip, F. [US/US]; 93 Canary Court, Livermore, CA 94550 (US). SCHMIDT, Robert, D. [US/US]; 979 Murdell Lane, Livermore, CA 94550 (US).

(74) Agents: PETERS, Howard, M. et al.; Peters Verny Jones & Biksa, L.L.P., Suite 6, 385 Sherman Avenue, Palo Alto, CA 94306-1840 (US).

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(54) Title: AMINATION OF ELECTROPHILIC AROMATIC COMPOUNDS BY VICARIOUS NUCLEOPHILIC SUBSTITUTION

(57) Abstract

The present invention relates to a process to aminate electrophilic aromatic compounds by vicarious nucleophilic substitution of hydrogen using quaternary hydrazinium salts. The use of trimethylhydrazinium iodide, as well as hydroxylamine, alkoxylamines, and 4-amino-1,2,4-triazole to produce aminated aromatic structures, such as 1,3-diamino-2,4,6-trinitrobenzene (DATB), 1,3,5-triamino-2,4,6-trinitrobenzene (TATB) and 3,5-diamino-2,4,6-trinitrotoluene (DATNT), is described. DATB and TATB are useful insensitive high explosives. TATB is also used for the preparation of benzenehexamine, a starting material for the synthesis of novel materials (optical imaging devices, liquid crystals, ferromagnetic compounds).

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AMINATION OF ELECTROPHILIC AROMATIC COMPOUNDS BY VICARIOUS NUCLEOPHILIC SUBSTITUTION

BACKGROUND OF THE INVENTION

Related Applications

This International Application is a continuation-in-part of U.S. Serial No. 08/440,017, filed May 12, 1995, and a continuation-in-part of U.S. Serial No. 08/440,024, filed May 12, 1995, both of which are incorporated herein by reference in their entirety.

Origin of the Invention

The United States Government has rights in this invention pursuant to Contract No. W-7405-ENG-48 between the U.S. Department of Energy and the University of California, for the operation of Lawrence Livermore National Laboratory, Livermore, California.

Field of the Invention for Amination

The present invention concerns the mono- and/or poly-amination of electrophilic aromatic compounds. In particular, the present invention concerns the discovery and use of quaternary hydrazinium salts, e.g., 1,1,1-trisubstituted hydrazinium salts, for vicarious nucleophilic substitution (VNS) of hydrogen, which provide new and improved syntheses of mono and/or poly amino-aromatic compounds, such as 1,3-diamino-2,4,6-trinitrobenzene (DATB) and 1,3,5-triamino-2,4,6-trinitrobenzene (TATB). The present invention also concerns the use of 4-amino-1,2,4-triazole, as well as hydroxylamine and its O-alkyl derivatives, to provide new and improved syntheses of aromatic amine compounds, such as DATB and TATB, by VNS reactions.

Description of the Problem and Related Art

The amination of organic aromatic compounds (both carbocyclic and heterocyclic) occurs according to a number of reactions known in the art. However, the methods of the art often are dangerous, require special equipment, have side reactions, separation problems, hazardous reagents, environmental problems and the like.

Some explosives are more sensitive to shock and heat than others having a similar

structure. Studies of explosives based on the benzene ring include, for example, 1,3,5-trinitrobenzene (TNB), 2,4,6-trinitrotoluene (TNT), 1-amino-2,4,6-trinitrobenzene (TNA) (aka picramide), 1,3-diamino-2,4,6-trinitrobenzene (DATB) and 1,3,5-triamino-2,4,6-trinitrobenzene (TATB). Although these compounds have much in common, the shock initiation thresholds, that is, the shock pressure required to cause detonation in 50% of the tests, vary widely. Table 1 shows the pattern.

TABLE 1

SHOCK INITIATION THRESHOLD OF EXPLOSIVES

Compound	Pressure (kilobars)
TNB	17
TNT	21
TNA	30
DATB	46
TATB	75

While not wanting to be bound by theory, it appears that adding amino groups to a nitro-substituted benzene ring raises the shock initiation threshold. This pattern occurs, because as the networks of hydrogen bonds increase, the networks absorb energy from a shock front and reduce the amount of shock that goes to the ring itself. See W. Worthy in "Shock Sensitivity of Explosives Clarified", Chemical and Engineering News, p. 25, (August 10, 1987) for further discussion.

It follows that DATB and TATB are highly desirable, insensitive explosives that are used primarily in specialty applications. Part of the reason that they are used in special as opposed to general explosive applications is high cost. They are too expensive to use in ordinary applications when other less expensive explosives can be used. One reason that TATB is expensive is that it is usually prepared from 1,3,5-trichlorobenzene which is expensive and is not generally available from domestic suppliers. The ammonium chloride byproduct (NH_4Cl) is difficult to remove completely and may cause compatibility problems in certain types of ordnance (e.g., U.S. Patent 4,032,377).

Alternative preparations of aminoaromatic compounds were sought, and include: T.M. Benziger, U.S. Patent 4,032,377 discloses a preparation of TATB by nitration of 1,3,5-trichlorobenzene to 1,3,5-trichloro-2,4,6-trinitrobenzene followed by treatment with ammonia to produce TATB. This patent also discloses the use of water

to separate the byproduct ammonium chloride.

D.G. Ott and T.M. Benziger, U.S. Patent 4,952,733 and Journal of Energetic Materials, vol. 5, pp. 343-354 (1987) disclose a preparation of TATB by nitration of 3,5-dichloroanisole to produce 3,5-dichloro-2,4,6-trinitroanisole which is chlorinated to give 1,3,5-trichloro-2,4,6-trinitrobenzene which is ammonolyzed to give TATB.

Additional art of interest includes, for example:

R.L. Atkins et al., in U.S. Patent 4,248,798 disclose a new method for preparing pentanitroaniline (PNA) and triaminotrinitrobenzene (TATB) from TNT. TNT is first reduced using H_2S to 4-amino-2,6-dinitrotoluene then nitrated using nitric acid/sulfuric acid to pentanitroaniline followed by reaction with ammonia to produce the TATB.

M. Makosza et al., review and discuss "Vicarious Nucleophilic Substitution of Hydrogen", in Accounts of Chemical Research, vol. 20, pp. 282-9 (1987), and teach the substitution of polynitrobenzene structures with a number of non-nitrogen containing vicarious nucleophilic substitution reagents. No nitrogen-containing reagents are disclosed or suggested.

A.R. Katritzky and K.S. Laurenzo, Journal of Organic Chemistry, vol. 51, pp. 5039-5040 (1986) disclose mono-amination of nitrobenzene and some substituted nitrobenzenes to give 4-nitroanilines by VNS reactions. The same authors, in the Journal of Organic Chemistry, vol. 53, pp. 3978-3982 (1988) disclose the use of a series of 4-(alkylamino)-1,2,4-triazoles to transfer the alkylamino group to the 4-position of nitrobenzene and 3-substituted nitrobenzenes by VNS. Only monoamination is taught or suggested.

T. Urbanski et al., Journal of Scientific and Industrial Research (India), vol. 37, p. 250-5 (1978), disclose the standard preparation and properties of several heat resistant explosives including DATB and TATB.

J.R. Holden et al., U.S. Naval Ordnance Laboratory, White Oak, Maryland, NAVORD Report 6299 (March 1959), disclose the properties of DATB.

S.K. Yasuda et al., in Journal of Chromatography, vol. 71, p. 484-86 (1972) discuss the separation and identification of 12 impurities of TATB by two dimensional thin-layer chromatography.

M. Makosza et al., Journal of Organic Chemistry, vol. 57, p. 4784-5 (1992), disclose the mono-amination of nitrobenzenes with sulfenamides via vicarious

nucleophilic substitution of hydrogen. See also U.S. Patent 5,262,539.

W.P. Norris et al., "CL-14, A New Dense, Insensitive, High Explosive", Naval Weapons Center, China Lake, California, Report No. TP 6597 (Unclassified), May 1985, disclose the use of hydroxylamine to di-aminate 4,6-dinitrobenzofuroxan (DNBF) thereby producing 5,7-diamino-4,6-dinitrobenzofuroxan (CL-14).

R.L. Atkins et al., in the Journal of Organic Chemistry, vol. 51, pp. 3261-3266 (1986), disclose the synthesis of a number of polynitro compounds, including TATB. Pentanitroaniline is reacted with ammonia to produce TATB.

T.R. Gibbs et al., LASL Explosives Properties Data (University of California Press, Berkeley, CA, 1980.

B.M. Dobratz, LLNL Explosives Handbook: Properties of Chemical Explosives and Explosive Simulants, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-52997 (March 16, 1981).

German patent, Ger. Offen DE 3,612,238) teaches the use of TATB to prepare components of lyotropic liquid-crystal phases for use in display devices.

TATB is also valuable in non-explosive applications. K. Praefake and B. Kohne, Ger. Offen. DE 3,612,238 disclose the use of TATB to prepare hexaaminobenzene derivatives which are used as components of lyotropic liquid-crystal phases, which can be used in display devices.

Additional art of interest includes, for example:

J. Meisenheimer et al., in Chemische Berichte, vol. 39, pp. 2533-2542 (1906) describe the di-amination of 1,3-dinitrobenzene with hydroxylamine under basic conditions to yield 2,4-dinitro-1,3-phenylenediamine. S. Seko in U.S. Patent 5,466,871 extends the work of Meisenheimer by employing O-alkylhydroxylamines to monoaminate substituted nitrobenzene derivatives thereby providing various nitroanilines.

J.A. Hoffman and C.F. McDonough, U.S. Patent 3,278,604 and J.C. Dacons et al., in U.S. Patent 3,394,183 both disclose the preparation of DATB via sulfonation and nitration (2 steps) of 1,3-dimethoxy-2,4,6-trinitrobenzene (DMTNB) which is then aminated to give DATB.

J.G. Kaey and E.F.V. Scriven in Chemical Specialties USA 91 Symposium disclose the regiospecific synthesis of 1-substituted-1,2,4-triazoles using 4-amino-1,2,4-triazole.

None of these references individually or collectively teach or suggest the present invention.

All patents, applications, articles, standards, references, etc., cited in this application and incorporated herein by reference.

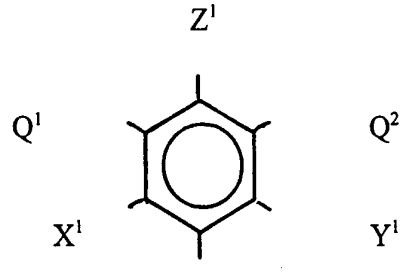
There is a need for new processes which are milder and more environmentally benign to convert aromatic compounds to mono- and/or polyamino aromatic compounds, such as DATB, TATB or mixtures thereof. The present invention provides such useful processes which avoid strong acids (H_2SO_4, HNO_3), avoid elevated temperatures (100-150°C), and avoid the need for noxious materials such as ammonia, thionyl chloride or hydrogen sulfide. The present invention provides useful processes which are also environmentally benign.

SUMMARY OF THE INVENTION

The present invention concerns the monoamination or polyamination of electrophilic aromatic compounds. In particular, the reagents used are 1,1,1-trialkylhydrazinium salts (e.g., halides) or 4-amino-1,2,4-triazole, hydroxylamine or O-alkylhydroxylamine, wherein alkyl is selected from groups having 1 to 10 carbon atoms.

The present invention relates to a process to produce one or more monoamino, diamino or polyamino aromatic compounds, which process comprises:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, a trinitroaromatic starting material compound V:



wherein Q^1, Q^2, Q^3, X^1, Y^1, and Z^1 are each independently selected from the group consisting of -H, $-NO_2$, $-CH_3$, -COOH, $-OCH_3$, and $-NH_2$, with the proviso that at least 1 of Q^1, Q^2, Q^3, X^1, Y^1, and Z^1 is hydrogen,

with (i) an effective amount of quaternary hydrazinium salts, such as 1,1,1,-

trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl, butyl or benzyl and the anion is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, or tetrafluoroborate, or

(ii) 4-amino-1,2,4-triazole, hydroxylamine or O-alkylhydroxylamine wherein alkyl has 1 - 10 carbon atoms;

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB and picramide are formed; and

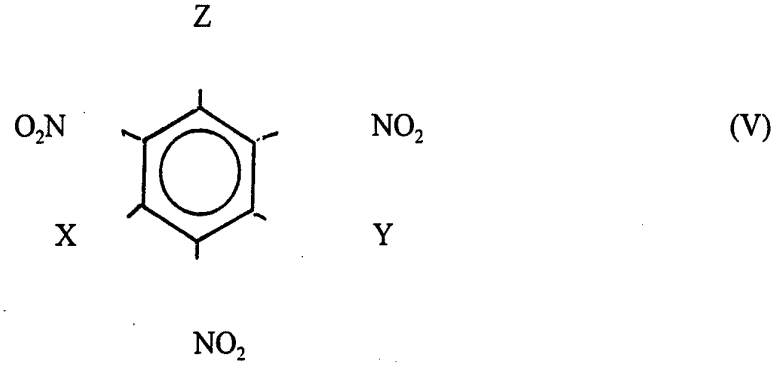
(b) isolating the monoamino, diamino or polyamino aromatic compound produced.

In a preferred embodiment, 4-amino-1,2,4-triazo is used with the proviso that only diamino or polyamino aromatic compounds are produced.

In another preferred embodiment the hydroxylamine and O-alkylhydroxylamine are used with the proviso that only diamino- or polyamino- aromatic compounds are produced.

The present invention also relates to a process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB), 1,3,5-triamino-2,4,6-trinitrobenzene (TATB) or 3,5-diamino-2,4,6-trinitrotoluene (DATNT) by:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, a trinitroaromatic starting material compound:



(V)

wherein X, Y, and Z are each independently selected from the group consisting of -H,

$-CH_3$, and $-NH_2$, with the proviso that at least 1 of X, Y, and Z are hydrogen;

with an amount effective to produce DATB, TATB, or DATNT of 1,1,1-trialkyl hydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl, butyl, or benzyl, and the anion of the salt is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate and the like;

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

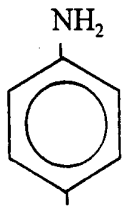
in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB and picramide are formed; and

(b) isolating the DATB, TATB or DATNT produced.

Preferably, X, Y and Z are each independently selected from -H, $-CH_3$, or NH_2.

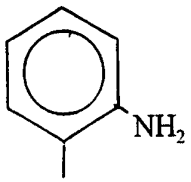
In another aspect, the present invention concerns a process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6-trinitrobenzene (TATB):

(a) by obtaining an aromatic compound of the structure:



(III)

,

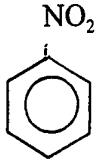


(IV)

or

mixtures thereof from commercial sources or by:

(i) reacting



at a temperature of between about 0 and 50°C for between about 0.1 and 24 hr

with an effective amount of 1,1,1-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl, butyl, or benzyl and the anion of the salt is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate and the like to produce compound III or compound IV;

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, or combinations thereof;

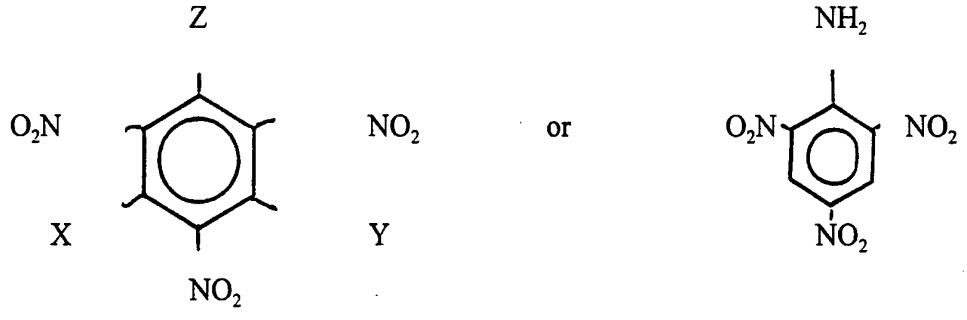
in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulfoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof, and isolating the product which is compound III and/or IV;

(ii) or nitrating aniline using a mixture of nitric acid and sulfuric acid to produce compounds III and IV; or

(iii) nitrating acetanilide using a mixture of nitric acid and sulfuric acid to produce 4-nitroacetanilide and nitrating further using a mixture of nitric acid and sulfuric acid to produce compound VI;

(b) reacting 2-nitroaniline, 4-nitroaniline or combinations thereof with a nitric acid, and sulfuric acid mixture under conditions to produce 2,4,6-trinitroaniline (VI);

(c) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr a trinitroaromatic compound:



(V) (VI)

wherein X, Y, and Z are each independently selected from the group consisting of -H, and -NH_2, with the proviso that at least 1 of X, Y, and Z is hydrogen;

with an effective amount of 1,1,1-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl, butyl, or benzyl, and the anion of the salt is selected from

chloride, bromide iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate and the like.

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof; and

(d) isolating the DATB or TATB produced.

Preferably, DATB is produced when the 1,1,1-trialkylhydrazinium salt is present in between about 1.9 and 2.3 molar equivalents per mole of compound V.

Preferably, starting material is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

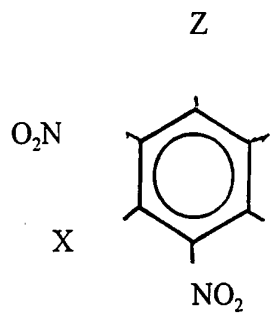
Preferably, the 1,1,1-trialkylhydrazinium salt is 1,1,1-trimethylhydrazinium iodide.

Preferably, the strong base is selected from sodium methoxide or potassium tert-butoxide.

Preferably, the solvents are selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB and picramide are formed.

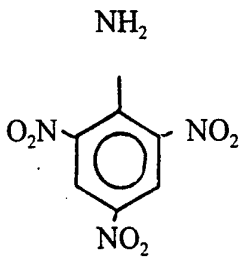
Preferably, TATB is produced when the 1,1,1-trialkylhydrazinium salt is present in between about 3.9 and 5.5 molar equivalents per mole of compound V.

In another embodiment, the present process includes reacting:



(V)

or



(VI)

wherein X, Y, and Z are each independently selected from the group consisting of -H, -CH_3, and -NH_2, with the proviso that at least 1 of X, Y, and Z is hydrogen,

with an effective amount of 1,1,1-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl or butyl and anion is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate, and the like.

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof; and

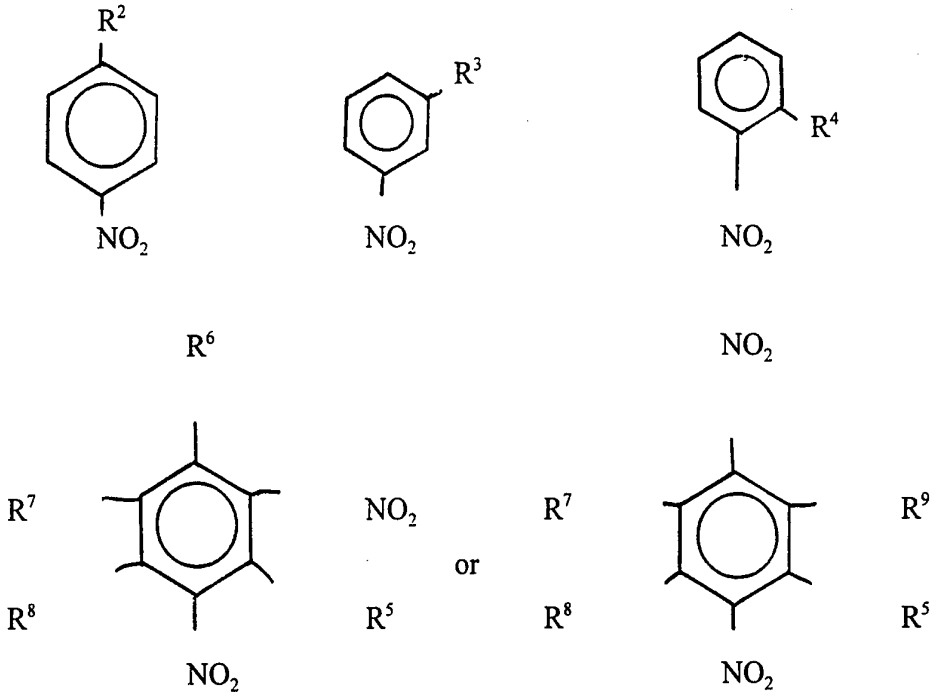
(B) isolating the DATB, or TATB produced.

In another embodiment of the process, the reaction temperature is between about 10 and 30°C.

In another aspect, the present invention concerns a process to produce aminated aromatic compounds, which process comprises:

(A) obtaining an electrophilic aromatic compound which is selected from benzene, naphthalene, quinoline, quinoxaline, pyridine, pyrazine, pyrimidine, pyrazole, imidazole, and the like. The electrophilic aromatic compound may be substituted with one or more electron withdrawing groups, such as -SO_3H, -NO_2, -CN, -CF_3, -COOR, -COR, Cl, Br, -NO_2 and the like which enhance the amination.

Examples from the nitrobenzenes include:



wherein R^2, R^3, and R^4 are each independently selected from -H, -CH_3, -F, -Cl, -Br, -I, -CN, -COOH, -$COOR^{11}$ where R^{11} is C1 to C10 alkyl, or -OCH_3,

and R^5 - R^9 are each independently selected from -H, -CH_3, -F, -Cl, -Br, -I, -CN, -COOH, or -OCH_3 or mixtures thereof;

(B) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr a nitro aromatic compound;

with an effective amount of 1,1-dialkyl-1,2-di-R-(where R=hydrogen, alkyl or aryl) hydrazinium salt wherein dialkyl is selected from methyl, ethyl, propyl, butyl, hexyl, cyclohexyl, (-CH_2 $(CH_2)_n$ CH_2-), -$(CH_2CH_2)O(CH_2CH_2)$-, hexyl, dodecyl, or pyridyl, and n is 1 to 10.

R is selected from H, C1 - C20 alkyl, or aryl, and anion is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate, and the like.

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

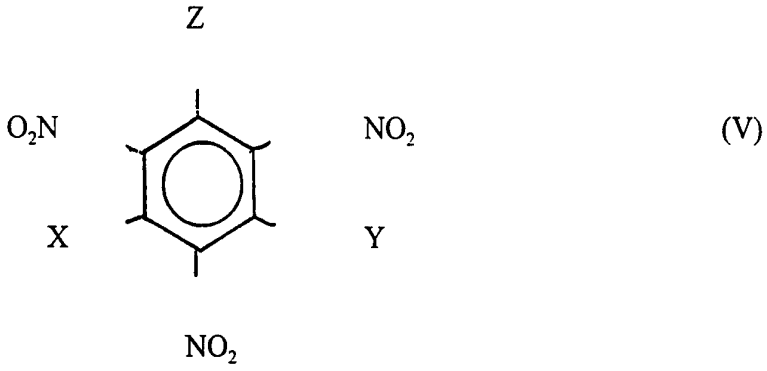
in a solvent selected from the group consisting of methanol, ethanol, propanol,

butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof; and

(c) isolating the monoamino, diamino or triaminosubstituted nitroaromatic compound produced.

In another aspect, the present invention concerns a process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6,-trinitrobenzene (TATB) by:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, a trinitroaromatic compound of structure V:



wherein X, Y, and Z are each independently selected from the group consisting of -H and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen,

with an effective amount of 4-amino-1,2,4-triazole (ATA) to produce DATB or TATB or hydroxylamine or O-alkylhydroxylamine, wherein alkyl has 1 to 10 carbon atoms, to primarily produce DATB;

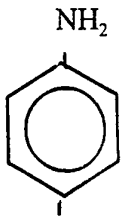
in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present or hydroxylamine or its O-alkyl derivatives replace ATA primarily DATB is formed; and

(b) isolating the DATB or TATB produced.

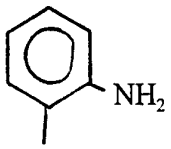
In another aspect, the present invention concerns a process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6,-trinitrobenzene (TATB):

(a) by obtaining an aromatic compound of the structure:



(III)

,

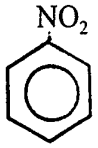


(IV)

or

mixtures thereof from commercial sources or by:

(i) reacting



at a temperature of between about 0 and 50°C for between about 0.1 and 24 hr with an effective amount of ATA, hydroxylamine or O-alkylhydroxylamine to produce mono or diamination,

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

in a solvent selected from the group consisting of dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof, and isolating the product which is compound III;

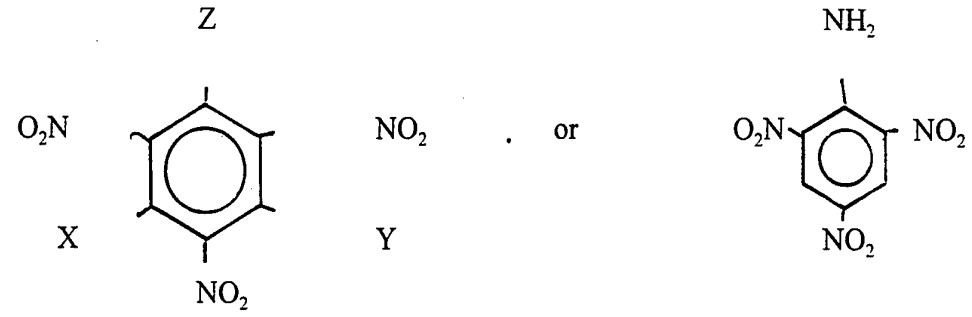
(ii) or nitrating aniline using a mixture of nitric acid and sulfuric acid to produce compounds III and IV; or

(iii) nitrating acetanilide using a mixture of nitric acid and sulfuric acid to produce 4-nitroacetanilide and nitrating further using a mixture of nitric acid and sulfuric acid to produce VI;

(b) reacting 2-nitroaniline, 4-nitroaniline or combinations thereof with a nitric acid, and sulfuric acid mixture under conditions to produce 2,4,6-trinitroaniline (VI);

(c) reacting at ambient pressure and a temperature of between about 0 and

50°C for between about 0.1 and 24 hr a trinitroaromatic compound of the structure:



(V) (VI)

wherein X, Y, and Z are each independently selected from the group consisting of -H and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen;

with an effective amount of 4-amino-1,2,4-triazole, hydroxylamine or O-alkylhydroxylamine wherein alkyl contains 1 to 10 carbon atoms;

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof, with the proviso that when alcohol is present or hydroxylamine and its O-alkyl derivatives replace ATA, primarily DATB is produced; and

(d) isolating the DATB or TATB produced.

Preferably, DATB is produced when ATA, hydroxyl amine or O-alkylhydroxylamine is present in between about 1.9 and 2.3 molar equivalents per mole of compound V.

Preferably, structure V is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

Preferably, the strong base is selected from sodium methoxide or potassium tert-butoxide.

Preferably, the solvents are selected from methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols

are present or hydroxylamine and its O-alkyl derivatives replace ATA, primarily DATB and picramide are formed.

Preferably, TATB is produced when ATA is present in between about 3.9 and 5.5 molar equivalents per mole of starting compound V.

Preferably, in all embodiments described herein, 4-amino-1,2,4-triazole, hydroxylamine, or O-alkylhydroxylamine are used with the proviso that diamino or polyamino aromatic compounds are produced.

DETAILED DESCRIPTION OF THE INVENTION AND PREFERRED EMBODIMENTS

Definitions

As used herein for amination of aromatic compounds using the reagents described herein:

"Alkyl" refers to alkyl groups, having 1 to 10 carbon atoms and includes alkylaryl groups such as benzyl or ethylenephenyl (-CH_2CH_2-phenyl).

"Aromatic compound" refers to any organic compound which has a conjugated ring structure and exhibits aromatic structure properties. It includes carbocyclic structures where only carbon atoms are present having substituents which include any electron withdrawing group recited herein. It includes heterocyclic aromatic compounds as defined herein.

"ATA" refers to 4-amino-1,2,4-triazole.

"DMF" refers to dimethylformamide.

"DMAC" refers to dimethylacetamide.

"DATB" refers to 1,3-diamino-2,4,6-trinitrobenzene.

"DMSO" refers to dimethylsulphoxide.

"Heterocyclic aromatic compound" refers to any organic compound which as a conjugated ring structure, has at least one heteroatom in the ring, e.g., N, O, S, etc. and exhibits aromatic structure properties. Nitrogen containing rings are preferred.

"HMPA" refers to hexamethylphosphoramide.

"NB" refers to nitrobenzene.

"NMP" refers to N-methypyrrolidone.

"NT" refers to nitrotoluene.

"Picramide" or "TNA" refers to 1-amino-2,4,6-trinitrobenzene.

"Salt" refers to the anions described herein. Halide is preferred.

"TATB" refers to 1,3,5-triamino-2,4,6-trinitrobenzene.

"TAHI" refers to trialkylhydrazium iodide.

"TMHI" refers to triamethylhydrazinium iodide.

"TNA" refers to 1-amino-2,4,6-trinitrobenzene.

"TNB" refers to 1,3,5-trinitrobenzene.

"TNT" refers to 2,4,6-trinitrotoluene.

"DATNT" refers to 3,5-diamino-2,4,6-trinitrontoluene.

The present invention includes the preparation of monoamino-, diamino-, or polyamino- aromatic compounds, e.g., DATB, TATB, and DATNT. TATB is also useful in the preparation of liquid crystals.

In the present invention, the starting material, an electrophilic aromatic compound, e.g., a mononitrated, dinitrated or trinitrated aromatic compound or heterocyclic compound, is contacted with strong base in the presence of a solvent at between about 0 and 50°C and ambient pressure for between about 0.1 and 24 hr, preferably between about 1 and 5 hr. Preferably, the temperature is between about 10 and 30°C, and more preferably about ambient temperature (i.e. 20°C). The electrophilic aromatic compound is reacted with 1,1,1-trialkylhydrazinium salt to provide amino-substituted aromatic compounds by VNS.

The reaction conditions for the VNS of specific aromatic substrates are described herein below for DATB and/or TATB. Examples include the conversion of 3-substituted nitrobenzenes to the corresponding nitroanilines, and conversion of trinitroarenes to the corresponding polyaminotrinitroarenes.

Chemical and Engineering News, May 8, 1995, p. 21 discloses that the Defense Nuclear Agency has given a contract to Thiokol Corp. to dispose of liquid propellant dimethyl hydrazine (fuel from Russian intercontinental ballistic missiles and the starting material for trimethylhydrazinium salts) by converting the fuel into commercial commodity chemicals. Also see H.H. Szmant, Organic Building Blocks of the Chemical Industry, John Wiley and Sons, New York, 1989, p. 83.

G.M. Omietanski et al., Journal of the American Chemical Society, vol. 78, p. 1211-1213 (1956), disclose the preparation of alkyl and cycloalkyl hydrazinium chlorides. O. Westphal, in Chem. Ber., vol. 74, 759ff (1941), disclose a preparation of quaternized

hydrazines.

The extent of the amination of carbocyclic aromatic compounds or heterocyclic aromatic compounds using the 1,1,1-trialkylhydrazinium salt is normally controlled by one of skill in the art by judicious choice of temperature, time, solvents, strong base and amount of 1,1,1-trialkylhydrazinium salt. Alcohol solvents usually limit the reaction to production of nitroaromatic compounds, such as DATB and picramide, because alcohols appear to slow or stop complete amination. The amount of reagent is also important to produce DATB, i.e. between about 1.9 and 2.3 molar equivalents per mole of structure V, preferably about 2.1 eq.

Solvents - In the present invention, solvents which are preferred include aliphatic alcohols having 1-6 carbon atoms (all isomers), cycloalkyl alcohols having 1-6 carbon atoms and the like. Useful dipolar aprotic solvents include, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, diethylformamide, dimethylacetamide and the like. The solvent may also include diluents (benzene, chloroform) as needed to optimize conditions and product yields. Mixtures of solvents are also claimed.

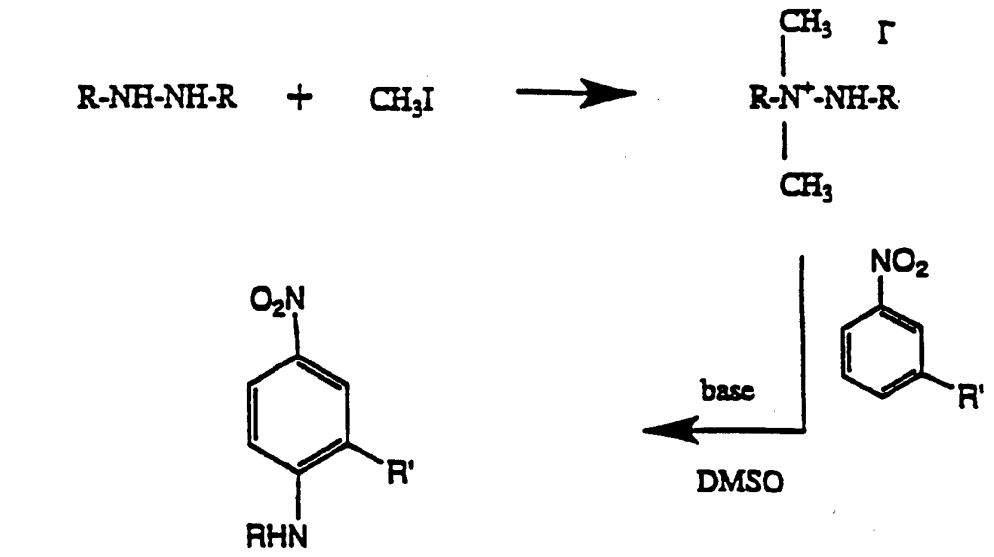
Strong Bases - In the present invention, strong bases are usually the alkali metal salts of alcohols. Alcohols having 1-15 carbon atoms are preferred, more preferred are alcohols having 1-10 carbon atoms, and most preferably are alcohols having 1-6 carbon atoms. Especially preferred alcohols include methanol, ethanol, propanol, (n- or iso-) and butanol (n-, iso-, sec-, or tert-).

This methodology is extended to the introduction of alkyl- or aryl-substituted amines to electrophilic aromatic and heteroaromatic rings. This may be accomplished by reaction of the electrophilic aromatic ring with a 1,1-dialkyl-1,2-di-R (R=alkyl or aryl) hydrazinium salt in DMSO in the presence of base.

The 1,1-dialkyl-1,2-di-R (R=alkyl or aryl) hydrazinium salt is synthesized by two general methods:

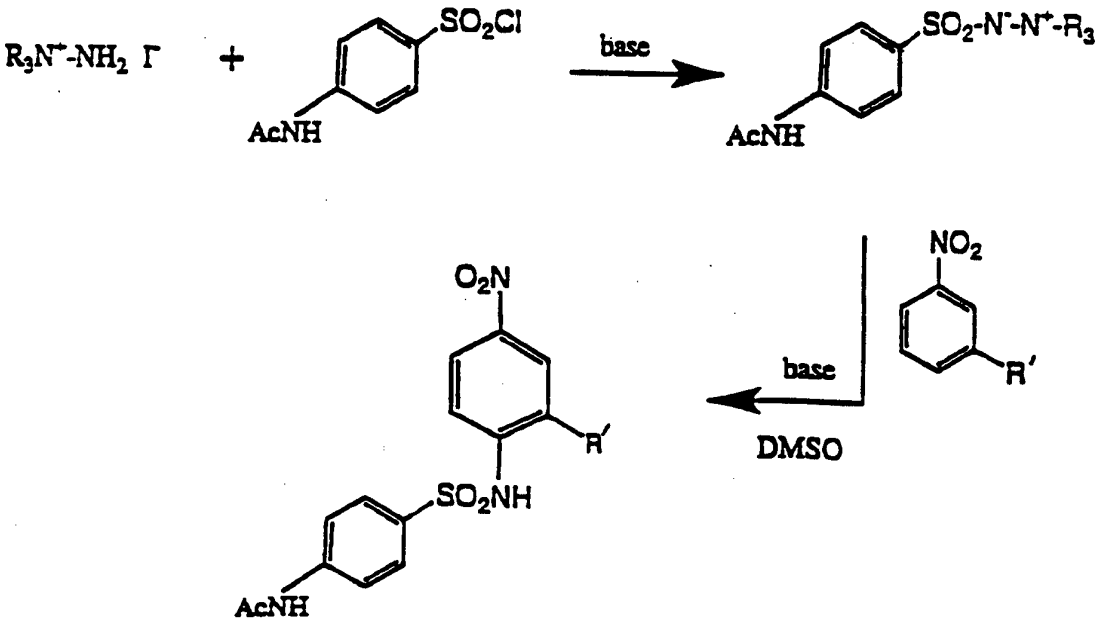
1. The reaction of a symmetrical hydrazine bearing an alkyl or aryl radical with methyl iodide produces a 1,1-dimethyl-1,2-dialkyl (or aryl) hydrazinium iodide. The identity of the substituted amine which is transferred in the VNS reaction is determined by the selection of the R- group on the symmetrical hydrazine starting material.

Therefore:



(see O. Westphal, Chem. Ber., (1941), 1362).

2. The reaction of a trialkylhydrazinium salt with an alkyl or acyl halide in the presence of base yields a 1,1,1-trialkyl-2-(R)-hydrazinium halide or the corresponding ylide. Therefore:



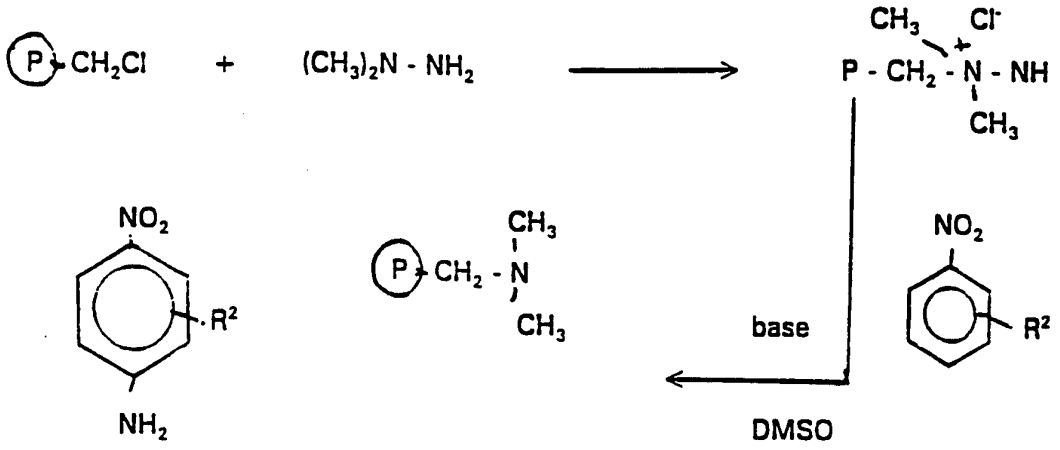
(see J.N. Ashley, et al., J. Chemical Soc., (1947), p. 60).

The VNS reaction is applied to substituted aromatics bearing at least one electron-

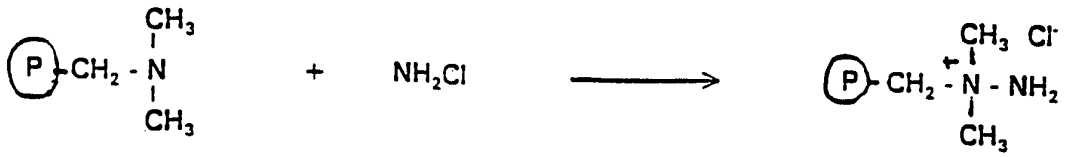
withdrawing group, e.g., a nitro-group. The aromatics include heterocycles such as substituted and unsubstituted pyridine, pyrimidine, pyrazine, quinoline, quinoxaline, imidazole, triazole and pyrazole.

The use of 1,1,1-triakylhydrazinium salts and 1,1-dialkyl-1,2-di-R (R=alkyl or aryl) hydrazinium salts, e.g., halides as VNS reagents to add amino-groups to electrophilic aromatic rings have not yet been described. The general utility of these reagents to add amino groups to electrophilic aromatic compounds is also claimed.

3. This methodology is extended to synthesis of polymeric VNS reagents for the introduction of amino groups onto electrophilic aromatic rings. Thus, chloromethyl-substituted polystyrene is reacted with 1,1-dimethylhydrazine to yield a polymeric 1,1,1-trialkylhydrazinium chloride which is used in VNS reactions to introduce amino-groups onto electrophilic aromatic rings.



The spent polymeric VNS reagent is then regenerated by reaction with chloramine.



(see G.M. Omietanski, et al., J. Chemical Society, (1956), p. 1211-13).

In the present invention, the starting material, e.g. trinitrated benzene structure is

contacted with strong base in the presence of one or more solvents at between about 0 and 50°C and ambient pressure for between about 0.1 and 24 hr, preferably between about 1 and 12 hr, more preferably between about 1 and 5 hr. Preferably, the temperature is between about 10 and 30°C, and more preferably about ambient temperature (i.e. about 20°C). The trinitrated aromatic compound is reacted with ATA.

The extent of the amination using 4-amino-1,2,4-triazole is normally controlled by one of skill in the art by judicious choice of temperature, time, solvents, strong base and amount of ATA. The amount of ATA reagent is also important to produce DATB, i.e. between about 1.9 and 2.3 molar equivalents per mole of structure V, preferably about 2.1 eq.

Hydroxylamine and its O-alkyl derivatives are also used to replace a stoichiometrically equivalent amount of ATA, and these reagents produce primarily DATB.

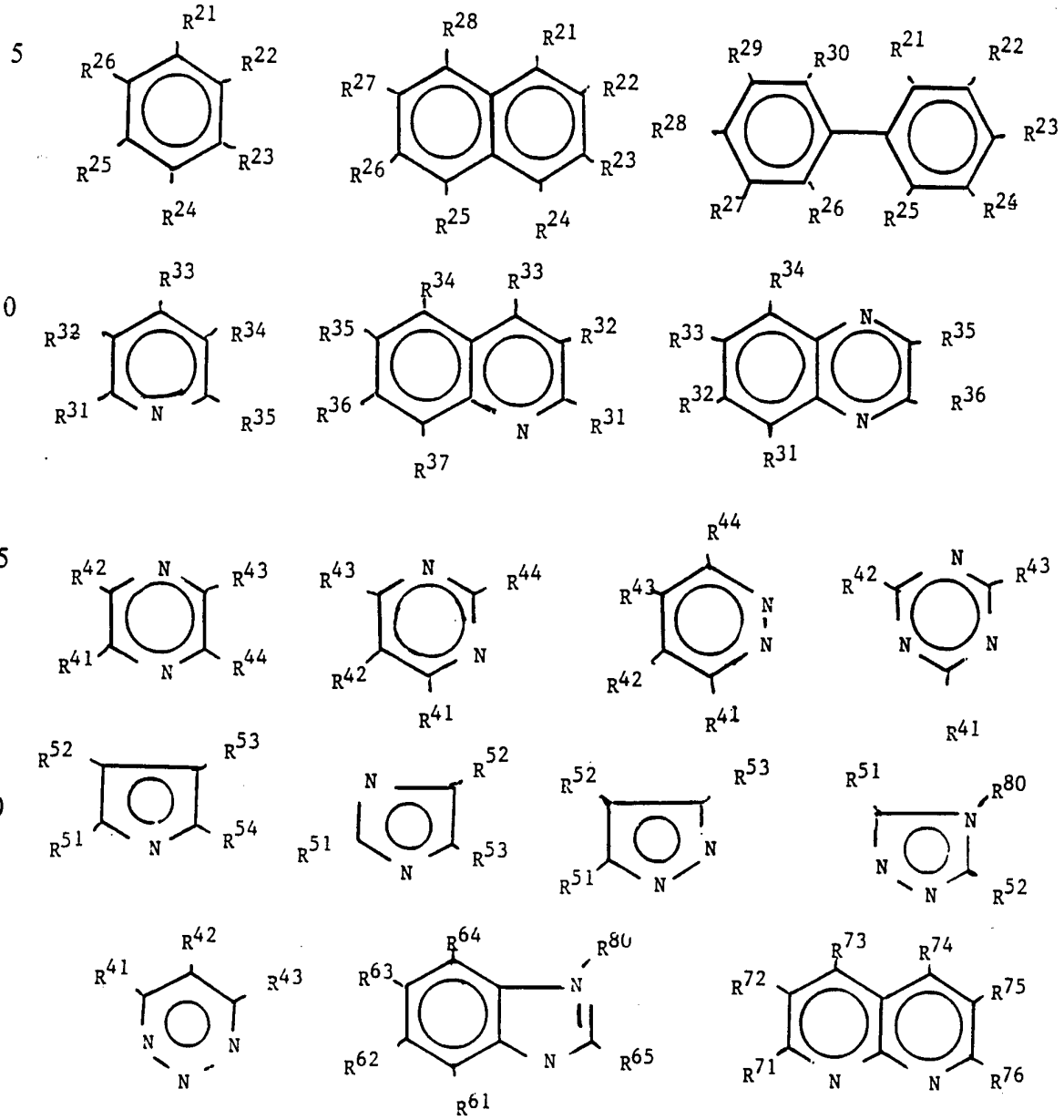
In the present invention, the starting material, an electrophic aromatic compound, such as a trinitrated benzene structure, is contacted with strong base in the presence of one or more solvents at between about 0 and 50°C and ambient pressure for between about 0.1 and 24 hr, preferably between about 1 and 12 hr, more preferably between about 1 and 5 hr. Preferably, the temperature is between about 10 and 30°C, and more preferably about ambient temperature (i.e. about 20°C). The electrophilic aromatic compound is reacted with ATA.

A. Katritzky et al., Journal of Organic Chemistry, vol. 51, pp. 5039-5040 (1986) disclose the use of 4-amino-1,2,4-triazole (ATA) for direct mono-amination of a substituted mononitrobenzene. There is no teaching or suggestion to use ATA for the multiple amination of nitro benzenes having two or more nitro substituents.

The extent of the amination using 1-amino-1,2,4-triazole is normally controlled by judicious choice of temperature, time, solvents, strong base and amount of ATA. The amount of ATA reagent is also important to produce DATB, i.e. between about 1.9 and 2.3 molar equivalents per mole of structure V, preferably about 2.1 eq.

Hydroxylamine and its O-alkyl derivatives are also used to replace a stoichiometrically equivalent amount of ATA, and they produce primarily DATB.

Aromatic structures produced by the present invention include, but are not limited to:



for benzene at least one of R^{21} to R^{26} is an electron withdrawing group, and at one of R^{21} to R^{26} is an amino group;

for pyridine at least one of R^{31} to R^{35} is an electron withdrawing group, and of R^{31} to R^{35} is an amino group; and

for naphthalene, at least one of R^{21} to R^{28} is an electron withdrawing group, and

at least one of R^{21} to R^{28} is an amino group;

for biphenyl, at least one of R^{21} to R^{30} is an electron withdrawing group, and at least one on one of R^{21} to R^{30} is amine, an amino group;

for quinoline, at least one of R^{31} to R^{37} is an electron withdrawing group, and at least one of R^{31} to R^{37} is an amino group;

for 1,4- quinoxaline at least one of R^{31} to R^{36} is an electron withdrawing group, and at least one of R^{31} to R^{36} is an amino group;

for the diamino six-membered rings, at least one of R^{41} to R^{44} is an electron withdrawing group, and at least one of R^{41} to R^{44} is an amino group;

for the six-membered rings containing three nitrogen atoms, at least one of R^{41} to R^{43} is an electron withdrawing group, and at least one on R^{41} to R^{43} is an amino group; and

for the five-membered heterocyclic rings containing one, two, or three nitrogens, at least one of R^{51} to R^{54} is an electron withdrawing group, and at lest one of R^{51} to R^{54} is an amino group,

for indole at lest one of R^{61} to R^{65} is an electron withdrawing group, and at least one of R^{61} to R^{65} is an amino group;

for fused pyridine have two six-membered rings, at least one of R^{71} to R^{76} is an electron withdrawing group, and at least one of R^{11} to R^{76} is an amino group;

wherein R^{80} is alkyl having 1 to 6 carbon atoms;

wherein the electron withdrawing group is selected from -CN, -NO_2, -COR, -CO_2R_1, -$CONR_2$, -SO_2R, -SO_3H, -CF_3, -F, -Cl, -Br, -I and -NH_2, where R_1 and R_2 are C^1 to C^6 alkyl.

Other substituents may be selected from either electron-withdrawing or electron-donating substituents and may be selected from but not restricted to the following: -NO_2, -CN, -CO_2R, -SO_2R, -CF_3, -F, -Cl, -Br, -I, -COR, -$CONR_2$, -OR, - SR, -alky, -aryl, -heteromatic, -SO_3H.

If the electrophilic aromatic compound contains more than one electron withdrawing group, then the number of amino groups which may be added to the ring may equal the number of electron withdrawing groups.

Solvents - In the present invention, solvents which are preferred include dipolar aprotic solvents including, but not limited to, dimethylsulphoxide N-methylpyrrolidone,

hexamethylphosphoramide, dimethylformamide, diethylformamide, dimethylacetamide and the like. The solvent may also include diluents (benzene, chloroform) as needed to optimize conditions and product yields. Mixtures of solvents are also included.

General

Picramide is obtained from commercial sources or prepared according to E.Y. Spencer et al., Canadian Journal Research, vol. 24B, pp. 204-207 (1946).

1,3,5-Trinitrobenzene is obtained from commercial sources or prepared according to Organic Synthesis.

2,4,6-Trinitrotoluene is obtained from commercial sources or is prepared according to any literature source.

DMSO is dried and stored over 4A molecular sieves.

4-Amino-1,2,4-triazole (ATA) is commercially available from Reilly Industries, Inc., 1500 South Tibbs Avenue, Indianapolis, IN 46242-0912.

The reactions were performed in TEFLON® capped reaction vessels or reaction vessels equipped with drying tubes containing anhydrous calcium sulfate to protect VNS reactions from atmospheric moisture.

The following Examples are to explain and describe the invention. They are not to be construed to be limiting in any way.

EXAMPLE 1

PREPARATION OF 1,1,1-TRIMETHYLHYDRAZINIUM IODIDE (TMHI)

(a) 1,1-Dimethylhydrazine (5.1 ml, 67 mmol) is dissolved in 60 ml of tetrahydrofuran (THF). Methyl iodide (4 ml, 67 mmol) is added with ice-bath cooling and mechanical stirring. The resulting slurry is diluted with THF to facilitate stirring. The reaction mixture is stirred at ambient temperature for 2 hr, and a white solid is collected by filtration. Recrystallisation from ethanol (100 ml) yields 11.6 g of TMHI (86%) as white plates; m.p. 230-232°C (softening at 223°C); ^{1}H-nmr (D_2O) δ 3.42 (-CH_3), 4.55 ppm (NH_2 exchangeable).

(b) Similarly, Example 1(a) is repeated except that 1,1-dimethylhydrazine is replaced by a stoichiometrically equivalent amount of 1,2-di-R (where R=alkyl or aryl) hydrazine and a similar amount of 1,1,-dimethyl-1,2-di-R-hydrazinium iodide is produced.

(c) Similarly, when Example 1(a) is repeated except that methiodide is

replaced by a stoichiometrically equivalent amount of ethyl chloride and reacted with 1,1-diethylhydrazine to produce a similar amount of 1,1,1-triethylhydrazinium chloride.

EXAMPLE 2

PREPARATION OF DATB FROM PICRAMIDE

(a) Picramide (0.30 g, 1.3 mmol) and TMHI (0.56 g, 2.8 mmol) are dissolved in 10 ml of dry dimethylsulphoxide (DMSO) with protection from atmospheric moisture. Sodium methoxide (0.31 g, 5.7 mmol) is added in one portion with stirring and the resulting red slurry is stirred at ambient temperature for 3 hr. The reaction mixture is poured into ice water (25 ml) and acidified to pH 4 with hydrochloric acid. The product is collected by filtration, washed with water and dried to yield 0.24 g (75%) of beige-yellow solid. The IR spectra for this material and a reference sample of DATB are identical.

(b) Similarly, Example 2(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium chloride, and a similar amount of DATB is produced.

(c) Similarly, when Example 2(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of methanol, ethanol n-propanol, iso-propanol or normal butanol, and the base is sodium methoxide, sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide, a mixture of picramide and DATB is produced. The DATB is purified by crystallization from DMF or DMSO.

EXAMPLE 3

PREPARATION OF TATB FROM PICRAMIDE

(a) Picramide (1.00 g, 4.38 mmol) and TMHI (3.54 g, 17.5 mmol) are dissolved in dry DMSO (34 ml). Sodium methoxide (1.89 g, 35.0 mmol) is added in one portion and the resulting red slurry is stirred for 16 hr at ambient temperature under a dry atmosphere. The reaction mixture is poured into ice water and acidified to pH 4 with concentrated hydrochloric acid. The resulting precipitate is collected, and washed with water (20 ml) and acetone (10 ml) to yield 1.07 g (95%) of beige-yellow powder; m.p. 355°C with decomposition. The IR spectra for this material and TATB are identical.

(b) Similarly, Example 3(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium chloride, and a similar amount of TATB is produced.

(c) Similarly, when Example 3(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of DMF, or DMAC, and sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of TATB is produced.

EXAMPLE 4

PREPARATION OF DATB FROM TNB

(a) DMSO (5 ml) is added with rapid stirring to a mixture of TNB (0.148 g, 0.695 mmol), TMHI (1.03 g, 5.10 mmol) and sodium methoxide (0.609 g, 11.3 mmol). The dark brown suspension is stirred at ambient temperature for 2 hr. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is collected, washed with water and dried to give 0.148 g (61%) of a dark orange solid. The IR spectra for this material and DATB are identical.

(b) Similarly, Example 4(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium chloride, and a similar amount of DATB is produced.

(c) Similarly, when Example 4(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of DMF or DMAC and sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or sodium tert-butoxide respectively, a mixture of picramide and DATB is produced. The DATB is purified by crystallization from DMF and DMSO.

EXAMPLE 5

PREPARATION OF TATB FROM TNB

(a) TNB (0.148 g, 0.693 mmol) and TMHI (1.03 g, 5.10 mmol) are dissolved in DMSO (10 ml) prior to the addition of sodium methoxide (0.600 g, 11.1 mmol). The dark brown suspension is stirred for 20 hr at ambient temperature. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is washed with water and dried to give 0.158 g (61%) of a light brown powder having the IR spectrum of TATB.

(b) Similarly, Example 5(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium

chloride, and a similar amount of TATB is produced.

(c) Similarly, when Example 5(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of DMF, DMAC, and sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of TATB is produced.

EXAMPLE 6

PREPARATION OF NITROANILINES FROM NITROBENZENE

(a) Nitrobenzene (0.133 ml, 1.29 mmol) and TMHI (0.283 g, 1.40 mmol) are dissolved in 7 ml DMSO. Potassium tert-butoxide (0.348 g, 3.10 mmol) is added in one portion and the resulting dark red-orange solution is stirred for 4 hr at ambient temperature. The reaction mixture is poured over 5g ice, acidified with 10% hydrochloric acid and stirred for 0.5 hr. The resulting solution is extracted with ethyl acetate (3x20 ml). The combined organic layers are washed with water, dried ($MgSO_4$) and evaporated. The resulting brown solid is chromatographed using silica gel eluted with, 9:1 petroleum ether-acetone to yield 0.096 g o-nitroaniline and 0.062 g p-nitroaniline (0.158 g total, 86% overall yield) in the relative isomer ratio of 61:39.

(b) Similarly, Example 6(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium chloride, and a similar amount of nitroanilines are produced.

(c) Similarly, when Example 6(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of DMF or DMAC, and potassium tert-butoxide is replaced by a stoichiometrically equivalent amount of sodium methoxide, sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or sodium tert-butoxide respectively, a similar amount of nitroanilines are produced.

EXAMPLE 7

AMINATION OF 3-SUBSTITUTED NITROBENZENES WITH TMHI

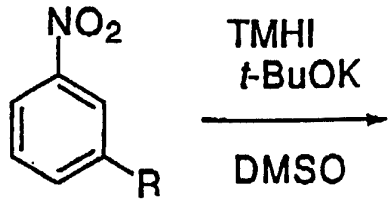
TMHI is reacted with the same 3- substituted nitrobenzene substrates used with 4-amino-1,2,4-triazole (ATA) as reported by A.R. Katritzky and K.S. Laurenzo, Journal of Organic Chemistry, vol. 51, pp. 5039-5040 (1986). The nitroaromatic substrate (1.3 mmol) and TMHI (1.4 - 1.9 mmol) are dissolved in dry DMSO (7 ml), and solid

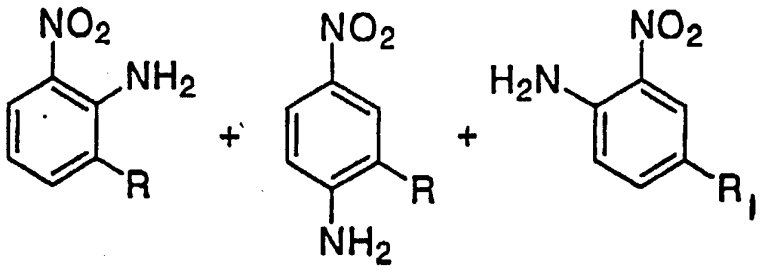
alkoxide (sodium methoxide or potassium tert-butoxide) is added with stirring. The solution immediately becomes nearly black in color. After 4-17 hr of stirring at room temperature, the reaction is quenched with 10% HCl. Precipitated solids are collected by filtration and washed with cold water. The filtrate is extracted with ethyl acetate and the crude products obtained upon evaporation of the solvent are subjected to chromatography on silica. The identity of all products is confirmed by comparison of melting points and/or ^{1}H NMR with authentic standards. The results are summarized in Table I.

Table I shows that TMHI is not as selective as ATA, producing in most cases multiple regioisomeric products. TMHI displays a tendency to aminate in the 2-position which contrasts with exclusive 4-amination in the case of ATA. The very high reactivity of TMHI is of interest and with m-dinitrobenzene diamination takes place even under stoichiometric conditions.

TABLE 1

Amination of 3-Substituted Nitrobenzenes





a b c

compd	R	% yield	isomer ratios		
			a	b	c
2	H	85	61	39	(na)
3	CH_3	84	38	35	27
4	Cl	82	32	49	19
5	COOH	95	0	71	29
6	OCH_3	66	90	10	0
7	F	84	45	47	8
8	I	76	45	38	17
9	CN	41	20	44	36

EXAMPLE 8

PREPARATION OF DIAMINO-TNT (DATNT) FROM TNT

(a) TNT (0.227 g, 1.00 mmol) and TMHI (1.03 g, 5.10 mmol) are dissolved in DMSO (10 ml). Sodium methoxide (0.600 g, 11.1 mmol) is added in one portion with stirring. The dark brown suspension is stirred for 23 hr at ambient temperature. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml) and stirred for 20 minutes prior to the collection of precipitate. The product is washed with water and dried to give 0.212 g (82%) of DATNT as a dark, olive green solid; ^{1}H-nmr (DMSO - d_6) δ 8.08 (br s, 4, NH_2) and 2.18 (s,3,$ArCH_3$).

(b) Similarly, Example 8(a) is repeated except that 1,1,1-trimethylhydrazinium iodide is replaced by a stoichiometrically equivalent amount of 1,1,1-triethylhydrazinium chloride, and a similar amount of DATNT is produced.

(c) Similarly, when Example 5(a) is repeated except that DMSO is replaced by a volumetrically equivalent amount of DMF or DMAC, and sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of DATNT is produced.

EXAMPLE 9

PREPARATION OF DATB FROM PICRAMIDE USING HYDROXYLAMINE

(a) Hydroxylamine hydrochloride (0.709 g, 10.2 mmol) and picramide (0.477 g, 2.09 mmol) are dissolved in 17 ml DMSO. Sodium methoxide (1.28 g, 23.6 mmol) in methanol (5.40 ml) is added with stirring, and the resulting brown suspension is stirred at ambient temperature for 4 hr. The reaction mixture is poured into 200 ml of saturated aqueous ammonium chloride. The product is collected by filtration, washed with water and cold acetone to yield 0.139 g (27%) of a yellow solid. The IR spectra for this material and DATB are identical.

(b) Similarly, when Example 9(a) is repeated except that methanol is replaced by a volumetrically equivalent amount of ethanol, n-propanol, iso-propanol or tert-butanol, and sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or sodium tert-butoxide respectively, a similar amount of DATB is produced.

EXAMPLE 10

PREPARATION OF DATB FROM PICRAMIDE USING O-METHYLHYDROXYLAMINE

(a) DMSO (10 ml) is added with rapid stirring to a mixture of picramide (0.477 g, 2.09 mmol), O-methylhydroxylamine hydrochloride (0.709 g, 10.2 mmol) and sodium methoxide (1.27 g, 23.6 mmol). The dark brown suspension is stirred at ambient temperature for 2 hr. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is collected, washed with water and dried to yield 0.454 g (89%) of a yellow solid. The IR spectra for this material and DATB are identical.

(b) Similarly, when Example 10(a) is repeated except that sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of DATB is produced.

EXAMPLE 11

PREPARATION OF DATB FROM PICRAMIDE USING O-BENZYLHYDROXYLAMINE

(a) DMSO (15 ml) is added with rapid stirring to a mixture of picramide (0.477 g, 2.09 mmol), O-benzylhydroxylamine (1.64 g, 10.3 mmol) and sodium methoxide (1.91 g, 35.4 mmol). The brown suspension is stirred at ambient temperature for 15 hr. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is collected, washed with water and dried to yield 0.444 g (87%) of DATB.

(b) Similarly, when Example 11(a) is repeated except sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of DATB is produced.

EXAMPLE 12

PREPARATION OF TATB FROM TNB USING ATA

(a) A suspension of sodium methoxide (1.19 g, 22.2 mmol) in DMSO (15 ml) is added to a solution of TNB (0.296 g, 1.39 mmol) and ATA (0.853 g, 10.2 mmol) in 4 ml DMSO with rapid stirring. The brown suspension is stirred for 2 hr at ambient

temperature. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is collected, washed with water and dried to yield 0.353 g (98%) of a yellow solid. The IR spectra for this material and TATB are identical.

(b) Similarly, when Example 12(a) is repeated except sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of TATB is produced.

EXAMPLE 13

PREPARATION OF TATB FROM DATB USING ATA

(a) Sodium methoxide (0.600 g, 11.1 mmol) is added to a solution of DATB (0.25 g, 1.05 mmol) and ATA (0.429 g, 5.10 mmol) in 15 ml DMSO. The reddish brown suspension is stirred for 2.5 hr at ambient temperature. The reaction mixture is poured into cold 0.12 N aqueous HCl (200 ml). The resulting precipitate is collected, washed with water and dried to yield 0.270 g (100%) of TATB.

(b) Similarly, when Example 13(a) is repeated except sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of TATB is produced.

EXAMPLE 14

PREPARATION OF TATB FROM PICRAMIDE USING ATA

(a) Sodium methoxide (1.19 g, 22.0 mmol) is added to a solution of picramide (0.228 g, 1.00 mmol) and ATA (0.841 g, 10.0 mmol) in 15 ml DMSO. The reddish orange suspension is stirred for 3 hr at ambient temperature. The reaction mixture is poured into cold 0.12 N aqueous HCl. The resulting precipitate is collected, washed with water and dried to yield 0.236 g (91%) of TATB.

(b) Similarly, when Example 14(a) is repeated except sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of TATB is produced.

EXAMPLE 15

PREPARATION OF DIAMINO-TNT (DATNT) FROM TNT

(a) A suspension of sodium methoxide (1.19 g, 22.2 mmol) in 13 ml DMSO is added to a solution of TNT (0.476 g, 2.10 mmol) and ATA (0.853 g, 10.2 mmol) in 4 ml DMSO. The brown suspension is stirred for 3 hr at ambient temperature and then poured into a saturated aqueous solution of ammonium chloride (200 ml). A deep yellow solid is collected, washed with water and dried to give 0.337 g (62%) of DATNT: ^{1}H-nmr ($CDCl_3$ + DMSO - d_6) δ 8.44 (br, s, 4, NH_2) and 2.35 (s, 3, $ArCH_3$).

(b) Similarly, when Example 15(a) is repeated except sodium methoxide is replaced by a stoichiometrically equivalent amount of sodium ethoxide, sodium n-propoxide, sodium isopropoxide, or potassium tert-butoxide respectively, a similar amount of DATNT is produced.

EXAMPLE 16

SYNTHESIS OF AMINOHETEROCYCLIC COMPOUNDS

(a) Example 2(a) is repeated except that the picramide is replaced by a stoicheometrically equivalent amount of mononitro- or dinitro- pyridine. The corresponding monoamino and diamino nitro pyridine is produced.

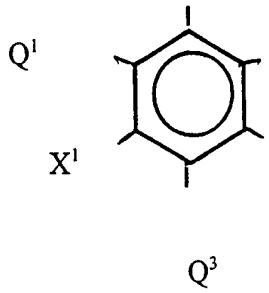
(b) Example 2(a) is repeated except that the picramide is replaced by a stoicheometrically equivalent amount of mononitro or dinitropyrazole and the corresponding monoamino and diamino-nitropyrazole is produced.

While only a few embodiments of the present invention have been shown and described herein, it is apparent to those skilled in the art that various modifications and changes can be made in these novel vicarious nucleophilic substitution processes of monoamination and/or polyamination of electrophilic aromatic compounds, using for example 1,1,1-trialkyl hydrazinium salts or 4-amino-1,2,4-triazole to produce amine compounds, such as DATB or TATB, without departing from the spirit and scope of the present invention. All such modifications and changes coming within the scope of the appended claims are intended to be covered thereby.

We Claim:

1. (Amended) A process to produce a mono amino, diamino or polyamino aromatic compound, which process comprises:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, an electrophilic aromatic compound:



(V)

wherein Q^1, Q^2, Q^3, X, Y, and Z are each independently selected from a variety of electron withdrawing groups, including but not restricted to -CN, $-NO_2$, -COR, $-CO_2R_1$, $-CONR_2$, $-SO_2R$, $-SO_3H$, $-CF_3$, -F, -Cl, -Br, -I and $-NH_2$, with the proviso that at least 1 of Q^1, Q^2, Q^3, X^1, Y^1, and Z^1 is hydrogen,

with an effective amount of reagent selected from:

(i) 1,1,1,-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl, butyl or benzyl and the anion is selected from chloride, bromide, iodide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrafluoroborate, and the like.

(ii) hydroxylamine,

(iii) O-alkyl hydroxyl amine where alkyl is C_1 to C_{10} carbon atoms, or

(v) 4-amino-1,2,4-triazole;

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

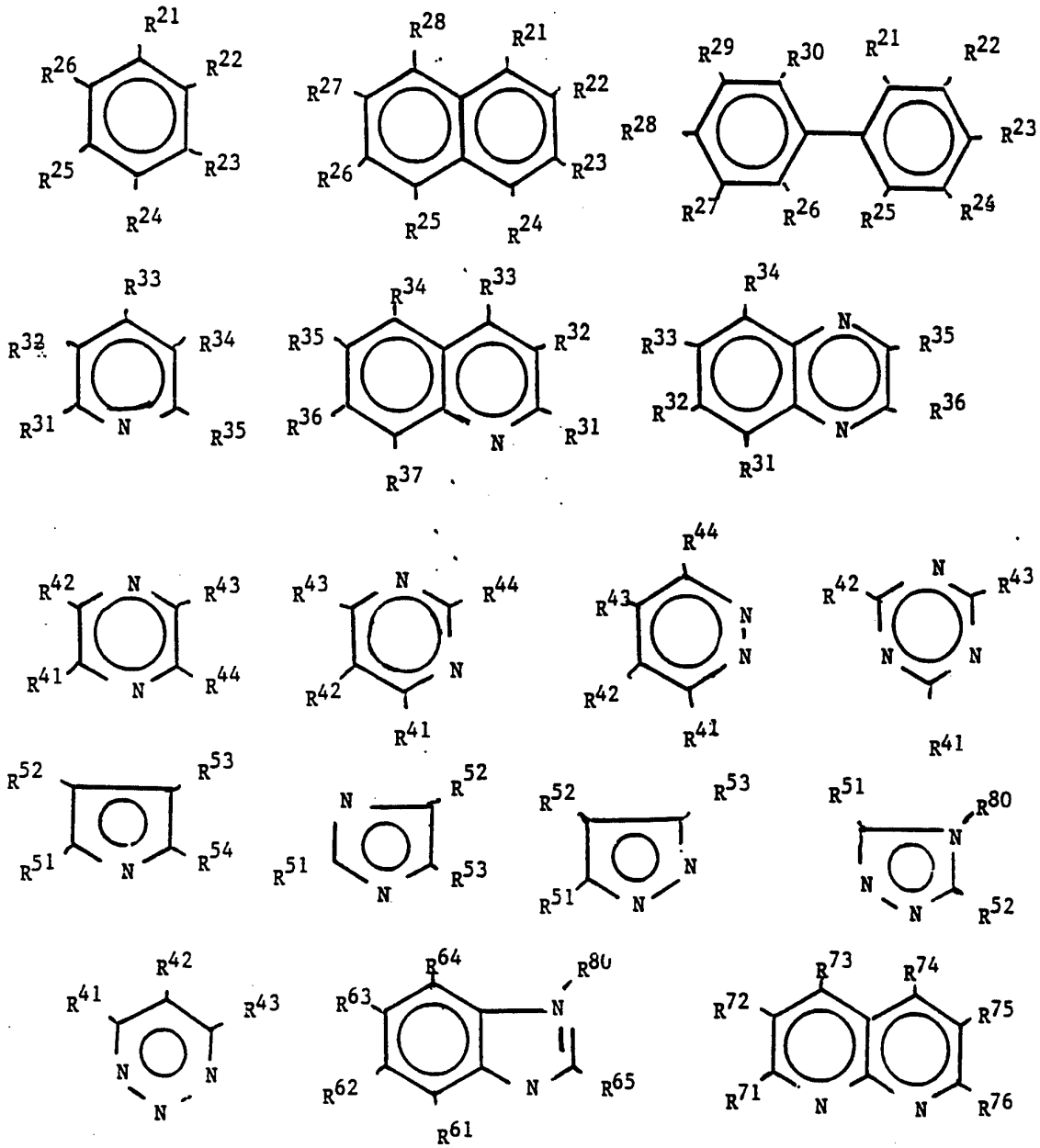
in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylforamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB and picramide are formed; and

(b) isolating the monoamino, diamino or polyamino aromatic compound produced.

2. The process of Claim 1 wherein the reaction temperature is between about 10 and 30°C.

3. The process of Claim 1 wherein the aminated aromatic compound produced is selected from the group consisting of

to:



for benzene at least one of R^{21} to R^{26} is an electron withdrawing group, and at one of R^{21} to R^{26} is an amino group;

for pyridine at least one of R^{31} to R^{35} is an electron withdrawing group, and of R^{31} to R^{35} is an amino group; and

for naphthalene, at least one of R^{21} to R^{28} is an electron withdrawing group, and at least one of R^{21} to R^{28} is an amino group;

for biphenyl, at least one of R^{21} to R^{30} is an electron withdrawing group, and at least one on one of R^{21} to R^{30} is amine, an amino group;

for quinoline, at least one of R^{31} to R^{37} is an electron withdrawing group, and at least one of R^{31} to R^{37} is an amino group;

for 1,4- quinoxaline at least one of R^{31} to R^{36} is an electron withdrawing group, and at least one of R^{31} to R^{36} is an amino group;

for the diamino six-membered rings, at least one of R^{41} to R^{44} is an electron withdrawing group, and at least one of R^{41} to R^{44} is an amino group;

for the six-membered rings containing three nitrogen atoms, at least one of R^{41} to R^{43} is an electron withdrawing group, and at least one on R^{41} to R^{43} is an amino group; and

for the five-membered heterocyclic rings containing one, two, or three nitrogens, at least one of R^{51} to R^{54} is an electron withdrawing group, and at lest one of R^{51} to R^{54} is an amino group,

for indole at lest one of R^{61} to R^{65} is an electron withdrawing group, and at least one of R^{61} to R^{65} is an amino group;

for fused pyridine have two six-membered rings, at least one of R^{71} to R^{76} is an electron withdrawing group, and at least one of R^{11} to R^{76} is an amino group;

wherein R^{80} is alkyl having 1 to 6 carbon atoms;

wherein the electron withdrawing group is selected from -CN, $-NO_2$, -COR, $-CO_2R_1$, $-CONR_2$, $-SO_2R$, $-SO_3H$, $-CF_3$, -F, -Cl, -Br, -I and $-NH_2$, where R_1 and R_2 are C^1 to C^6 alkyl.

4. The process of Claim 1 wherein

the starting material compound is carbocycle;

the reagent is 1,1,1-trialkyl hydrazinum salt where alkyl is methyl, ethyl, propyl or butyl, and is present in between 1.9 and 2.3 molar equivalents of starting

material;

the anion of the salt is halide;

the temperature is between about 10 and 30°C;

the strong base is selected from sodium metboxide, sodium ethoxide, potassium metxide, and combination thereof; and

the solvent does not contain alcohol.

5. The process of Claim 1 wherein:

the starting material compound is a heterocyclic aromatic compound;

the reagent is 1,1,1-trialkyl hydrazinum salt where alkyl is methyl, ethyl, propyl or butyl and is present in between about 1.9 and 2.3 molar equivalents of starting material;

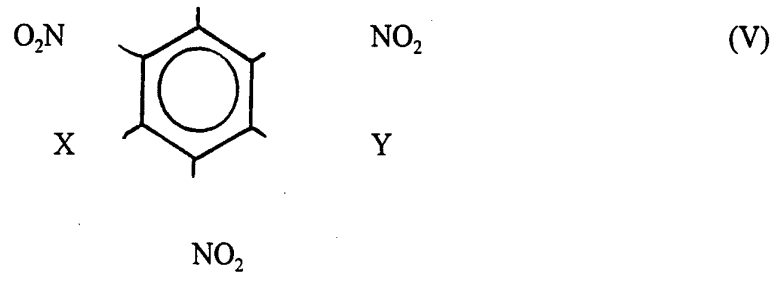
the temperature is between about 10 and 30°C;

the strong base is selected from sodium methoxide, sodium ethoxide, potassium methoxide, potassium methoxide, and combinations thereof;

the solvent does not contain alcohol.

6. The process of Claim 1 to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6,-trinitrobenzene (TATB), which process comprises:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, a trinitroaromatic starting material compound V:



(V)

wherein X, Y, and Z are each independently selected from the group consisting of -H, and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen,

with an amount effective to produce DATB or TATB of 1,1,1,-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl or butyl and anion is selected from chloride, bromide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrofluoroborate,

and the combination thereof.

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB and picramide are formed; and

(b) isolating the DATB or TATB produced.

7. The process of Claim 6 wherein the reaction temperature is between about 10 and 30°C.

8. The process of Claim 7 wherein DATB is produced and the 1,1,1-trialkylhydrazinium salt is present in between about 1.9 and 2.3 molar equivalents per mole of starting material compound V.

9. The process of Claim 7 wherein starting material compound V is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

10. The process of Claim 7 wherein the 1,1,1-trialkylhydrazinium salt is 1,1,1-trimethylhydrazinium iodide.

11. The process of Claim 7 wherein the strong base is selected from sodium methoxide or potassium tert-butoxide.

12. The process of Claim 7 wherein the solvents are methanol, ethanol, propanol, butanol or a mixture thereof.

13. The process of Claim 7 wherein

starting material compound V is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline;

the 1,1,1-trialkylhydrazinium salt is 1,1,1-trimethylhydrazinium iodide;

the strong base is selected from sodium methoxide or potassium tert-butoxide; and

the solvent is selected from methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide or mixtures thereof.

14. The process of Claim 7 wherein TATB is produced and the 1,1,1-trialkylhydrazinium salt is present in between about 3.9 and 5.5 molar equivalents per mole of compound V.

15. The process of Claim 14, wherein the starting material is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

16. The process of Claim 14 wherein the 1,1,1-trialkylhydrazinium salt is 1,1,1-trimethylhydrazinium iodide.

17. The process of Claim 14 wherein the strong base is selected from sodium methoxide or potassium tert-butoxide.

18. The process of Claim 14 wherein the solvent is a dipolar aprotic solvent selected from dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof.

19. The process of Claim 14 wherein

the starting material is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene;

the 1,1,1-trialkylhydrazinium salt is 1,1,1-trimethylhydrazinium iodide;

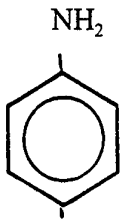
the strong base is selected from sodium methoxide or potassium tert-butoxide;

and the solvent is selected from dimethylsulphoxide N-methylpyrrolidone hexamethyl phosphoramide, dimethylformamide, dimethylacetamide or mixtures thereof.

20. A process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-

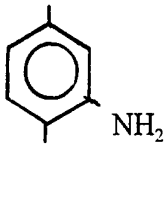
triamino-2,4,6,-trinitrobenzene (TATB), which process comprises:

(a) obtaining an aromatic compound as a starting material selected from:



(III)

,

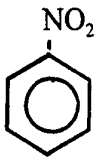


(IV)

or

mixtures thereof from commercial sources or by:

(i) reacting



at a temperature of between about 0 and 50°C for between about 0.1 and 24 hr with an amount effective of 1,1,1-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl or butyl and salt is selected from chloride, bromide or iodide.

in the presence of a base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and combinations thereof;

in a solvent selected from the group consisting of dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof, and isolating the product which is III and/or IV;

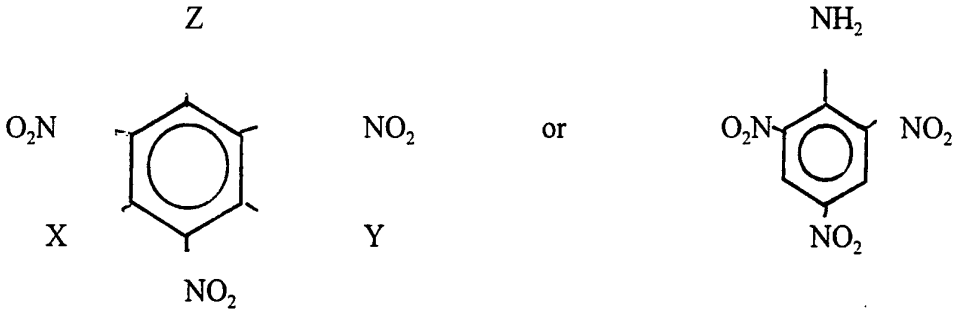
(ii) or nitrating aniline using a mixture of nitric acid and sulfuric acid to produce structures III and IV; or

(iii) nitrating acetanilide using a mixture of nitric acid and sulfuric acid to produce 4-nitroacetanilide and nitrating further using a mixture of nitric acid and sulfuric acid to produce VI;

(b) reacting 2-nitroaniline, 4-nitroaniline or combinations thereof with a nitric

acid, and sulfuric acid mixture under conditions to produce 2,4,6-trinitroaniline (VI);

(c) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr a trinitro aromatic compound selected from:



(V) (VI)

wherein X, Y, and Z are each independently selected from the group consisting of -H and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen,

with an effective amount of 1,1,1-trialkylhydrazinium salt wherein alkyl is selected from methyl, ethyl, propyl or butyl and anion is selected from chloride, bromide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrofluoroborate, and the like,

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof; and

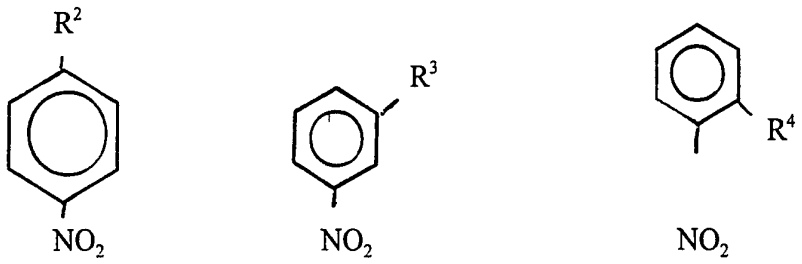
(d) isolating the DATB or TATB produced.

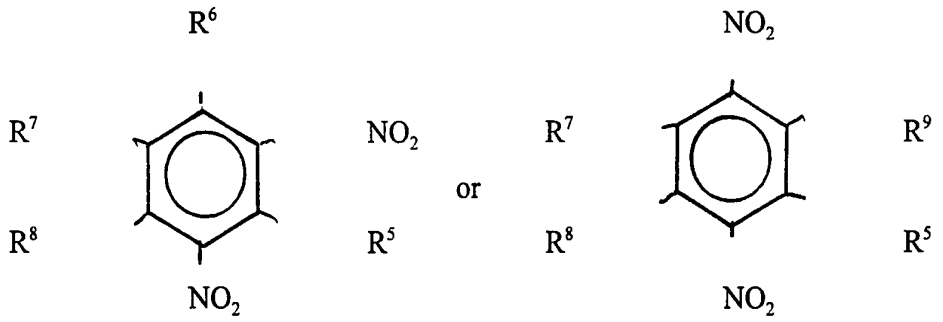
21. The process of Claim 16 wherein the reaction temperature is between about 10 and 30°C.

22. A process to produce mono or polyamino, mono or poly nitrobenzene, which process comprises:

(a) obtaining an aromatic compound as a starting material selected from the

following structures:





wherein R^2, R^3, and R^4 are each independently selected from -H, -CH_3, F, -Cl, -Br, -I, CN, COOH, COOR, or OCH_3,

and R^5 - R^9 are each independently selected from -H, -CH_3, F, -Cl, -Br, -I, -CN or -OCH_3 or mixtures thereof, with the proviso that at least 1 of R^5 - R^9 is H;

(b) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr a nitro aromatic compound;

with an effective amount of 1,1,-dialkyl-1,2-di-R-hydrazinium salt wherein dialkyl is selected from methyl, ethyl, propyl, butyl, hexyl, cyclohexyl, dodeyl, pyridyl, -CH_2 $(CH_2)_n$ CH_2-, -$(CH_2CH_2)O(CH_2CH_2)$-, where n is between 1 to 10, R is selected from H, C_1 - C_{20} alkyl, or aryl, and the anion is selected from chloride, bromide, fluoride, sulfate, hydroxide, mesylate, triflate, tetrofluoroborate, and the like,

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof; and

(C) isolating the monoamino, diamino or triaminosubstituted nitroaromatic

compound produced.

23. The process of Claim 22 wherein

the temperature is between about 10 and 30°C;

the time is between about 0.1 and 24 hr;

the starting material is a substituted or unsubstituted mononitro or dinitro benzene;

R is hydrogen; and

halide is iodide.

24. The process of Claim 20 wherein in the starting material V where

X, Y and Z are independently selected from H or NHR; and

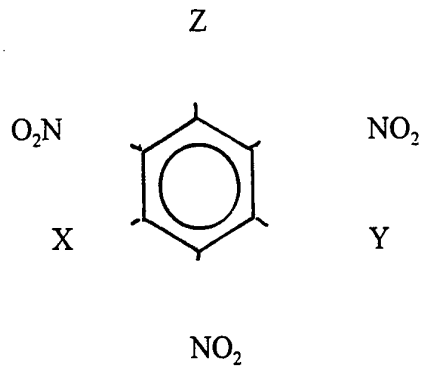
the reaction temperature is between about 10 and 30°C.

25. The process of Claim 24 wherein the solvent is not an alcohol and TATB is produced.

26. The process of Claim 1 to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6,-trinitrobenzene (TATB), which process comprises:

(a) reacting at ambient pressure and a temperature of between about 0 and 50°C for between about 0.1 and 24 hr, a trinitroaromatic starting material compound of

the structure:



wherein X, Y, and Z are each independently selected from the group consisting of -H and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen;

with an effective amount of 4-amino-1,2,4-triazole, or hydroxylamine or O-alkyl hydroxylamine wherein alkyl has 1 to 10 carbon atoms, provided that hydroxylamine and O-alkyl hydroxylamine, when used, produces primarily DATB;

in the presence of a strong base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, or combinations thereof;

in a solvent selected from the group consisting of methanol, ethanol, n-propanol, iso-propanol, n-butanol, iso-butanol, sec-butanol, tert-butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide and mixtures thereof, provided that when alcohols are present primarily DATB is formed; and

(b) isolating the DATB or TATB produced.

27. The process of Claim 26 wherein the reaction temperature is between about 10 and 30°C; and 4-amino-1,2,4-triazole is used.

28. The process of Claim 26 wherein DATB is produced and the 4-amino-1,2,4-triazole is present in step (a) in between about 1.9 and 2.3 molar equivalents per mole of the trinitroaromatic starting material compound.

29. The process of Claim 26 wherein the trinitroaromatic starting material compound is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

30. The process of Claim 26 wherein the 4-amino-1,2,4-triazole is present in about 2.1 mole eq.

31. The process of Claim 26 wherein the strong base is sodium methoxide or potassium tert-butoxide.

32. The process of Claim 26 wherein the solvents are selected from the group consisting of methanol, ethanol, propanol, butanol and mixtures thereof and hydroxylamine or its O-alkyl derivatives are used to produce DATB.

33. The process of Claim 26 wherein

the starting material compound is selected from 1,3,5-trinitrobenzene, or 2,4,6-trinitroaniline;

the strong base is selected from sodium methoxide or potassium tert-butoxide; and

the solvent is DMSO, an alcohol or mixtures thereof, and

hydroxylamine and O-alkyl hydroxylamine.

34. The process of Claim 27 wherein TATB is produced and the 4-amino-1,2,4-triazole is present in between about 3.9 and 5.5 molar equivalents per mole of the trinitroaromatic starting material compound.

35. The process of Claim 34, wherein the trinitroaromatic starting material compound is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene.

36. The process of Claim 34 wherein the 4-amino-1,2,4-triazole is present in about 4.5 mole eq.

37. The process of Claim 34 wherein the strong base is sodium methoxide.

38. The process of Claim 34 wherein the solvent is a dipolar aprotic solvent selected from dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof.

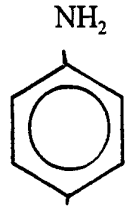
39. The process of Claim 34 wherein

the trinitroaromatic starting material compound is selected from 1,3,5-trinitrobenzene, 2,4,6-trinitroaniline, or 1,3-diamino-2,4,6-trinitrobenzene;

the strong base is selected from sodium methoxide and the solvent is selected from dimethylsulphoxide N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide or mixtures thereof.

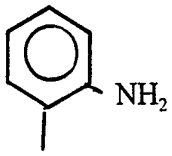
40. A process to produce 1,3-diamino-2,4,6-trinitrobenzene (DATB) or 1,3,5-triamino-2,4,6,-trinitrobenzene (TATB), which process comprises:

(a) obtaining an aromatic starting material compound of the structure:



(III)

,

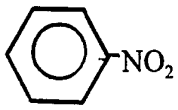


(IV)

or

mixtures thereof from commercial sources or by:

(i) reacting



with an amount of 4-amino-1,2,4-triazole, hydroxylamine, effective to produce compound III or IV, or mixtures thereof;

in the presence of a base selected from sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium

methoxide, potassium methoxide, and combinations thereof;

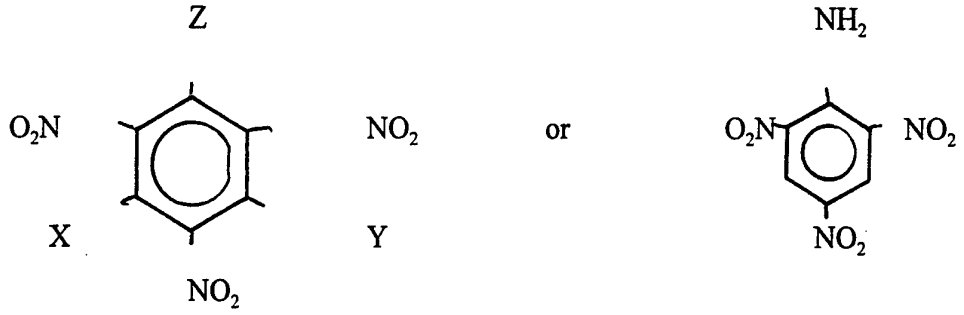
in a solvent selected from the group consisting of dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, or mixtures thereof, or isolating the product which is III;

(ii) or nitrating aniline using a mixture of nitric acid and sulfuric acid to produce compounds III and IV; or

(iii) nitrating acetanilide using a mixture of nitric acid and sulfuric acid to produce 4-nitroacetanilide and nitrating further using a mixture of nitric acid and sulfuric acid to produce compound VI;

(b) reacting 2-nitroaniline, 4-nitroaniline or combinations thereof with a nitric acid, and sulfuric acid mixture under conditions to produce 2,4,6-trinitroaniline;

(A) reacting at temperature of between about 0 and 50°C for between about 0.1 and 24 hr a trinitroaromatic starting material compound:



(V) (VI)

wherein X, Y, and Z are each independently selected from the group consisting of -H and $-NH_2$, with the proviso that at least 1 of X, Y, and Z is hydrogen;

with an effective amount of 4-amino-1,2,4-triazole, or hydroxylamine, or O-alkylhydroxylamine where alkyl has 1 to 10 carbon atoms;

in the presence of a base selected from the group consisting of sodium butoxide, potassium butoxide, potassium propoxide, sodium propoxide, sodium ethoxide, potassium ethoxide, sodium methoxide, potassium methoxide, and mixtures thereof;

in a solvent selected from the group consisting of methanol, ethanol, propanol, butanol, dimethylsulphoxide, N-methylpyrrolidone, hexamethylphosphoramide, dimethylformamide, dimethylacetamide, and mixtures thereof provided that when an alcohol is present or when hydroxylamine or its O-alkyl hydroxylamine replaces 4-amino-

1,2,4-triazole, primarily DATB is produced; and

(B) isolating the DATB or TATB produced.

41. The process of Claim 36 wherein the reaction temperature is between about 10 and 30°C.

42. The process of Claim 26 wherein 4-amino-1,2,4 triazole is used in between about 1.9 and 2.3 molar equivalents or between about 3.9 and 5.5 equivalents per mole of compound V;

the temperature is between 10 and 30°C;

the time is between about 0.1 and 24 hr;

the strong base is sodium methoxide or potassium tert-butoxide; and

the solvent comprises dimethylsulphoxide.

43. The process of Claim 26 wherein

hydroxylamine is used in between about 1.9 and 2.3 molar equivalents or between about 3.9 and 5.5 equivalents per mole of compound V;

the temperature is between about 10 and 30°C;

the strong base is sodium methoxide or potassium tert-butoxide; and

the solvent comprises dimethylsulphoxide;

alcohol or mixtures thereof.

44. The process of Claim 26 wherein

O-alkyl hydroxylamine is used in between about 1.9 and 2.3 molar equivalents or between about 3.9 and 5.5 equivalents per mole of said trinitroaromatic starting material compound;

the strong base is selected from sodium methoxide or potassium tert-butoxide; and

the solvent comprises dimethylsulphoxide.

45. The process of Claim 44 wherein the alkyl of the O-alkyl group of O-alkylhydroxamine is methyl, ethyl, propyl, butyl, pentyl, hexyl, benzyl or -CH_2CH_2-phenyl.

INTERNATIONAL SEARCH REPORT

Internatio.. . application No.
PCT/US96/06663

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :C07C 209/00, 205/00
US CL :564/395; 568/932, 934
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 564/395; 568/932, 934

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	Katritzky et al., Journal of Organic Chemistry 1986, Vol. 51, 5039-5040, see entire document.	1-3, 26-31, 34-42 --- 1-3, 26, 29, 31-33, 40, 43-45
Y, P	US, A, 5,466,871 (SEKO) 14 November 1995, see entire document.	1-3, 26, 29, 31-33, 40, 43-45

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
13 SEPTEMBER 1996

Date of mailing of the international search report
09 OCT 1996

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
JOHN R. HARDEE
Telephone No. (703) 306-4154

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/06663

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Claims 1-3, 26, 29, 31-33 and 40 are generic to four distinct reagents for effecting vicarious neucleophilic substitution of nitroaromatics. These reagents are :

1,1,1-trialkylhydrazinium salts (claims 1-25)
hydroxylamine (claims 1-3, 26, 29, 31-33, 40 and 43)
O-alkylhydroxylamine (claims 1-3, 26, 29, 31-33, 44 and 45)
4-amino-1,2,4-triazole (claims 1-3, 26-31 and 34-42)
Claims drawn to 1,1,1-trialkylhydrazinium salts are free of the prior art. The generic claims do not avoid the prior art.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.