Russian Journal of Organic Chemistry, Vol. 40, No. 6, 2004, pp. 829–833. From Zhurnal Organicheskoi Khimii, Vol. 40, No. 6, 2004, pp. 869–872.

Dedicated to the Memory of Prof. Marian Woźniak

Amination of Some 1,3-Dinitrobenzenes with Liquid Ammonia–Potassium Permanganate*

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Abstract—1,3-Dinitrobenzene and some its 2- and 4-substituted derivatives are dehydroaminated in a solution of potassium permanganate in liquid ammonia to give the corresponding mono- or diamino-1,3-dinitrobenzenes. Under the same conditions, 4-fluoro-1,3-dinitrobenzene is converted into 2,4-dinitroaniline via replacement of the fluorine atom, while 2,4-dinitrobenzaldehyde gives rise to 2,4-dinitrobenzamide.

In the preceding communication [1] we reported that dinitrobenzenes undergo dehydromethylamination in liquid methylamine in the presence of potassium permanganate. The reaction involves intermediate formation of methylamino-σ-adduct which is oxidized with potassium permanganate to the corresponding methylamino nitro compound. In some cases, intermediate σ-adducts can be detected by ^{1}H NMR spectroscopy [1]. In view of these results, it was interesting to elucidate whether the system liquid ammonia–potassium permanganate is applicable to amination of π-deficient aromatic compounds, i.e., those containing electron-withdrawing groups. Our studies on the behavior of some simple nitrobenzene derivatives toward liquid ammonia–potassium permanganate have been covered by patent [2]. Oxidative amination of nitroaromatic compounds in liquid ammonia in the presence of $KMnO_4$ opens an easy and safe way of introducing an amino group into nitroaromatic compounds. Amino derivatives of 1,3-dinitrobenzene can find application in industry and medicine. For example, some nitroanilines are used as components in the synthesis of azo dyes [3– 7] and as inhibitors of polymerization of butadiene [8] and vinyl monomers [9]. 2,4-Dinitroaniline is an efficient fluorescence quencher for Fluorescein-labeled oligonucleotides [10, 11], a modifier of polyvinyl esters with high photoconductivity [12], etc.

Oxidative nucleophilic substitution of hydrogen (S_NH) involves addition of ammonia to 1,3-dinitrobenzene **I** with formation of intermediate Meisenheimer σ-adduct which is then oxidized with potassium permanganate, leading to the corresponding amine **II**. The amination of dinitrobenzenes **Ia**–**Ij** was carried out at the boiling point of liquid ammonia (–33°C). The results are given in Scheme 1. The structure of the products was confirmed by the spectral data (including ^{1}H NMR spectra), as well as by comparing with authentic samples. Nitrobenzene itself did not react with NH_3 (liq.)–$KMnO_4$; the initial compound was recovered almost quantitatively from the reaction mixture. Apparently, the π-electron deficiency in the aromatic ring of nitrobenzene is insufficient to ensure formation of a σ-adduct with NH_3. 1,2- and 1,4-Dinitrobenzenes also failed to react with NH_3(liq.)–$KMnO_4$. By contrast, treatment of 1,3-dinitrobenzene with NH_3 (liq.)–$KMnO_4$ afforded 2,4-dinitroaniline (**IIa**) as the major product and a small amount of 2,4-dinitro-1,3-phenylenediamine (**IIb**). Intermediate σ-adduct was detected by ^{1}H NMR spectroscopy. For this purpose, 1,3-dinitrobenzene was dissolved in liquid ammonia at –40°C, and ^{1}H NMR spectrum of the solution was recorded. All signals in the spectrum were displaced upfield relative to the spectrum recorded in $CDCl_3$. The greatest shift was observed for the 4-H signal, $\Delta\delta$ = 3.90 ppm. This value is in excellent agreement with the data of our previous studies on the amination of nitroaromatic compounds [13].

Despite the presence of an electron-donor substituent, 2,6-dinitroaniline (**Ib**) reacted with the system NH_3 (liq.)–$KMnO_4$ to give 2,4-dinitro-1,3-phenylenediamine (**IIb**) in a moderate yield. By contrast, 2,4-dinitroaniline failed to react under analogous conditions. Dehydroamination of 2-chloro-1,3-dinitrobenzene (**Ic**)

* The original article was submitted in English.

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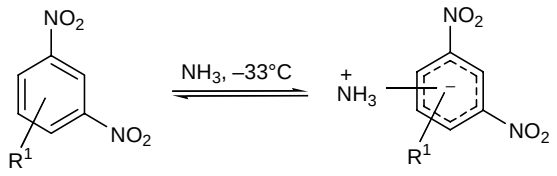
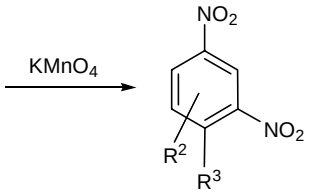
Scheme 1.

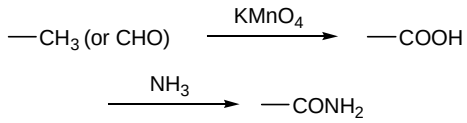




Initial comp. no.	R^1	Product	R^2	R^3	Yield, %
Ia	H	**IIa**	H	4-NH_2	70
Ib	H	**IIb**	2-NH_2	4-NH_2	2
	2-NH_2	**IIb**	2-NH_2	4-NH_2	30
Ic	2-Cl	**IIc**	2-Cl	4-NH_2	16
		IIb	2-NH_2	4-NH_2	11
Id	2-OC_2H_5	**IIb**	2-NH_2	4-NH_2	28
Ie	2-CH_3	**IId**	2-CH_3	4-NH_2	10
If	4-Cl	**IIe**	6-NH_2	4-Cl	52
Ig	4-OC_2H_5	**IIf**	6-NH_2	4-OC_2H_5	43
Ih	4-CH_3	**IIg**	6-NH_2	4-CH_3	13
		IIa	H	4-NH_2	2
		IIh	H	4-$CONH_2$	6
Ii	4-F	**IIa**	H	4-NH_2	73
Ij	4-CHO	**IIh**	H	4-$CONH_2$	26

at the 6-position was accompanied by replacement of the chlorine atom. As a result, 3-chloro-2,4-dinitroaniline (**IIc**) (major product) and compound **IIb** were obtained. Treatment of 2-ethoxy-1,3-dinitrobenzene (**Id**) with NH_3 (liq.)–$KMnO_4$ resulted in complete deethoxyamination with formation of compound **IIb** in a moderate yield. It should be noted that the nucleofugal chlorine atom in 4-chloro-1,3-dinitrobenzene (**If**) and ethoxy group in 4-ethoxy-1,3-dintrobenzene (**Ig**) were not replaced by amino group; in these cases, only dehydroamination occurred at the 6-position, and the products were exclusively 5-chloro-2,4-dinitroaniline (**IIe**) and 5-ethoxy-2,4-dinitroaniline (**IIf**), respectively.

The amination of 2,6-dinitrotoluene (**Ie**) and 2,4-dinitrotoluene (**Ih**) with NH_3 (liq.)–$KMnO_4$ gave 3-methyl-2,4-dinitroaniline (**IId**) and 5-methyl-2,4-dinitroaniline (**IIg**), respectively, in high yields. In the reaction with compound **Ih**, 2,4-dinitrobenzamide (**IIh**) was also isolated. The same product was obtained by oxidative amination of 2,4-dinitrobenzaldehyde (**Ij**). Obviously, compound **IIh** was formed as a result of oxidation of the methyl (or formyl) group to carboxy and subsequent amination of the latter.



Further dehydroamination of **IIh** was not observed. Interestingly, the fairly inert methyl group in **Ih** is partially replaced by amino group to give a small amount of 2,4-dinitroaniline (**IIa**). Unlike 4-chloro-1,3-dinitrobenzene, the amination of 4-fluoro-1,3-dinitrobenzene (**Ii**) with liquid ammonia in the presence of potassium carbonate gave 2,4-dinitroaniline (**IIa**) as the only product in a good yield. Presumably, the rate of nucleophilic substitution of the highly labile fluorine atom on C^4 by amino group exceeds the rate of oxidative dehydroamination at the 6-position. This is in agreement with great sensitivity of fluorobenzene derivatives to nucleophilic substitution of the fluorine atom [14].

The results of the present study lead us to conclude that the system liquid ammonia–potassium permanganate is effective for the amination of 1,3-dinitrobenzene and its simple monosubstituted derivatives. The described reaction can be used for the preparation of some amino-1,3-dinitrobenzenes, specifically of 2,4-dinitroaniline (**IIa**). The proposed procedure allows an amino group to be introduced in an aromatic ring containing or not containing other readily departing groups (e.g., Cl or OC_2H_5) without replacement of the latter. A practical significance of the examined reactions is that they ensure direct amination of 1,3-dinitrobenzene and its 4-chloro and 4-ethoxy derivatives with high selectivity and good yields.

EXPERIMENTAL

The melting points were determined on a Kofler plate and are uncorrected. The ^1H NMR spectra were recorded on a Tesla BS-587A spectrometer (80 MHz). The IR spectra were obtained on a UR-20 spectrometer from samples prepared as KBr pellets. The mass spectra were run on an LKB GC/MS 9000 instrument. Silica gel (230–400 mesh, Merck) was used for

column chromatography. Preparative thin-layer chromatography was performed using standard Silica gel 60 PF-254 plates (20×40 cm, Merck).

Commercial 1,3-dinitrobenzene and its 2-amino, 2-chloro, 2-methyl, 4-ethoxy, 4-fluoro-, 4-formyl, and 4-methyl derivatives were used. 2-Ethoxy-1,3-dinitrobenzene [15], 4-chloro-1,3-dinitrobenzene [16], and 2,4-dinitrobenzamide [17] were synthesized according to known procedures.

Amination of 1,3-dinitrobenzenes with the system liquid ammonia–potassium permanganate (*general pocedure*). 1,3-Dinitrobenzene **I**, 0.5 g, and potassium permanganate, 0.8–1.0 g, were added to 25–30 ml of liquid ammonia, and the mixture was stirred for 0.5–2.0 h at –33°C. After evaporation of ammonia, ~30 ml of water was added to the residue, and the mixture was continuously extracted with chloroform for 15–30 h. The solvent was removed from the extract, and the residue was treated as described below.

Amination of 1,3-dinitrobenzene (Ia). The amination was carried out according to the general procedure using 0.5 g (2.98 mmol) of compound **Ia**. The residue was subjected to chromatographic separation on a 3×35-cm column using chloroform as eluent. From the first fraction (100 ml) 25 mg (5%) of the initial compound was recovered. The second fraction (350 ml) was evaporated, and the residue was recrystallized from aqueous acetone to obtain 0.38 g (70%) of 2,4-dinitroaniline (**IIa**); yellow crystals, mp 177–178°C; published data [18]: mp 176°C. The product was identical in R_f value and spectral parameters (^{1}H NMR, IR) to an authentic sample (commercially available). The residue isolated from the third fraction (200 ml) was washed with cold hexane; it was 2,4-dinitro-1,3-phenylenediamine (**IIb**), yield 12 mg (2%), orange crystals, mp 256–257°C; published data: mp 253–254°C [19], 260°C [20]. Compound **IIb** was identical in R_f value and spectral parameters (^{1}H NMR, IR) to a sample obtained by amination of **Ib**.

Amination of 2,6-dinitroaniline (Ib). Compound **Ib**, 0.5 g (2.73 mmol), was subjected to amination according to the general procedure. The residue was recrystallized from methanol to obtain 0.16 g (30%) of 2,4-dinitro-1,3-phenylenediamine (**IIb**) as orange crystals with mp 259–260°C; published data: mp 253–254°C [19], 260°C [20]. IR spectrum, ν, cm^{-1}: 3395 m and 3290 m (2-NH_2), 3435 m and 3320 m (4-NH_2). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 9.44 br.s (NH_2), 9.05 br.s (NH_2), 8.09 d (5-H), 6.29 d (6-H), $J_{5,6}$ = 9.5 Hz. Mass spectrum (70 eV), *m/z* (I_{rel}, %): 198 M^+ (100). Found, %: C 36.28; H 2.97; N 28.30. $C_6H_6N_4O_4$. Calculated, %: C 36.37; H 3.05; N 28.27. *M* 198.1.

Amination of 2-chloro-1,3-dinitrobenzene (Ic). Compound **Ic**, 0.5 g (2.47 mmol), was subjected to amination according to the general procedure. The residue was recrystallized from methanol to obtain 2,4-dinitro-1,3-phenylenediamine (**IIb**). The mother liquor was evaporated, and the residue was separated by column chromatography (2.5×25 cm) using chloroform as eluent. From the first fraction (100 ml) 0.27 g (54%) of the initial compound was recovered. The second fraction (150 ml) was evaporated, and the residue was recrystallized from chloroform to afford 86 mg (16%) of 3-chloro-2,4-dinitroaniline (**IIc**), yellow needles, mp 145–145.5°C. IR spectrum, ν, cm^{-1}: 3470 m and 3380 m (NH_2). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 8.08 d (5H), 7.32 br.s (NH_2), 6.93 d (5-H), $J_{5,6}$ = 9.5 Hz. Mass spectrum (70 eV), *m/z* (I_{rel}, %): 219 (26), 217 (78) [M^+], 187 (100) [M – NO]$^+$. Found, %: C 32.71; H 1.71; N 19.13. $C_6H_4ClN_3O_4$. Calculated, %: C 33.12; H 1.85; N 19.30. *M* 217.59.

The residue obtained after evaporation of the third fraction (100 ml) was washed with hexane to obtain an additional amount of pure compound **IIb**; overall yield 54 mg (11%). The product was identified by comparing with a sample prepared as described above by the melting point, R_f, and ^{1}H NMR and IR spectra.

Amination of 2-ethoxy-1,3-dinitrobenzene (Id). The reaction was carried out with 0.5 g (2.36 mmol) of compound **Id** according to the general procedure. The product was recrystallized from methanol; 0.13 g (28%) of 2,4-dinitro-1,3-phenylenediamine (**IIb**) was thus isolated. It was identical in the melting point, R_f value, and IR spectrum to a sample obtained by amination of **Ib**.

Amination of 2,6-dinitrotolune (Ie). The reaction was carried out with 0.5 g (2.75 mmol) of compound **Ie** according to the general procedure. The residue was dissolved in chloroform, and the solution was applied to a 3.0×30-cm column for chromatographic separation using chloroform as eluent. From the first fraction (200 ml) we isolated 0.42 g (84%) of the initial compound. The second fraction (150 ml) was evaporated, and the residue was washed with hexane to obtain 54 mg (10%) of 3-methyl-2,4-dinitroaniline (**IId**), yellow crystals, mp 133°C; published data [21]: mp 132.5°C. ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 8.02 d (5-H), 7.06 br.s (NH_2), 6.87 d (6H), 2.39 s

(CH_3), $J_{5,6}$ = 9.5 Hz. Mass spectrum (70 eV), *m/z* (I_{rel}, %): 197 (100) [M^+].

Amination of 4-chloro-1,3-dinitrobenzene (If). The reaction was carried out with 0.5 g (2.47 mmol) of compound **If** according to the general procedure. The residue was recrystallized from ethanol to obtain 0.28 g (52%) of 5-chloro-2,4-dinitroaniline (**IIe**) as orange needles with mp 174–175°C; published data [22]: mp 174°C. ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 8.78 s (3-H), 8.31 br.s (NH_2), 7.20 s (6-H). Mass spectrum (70 eV), *m/z* (I_{rel}, %): 219 (33), 217 (100) [M^+].

Amination of 4-ethoxy-1,3-dinitrobenzene (Ig). According to the general procedure, 0.5 g (2.36 mmol) of compound **Ig** was brought into amination. The residue was recrystallized from methanol to obtain 5-ethoxy-2,4-dinitroaniline (**IIf**) as yellow crystals with mp 172–173°C; published data [23]: mp 169–170°C. The mother liquor was evaporated, and the residue was subjected to chromatographic separation in a 2.5×25-cm column using chloroform as eluent. From the first fraction (150 ml) we isolated 0.12 g (24%) of initial compound **Ig**. The second fraction (200 ml) was evaporated, and the residue was washed with hexane to afford an additional amount of compound **IIf**. Overall yield of 5-ethoxy-2,4-dinitroaniline (**IIf**) 0.23 g (43%). ^{1}H NMR spectrum (DMSO-d_6), δ, ppm: 8.70 s (3-H), 8.06 br.s (NH_2), 6.62 s (6-H), 4.17 q (CH_2), 1.38 t (CH_3), J = 7.0 Hz (C_2H_5). Mass spectrum (70 eV), *m/z* (I_{rel}, %): 227 (100) [M^+].

Amination of 2,4-dinitrotoluene (Ih). According to the general procedure, 0.5 g (2.75 mmol) of compound **Ih** was brought into amination. The products were isolated by preparative thin-layer chromatography. The residue was dissolved in methanol, and the solution was applied to two chromatographic plates which were developed with chloroform. The obtained bands were extracted into chloroform in a Soxhlet apparatus over a period of 8 h. From the first band (with the greatest R_f value) we isolated 0.22 g (44%) of the initial compound. The product isolated from the second band was recrystallized from toluene to obtain 70 mg (13%) of 5-methyl-2,4-dinitroaniline (**IIg**); yellow crystals, mp 197–198°C; published data [24]: mp 195°C. IR spectrum, ν, cm^{-1}: 3480 m and 3375 m (NH_2). ^{1}H NMR spectrum, δ, ppm: in DMSO-d_6: 8.77 s (3-H), 8.29 br.s (NH_2), 6.92 s (6-H); in CF_3COOD: 9.23 s (3-H), 6.97 (6-H), 2.70 s (CH_3). Mass spectrum (70 eV), *m/z* (I_{rel}, %): 197 (70) [M^+].

The extract of the third band was evaporated, and the residue was washed with hexane to afford 10 mg (2%) of 2,4-dinitroaniline (**IIa**). The product isolated from the fourth band was recrystallized from toluene; it was 2,4-dinitrobenzamide (**IIh**), yield 35 mg (6%); the product was identical in the melting point and IR spectrum to a sample obtained by amination of 2,4-dinitrobenzaldehyde (**Ij**).

Amination of 4-fluoro-1,3-dinitrobenzene (Ii). The reaction was carried out with 0.5 g (2.55 mmol) of compound **Ii** according to the general procedure. The product was recrystallized from aqueous acetone to obtain 0.36 g (73%) of 2,4-dinitroaniline (**IIa**).

Amination of 2,4-dinitrobenzaldehyde (Ij). The reaction was carried out with 0.5 g (2.75 mmol) of compound **Ij** according to the general procedure. The product was recrystallized from toluene to obtain 0.14 g (26%) of 2,4-dinitrobenzamide (**IIh**); light yellow needles, mp 202–204°C; published data [17]: mp 203°C. The ^{1}H NMR and IR spectra of compound **IIh** were identical to those of an authentic sample.

The authors thank Dr. E. Cholewka for measuring the ^{1}H NMR and IR spectra, Mr. T. Wiśniowski for recording the mass spectra, and Mrs. B. Schmidt for performing elemental analysis.

REFERENCES

1. Woźniak, M., Grzegożek, M., Roszkiewicz, W., and Szpakiewicz, B., *Recl. Trav. Chim. Pays–Bas*, 1995, vol. 114, p. 13.
2. Woźniak, M. and Szpakiewicz, B., PL Patent no. 162466, B1, 1993.
3. Farbenfabriken Bayer AG., UK Patent no. 761184, 1956; *Chem. Abstr*., 1957, vol. 57, p. 9166a.
4. Rudaya, A.M. and Semenova, N.P., USSR Inventor's Certificate no. 172938, 1965; *Chem. Abstr*., 1966, vol. 64, p. 918g.
5. Deucker, W. and Sommer, K., Ger. Offen. no. 2601224, 1977; *Chem. Abstr*., 1977, vol. 87, no. 153331e.
6. Chemiewerk Nuenchritz, Belg. Patent no. 875159, 1979; *Chem. Abstr*., 1979, vol. 87, no. 159040p.
7. Ayyangar, N.R., Lugade, A.G., and Moghe, P.P., *Dyes Pigments*, 1987, vol. 8, p. 63; *Chem. Abstr*., 1987, vol. 106, no. 103791v.
8. Sakuragi, T. and Sakashita, T., Ger. Offen. no. 1816826, 1969; *Chem. Abstr*., 1969, vol. 71, p. 81869f.
9. Nitto Chemical Industry Co., Jpn. Kokai Koho JP 60-81201 [85-81201], 1985; *Chem. Abstr*., 1983, vol. 103, no. 105421m.

10. Maier, T. and Pfleiderer, W., *Nucleosides Nucleotides*, 1995, vol. 14, p. 961.
11. Zelenko, O., Neumann, U., Brill, W., Pieles, U., Moser, H.E., and Hofsteenge, J., *Nucleic Acids Res*., 1994, vol. 22, p. 2731.
12. Suh, M.C., Suh, S.C., Shim, S.C., and Jeong, B.M., *Synth. Metals*, 1998, vol. 96, p. 195.
13. Szpakiewicz, B. and Woźniak, M., *Mol. Phys. Rep*., 2001, vol. 33, p. 66.
14. *Methoden der organischen Chemie (Houben–Weyl)*, Stuttgart: Georg Thieme, 1962, 4th ed., vol. 3, p. 410.
15. Borsche, W. and Rantscheft, D., *Justus Liebigs Ann. Chem*., 1911, vol. 379, p. 159.
16. Hodgson, H.H., *J. Chem. Soc*., 1948, p. 1006.
17. Friedlander, P. and Cohn, G., *Monatsh. Chem*., 1902, vol. 23, p. 560.
18. Benda, L., *Ber*., 1912, vol. 45, p. 56.
19. Holleman, A.F., *Recl. Trav. Chim. Pays–Bas*, 1920, vol. 39, p. 459.
20. Meisenheimer, J. and Patzig, E., *Ber*., 1906, vol. 39, p. 2538.
21. Meisenheimer, J. and Patzig, E., *Ber*., 1906, vol. 39, p. 2540.
22. Nietzki, R. and Zanker, W., *Ber*., 1903, vol. 36, p. 3955.
23. Reverdin, F. and Lokietek, *Bull. Soc. Chim. Fr*., 1916, vol. 19, p. 259.