(gradual decomposition above 130°). A sample was obtained as colorless feathery needles from ethanol, and dried at 55° *in vacuo* for analysis.

Anal. Calcd. for $C_7H_6N_4O$: C, 51.84; H, 3.73; N, 34.55. Found: C, 52.00; H, 3.89; N, 34.76.

The infrared spectrum (Nujol mull) of this material was identical in all respects with the substance obtained by the rearrangement of IV. The carbonyl absorption appeared at 5.7 μ in the infrared.

Thermal decomposition of V produced benzotriazole (VI) and cyanuric acid. For example, a 0.5-g. sample of V was placed in a test tube and heated at 160–170° in an oil bath for 0.5 hr. The reaction mass was cooled to room temperature, broken up into a powder, and extracted with 15 ml. of hot benzene. The filtrate gave 0.35 g. (95%) of colorless needles when concentrated and chilled, m.p. 94–96°. A mixed melting point with authentic benzotriazole was undepressed. The benzene-insoluble portion (m.p. > 300°, 80 mg.) was identified as cyanuric acid by comparison of infrared spectra.

Rearrangement of 3-hydroxy-1,2,4-benzotriazine-1-oxide (VII). 3-Hydroxy-1,2,4-benzotriazine 1-oxide (VII)[2a,6] (2.5 g., 0.015 mole) was dissolved in 25 ml. of 10% sodium hydroxide solution, and refluxed a total of 14 hr. Aliquots withdrawn at the end of 3.5 hr. and 7.5 hr. still gave VII when acidified. The reaction mixture was cooled and adjusted to *p*H 4–5 with hydrochloric acid. A work-up identical to that used for the rearrangement of IV (see above) gave 0.81 g. (45%) of benzotriazole (VI), m.p. 95.5–96.5° (mixed melting point undepressed).

3-Amino-1,2,4-benzotriazine (VIII). Attempts to prepare this compound by reduction of IV with zinc dust and aqueous ammonium chloride[5,6] resulted only in a 96% recovery of starting material. The following procedure gave satisfactory results, however.

3-Amino-1,2,4-benzotriazine 1-oxide (IV) (3.5 g., 0.022 mole) was mixed with 50 ml. of glacial acetic acid, 5 ml. of water, and 2.6 g. (0.04 mole) of zinc dust, and heated on a steam bath with vigorous stirring until an aliquot gave no precipitate when diluted with an equal volume of water (6.75 hr. required). The solution was filtered to remove unchanged zinc, evaporated to dryness *in vacuo*, and the residue slurried in 40 ml. of water. Filtration gave 2.1 g. of a yellow solid, m.p. 211.0–211.5°. The filtrate was rendered quite strongly basic with concd. ammonium hydroxide, and after standing at room temperature for several hours, filtered to obtain an additional 0.67 g. of product (m.p. 209–210°). The total yield was 2.77 g. (87.4%). Recrystallization from ethanol did not raise the melting point (Arndt[2a] gives m.p. 207° for this compound). The infrared spectrum was identical to that of an authentic sample[2a] of VIII.

Base-catalyzed hydrolysis of 3-amino-1,2,4-benzotriazine (VIII). One gram (0.0069 mole) of VIII was suspended in 10 ml. of 10% sodium hydroxide solution and refluxed for 30 hr. The starting material slowly dissolved during this period to form a deep yellow solution. The reaction mixture was cooled to room temperature, filtered to remove a small quantity of insoluble material (infusible), and finally acidified with glacial acetic acid. The resulting yellow precipitate was filtered with suction and washed with water. This solid was extracted with 25 ml. of boiling water, filtered hot to remove silicates, and chilled to 5° to obtain 0.54 g. (54%) of yellow-brown prisms, m.p. 201–206° dec. Recrystallization from water with Norit gave yellow scales, m.p. 207–210° dec., identical in all respects with an authentic sample of 3-hydroxy-1,2,4-benzotriazine (X),[2b] obtained by the treatment of 3-amino-1,2,4-benzotriazine (VIII) with nitrous acid as directed by Arndt.[2b]

Rearrangement of 3-amino-1,2,4-benzotriazine 2-oxide (IX). One gram (0.0062 mole) of 3-amino-1,2,4-benzotriazine 2-oxide (IX)[2b] was mixed with 15 ml. of 1*N* sodium hydroxide and heated to reflux. The starting material quickly dissolved in the hot alkali to form a dark brown solution (no gas evolution observed). After 10 min. of refluxing an aliquot gave no precipitate of IX when chilled. At the end of 15 min. the solution was cooled to room temperature and acidified to *p*H 1 with hydrochloric acid to obtain 0.51 g. (51%) of tan colored needles of *benzotriazole-1-carboxamide* (V), gradual dec. above 130°, identical in all respects with an authentic sample (see above).

The filtrate from V was adjusted to *p*H 5 with ammonium hydroxide and acetic acid. The oil was extracted into methylene chloride (three portions), the extracts dried over magnesium sulfate, filtered, and evaporated to leave 0.28 g. (38%) of a brownish solid, with an infrared spectrum identical to that of an authentic sample of *benzotriazole* (VI). Recrystallization from benzene gave yellowish leaflets, m.p. 95–96°, undepressed by admixture with authentic benzotriazole (VI).

Acknowledgment. The author is indebted to Mr. E. F. Shelberg and his staff for the microanalyses and to Mr. W. Washburn and his staff for the infrared spectra.

NORTH CHICAGO, ILL.

[CONTRIBUTION FROM THE EATON LABORATORIES, DIVISION OF THE NORWICH PHARMACAL CO.]

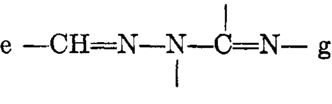
Chemotherapeutic Nitrofurans. VII.[1] The Formation of 5-Nitrofurfurylidene Derivatives of Some Aminoguanidines, Aminotriazoles, and Related Compounds

FRANK F. EBETINO AND GABRIEL GEVER

Received July 17, 1961

A number of aminoguanidines have been prepared by the reaction of substituted hydrazines with cyanamide or *S*-methylisothiourea. These compounds in addition to some *N*-aminotriazoles and other related *N*-amino compounds have been converted to 5-nitrofurfurylidene derivatives. The reactions of 5-nitro-2-furaldehyde thiosemicarbazone with chloroacetic acid and β-propiolactone are described.

As 1-(5-nitrofurfurylideneamino)guanidine sulfate[2] (I) and 3-(5-nitrofurfurylideneamino)-2-iminooxazolidine[3] (II) have been found to exhibit chemotherapeutic activity, we have undertaken the synthesis of related nitrofuran compounds containing the



$—CH{=}N—N—C{=}N—$ group.

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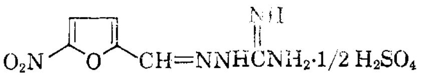
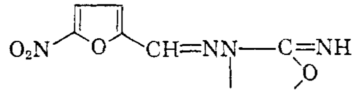
[1] For the previous paper in this series, see J. G. Michels, *J. Org. Chem.*, **25**, 2246 (1960).

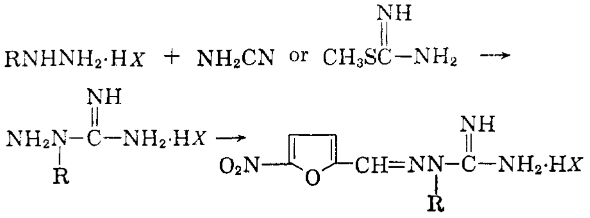


I



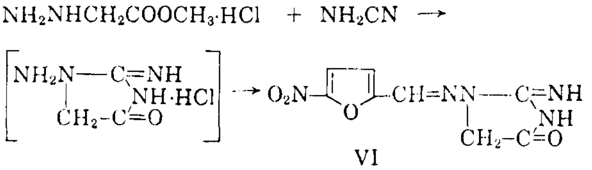
II

Substituted aminoguanidines were prepared by reaction of the appropriate hydrazine with cyanamide, or in some cases with *S*-methylisothiourea in aqueous or alcoholic solution at reflux temperature. The aminoguanidines were not isolated but were converted to their 5-nitrofurfurylidene derivatives by condensation with 5-nitro-2-furaldehyde. The unstable nature of the guanidine structure in the form of the free base, and the fact that cyanamide hydrolyzes to urea in acid or strong alkali and polymerizes in weak alkali limited the cyanamide reaction to a *p*H range of 5 to 6.



III. R = CH_3, X = HSO_4^-
IV. R = CH_2CH_2OH; X = HSO_4^- or Cl^-
V. R = $CH_2CH_2N(CH_3)_2\cdot HCl$; X = Cl^-

Methyl hydrazinoacetate hydrochloride reacted with cyanamide to produce the ring closed compound 1-amino-2-iminohydantoin which was isolated and identified as its 5-nitrofurfurylidene derivative (VI).

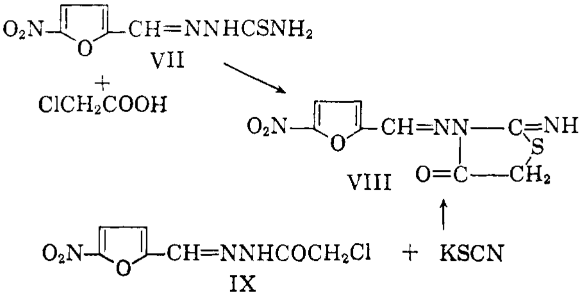


Subsequent to the preparation of these compounds, Uoda *et al.*[4] in their paper on furan compounds showed generic formulas which included structures, III, IV, and VI. However, no experimental evidence or discussion concerning these structures was presented.

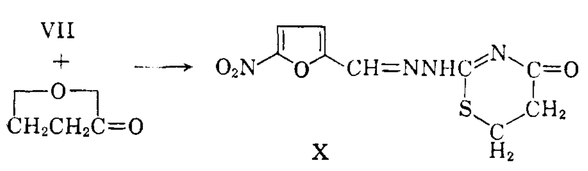
The 5-nitrofurfurylidene derivatives of a number of known *N*-amino compounds such as 1,3-diaminoguanidine; 4-amino-1,2,4-triazole; 4-amino-3,5-dimethyl-1,2,4-triazole; 3-amino-2-imino-4-methyl-4-thiazoline; 3,4-diamino-1,2,4-triazole, 3,4-diamino-5-methyl-1,2,4-triazole and *N*,*N*″-diaminooxamidine were prepared in this work. All these nitrofurans contain the $\text{—CH=N}\overset{|}{\text{N}}\underset{|}{\text{C}}\text{=N—}$group.

Sasaki[5] reported the preparation of the 5-nitrofurfurylidene derivative (XI) of 4-amino-1,2,4-triazole. However, this compound was reported to melt at 213° compared with the melting point of 230–235° found in our work.

Several other sulfur containing compounds in this general class were prepared. Reaction of 5-nitro-2-furaldehyde thiosemicarbazone (VII) with chloroacetic acid in a sodium acetate–acetic acid medium produced 2-imino-3-(5-nitrofurfurylideneamino)-4-thiazolidinone (VIII). The structure assigned to VIII was proved by an unequivocal synthesis from 5-nitro-2-furaldehyde chloroacetylhydrazone (IX) and potassium thiocyanate. IX was obtained by reaction of 5-nitro-2-furaldehyde hydrazone with chloroacetic anhydride.



β-Propiolactone reacted with VII in acetone or acetic acid to give a cyclic compound. This compound, unlike VIII, lacks strong C=NH absorption at 6.2 μ and absorbs at slightly longer wave lengths in the ultraviolet than VIII. As thiosemicarbazones are known to be alkylated on the sulfur atom with β-propiolactone, the product is probably 2-(5-nitrofurfurylidenehydrazino)-5,6-dihydro-1,3,4-thiazin-4-one (X).



The ultraviolet absorption maxima of these compounds are reported in the experimental section.

EXPERIMENTAL[6,7]

1-Methyl-1-(5-nitrofurfurylideneamino)guanidine sulfate (III). A. 1-Methyl-1-aminoguanidine sulfate was prepared by reaction of 34.5 g. (0.24 mole) of methylhydrazine sulfate and 35 g. (0.126 mole) of *S*-methylthiourea sulfate[8]

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(2) W. Stillman and A. Scott, U. S. Patent 2,416,233 (1947).

(3) K. Hayes *et al.*, *J. Am. Chem. Soc.*, **77**, 2282 (1955); U. S. Patent 2,759,932 (1956).

(4) H. Uoda *et al.*, *J. Pharm. Soc. Japan*, **75**, 117 (1955).

(5) T. Sasaki, *Pharm. Bull., Tokyo*, **2**, 123 (1954); *Chem. Abstr.*, **50**, 971*i* (1956).

(6) All melting points unless otherwise noted were taken on a Fisher-Johns apparatus and are uncorrected.

(7) Microanalyses and spectral analyses were carried out by Mr. G. Ginther and associates of this laboratory.

according to Greer and Smith.[9] Without isolating the aminoguanidine sulfate, the solution was diluted with 700 ml. of water, made strongly acid with sulfuric acid and treated with a solution of 30 g. (0.213 mole) of 5-nitro-2-furaldehyde in ethanol. After cooling, the precipitated product was filtered, washed with water and ethanol, and recrystallized from water to give 29 g. (48%) of III melting at 255–260° dec. The melting point was unchanged after several recrystallizations from water; $\lambda_{max}^{H_2O}$ 365 mμ (log ϵ 4.20).

Anal. Calcd. for $C_7H_9N_5O_3\cdot{}^1/_2\,H_2SO_4\cdot{}^1/_2H_2O$: C, 31.25; H, 4.12; S, 5.94. Found: C, 31.4; H, 4.14; S, 5.89.

B. A solution of 11.0 g. (0.217 mole) of methylhydrazine in 100 ml. of water was adjusted to *p*H 5–6 with 12 g. of sulfuric acid. This solution was added dropwise to a solution of 15 g. (0.357 mole) of cyanamide in 180 ml. of water over a period of 12 min., keeping the temperature at 0–5° by cooling in an ice bath. The resulting solution was then stirred at room temperature for 2 hr. and then at 90° for 3 hr. The solution was treated with 36 g. of potassium bicarbonate, a little insoluble material removed by filtration and the filtrate cooled overnight at 5°. The mixture was filtered and the solid washed with a little cold water, isopropyl alcohol, and ether to yield 9.2 g. of 1-amino-1-methylguanidine carbonate. The latter was suspended in 100 ml. of water and made acid with 3.4 g. of sulfuric acid. To this solution was added a solution of 10 g. of 5-nitro-2-furaldehyde in 50 ml. of ethanol. The mixture was stirred for 1 hr. (50 ml. of water added for fluidity), cooled and filtered. After washing with isopropyl alcohol and ether there was obtained 8.9 g. (9%) of III melting with decomposition at 260°.

Anal. Calcd. for $C_7H_9N_5O_3\cdot{}^1/_2H_2SO_4\cdot{}^1/_2H_2O$: C, 31.25; H, 4.12; Found: C, 31.4; H, 3.94.

1-(2-Hydroxyethyl)-1-(5-nitrofurfurylideneamino)guanidine (IV) *sulfate.* To a solution of 35 g. (0.126 mole) of *S*-methylthiourea sulfate in 60 ml. of water was added a solution of 18 g. (0.237 mole) of 2-hydrazinoethanol in 125 ml. of water and the mixture refluxed for 45 min. The solution was evaporated on the steam bath and the resulting oil (74 g.) was taken up in 100 ml. of ethanol, acidified with 25 g. of sulfuric acid, and treated with a solution of 18 g. (0.128 mole) of 5-nitro-2-furaldehyde in 90 ml. of ethanol. There was obtained 2.5 g. (3.6%) of the sulfate of IV melting at 195–200° dec. Recrystallization from water gave a product melting at 215° dec.; $\lambda_{max}^{H_2O}$ 365 mμ (log ϵ 4.22).

Anal. Calcd. for $C_8H_{11}N_5O_4\cdot{}^1/_2H_2SO_4$: C, 33.12; H, 4.17; N, 24.13; Found: C, 33.08; H, 4.14; N, 24.0.

1-(2-Hydroxyethyl)-1-(5-nitrofurfurylideneamino)guanidine (IV) *hydrochloride.* A solution of 22.8 g. (0.3 mole) of 2-hydrazinoethanol in 750 ml. of absolute ethanol was acidified with dry hydrogen chloride to *p*H 6 (*p*Hydrion paper) and then treated with 15 g. (0.357 mole) of cyanamide. After refluxing the mixture for 22 hr. the clear yellow solution was cooled, acidified to *p*H 2 with concentrated hydrochloric acid, and finally treated with a solution of 42.3 g. (0.3 mole) of 5-nitro-2-furaldehyde in 120 ml. of absolute ethanol. The solution was heated on a steam bath for 15 min. to give 21.2 g. (25%) of the hydrochloride of IV melting at 243–245° dec. Purification by recrystallization from a mixture of ten parts ethanol, seven parts water and thirty-five parts concentrated hydrochloric acid gave a yellow product melting at 250° dec.; $\lambda_{max}^{H_2O}$ 366 mμ (log ϵ 4.19).

Anal. Calcd. for $C_8H_{11}N_5O_4\cdot HCl$: C, 34.55; H, 4.36; Cl, 12.78. Found: C, 34.43; H, 4.00; Cl, 12.83.

1-(2-Dimethylaminoethyl)-1-(5-nitrofurfurylideneamino)-guanidine dihydrochloride (V). A solution of 44 g. (0.427 mole) of 2-dimethylaminoethylhydrazine[10,11] in 1065 ml. of absolute ethanol was acidified with dry hydrogen chloride to *p*H 6, treated with 21 g. (0.5 mole) of cyanamide and heated at reflux for 22 hr. To the acidified mixture was then added at reflux temperature a methanol solution of 40 g. (0.284 mole) of 5-nitro-2-furaldehyde. After refluxing for 15 min. the mixture was cooled, and the orange precipitate filtered and rinsed with absolute ethanol. The yield of crude solid was 40 g. (39%), m.p. 240° dec. (copper block). After several recrystallizations from 50% methanol an analytical sample decomposing at 262° was obtained; $\lambda_{max}^{H_2O}$ 360 mμ (log ϵ 4.23).

Anal. Calcd. for $C_{10}H_{16}N_6O_3.2HCl$: C, 35.25; H, 5.32; Cl, 20.80. Found: C, 35.17; H, 5.18; Cl, 20.50.

Methyl hydrazinoacetate hydrochloride. The procedure described in the literature[12] for the preparation of the ethyl ester hydrochloride from hydrazine and chloroacetic acid was used to prepare methyl hydrazinoacetate hydrochloride, m.p. 145.5–146.5°.

Anal. Calcd. for $C_3H_8N_2O_2\cdot HCl$: C, 25.61; H, 6.41; Cl, 25.25. Found: C, 25.57; H, 6.52; Cl, 25.30.

2-Imino-1-(5-nitrofurfurylideneamino)hydantoin (VI). A solution of 70.25 g. (0.5 mole) of methyl hydrazinoacetate hydrochloride and 25 g. (0.6 mole) of cyanamide in 1.25 l. of absolute ethanol was heated at reflux for 22 hr. The resulting clear yellow solution was cooled, acidified with concentrated hydrochloric acid to *p*H 2–3, and treated with a solution of 70.5 g. (0.5 mole) of 5-nitro-2-furaldehyde in 200 ml. of absolute ethanol. After heating on the steam bath for 20 min., the solution was evaporated to dryness. The solid residue was washed several times with isopropyl alcohol and then with ether to give 52.5 g. (38.4%) of hydrochloride. The hydrochloride salt was added to 1.3 l. of water, warmed to 55°, and the free base filtered. The cooled filtrate was treated with saturated sodium bicarbonate solution to precipitate more free base. The combined yield of VI was 36.6 g. (31%). Several recrystallizations from water gave pure VI decomposing at 250–280°; $\lambda_{max}^{2\%\ DMF}$ 378 mμ (log ϵ 4.27).

Anal. Calcd. for $C_8H_7N_5O_4$: C, 40.51; H, 2.97; N, 29.53. Found: C, 40.5; H 2.86; N, 29.8.

1,3-Bis(5-nitrofurfurylideneamino)guanidine. To a solution of 11.3 g. (0.08 mole) of 5-nitro-2-furaldehyde in 380 ml. of 67% ethanol was added a solution of 6.1 g. (0.04 mole) of 1,3-diaminoguanidine nitrate[13] in 130 ml. of water. The solution was made strongly acid with concentrated hydrochloric acid to precipitate 1,3-bis(5-nitrofurfurylideneamino)guanidine hydrochloride; 14.3 g. (96%), m.p. above 200° dec. A suspension of the hydrochloride in 700 ml. of ethanol was heated on a steam bath and treated with 350 ml. of water and then gradually with 10% sodium bicarbonate solution to *p*H 6. After heating for 20 min. the red solid was filtered and extracted once again with hot 67% ethanol. The yield of red needles decomposing at 275–285° was 12.3 g. (93%); $\lambda_{max}^{2\%\ DMF-98\%\ C_2H_5OH}$ 449 mμ (log ϵ 4.61).

Anal. Calcd. for $C_{11}H_9N_7O_6\cdot{}^1/_2H_2O$: C, 38.38; H, 2.93; N, 28.50. Found: C, 38.32; H, 2.57; N, 28.15.

4-(5-Nitrofurfurylideneamino)-1,2,4-triazole (XI). A solution of 21 g. (0.25 mole) of 4-amino-1,2,4-triazole[14] was acidified to *p*H 3 with concentrated hydrochloric acid and treated with a solution of 35.3 g. (0.25 mole) of 5-nitro-2-furaldehyde in 180 ml. of ethanol. After heating at reflux temperature for 1 hr. the mixture was cooled and the solid filtered. The yield of yellow needles decomposing at 230–235° was 48.3 g. (93%). The decomposition point was

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(8) P. R. Shildneck and W. Windus, *Org. Syntheses*, **Coll. Vol. II,** 411 (1943).

(9) A. Greer and G. Smith, *J. Am. Chem. Soc.*, **72,** 874 (1950).

(10) G. Gever and W. C. Ward, U. S. Patent **2,726,241** (1955).

(11) J. H. Biel, W. K. Hoya, and H. A. Leiser, *J. Am. Chem. Soc.*, **81,** 2527 (1959).

(12) A. Darapsky and M. Prabhakar, *Ber.* **45,** 1660 (1912).

(13) G. I. Keim, R. A. Henry, and G. B. L. Smith, *J. Am. Chem. Soc.*, **72,** 4944 (1950).

(14) C. F. H. Allen and A. Bell, *Org. Syntheses*, **Coll. Vol. III,** 96 (1955).

unchanged after several recrystallizations from 2% hydrochloric acid; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 340 mμ (log ε 4.24).

Anal. Calcd. for $C_7H_5N_5O_3$: C, 40.59; H, 2.43; N, 33.81. Found: C, 40.2; H, 2.51; N, 33.80.

3,5-Dimethyl-4-(5-nitrofurfurylideneamino)-1,2,4-triazole. A mixture of 28 g. (0.25 mole) of 4-amino-3,5-dimethyl-1,2,5-triazole[15] 35.3 g. (0.25 mole) of 5-nitro-2-furaldehyde, and 20.5 g. (0.25 mole) of fused sodium acetate in 150 ml. of acetic acid was heated on a steam bath for 20 min. The solution was diluted with 250 ml. of water and cooled to precipitate a yellow solid which was filtered and rinsed with water. The yield of solid decomposing at 235–240° was 43.7 g. (75%). Recrystallization from water gave yellow needles decomposing at 236–237°; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 335 mμ (log ε 4.21).

Anal. Calcd. for $C_9H_9N_5O_3$: C, 45.96; H, 3.86; N, 29.78. Found: C, 45.7; H, 3.73; N, 29.83.

2-Imino-4-methyl-3-(5-nitrofurfurylideneamino)-4-thiazoline hydrochloride. To a solution of 50 g. (0.3 mole) of 3-amino-2-imino-4-methyl-4-thiazoline hydrochloride[16] in 400 ml. of 50% ethanol was added a solution of 44 g. (0.31 mole) of 5-nitro-2-furaldehyde in 200 ml. of ethanol over 15 min. The solution was heated at 50° for 10 min. and then allowed to evaporate. The resulting solid after washing with acetonitrile weighed 67 g. (78%). Recrystallization from ethanol containing a trace of concentrated hydrochloric acid gave bright yellow needles which decompose above 200°; $\lambda_{\max}^{5\%\ C_2H_5OH}$ 317 mμ (log ε 4.16).

Anal. Calcd. for $C_9H_8N_4O_3S \cdot HCl$: C, 37.47; H, 3.14; S, 11.1. Found: C, 37.40; H. 3.05; S, 10.98.

3-Amino-4-(5-nitrofurfurylideneamino)-1,2,4-triazole. To 17.2 g. (0.106 mole) of 3,4-diamino-1,2,4-triazole nitrate[17] dissolved in a mixture of 43 ml. of water, 215 ml. of ethanol, and 11 ml. of concd. hydrochloric acid at 60° was added a solution of 15 g. (0.016 mole) of 5-nitro-2-furaldehyde in 43 ml. of ethanol and then the solution was evaporated to dryness. The residual solid was dissolved in 300 ml. of warm water and the free base was precipitated by adding 10% sodium bicarbonate solution. The yield of yellow solid decomposing at 233° was 20.4 g. (87%). After recrystallization from water the solid decomposed at 234°; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 350 mμ (log ε 4.22).

Anal. Calcd. for $C_7H_6N_6O_3$: C, 37.84; H, 2.72; N, 37.83. Found: C, 38.1; H, 2.68; N, 37.53.

3-Amino-5-methyl-4-(5-nitrofurfurylideneamino)-1,2,4-triazole. To 17.3 g. (0.098 mole) of 3,4-diamino-5-methyl-1,2,4-triazole nitrate[17] dissolved in a mixture of 35 ml. of water and 11 ml. of concd. hydrochloric acid was added 175 ml. of ethanol and then a solution of 13.8 g. (0.098 mole) of 5-nitro-2-furaldehyde in 35 ml. of ethanol. After heating at 60–70° for 15 min. the solution was evaporated to dryness, the residue dissolved in 630 ml. of water, and the free base precipitated with 10% sodium bicarbonate solution. The yield of orange crystals decomposing at 214° was 18 g. (81%). Recrystallization from water gave orange needles decomposing at 215°; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 341 mμ (log ε 4.20).

Anal. Calcd. for $C_8H_8N_6O_3$: C, 40.68; H, 3.41. Found: C, 40.55; H, 3.24.

N,N″-Bis(5-nitrofurfurylideneamino)oxamidine. A solution of 4.7 g. (0.0405 mole) of *N,N″*-diaminooxamidine[18] in 500 ml. of 20% ethanol was acidified to *p*H 5 with concentrated hydrochloric acid, filtered, and added to a solution of 11.4 g. (0.081 mole) of 5-nitro-2-furaldehyde in 400 ml. of ethanol. The yellow hydrochloride salt was filtered and rinsed with ethanol. The yield of solid decomposing at 278° (copper block) was 12.4 g. The free base prepared by recrystallization of the hydrochloride from dimethylformamide decomposed at 284° (copper block) and weighed 9.8 g. (67%); $\lambda_{\max}^{5\%\ \mathrm{DMF}-95\%\ C_2H_5OH}$ 408 mμ (log ε 4.62).

Anal. Calcd. for $C_{12}H_{10}N_8O_6$: C, 39.78; H, 2.78; N, 30.93. Found: C, 39.80; H, 2.56; N, 31.5.

2-Imino-3-(5-nitrofurfurylideneamino)-4-thiazolidinone (VIII). A mixture of 30 g. (0.14 mole) of 5-nitro-2-furaldehyde thiosemicarbazone,[19] 14 g. (0.148 mole) of chloroacetic acid and 12.2 g. (0.149 mole) of anhydrous sodium acetate in 400 ml. of acetic acid was heated at reflux temperature for 2 hr. The reaction mixture was cooled, and the solid removed by filtration and washed with water. The crude solid was recrystallized twice from acetic acid to give yellow crystals decomposing at 273–275°; 15 g. (42%). Recrystallization from nitromethane did not change the decomposition point; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 379 mμ (log ε 4.28).

Anal. Calcd. for $C_8H_6N_4O_4S$: C, 37.76; H, 2.38; N, 22.04; S, 12.63. Found: C, 37.8, H, 2.02; N, 21.7; S, 12.38.

2-(5-Nitrofurfurylidenehydrazino)-5,6-dihydro-1,3,4-thiazin-4-one (X). To 30 g. (0.14 mole) of 5-nitro-2-furaldehyde thiosemicarbazone[19] in 300 ml. of acetic acid at 75° was added 30 g. (0.416 mole) of β-propiolactone. After heating at reflux temperature for 30 min. the solution was cooled, and the yellow solid removed by filtration and rinsed with ethanol. The yield of solid decomposing at 244–248° was 19.2 g. (51%). After recrystallization from acetic acid the solid decomposed at 247–248°; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 383 mμ (log ε 4.28).

Anal. Calcd. for $C_9H_8N_4O_4S$: C, 40.30; H, 3.01; S, 11.95. Found: C, 40.45; H, 2.74; S, 11.78.

5-Nitro-2-furaldehyde chloroacetylhydrazone (IX). To 40 g. (0.258 mole) of 5-nitro-2-furaldehyde hydrazone[20] suspended in 600 ml. of dry benzene was added with stirring a solution of 48 g. (0.28 mole) of chloroacetic anhydride in 160 ml. of dry benzene. The mixture was heated at reflux with stirring for 45 min., cooled, and filtered. The yellow solid was rinsed with benzene and ether and recrystallized from 1900 ml. of ethanol with decolorizing charcoal. The yield of solid melting at 179–180° was 51 g. (85%). Recrystallization from isopropyl alcohol produced an analytical sample melting at 180–181°; $\lambda_{\max}^{2\%\ \mathrm{DMF}}$ 360 mμ (log ε 4.25).

Anal. Calcd. for $C_7H_6ClN_3O_4$: C, 36.30; H, 2.62; Cl, 15.35. Found: C, 36.52; H, 2.77; Cl, 15.23.

NORWICH, N. Y.

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