# REACTIONS OF POLYHALOPYRIDINES

## 3. REACTION OF HEPTACHLORO-2-PICOLINE WITH HYDRAZINE HYDRATE. STRUCTURE OF THE 3,5,6-TRICHLORO-4-HYDRAZINO-2-TRICHLOROMETHYLPYRIDINE MOLECULE

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*The reaction of heptachloropicoline with hydrazine hydrate has been studied. The formation of two isomers of hexachlorohydrazinopicoline was discovered corresponding to nucleophilic substitution at positions 2 and 4 of the pyridine ring. The structure of the isomers was determined with the aid of NMR spectroscopy and of x-ray structural analysis.*

Pyridine-containing pesticides are used widely in agricultural chemistry [1] and one of the best known pesticides of this series is 3,6-dichloropicolinic acid [2]. This preparation is synthesized by the intramolecular oxidation−reduction dechlorination of 3,5,6-trichloro-4-hydrazinopicolinic acid taking place in an aqueous alkaline medium [3].

In order to develop a method for obtaining 3,6-dichloropicolinic acid using 4-hydrazinohexachloro-2-picoline (II) we have carried out a series of experiments on the reaction of heptachloro-2-picoline (I) with hydrazine hydrate under conditions guaranteeing a practical method for the process [4]. Compound (II) is readily converted into the acid (IV) on heating in concentrated sulfuric acid analogously to the hydrolysis of 4-aminohexachloropicoline to 4-aminotrichloropicolinic acid [5].

By reacting hydrazine hydrate and heptachloropicoline (I) in ethanol a light brown substance was obtained. It had mp 113-115°C which is identical to the melting point of the 4-hydrazino derivative (II) obtained by a similar method and described as a single chemical compound in [4]. Spectral investigations showed however the presence of two isomers of hydrazinohexachloropicoline differing in the position of the hydrazine group in the pyridine ring. This result is in agreement with data on the chemical reactivity of the polychloropyridines [6] according to which the formation of a mixture of the two isomers (II) and (III) with the former predominating would be expected from the reaction of heptachloropicoline (I) with hydrazine hydrate.
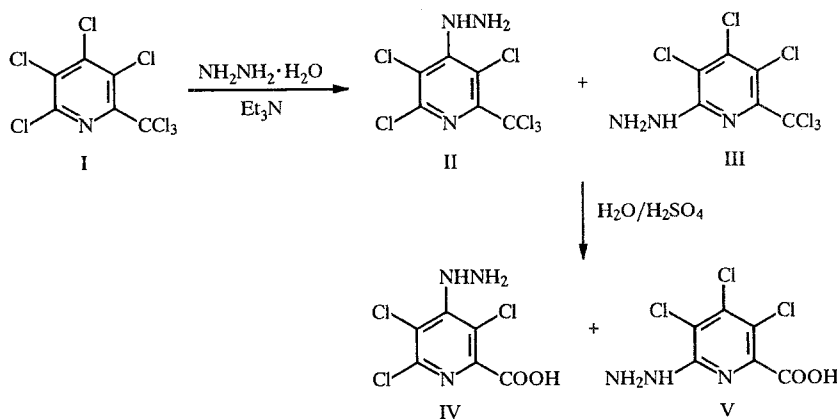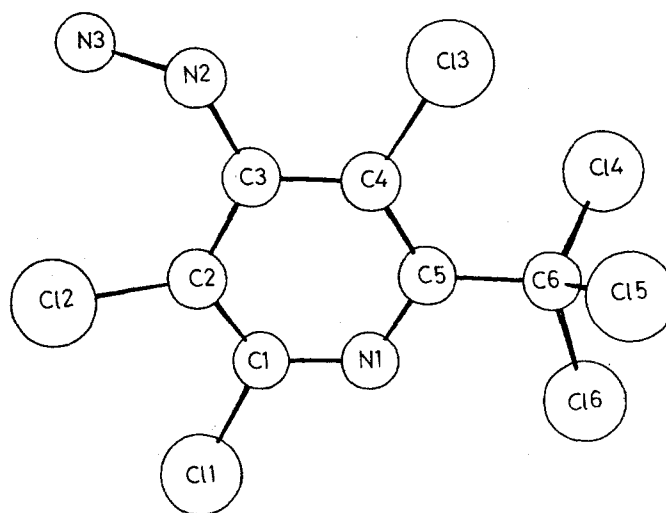
Fig. 1. Structure of the 3,5,6-trichloro-4-hydrazino-2-trichloromethyl-pyridine molecule (II).

TABLE 1. Bond Lengths in Compound (II)*

| Bond | $d$,Å | Bond | $d$,Å | Bond | $d$,Å |
|---|---|---|---|---|---|
| $Cl_{(1)}$—$C_{(1)}$ | 1,75 (1) | $C_{(1)}$—$C_{(2)}$ | 1,36 (2) | $Cl_{(16)}$—$C_{(16)}$ | 1,77 (1) |
| $Cl_{(2)}$—$C_{(2)}$ | 1,70 (1) | $C_{(2)}$—$C_{(3)}$ | 1,40 (2) | $N_{(11)}$—$C_{(11)}$ | 1,31 (1) |
| $Cl_{(3)}$—$C_{(4)}$ | 1,74 (1) | $C_{(3)}$—$C_{(4)}$ | 1,40 (2) | $N_{(11)}$—$C_{(15)}$ | 1,34 (2) |
| $Cl_{(4)}$—$C_{(6)}$ | 1,74 (1) | $C_{(4)}$—$C_{(5)}$ | 1,41 (2) | $N_{(12)}$—$N_{(13)}$ | 1,44 (1) |
| $Cl_{(5)}$—$C_{(6)}$ | 1,81 (2) | $C_{(5)}$—$C_{(6)}$ | 1,51 (2) | $N_{(12)}$—$C_{(13)}$ | 1,37 (2) |
| $Cl_{(6)}$—$C_{(6)}$ | 1,75 (1) | $Cl_{(11)}$—$C_{(11)}$ | 1,75 (1) | $C_{(11)}$—$C_{(12)}$ | 1,36 (2) |
| $N_{(1)}$—$C_{(1)}$ | 1,35 (1) | $Cl_{(12)}$—$C_{(12)}$ | 1,73 (1) | $C_{(12)}$—$C_{(13)}$ | 1,40 (2) |
| $N_{(1)}$—$C_{(5)}$ | 1,32 (1) | $Cl_{(13)}$—$C_{(14)}$ | 1,70 (1) | $C_{(13)}$—$C_{(14)}$ | 1,44 (2) |
| $N_{(2)}$—$N_{(3)}$ | 1,46 (1) | $Cl_{(14)}$—$C_{(16)}$ | 1,75 (1) | $C_{(14)}$—$C_{(15)}$ | 1,35 (2) |
| $N_{(2)}$—$C_{(3)}$ | 1,36 (2) | $Cl_{(15)}$—$C_{(16)}$ | 1,77 (1) | $C_{(15)}$—$C_{(16)}$ | 1,53 (2) |

*The numbering of atoms in Tables 1-3 corresponds to that given in Fig. 1.

The isomers were isolated in a pure state in a 6:1 ratio (II:III) after chromatographic resolution. Their melting points were significantly greater than that given in the literature and were 120-122°C (II) and 139-141°C (III), respectively.

The structure of compound (II) was confirmed by x-ray structural analysis. It turned out that this compound, having the lower melting point, was the 4-hydrazino derivative. There were two crystallographically independent molecules of practically identical structure in the unit cell. The general form of the molecule is shown in Fig. 1 and the bond lengths and valence angles of the two independent molecules are given in Tables 1 and 2. It is evident from the Tables that the bond lengths and valence angles in the molecules are close to one another and have generally accepted values for the appropriate bonds. Compounds (II) and (III) differ significantly from the initial (I) and from one another in spectral characteristics. Shifts were observed in the $^{13}C$ NMR spectra of the 4-hydrazino derivative for the $C_{(4)}$ signal of 6.2 ppm toward low field and for the $C_{(6)}$ signal of isomer (III) of 1.5 ppm compared with the initial heptachloropicoline. The chemical shifts of the $C_{(6)}$ and $C_{(5)}$ carbon atoms underwent the greatest change in both cases, by 13-18 ppm toward high field. The differences in IR spectra between the isomers reduced to a higher value for the absorption band of the hydrazino group of isomer (III).

It follows from the results obtained that if the isomers are not separated then on hydrolyzing the reaction mixture of hydrazino derivatives (II) and (III) a mixture will be obtained containing the isomeric 3,5,6-trichloro-4-hydrazinopicolinic acid (IV) and 3,4,5-trichloro-6-hydrazinopicolinic acid (V). The latter is not subject to further chemical dechlorination but remains

TABLE 2. Valence Angles in Compound (II)

| Angle | $\omega$, deg | Angle | $\omega$, deg |
|---|---|---|---|
| C(1)—N(1)—C(5) | 116 (1) | C(11)—N(11)—C(15) | 117 (1) |
| N(3)—N(2)—C(3) | 122,1 (9) | N(13)—N(12)—C(13) | 119,5 (9) |
| Cl(1)—C(1)—N(1) | 112,7 (8) | Cl(11)—C(11)—N(11) | 114,9 (9) |
| Cl(1)—C(1)—C(2) | 120,9 (9) | Cl(11)—C(11)—C(12) | 119,8 (9) |
| N(1)—C(1)—C(2) | 126 (1) | N(11)—C(11)—C(12) | 125 (1) |
| Cl(2)—C(2)—C(1) | 119,8 (9) | Cl(12)—C(12)—C(11) | 120,0 (9) |
| Cl(2)—C(2)—C(3) | 121,5 (9) | Cl(12)—C(12)—C(13) | 120,3 (9) |
| C(1)—C(2)—C(3) | 118 (1) | C(11)—C(12)—C(13) | 120 (1) |
| N(2)—C(2)—C(3) | 125 (1) | N(12)—C(12)—C(13) | 125 (1) |
| N(2)—C(3)—C(4) | 120 (1) | N(12)—C(13)—C(14) | 120 (1) |
| C(2)—C(3)—C(4) | 116 (1) | C(12)—C(13)—C(14) | 114 (1) |
| Cl(3)—C(4)—C(3) | 117,3 (9) | Cl(13)—C(14)—C(13) | 115,9 (8) |
| Cl(3)—C(4)—C(5) | 121,2 (9) | Cl(13)—C(14)—C(15) | 123,4 (9) |
| C(3)—C(4)—C(5) | 122 (1) | C(13)—C(14)—C(15) | 121 (1) |
| N(1)—C(5)—C(4) | 121 (1) | N(11)—C(15)—C(14) | 122 (1) |
| N(1)—C(5)—C(6) | 117 (1) | N(11)—C(15)—C(16) | 112 (1) |
| C(4)—C(5)—C(6) | 122 (1) | C(14)—C(15)—C(16) | 125 (1) |
| Cl(4)—C(6)—Cl(5) | 105,2 (6) | Cl(14)—C(16)—Cl(15) | 107,1 (7) |
| Cl(4)—C(6)—Cl(6) | 110,5 (7) | Cl(14)—C(16)—Cl(16) | 108,4 (7) |
| Cl(4)—C(6)—C(5) | 114,3 (9) | Cl(14)—C(16)—C(15) | 113,0 (8) |
| Cl(5)—C(6)—Cl(6) | 106,1 (6) | Cl(15)—C(16)—Cl(16) | 108,1 (7) |
| Cl(5)—C(6)—C(5) | 109,0 (8) | Cl(15)—C(16)—C(15) | 110,3 (8) |
| Cl(6)—C(6)—C(5) | 111,2 (8) | Cl(16)—C(16)—C(15) | 109,9 (8) |

TABLE 3. Atomic Coordinates ($\times 10^4$) for Compound (II)

| Atom | $x$ | $y$ | $z$ | Atom | $x$ | $y$ | $z$ |
|---|---|---|---|---|---|---|---|
| Cl(1) | 6584 (2) | 4197 (2) | 1717 (4) | Cl(11) | 820 (2) | 4852 (2) | 1937 (4) |
| Cl(2) | 6976 (2) | 4632 (2) | -1460 (4) | Cl(12) | -1281 (2) | 5186 (2) | 2342 (4) |
| Cl(3) | 3809 (2) | 3548 (2) | 2947 (4) | Cl(13) | -1024 (2) | 2875 (2) | 6403 (4) |
| Cl(4) | 2640 (2) | 3516 (2) | 4 (5) | Cl(14) | 2175 (2) | 2604 (2) | 4808 (5) |
| Cl(5) | 3832 (2) | 2843 (2) | 2174 (5) | Cl(15) | 1143 (2) | 2726 (2) | 7378 (4) |
| Cl(6) | 3863 (2) | 2080 (2) | -565 (5) | Cl(16) | 679 (2) | 1669 (2) | 5131 (4) |
| N(1) | 5092 (6) | 3686 (5) | 798 (11) | N(11) | 797 (6) | 3749 (5) | 3896 (11) |
| N(2) | 5287 (6) | 4532 (5) | -3410(12) | N(12) | -1979 (6) | 4245 (5) | 4897 (13) |
| N(3) | 5642 (6) | 5296 (4) | -3739 (12) | N(13) | -2402 (6) | 5072 (5) | 4997 (13) |
| C(1) | 5805(7) | 4063 (6) | 343 (15) | C(11) | 270 (8) | 4317 (6) | 3229 (14) |
| C(2) | 5951 (7) | 4314 (6) | -1016 (15) | C(12) | -644 (4) | 4499 (6) | 3455 (14) |
| C(3) | 5279 (8) | 4234 (6) | -2051 (15) | C(13) | -1072 (8) | 4096 (6) | 4534 (13) |
| C(4) | 4576 (8) | 3785 (6) | -1627 (15) | C(14) | -502 (7) | 3437 (6) | 5187 (13) |
| C(5) | 4492 (7) | 3528 (5) | -190 (16) | C(15) | 399 (8) | 3300 (6) | 4862 (14) |
| C(6) | 3741 (8) | 3033 (6) | 263 (15) | C(16) | 1068 (8) | 2617 (6) | 5492 (15) |

in the reaction mixture and hinders the isolation of the pure desired product, viz. 3,6-dichloropicolinic acid. This is similar to the hydrolysis of the reaction mixture of hydrazino derivatives of trichloro-2-cyanopyridine when using tetrachloro-2-cyanopyridine as starting material as in the method of [3]. The moderate yield of 3,6-dichloropicolinic acid (less than 70%) obtained through hydrazino derivatives by the method of [3] is also understandable. Consequently one possible direction of investigation might be the selection of conditions securing the maximum yield of 4-hydrazinohexachloropicoline (II).

## EXPERIMENTAL

The IR spectra were recorded on a Specord M-80 instrument in chloroform solution and the $^{13}$C NMR spectra on a Bruker AC 200 instrument (operating frequency 50 MHz). A mixture of heptachloropicoline (16.7 g:0.05 mole) and ethanol (250 ml) was heated to give complete solution of the starting material, hydrazine hydrate (2.75 g:0.055 mole) and triethylamine (5 g:0.05 mole) were added, and the mixture boiled for 1 h. The mixture was then cooled and poured into water (0.5 liter). The solid formed was filtered off, washed on the filter, and dried. A mixture (15 g) of isomers was obtained.

The mixture (2 g) was chromatographed on a column of silica gel (eluent was benzene). Compound (II) (0.78 g) was obtained from the first fraction and compound (III) (0.73 g) from the second.

**3,5,6-Trichloro-4-hydrazino-2-trichloromethylpyridine (III)** had mp 120-122°C. IR spectrum: 3400 cm$^{-1}$ (NHNH$_2$). $^{13}$C NMR spectrum: 95.4 (CCl$_3$), 116.1, 118.4 (C$_{(3)}$, C$_{(5)}$), 145.8 (C$_{(6)}$), 149.6 (C$_{(2)}$), 152.8 ppm (C$_{(4)}$).

**3,4,5-Trichloro-6-hydrazino-2-trichloromethylpyridine (III)** had mp 139-141°C. IR spectrum: 3460 cm$^{-1}$ (NHNH$_2$). $^{13}$C NMR spectrum: 96.4 (CCl$_3$), 115.4, 118.0 (C$_{(3)}$, C$_{(5)}$), 143.8 (C$_{(4)}$), 148.8 (C$_{(6)}$), 151.0 ppm (C$_{(2)}$).

**X-Ray Investigation of Compound (II).** Colorless well-defined monoclinic crystals C$_6$H$_3$N$_3$Cl$_6$: $a = 14.719(3)$, $b = 16.589(3)$, $c = 9.304(2)$ Å, $\gamma = 83.5(1)°$, $V = 2259.2$ Å$^3$, $M = 330$, $d_{calc} = 1.95$ g/cm$^3$, $Z = 8$. Space group P2$_1$/$b$. The experimental data of 2469 independent nonzero reflections were obtained on a DAR-UM automatic diffractometer with monochromatized CuK$\alpha$ radiation. Sin $\vartheta/\lambda$ max $= 0.6$. The crystals were unstable to radiation which showed in the quality of the experiment. The structure was solved by the direct statistical method. Refinement was carried out in a full matrix anisotropic approach to R $= 0.072$. Hydrogen atoms were not localized. All calculations were carried out on a PC-AT with the Sheldrick set of programs [7]. Atomic coordinates are given in Table 3.

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