EXPERIMENTAL

The boiling and melting points of all substances described here are uncorrected.

The hydroxyalkyl dialkyldithiocarbamates mentioned here were prepared from 2-bromoethanol, 3-bromopropanol, or 4-chlorobutanol, and the sodium salt of the requisite dithiocarbamic acid, using the general procedure described in Part I.

The syntheses of two of the cyclic quaternary salts, one by Method A and one by Method B, illustrate the general technique employed. The individual compounds are named, associated by Roman numerals, with the data in the tables and accompanied by any pertinent miscellaneous information below them.

Method A. 1,3-Dithian-2-diethylimmonium perchlorate (XX). A solution of 20.7 g. of 3-hydroxypropyl diethyldithiocarbamate (XIV) and 19.1 g. of *p*-toluenesulfonyl chloride in 50 ml. of dimethylformamide, with a stream of nitrogen to dispel the by-product, hydrogen chloride, was maintained for 1 hr. at 60° by intermittent cooling. The reaction solution, without the nitrogen stream, was heated further at 60° for 24 hr. The cooled solution was then poured into 200 ml. of water containing 15 g. of sodium perchlorate. The resulting white crystalline solid was recrystallized from water–acetone solution.

A solution of 0.005 mole of XX in 30 ml. of water was mixed with 0.0055 mole of sodium tetraphenylboron in 30 ml. of water. The resulting white solid was removed by filtration and recrystallized from dimethyl sulfoxide. The pure 1,3-dithian-2-diethylimmonium tetraphenylboron melted at 184°.

Method B. 1,3-Dithiolan-2-diethylimmonium tetraphenylboron (XXIV). A solution of 19.5 g. of 2-hydroxyethyl diethyldithiocarbamate (XVII) in 100 ml. of benzene containing 18 ml. of triethylamine was treated with 22 g. of *p*-toluenesulfonyl chloride. After the solution had been stirred for 3 hr., it was filtered; 16 g. of triethylamine hydrochloride remained on the filter. The filtrate was heated under reflux for 1.5 hr., after which 32 ml. of benzene-insoluble oil was separated. Volatiles were removed *in vacuo* from the warmed oil; the final weight of viscous oil was 20 g. A solution of 1.73 g. of this oil in 25 ml. of water was treated with 1.71 g. of sodium tetraphenylboron in 80 ml. of water. The white crystalline solid was removed from the cooled solution by filtration and recrystallized from dimethylsulfoxide.

Purification of 3-hydroxypropyl dibenzyldithiocarbamate (XVI). This compound appeared to decompose above 200° at a pressure of 0.03–0.04 mm. Consequently, it was purified chromatographically, by means of a 22-in. column of alumina with an outside diameter of 1.25 in., and benzene as the solvent. Fractions of about 50 ml. were collected; only those fractions which gave the proper analysis were employed. The pure compound is a very viscous oil.

Hydrolysis of 1,3-dithian-2-diethylimmonium perchlorate (XX). The relative yields of hydrolysis fragments varied with the mode of hydrolysis. A solution of 87 g. of XX and 48 g. of sodium hydroxide in 300 ml. of water was heated on the steam bath for 4 hr. The reaction solution was cooled, acidified, and extracted with ether. The ether was evaporated and the residual oil was distilled, giving 7 g. of VI, 3 g. of VII, and 21 g. of VIII. VII was further purified chromatographically, using a 24-in. column (outside diameter = 2 in.) filled with alumina and benzene as the solvent.

A solution of 20 g. of XX and 7.5 g. of sodium carbonate in 100 ml. of water was steam-distilled. The distillate was extracted with ether, the ether was evaporated, and the residue was distilled, giving 1 g. of VI and 6 g. of VII.

The polarographic study was made with a Sargent Model XXI polarograph. Polarograms were recorded on millimolar solutions of the dithiane in 0.5*M* ammonium sulfate–ammonium hydroxide buffer containing 50% methanol by volume. The maxima suppressor employed was 0.001% Triton-X-100. Polarograms were recorded on solutions 0, 15, and 30 min. after mixing. The hydrolysis reaction was essentially complete after 30 min.

The silver mercaptide was isolated by precipitating it from an ammoniacal solution of the hydrolyzed dithiane. This salt was dried *in vacuo* and identified by its silver, carbon, hydrogen, and sulfur analyses.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, MICHIGAN STATE UNIVERSITY]

Cyanoethylation of the 5-Aminotetrazoles[1]

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Cyanoethylation of 5-aminotetrazole gave a mixture of 1- and 2-β-cyanoethyl-5-aminotetrazole. The same mixture of products was obtained by alkylation of 5-aminotetrazole with β-bromopropionitrile. Interaction of 1-benzyl-5-aminotetrazole and acrylonitrile gave both 1-benzyl-5-β-cyanoethylaminotetrazole and 1-benzyl-5-di-β-cyanoethylaminotetrazole. 1-β-Cyanoethyl-5-aminotetrazole was also obtained from β-aminopropionitrile by interaction successively with cyanogen bromide and hydrazoic acid. Under similar conditions β,β′-iminodipropionitrile gave 5-di-β-cyanoethylaminotetrazole. 1-Benzyl-4-β-cyanoethyl-5-iminotetrazoline hydrochloride was formed on alkylation of 1-benzyl-5-aminotetrazole with β-chloropropionitrile or on benzylation of 1-β-cyanoethyl-5-aminotetrazole.

Many compounds containing active hydrogen atoms will undergo the cyanoethylation reaction.[4] The purpose of this investigation was to determine the conditions for the cyanoethylation of 5-aminotetrazole and to establish the structures of the resulting products. Tautomerism of the 5-aminotetrazole structure[5] makes conceivable the formation of three monocyanoethylated products: 1-β-cyanoethyl-5-aminotetrazole (I), 2-β-cyanoethyl-5-aminotetrazole (II), and 5-β-cyanoethylaminotetrazole (VII). An even greater number of

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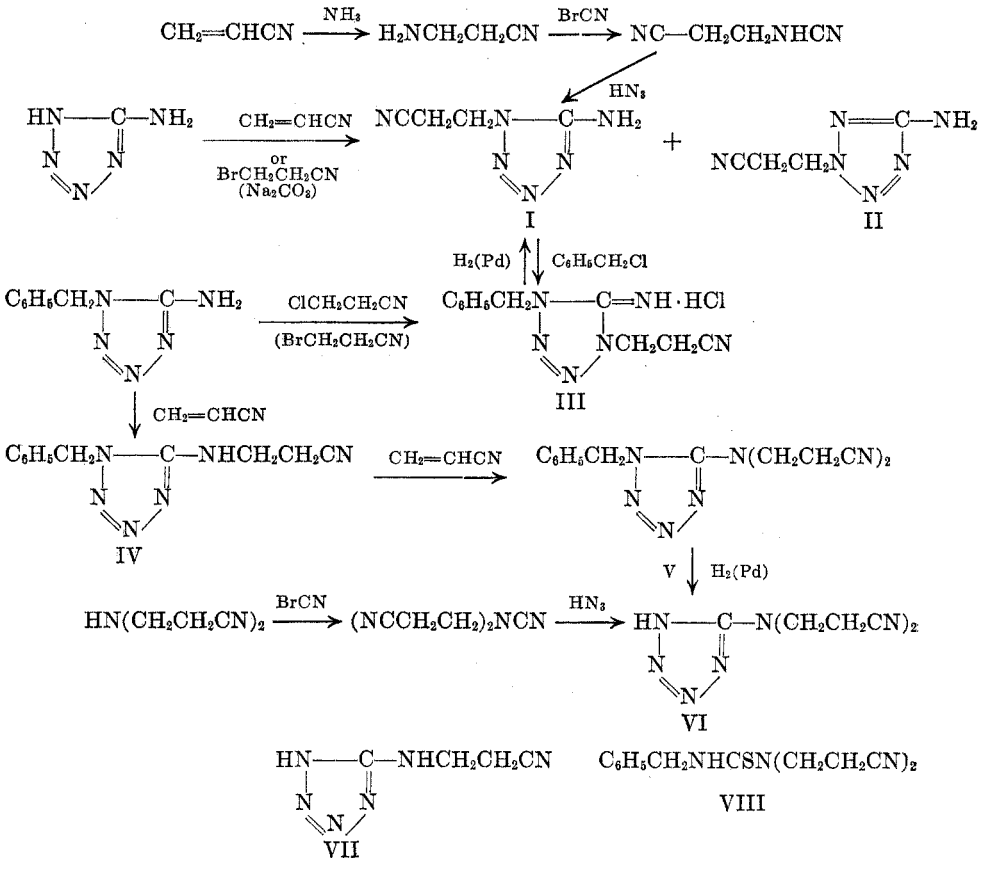
(4) H. A. Bruson, *Org. Reactions*, V, 79–135 (1949).

(5) R. M. Herbst, C. W. Roberts, and E. K. Harvill, *J. Org. Chem.*, 16, 139 (1951).



di- and tricyanoethylated products could arise from the reaction of 5-aminotetrazole with acrylonitrile. In order to limit the number of cyanoethylation products the interaction of 1-benzyl-5-aminotetrazole and acrylonitrile was also investigated. Since the benzyl group can be removed from the tetrazole nucleus by hydrogenolysis,[6] the cyanoethylation products of 1-benzyl-5-aminotetrazole can be related to the products obtained from 5-aminotetrazole. Hydrogenolytic removal of the benzyl group from the tetrazole nucleus has been employed on other occasions to elucidate the position of substituent groups.[7-10]

1-β-Cyanoethyl-5-aminotetrazole (I) was prepared as a reference compound by interaction of β-aminopropionitrile successively with cyanogen bromide and hydrazoic acid. It has been shown[11] that the interaction of monosubstituted cyanamides and hydrazoic acid leads to 1-substituted 5-aminotetrazoles. During the formation of 1-substituted 5-aminotetrazoles by the method of von Braun and Keller[12] from alkyl or aryl cyanides and hydrazoic acid in the presence of concentrated sulfuric acid small amounts of the isomeric 5-alkyl aminotetrazoles may be formed.[7] Under these conditions less than one percent of 5-methylaminotetrazole was isolated after interaction of acetonitrile with hydrazoic acid and concentrated sulfuric acid;[7] the major product was 1-methyl-5-aminotetrazole. Similarly, in the application of Thiele's method[13] to 1-alkyl-2-aminoguanidinium salts treatment of the latter with nitrous acid gives primarily 1-alkyl-5-aminotetrazoles (60–80% yields) accompanied by small amounts of 5-alkylaminotetrazoles (2–11%).[7] Only when the highly electronegative nitro group is present, as in 1-amino-2-nitroguanidine, does the primary product appear to be 5-nitraminotetrazole.[14]

Cyanoethylation of 5-aminotetrazole with acrylonitrile in the presence of aqueous benzyltrimethylammonium hydroxide gave a mixture of two monocyanoethylated derivatives that could be separated by extraction with hot ethylene chloride. The material insoluble in ethylene chloride proved to be identical with I while the soluble product appears to be 2-β-cyanoethyl-5-aminotetrazole (II). Both

(6) L. Birkhofer, *Ber.*, **75B**, 429 (1942).
(7) W. G. Finnegan, R. A. Henry, and E. Lieber, *J. Org. Chem.*, **18**, 779 (1953).
(8) R. M. Herbst and D. F. Percival, *J. Org. Chem.*, **19**, 439 (1954).
(9) R. A. Henry, W. G. Finnegan, and E. Lieber, *J. Am. Chem. Soc.*, **76**, 2894 (1954).
(10) D. F. Percival and R. M. Herbst, *J. Org. Chem.*, **22**, 925 (1957).
(11) W. L. Garbrecht and R. M. Herbst, *J. Org. Chem.*, **18**, 1014 (1953).
(12) J. von Braun and W. Keller, *Ber.*, **65**, 1677 (1932).
(13) J. Thiele, *Ann.*, **270**, 54 (1892).
(14) E. Lieber, E. Sherman, R. A. Henry, and J. Cohen, *J. Am. Chem. Soc.*, **73**, 2327 (1951).

compounds melt at almost the same temperature, 115–116° and 117–117.5°, respectively, but mixture melting points are markedly depressed. The respective acetyl derivatives show widely different melting points. Since 5-alkylaminotetrazoles undergo thermal isomerization to 1-alkyl-5-aminotetrazoles[7,15] and form 1-alkyl-5-acetamidotetrazoles on acetylation,[16] the failure of II to rearrange to I on heating or to form the same acetyl derivative makes rather unlikely the 5-β-cyanoethylaminotetrazole structure (VII) for the soluble product. Although thermal rearrangement of substituted 5-aminotetrazoles is an equilibrium process in homogeneous solutions or undisturbed melts,[17] it should be noted that such melts of alkyl 5-aminotetrazoles contain less than 10 percent of the 5-alkylaminotetrazole isomer.[17] Under other conditions 5-alkylaminotetrazoles have been observed to rearrange completely to the isomeric 1-alkyl 5-aminotetrazoles while 1-aryl-5-aminotetrazoles may rearrange completely to the isomeric 5-arylaminotetrazoles.

Both I and II were also obtained by treatment of the sodium salt of 5-aminotetrazole with an equimolar amount of β-bromopropionitrile. Although the two products were isolated in approximately equal amounts, no quantitative significance as to the relative reactivities of the 1 and 2 positions of the tetrazole ring can be attached to this observation. It is interesting to note that Henry and Finnegan[18] observed the formation of only 1 and 2 substituted products on alkylation of the sodium salt of 5-aminotetrazole with alkyl halides and sulfates. The possibility that the sodium salt of 5-aminotetrazole may have caused dehydrohalogenation of the β-bromopropionitrile cannot be ruled out. In this case formation of the same products could be accounted for if cyanoethylation of 5-aminotetrazole is assumed to occur in a very weakly basic medium. Barkley and Levine[19] have observed cyanoethylation products of certain ketones during interaction with β-chloropropionitrile in absolute ether in the presence of sodamide.

Hydrolysis of I in aqueous barium hydroxide solution caused decyanoethylation; only 5-aminotetrazole could be recovered from the hydrolyzate.

Further support for the structure of I rests upon the formation of 1-benzyl-4-β-cyanoethyl-5-iminotetrazoline hydrochloride (III) when I is heated with benzyl chloride. The same product is obtained from 1-benzyl-5-aminotetrazole on heating with β-chloropropionitrile or β-bromopropionitrile. In the latter case the base was liberated from the crude hydrobromide and converted into the hydrochloride. The formation of the same disubstituted aminotetrazole derivative from either I or 1-benzyl-5-aminotetrazole could take place only if the substituents are symmetrically placed in the 1 and 4 positions.[7–10] The formation of I on hydrogenolysis of III prepared from 1-benzyl-5-aminotetrazole requires that the cyanoethyl group occupy the 4 position.

The interaction of 1-benzyl-5-aminotetrazole with acrylonitrile led to both mono- and dicyanoethylated products depending on conditions. Equimolar quantities of reactants gave chiefly 1-benzyl-5-β-cyanoethylaminotetrazole (IV) while the use of a large excess of acrylonitrile gave primarily 1-benzyl-5-di-β-cyanoethylaminotetrazole (V). It was also possible to convert IV into V by treatment with acrylonitrile. The monocyanoethylated product, IV, is only weakly basic and does not easily form a hydrochloride of constant composition. In this respect it is similar to other 1-alkyl-5-alkylaminotetrazoles which appear to be considerably weaker as bases than the corresponding 1,4-dialkyl-5-iminotetrazolines.[10] The structure of IV is also supported by its conversion to V. Several attempts to prepare 5-cyanoethylaminotetrazole (VII) by hydrogenolysis of IV led only to sirupy products which failed to crystallize and could not be purified by distillation. Acetylation of the crude product gave an acetyl derivative identical with that obtained from I. Since acetylation is known to cause 5-alkylaminotetrazoles to rearrange to 1-alkyl-5-acetamidotetrazoles,[16] the presence of VII in the crude material obtained by debenzylation of IV is possible. Attempted thermal rearrangement of these crude products failed to produce isolable amounts of I.

The structure of V is supported by its conversion to 5-di-β-cyanoethylaminotetrazole (VI) upon hydrogenolysis. The latter was also prepared independently by interaction of β,β′-iminodipropionitrile successively with cyanogen bromide and hydrazoic acid. VI is a weakly acidic product, pK_a 4.85, whose behavior on potentionetric titration is similar to that of other 5-dialkylaminotetrazoles.[20]

Attempts to prepare V from *N*-benzyl-*N*′,*N*′-di-β-cyanoethylthiourea (VIII) were not successful. VIII was prepared by interaction of benzyl isothiocyanate and β,β′-iminodipropionitrile. Treatment of VIII with methyl iodide appeared to give the expected *S*-methylthiuronium iodide which reacted readily with hydrazine in ethanol solution. When the solution of the aminoguanidinium iodide was treated with silver nitrate in the presence of nitric acid, a gummy, pink precipitate formed.

(15) W. L. Garbrecht and R. M. Herbst, *J. Org. Chem.*, **18**, 1269 (1953).

(16) R. M. Herbst and W. L. Garbrecht, *J. Org. Chem.*, **18**, 1283 (1953).

(17) R. A. Henry, W. G. Finnegan, and E. Lieber, *J. Am. Chem. Soc.*, **76**, 88 (1954).

(18) R. A. Henry and W. G. Finnegan, *J. Am. Chem. Soc.*, **76**, 923 (1954).

(19) L. B. Barkley and R. Levine, *J. Am. Chem. Soc.*, **72**, 3699 (1950).

(20) W. L. Garbrecht and R. M. Herbst, *J. Org. Chem.*, **18**, 1003 (1953).

The latter was soluble only in glacial acetic acid. Attempts to obtain a tetrazole from this material by treatment with nitrous acid were unsuccessful. Similar difficulties were encountered when 4-benzylthiosemicarbazide was treated first with methyl iodide and then with iminodipropionitrile. The benzyl-di-β-cyanoethyl-aminoguanidinium iodide presumably formed from this sequence of reactions gave only a gummy, pink precipitate on attempts to convert it to the nitrate. The product was again soluble only in glacial acetic acid and could not be converted into a tetrazole with nitrous acid.

EXPERIMENTAL[21,22]

1-β-Cyanoethyl-5-aminotetrazole (I). To a solution of 7 g. (0.1 mole) of β-aminopropionitrile[23] in 100 ml. of anhydrous ether was added dropwise a solution of 10.6 g. (0.1 mole) of cyanogen bromide[24] in 50 ml. of anhydrous ether with stirring and cooling below 10°. After complete addition of the reagent the mixture was allowed to stand at room temperature for 2 hr. when the precipitate of amine hydrobromide was filtered off. The filtrate was treated with 40 ml. of xylene containing 4.5 g. (0.1 mole) of hydrazoic acid[24] and heated under reflux for 20 hr. The product that separated on cooling was filtered off and recrystallized from absolute ethanol, yield 4.2 g. (61%), m.p. 115–116°.

Anal. Calcd. for $C_4H_6N_6$: C, 34.8; H, 4.4; N, 60.8. Found: C, 35.0; H, 4.4; N, 60.7.

The *acetyl derivative* was prepared by heating I under reflux with acetic anhydride for 2 hr. and recrystallizing from 95% ethanol, m.p. 104–105°.

Anal. Calcd. for $C_6H_8N_6O$: C, 40.0; H, 4.5; N, 46.6. Found; C, 40.1; H, 4.5; N, 46.8.

Cyanoethylation of 5-aminotetrazole. To a cooled, intimate mixture of 8.5 g. (0.1 mole) of anhydrous 5-aminotetrazole[25] and 4 drops of 40% aqueous benzyltrimethylammonium hydroxide was added 5.3 g. (0.1 mole) of freshly distilled acrylonitrile. After the initial exothermic reaction subsided, the mixture was heated on a steam bath under reflux for 12 hr. The crude, yellow product was extracted with hot ethylene chloride. The material insoluble in ethylene chloride was recrystallized twice from 95% ethanol to give 4.6 g. (33%) of product, m.p. 115–116°, identical with I as evidenced by mixture melting points and comparison of infrared spectra. A second product separated from the ethylene chloride extracts on cooling, was crystallized from 95% ethanol, yield 3.7 g. (27%), m.p. 117–117.5°, and appeared to be 2-β-cyanoethyl-5-aminotetrazole (II). Mixture melting point with I was depressed 20°.

Anal. Calcd. for $C_4H_6N_6$: C, 34.8; H, 4.4; N, 60.8. Found: C, 34.7; H, 4.4; N, 60.7.

II did not rearrange to I on heating above its melting point. The acetyl derivative, prepared by heating with acetic anhydride in chloroform solution, crystallized from chloroform, m.p. 136–137° and depressed the melting point of the acetyl derivative of I.

Anal. Calcd. for $C_6H_8N_6O$: C, 40.0; H, 4.5; N, 46.6. Found: C, 40.2; H, 4.6; N, 46.6.

Alkylation of 5-aminotetrazole with β-bromopropionitrile. To a boiling suspension of 8.5 g. (0.1 mole) of anhydrous 5-aminotetrazole in 150 ml. of 95% ethanol was added slowly with stirring a solution of 6.2 g. (0.05 mole) of sodium carbonate monohydrate in 35 ml. of water followed by dropwise addition of a solution of 13.4 g. (0.1 mole) of β-bromopropionitrile in 15 ml. of 95% ethanol. Stirring and heating were continued for 2 hr. after complete addition of the reagents. The solvent was gradually removed under reduced pressure and replaced with absolute ethanol. After removal of the sodium bromide that separated on cooling, the filtrate was evaporated to dryness. The residue was extracted with hot ethylene chloride. Concentration of the extracts gave a crystalline product which was recrystallized from 95% ethanol, m.p. 116–117°, yield 4.2 g. (32%), whose identity with II was supported by mixture melting point and infrared spectra. The ethylene chloride insoluble fraction was extracted with acetone. Evaporation of the acetone solution left a solid from which a small amount of 5-aminotetrazole was recovered by extraction with cold, dilute sodium hydroxide. The alkali insoluble material was recrystallized twice from 95% ethanol, m.p. 115–116°, yield 3.7 g. (27%), and proved to be identical with I on the basis of mixture melting point and comparison of infrared spectra.

Benzylation of 1-β-cyanoethyl-5-aminotetrazole. A mixture of 0.14 g. of I and 0.13 g. of benzyl chloride was heated at 125°. On stirring the two phase system a vigorously exothermic reaction ensued and was followed by solidification of the mixture. The resulting 1-benzyl-4-β-cyanoethyl-5-iminotetrazoline hydrochloride (III) was crystallized twice from 95% ethanol, colorless needles, m.p. 215–216° with some decomposition, yield 0.24 g. (93%).

Anal. Calcd. for $C_{11}H_{13}ClN_6$: Cl, 13.4; N, 31.8. Found: Cl, 13.4; N, 31.8.

Alkylation of 1-benzyl-5-aminotetrazole with β-chloropropionitrile. A mixture of 1.75 g. (0.01 mole) of 1-benzyl-5-aminotetrazole[10] and 0.88 g. (0.01 mole) of β-chloropropionitrile was heated in an oil bath at 150° for 2 hr. The homogeneous melt solidified on cooling and was recrystallized from 95% ethanol, m.p. 213–215°. The product was identical with III obtained by benzylation of I.

The same product was obtained from 1-benzyl-5-aminotetrazole and β-bromopropionitrile by heating at 145° for 0.5 hr. The base was liberated from the crude hydrobromide and converted into hydrochloride in ether solution.

Debenzylation of 1-benzyl-4-β-cyanoethyl-5-iminotetrazoline hydrochloride. A solution of 1 g. of III, obtained from 1-benzyl-5-aminotetrazole and β-chloropropionitrile, in 75 ml. of 80% ethanol was shaken with 0.2 g. of palladium oxide catalyst at 49 p.s.i. hydrogen pressure for 2.25 hr. After removal of the catalyst the filtrate was neutralized with sodium carbonate, filtered again and concentrated. The crude product was recrystallized from 95% ethanol and proved to be identical with I on the basis of mixture melting point and infrared spectra.

Hydrolysis of 1-β-cyanoethyl-5-aminotetrazole. Barium hydroxide octahydrate (9.6 g.) was heated on a steam bath until self-solution had occurred when a solution of 4.1 g. of I in 50 ml. of hot water was added while keeping the mixture at 85–90°. Heating on the steam bath was continued for 2 hr. after which the solution was diluted with 250 ml. of water and saturated with carbon dioxide. The barium carbonate was removed by filtration and washed thoroughly with hot water. The combined filtrate and washings were evaporated to a small volume under reduced pressure, just enough sulfuric acid was added to remove the remaining barium ion and barium sulfate was removed by centrifugation. Concentration of the filtrate gave a product which after recrystallization from water proved to be 5-aminotetrazole monohydrate, m.p. and mixture m.p. 200–201°.

Cyanoethylation of 1-benzyl-5-aminotetrazole. A. 1-Benzyl-5-aminotetrazole (7 g., 0.04 mole) and 4 drops of 40% aqueous benzyltrimethylammonium hydroxide were intimately mixed, chilled, and treated with 2.1 g. (0.04 mole) of

(21) All analyses were done by Micro-Tech Laboratories, Skokie, Ill.

(22) We are indebted to the Monsanto Chemical Company for samples of acrylonitrile and to the American Cyanamid Company for samples of β,β′-iminodipropionitrile.

(23) S. R. Buc, *Org. Syntheses*, 93 (1955).

(24) All reactions with cyanogen bromide or hydrazoic acid must be done in a well ventilated hood. Exposure to their highly toxic vapors should be avoided.

(25) R. M. Herbst and J. A. Garrison, *J. Org. Chem.*, 18, 941 (1953).

freshly distilled acrylonitrile added dropwise with stirring. The mixture liquefied and then resolidified to a yellow mass. Interaction was completed by heating for 1 hr. on a steam bath. The 1-benzyl-5-β-cyanoethylaminotetrazole (IV) was recrystallized first from ethylene chloride and then from 95% ethanol, m.p. 132.5–133°, yield 5.4 g. (59%).

Anal. Calcd. for $C_{11}H_{12}N_6$: C, 57.9; H, 5.3; N, 36.8. Found: C, 58.1; H, 5.5; N, 36.6.

B. In a similar experiment using a small excess of acrylonitrile 1-benzyl-5-di-β-cyanoethylaminotetrazole (V) separated from the warm solution during crystallization of the reaction mixture from 95% ethanol, shimmering platelets, m.p. 80–81.5°, yield 15%.

Anal. Calcd. for $C_{14}H_{15}N_7$: C, 59.7; H, 5.3; N, 34.9. Found: C, 59.6; H, 5.4; N, 35.1.

Chilling the filtrate gave a crude crystallizate from which IV was separated by recrystallization from 95% ethanol, yield 66%.

C. Interaction of 1-benzyl-5-aminotetrazole with a five-fold excess of acrylonitrile under similar conditions gave 46% of V.

D. A mixture of 2.3 g. of IV, 5 ml. of freshly distilled acrylonitrile and 4 drops of 40% aqueous benzyltrimethylammonium hydroxide warmed at steam bath temperature for 2 hr. gave a product from which V, m.p. 79–81°, was isolated by successive crystallizations from ethylene chloride and 95% ethanol.

5-Di-β-cyanoethylaminotetrazole (VI). A well stirred solution of 24.6 g. (0.2 mole) of β,β′-iminodipropionitrile in 50 ml. of ethyl acetate was kept below 10° while a solution of 10.6 g. (0.1 mole) of cyanogen bromide[24] in 50 ml. of ethyl acetate was added. Stirring was continued for 1 hr. at ice bath temperature and 8 hr. at room temperature. A precipitate of amine hydrobromide was removed by filtration and washed with hot ethyl acetate. The combined filtrate and washings were concentrated to about 50 ml. on a steam bath under reduced pressure.

N,N-Di-β-cyanoethylcyanamide, m.p. 50–51°, may be isolated at this point if the solution is further concentrated and the residue crystallized from 95% ethanol.

Anal. Calcd. for $C_9H_8N_4$: C, 56.7; H, 5.5; N, 37.8. Found: C, 56.3; H, 5.6; N, 36.8.

The concentrated ethyl acetate solution was treated with 100 ml. of benzene containing 15 g. of hydrazoic acid[24] and boiled under reflux for 8 hr., when a second 100 ml. of benzene-hydrazoic acid solution was added and heating continued for 16 hr. The product, (VI), which had started to separate during the heating period was collected after chilling the reaction mixture and recrystallized from 95% ethanol, m.p. 133.5–134°, yield 11.8 g. (62%).

Anal. Calcd. for $C_7H_8N_7$: C, 44.0; H, 4.8; N, 51.2; Neut. equiv., 191. Found: C, 43.9; H, 4.8; N, 51.2; Neut. equiv., 192.

Potentiometric titration of VI in about 0.14*M* aqueous solution with 0.1*N* sodium hydroxide using a Beckman *p*H Meter, Model G, indicated an apparent pK_a of 4.85.

Debenzylation of 1-benzyl-5-di-β-cyanoethylaminotetrazole. A solution of 1 g. of V in 50 ml. of 95% ethanol and 1 ml. of concentrated hydrochloric acid was shaken with 0.1 g. of 5% palladium on charcoal at 49 p.s.i. hydrogen pressure for 5 hr. After removal of the catalyst the solvent was evaporated. The residue was triturated with ether to induce solidification and recrystallized from 95% ethanol. A small amount of product, m.p. 127–129°, identical with VI as evidenced by mixture melting point and comparison of infrared spectra was isolated.

N-Benzyl-N′,N′-di-β-cyanoethylthiourea. Benzyl isothiocyanate (74.5 g., 0.5 mole) diluted with 25 ml. of absolute ethanol was chilled in an ice bath and treated with 61.5 g. (0.5 mole) of β,β′-iminodipropionitrile diluted with 25 ml. of absolute ethanol. The latter was added dropwise with stirring while the temperature was kept below 20°. The resulting solution was boiled under reflux for 1 hr. On chilling only a few crystals separated but on diluting with 500 ml. of hot absolute ethanol and cooling gradually the product crystallized copiously. After two recrystallizations from absolute ethanol the product was obtained as colorless plates, m.p. 145–145.5°, yield 121 g. (89%).

Anal. Calcd. for $C_{14}H_{16}N_4S$: C, 61.7; H, 5.9; N, 20.6; S, 11.8. Found: C, 61.8; H, 6.0; N, 20.4; S, 11.6.

The thiourea derivative reacted smoothly with methyl iodide in ethanolic solution and the resulting *S*-methylthiuronium iodide appeared to react smoothly with hydrazine with elimination of methyl mercaptan. Attempts to convert the aminoguanidinium iodide to the nitrate with silver nitrate in the presence of excess nitric acid gave, in addition to the silver iodide, only an insoluble, gummy, pink precipitate which could not be purified for analysis. Attempts to convert this material or any soluble aminoguanidinium nitrate to the desired tetrazole with nitrous acid were unsuccessful.

An attempt to prepare V from 4-benzylthiosemicarbazide[26] by interaction with methyl iodide followed by treatment of the resulting *S*-methyl hydriodide with β,β′-iminodipropionitrile appeared to give an aminoguanidinium iodide. The same results noted above were encountered on attempts to convert the iodide to the nitrate. Neither the precipitate nor the filtrate after treatment with silver nitrate could be converted into V with nitrous acid.

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(26) G. Pulvermacher, *Ber.*, **27**, 613 (1894).