The Condensation of Amino- and Nitroimidazoles with Picryl Halides (1)

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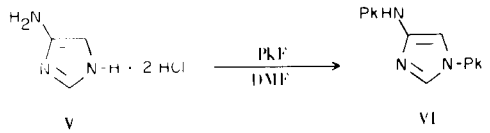
The condensation of 2-aminoimidazole hydrochloride (I) with picryl fluoride in DMF at 25° produced 1,3-dipicryl-2-imino-4-imidazoline hydrochloride (II). This product was obtained even when an excess of I was employed in the reaction. Picryl chloride failed to react with I in DMF at 25°, but at 85° a reaction occurred and 2-picrylimino-4-imidazoline (III) was isolated as a crystalline 1:1 solvate with DMF. Structure III is preferred to that of the tautomeric 2-picrylaminoimidazole because the product reacted with picryl fluoride in DMF at 25° to give 1,3-dipicryl-2-picrylimino-4-imidazoline (IV) as a 1:1 solvate with DMF. Structures II, III, and IV are consistent with the nmr spectra (see Table I) and the elemental analyses of the products.

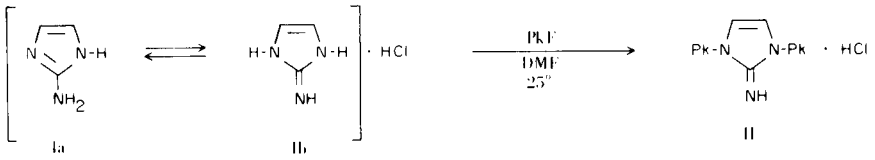
A possible explanation of these results is that I exists predominantly as the imino form (Ib) in DMF at 25° and is sufficiently nucleophilic to react with picryl fluoride to give II, but not with picryl chloride, which is much less susceptible to nucleophilic attack than picryl fluoride (2); at higher temperatures, picryl chloride reacts with the amino form (Ia), a stronger nucleophile than Ib, to give 2-picrylaminoimidazole, which tautomerizes to III.

4-Aminoimidazole dihydrochloride (V) reacted with picryl fluoride in DMF to give 1-picryl-4-picrylaminoimidazole (VI), which was obtained regardless of which reactant was used in excess. Structure VI is preferred to that of 1-picryl-5-picrylaminoimidazole or a possible imino form because the nmr chemical shifts of the imidazole protons of the product correspond closely to those of the C-2 and C-5 protons of 1-picrylimidazole (see Table I).

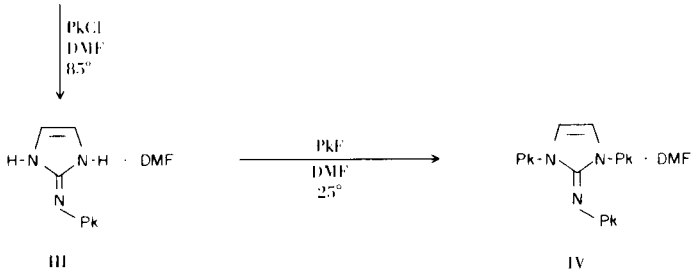


V VI

Imidazole (VII) condensed with picryl fluoride in DMF to give 1-picrylimidazole (VIII) and, under similar conditions, the various nitroimidazoles were converted into their 1-picryl derivatives. 2-Nitroimidazole (IX) produced 2-nitro-1-picrylimidazole (X), while 4-nitroimidazole (XI) provided 4-nitro-1-picrylimidazole (XII). The reaction of 2,4-dinitroimidazole (XIII) with picryl fluoride gave 2,4-dinitro-1-picrylimidazole (XIV), a moderately sensitive explosive. The physical and explosive properties of these products are given in Table II.



Ia Ib II



III IV

Pk = 2,4,6-Trinitrophenyl

TABLE I

NMR SPECTRA (a)

Compound	δC-H (p.p.m.) C-2	C-4	C-5	Picryl
Imidazole	7.88	7.20	7.20	
2-Nitroimidazole		7.42	7.42	
4-Nitroimidazole	8.32		7.87	
2,4-Dinitroimidazole			8.58	
1-Picrylimidazole	7.95	7.17	7.47	9.33
2-Nitro-1-picrylimidazole		7.55	7.97	9.40
4-Nitro-1-picrylimidazole	8.83		8.27	9.42
2,4-Dinitro-1-picrylimidazole			9.13	9.45
1-Picryl-4-picrylaminoimidazole	7.78		7.43	9.00, 9.32
2-Picrylimino-4-imidazoline·DMF		7.15	7.15	8.67
1,3-Dipicryl-2-imino-4-imidazoline·HCl		7.63	7.63	9.42
1,3-Dipicryl-2-picrylimino-4-imidazoline·DMF		7.92	7.92	8.59, 9.41

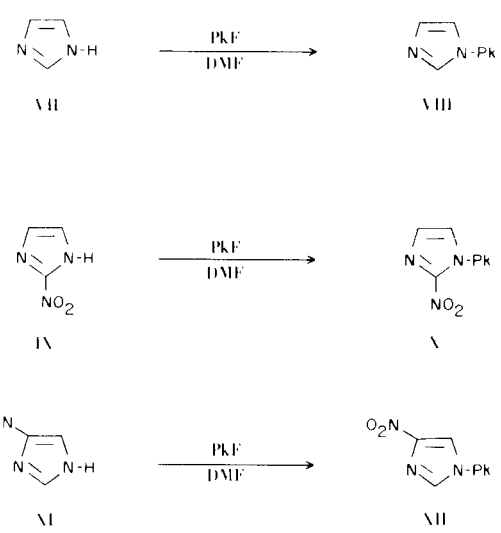
(a) Determined with a Varian A-60A spectrometer as DMSO-d_6 solutions using tetramethylsilane as an internal standard. All of the spectra which contain more than one peak were integrated, and the ratios of the peaks were consistent with the structural assignments.

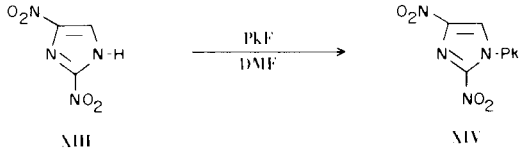
TABLE II

Physical and Explosive Properties

Compound	Melting Point (°C)	Thermal Stability (°C) (a)	Crystal Density (g/cc)	Impact Sensitivity (cm) (b)
1-Picrylimidazole	209-210	205	1.75	>320
2-Nitro-1-picrylimidazole	202-203	205	1.70	312
4-Nitro-1-picrylimidazole	286-287	300	1.75	161
2,4-Dinitro-1-picrylimidazole	252	240	1.75	46

(a) Temperature of the beginning of the first exotherm in differential thermal analysis at 10°/min. (b) Determined with the LASL Type 12 machine (2.5 kg weight, sample on sandpaper). The 50% points of several common explosives are: PETN, 11 cm; RDX, 23 cm; TNT, 160 cm.





Structure XII was chosen over that of the isomeric 5-nitro-1-picrylimidazole when we compared the chemical shifts of the imidazole protons of XI with those of the product (see Table I). It appears that both imidazole protons of the product are considerably deshielded; thus the picryl group is probably adjacent to both of these protons. Note that the picryl groups in VIII and X significantly deshield the adjacent C-5 protons while they have very little effect on the C-4 protons. The assignment of structure XIV was also based on the deshielding of the imidazole proton of the product as compared with XIII.

EXPERIMENTAL (3)

1,3-Dipicryl-2-imino-4-imidazoline Hydrochloride (II).

A solution of 2-aminoimidazole hydrochloride (4) (1.20 g., 0.01 mole) and picryl fluoride (5.0 g., 0.022 mole) in DMF (20 ml.) was stirred at 25° for 16 hours. The solution was poured into 400 ml. of water with stirring and the solid that precipitated was collected by filtration, washed with water and dried. The product was digested in boiling acetone (50 ml.), collected by filtration, and dried to provide 3.7 g. (68%) of IV, m.p. 211° dec.

Anal. Calcd. for $C_{15}H_8ClN_9O_{12}$: C, 33.25; H, 1.49; N, 23.27; Cl, 6.55. Found: C, 32.69; H, 1.27; N, 22.85; Cl, 6.21.

2-Picrylimino-4-imidazoline·DMF (III).

A solution of 2-aminoimidazole hydrochloride (4) (1.20 g., 0.01 mole) and picryl chloride (2.48 g., 0.01 mole) in DMF (20 ml.) was heated at 85° for 16 hours. The solution was poured into 400 ml. of water with stirring and the precipitated solid was collected by filtration, washed with water, and recrystallized from ethanol to yield 2.45 g. (67%) of II, m.p. 191° dec.

Anal. Calcd. for $C_{12}H_{13}N_7O_7$: C, 39.24; H, 3.57; N, 26.70. Found: C, 39.37; H, 3.89; N, 26.78.

1,3-Dipicryl-2-picrylimino-4-imidazoline·DMF (IV).

2-Picrylimino-4-imidazoline·DMF (0.76 g., 0.002 mole) and picryl fluoride (0.5 g., 0.002 mole) were dissolved in DMF (20 ml.). The solution was stirred at 25° for 16 hours, then it was poured into 400 ml. of water. The solid was collected by filtration, washed with water, and recrystallized from ethanol to give 0.73 g. (92%) of III, m.p. 229° dec.

Anal. Calcd. for $C_{24}H_{15}N_{13}O_{19}$: C, 36.51; H, 1.92; N, 23.06. Found: C, 36.84; H, 1.91; N, 23.04.

4-Aminoimidazole Dihydrochloride (V).

4-Nitroimidazole (2.26 g., 0.02 mole) was hydrogenated in 100 ml. of acetic acid over 5% palladium on charcoal under 50 psi of hydrogen in a Parr low pressure hydrogenation apparatus for one hour. The catalyst was removed by filtration and the solution was saturated with dry hydrogen chloride. Anhydrous ether (400 ml.) was added to complete the precipitation of the solid, which was collected by filtration, washed with ether, and recrystallized from methanol-ether to yield 1.63 g. (52%) of V, m.p. 180° dec. [lit. (5) m.p. 184°].

1-Picryl-4-picrylaminoimidazole (VI).

4-Aminoimidazole dihydrochloride (0.78 g., 0.005 mole) and picryl fluoride (3.46 g., 0.015 mole) were dissolved in DMF (20 ml.) and the resulting solution was stirred at 25° for 16 hours. The solution was poured into 400 ml. of water with stirring and the precipitated solid was collected by filtration. Recrystallization of the product from acetone-ethanol provided 1.41 g. (56%) of VI, m.p. 211° dec.

Anal. Calcd. for $C_{15}H_7N_9O_{12}$: C, 35.66; H, 1.40; N, 24.95. Found: C, 35.62; H, 1.36; N, 24.95.

General Procedure for Nitropicrylimidazoles.

A solution of 1.0 g. of the appropriate imidazole and an equimolar quantity of picryl fluoride in 25 ml. of DMF was stirred at room temperature for 24 to 48 hours. This solution was poured with stirring into water, and the precipitated product was filtered off, washed with water, and dried. The imidazole, solvent of recrystallization, yield, melting point, and analysis are given below.

1-Picrylimidazole (VIII) (6).

Imidazole, ethanol-acetone, 61%, m.p. 209-210°.

Anal. Calcd. for $C_9H_5N_5O_6$: C, 38.72; H, 1.81; N, 25.09. Found: C, 38.62; H, 1.55; N, 24.96.

2-Nitro-1-picrylimidazole (X).

2-Nitroimidazole, acetone-heptane, 46%, m.p. 202-203°.

Anal. Calcd. for $C_9H_4N_6O_8$: C, 33.35; H, 1.24; N, 25.93. Found: C, 33.36; H, 0.93; N, 25.93.

4-Nitro-1-picrylimidazole (XII).

4-Nitroimidazole, ethanol-acetone, 68%, m.p. 286-287°.

Anal. Calcd. for $C_9H_4N_6O_8$: C, 33.35; H, 1.24; N, 25.93. Found: C, 33.40; H, 1.17; N, 26.03.

2,4-Dinitro-1-picrylimidazole (XIV).

2,4-Dinitroimidazole (7), acetone-water, 28%, m.p. 252-254°.

Anal. Calcd. for $C_9H_3N_7O_{10}$: C, 29.28; H, 0.82; N, 26.56. Found: C, 29.37; H, 0.65; N, 26.60.

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REFERENCES

(1) This work was performed under the auspices of the U. S. Atomic Energy Commission.

(2) R. E. Parker and T. O. Read, *J. Chem. Soc.*, 9 (1962).

(3) Microanalyses by M. J. Naranjo. Crystal densities by Marion Clancy. Drop-weight impact sensitivities by F. M. Muse.

(4) A. Lawson, *J. Chem. Soc.*, 307 (1956).

(5) G. Hunter and J. A. Nelson, *Can. J. Research*, 19B, 296 (1941).

(6) The nmr spectrum of 1-picrylimidazole has been reported by A. Mannschreck, W. Seitz and H. A. Staab, *Ber. Bunsenges. Phys. Chem.*, 67, 470 (1963), but no synthetic procedure was given for the preparation of this compound.

(7) G. C. Lancini, N. Maggi, and P. Sensi, *Farmaco (Pavia), Ed. Sci.*, **18**, 390 (1963).

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