

A Novel Displacement Reaction of 5-Nitro-2-furaldehyde

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An earlier paper from these laboratories reported the formation of 5-methoxy-2-furaldehyde, isolated as the oxime, by the reaction of sodium methoxide with 5-nitro-2-furaldehyde (I) (1). A paper by Powers (2) described the photolysis of *N-n*-butyl-5-nitro-2-furamide in methanol to yield *N-n*-butyl-5-methoxy-2-furamide. Recently, a paper by Lieb and Eiter (3) reported the preparation of 5-azido-, 5-alkylmercapto-, and 5-phenylsulfonyl-2-furaldehyde from I. This paper reports the formation of 5-chloro-2-furaldehyde (II) from 5-nitro-2-furaldehyde diacetate (III) by the action of concentrated hydrochloric acid.

During the course of an investigation into the formation of I from III in the presence of methanol and concentrated hydrochloric acid, a small amount of material (II) was obtained which was neither of the expected products, *i.e.* methyl acetate and I. Elemental analysis of the purified material suggested the empirical formula of $C_5H_3ClO_2$. The ir spectrum showed the presence of a C=O group together with a furan ring and the absence of the NO_2 group. The nmr spectrum indicated the presence of two furan protons and a methine proton. The observations suggest the presence of a 5-substituted-2-furaldehyde. It appeared that a displacement of the 5- NO_2 by a Cl to give II had taken place. Compound II was converted to the semicarbazone IV. Both II and IV were compared with authentic samples (4,5) and were identical in all respects, *i.e.* m.p., ir, and nmr spectra.

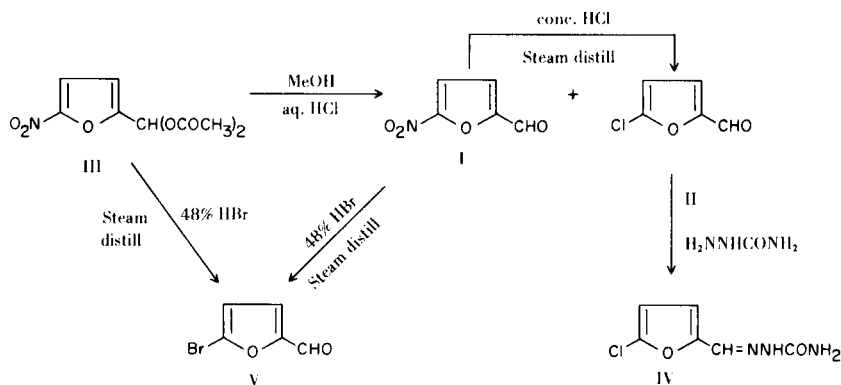
In order to test the displacement reaction further, I was treated with 48% hydrobromic acid and the mixture was steam distilled to yield 5-bromo-2-furaldehyde (V). Compound V, and its semicarbazone, were compared with authentic samples (6,7) and found to be identical. The treatment of I with concentrated hydrochloric acid followed by steam distillation yielded II. Finally, when III was steam distilled in the presence of 48% hydrobromic acid, V was obtained.

EXPERIMENTAL (8)

5-Chloro-2-furaldehyde (II) (4).

A. From 5-Nitro-2-furaldehyde Diacetate (III).

Compound III (486.0 g., 2.0 moles) was placed in a 1-ℓ distillation flask together with methanol (260.0 g., 8.1 moles) and concentrated hydrochloric acid (20 g.). The mixture was fractionally distilled at atmospheric pressure using a 20-plate Oldershaw column. The methyl acetate-methanol azeotrope distilled at 53° and the excess methanol distilled at 65.5° with a 1/1 reflux ratio at a maximum pot temperature of 105°. A total of 300 g. was collected. The pressure was gradually reduced to 25 mm and the distillation was continued with a 2/1 reflux ratio at a head temperature of 45° and a pot temperature of 109°. After collecting *ca.* 50 ml. of distillate (a solid and liquid mixture) the receiver was changed and the distillation was continued at 2 mm with a pot temperature of 135° and a head temperature of 24°. When distillation ceased, the combined distillates were chilled and filtered to yield 6.0 g. (2.3%) of II. The distillation residue was crude I. The crude II was sublimed at 100°/313 mm to give 3.4 g., m.p. 30.0°. The sample was purified by recrystal-



lization from hexane (charcoal), m.p. 30.5-31°.

Anal. Calcd. for $C_5H_3ClO_2$: C, 46.01; H, 2.32; Cl, 27.16. Found: C, 46.03; H, 2.22; Cl, 26.80.

Analysis of an authentic sample gave similar results.

The nmr spectrum contained signals at $\delta = 6.42$ and 7.25 (2 furan protons, 2 doublets, $J = 4$ cps) and 9.50 (a methine proton, a singlet).

The infrared spectrum showed absorption maxima at 1710 and 1680 cm^{-1} (C=O).

Compound II was converted to the semicarbazone IV in the usual manner. The material was purified by recrystallization from 2-propanol (charcoal), m.p. 199-201°.

Anal. Calcd. for $C_6H_6ClN_3O_2$: C, 38.41; H, 3.22; N, 22.40; Cl, 18.90. Found: C, 38.45; H, 3.15; N, 22.39; Cl, 18.87.

The nmr spectrum contained signals at $\delta 6.61$ and 6.91 (2 furan protons, 2 doublets, $J = 4$ cps), 7.76 (a methine proton, a singlet), 6.61 (2 exchangeable protons, a singlet), and 10.38 (one exchangeable proton, a singlet).

Compounds II and IV were identical with authentic samples (4,5).

B. From 5-Nitro-2-furaldehyde (I).

Compound I (141.0 g., 1.0 mole) was placed in a 3-ℓ, 3-necked flask fitted for steam distillation into a 2-ℓ, 3-necked flask which was submerged in an ice-water bath. Concentrated hydrochloric acid (600 ml.) was added to I and the mixture was steam distilled for about 15 minutes after which there was no evidence of the formation of II. The distillate was filtered and the product collected to yield II, 28.0 g. (20.0%), m.p. 28-29°. A sample (1.0 g.) was recrystallized from hexane (charcoal), m.p. 30-31°. The material was identical to the authentic sample.

5-Bromo-2-furaldehyde (V).

A. From 5-Nitro-2-furaldehyde (I).

Compound I (141.0 g., 1.0 mole) was placed in a 2-ℓ, 3-necked flask fitted for steam distillation. Hydrobromic acid (48%) (ca. 500 ml.) was added and the mixture was steam distilled. An oil first appeared which crystallized in the condenser. The distillation was continued until there was no longer any product appearing in the distillate. The total time was about 0.5 hour. There was a black, tarry residue in the distillation flask. The distillate was chilled and the product collected and dried to yield 38.0 g. (21.7%) of V, m.p. 66-68°. The material was purified by recrystallization from aqueous methanol (charcoal), m.p. 80-81°. The material was identical to an authentic sample (5).

The semicarbazone was prepared from V and was identical to an authentic sample (7).

B. From 5-Nitro-2-furaldehyde Diacetate (III).

A 3-ℓ, 3-necked flask was fitted for steam distillation and charged with III (242.0 g., 1.0 mole). Hydrobromic acid (500 ml. of 48%) was added and the mixture was steam distilled for 0.5 hour. The chilled distillate was filtered and the product dried to yield 1.0 g. (0.63%) of V, m.p. 70-73°. Recrystallization of the product from aqueous methanol (charcoal) gave V, m.p. 80-81°, which was identical to the authentic sample.

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- (8) The melting points, obtained in open capillaries on a Mel-Temp melting point apparatus, are uncorrected. The infrared spectra were obtained as Nujol mulls on the Perkin-Elmer Infra-cord Model 137. The nmr spectra were determined on a Varian Model A-60A spectrometer using deuterated DMSO or deuteriochloroform with TMS as an internal standard.