clear solution was acidified to pH 3 with 6 *N* hydrochloric acid. The crude waxy crystals were recrystallized from acetone–*n*-hexane (1:5). The yield was quantitative; m.p. 74–75°.

Anal. Calcd. for $C_{21}H_{22}N_2O_7 \cdot H_2O$: C, 58.3; H, 5.6; N, 6.5. Found: C, 58.6; H, 6.0; N, 6.5.

***p*-Methylaminobenzoyl-L-glutamic Acid Hydrobromide.**— To N-{*p*-[(carbobenzyloxy)methylamino]benzoyl}-L-glutamic acid (1 g., 2.4 mmoles), 3 ml. of 40% hydrobromic acid in glacial acetic acid[4] was added with vigorous stirring at 25° for 1 hr. The evolution of carbon dioxide had almost subsided in 15 min. and the clear solution was stirred for another 30 min. Anhydrous ether (30 ml.) was added and the mixture was stirred continuously at 4° for 20 hr. After decantation of the ether, the semisolid was dried *in vacuo* over phosphorus pentoxide, concentrated sulfuric acid, and sodium hydroxide pellets. A white hygroscopic crystalline powder was obtained and no further purification was necessary. The yield was 78%; m.p. 72–74° dec. (sealed tube), $\lambda_{max}^{H_2O}$ 291 mμ (ε 15,050), $[\alpha]^{25}D$ −7.45° (H_2O).

Anal. Calcd. for $C_{13}H_{16}N_2O_5 \cdot HBr$: C, 43.2; H, 4.8; Br, 22.1; N, 7.8. Found: C, 43.2; H, 5.2; Br, 21.8; N, 7.7.

Diethyl *p*-Methylaminobenzoyl-L-glutamate.—Diethyl N-{*p*-[(carbobenzyloxy)methylamino]benzoyl}-L-glutamate (1 g., 2.4 mmoles) and 3.5 ml. of 40% hydrobromic acid in glacial acetic acid were stirred at 25° for 45 min., by the end of which time evolution of carbon dioxide had subsided. Anhydrous ether (30 ml.) was added and the reaction mixture was continuously stirred at 4° for 20 hr. The ether was decanted and the residual semisolid was dried *in vacuo* over phosphorus pentoxide, concentrated sulfuric acid, and sodium hydroxide pellets. The crude diethyl *p*-methylaminobenzoyl-L-glutamate hydrobromide was obtained as a white hygroscopic powder.

The crude product (0.65 g.) was dissolved in 8 ml. of absolute ethanol and filtered through Darco.[8] To the clear solution were added 0.5 ml. of pyridine, a few crystals of sodium hydrogen sulfite, and 40 ml. of water. The crystallization of diethyl *p*-methylaminobenzoyl-L-glutamate was complete at the end of 72 hr. at 0°. The yield was 75%; white needles from either ethyl acetate–*n*-hexane (1:5) or dilute ethanol, m.p. 89–91°, $[\alpha]^{25}D$ −20.50° (1 *N* HCl); lit.[2] m.p. 89.8–91.0°, $[\alpha]^{25}D$ −21° (1 *N* HCl).

Anal. Calcd. for $C_{17}H_{24}N_2O_5$: C, 60.7; H, 7.2; N, 8.3. Found: C, 61.0; H, 7.3; N, 8.5.

This ester was also formed when a solution of 1 g. (2.8 mmoles) of *p*-methylaminobenzoyl-L-glutamic acid hydrobromide in 10 ml. of absolute ethanol saturated with hydrogen chloride was allowed to stand in a closed vessel for 36 hr. at room temperature. After removal of the solvent under reduced pressure, the residue was treated with pyridine and then twice recrystallized from ethyl acetate–*n*-hexane (1:5). The pure diethyl *p*-methylaminobenzoyl-L-glutamate was obtained in 60% yield; the physical properties were the same as those described above.

Anal. Found: C, 60.9; H, 7.1; N, 8.3.

Acknowledgment.—The authors wish to express their appreciation to Dr. Leonard T. Capell, Chemical Abstracts Service, for discussion of the nomenclature.

(8) Darco, grade G-60, Atlas Chemical Industries, Wilmington, Del.

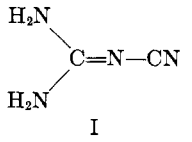
The Synthesis of Cyanovinylguanidines

WILLIAM J. FANSHAWE, VICTOR J. BAUER, AND S. R. SAFIR

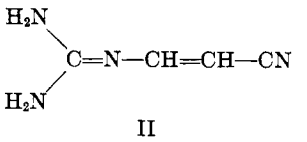
Organic Chemical Research Section, Lederle Laboratories, A Division of American Cyanamid Company, Pearl River, New York

Received December 1, 1964

Cyanoguanidine (I) has enjoyed considerable utility as a reagent in organic synthesis.[1] The vinylogous cyanoguanidine system II is, however, unknown. In this communication, we describe the preparation and properties of *trans*- and *cis*-tetramethylcyanovinylguanidines VII and VIII, substituted examples of structure II, and our unsuccessful efforts to isolate II itself.

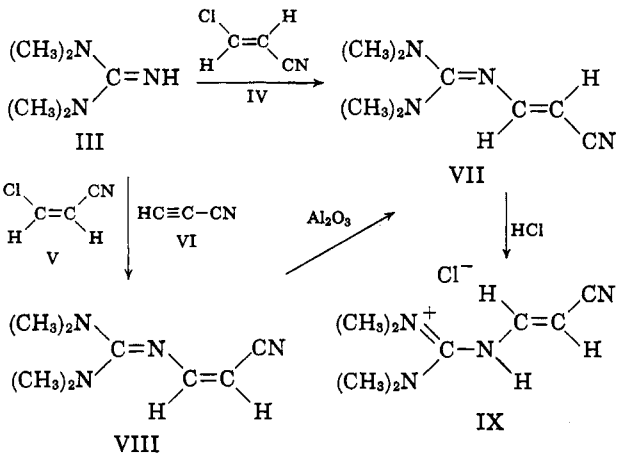


I



II

The first synthetic route employed was predicated upon conjugate addition of tetramethylguanidine (III) to 3-chloroacrylonitrile. Single different products were obtained when *trans*- and *cis*-3-chloroacrylonitrile (IV and V) were used. The spin–spin coupling constants (14 and 7 c.p.s.) of the olefinic protons in the n.m.r. spectra of the respective isomeric products indicated[2] that they were *trans*- and *cis*-2-(2-cyanovinyl)-1,1,3,3-tetramethylguanidine (VII and VIII).



These stereochemical results imply that a likely course of reaction is addition of the guanidine to the acrylonitrile, followed by rotation about the central C–C bond of the anion to achieve the *trans* coplanarity necessary for elimination of chloride. The sequence is illustrated for the *trans* and *cis* isomers by eq. 1 and 2. These results are in complete accord with the recently published observations of Scotti and Frazza[4] on the addition of other nucleophiles to 3-chloroacrylonitrile.

A second synthetic route consisted of the addition of tetramethylguanidine to propiolonitrile (VI). As expected, the product formed by *trans* addition to the acetylenic bond[5] was the *cis*-cyanovinylguanidine VIII.

trans-Cyanovinylguanidine VII formed a crystalline hydrochloride. Evidence for protonation on the central nitrogen (IX) was found in the ultraviolet spectrum, which showed a marked hypsochromic shift relative to the base. The *trans* isomer VII appears to be more stable than *cis* isomer VIII, as shown by the conversion of VIII to VII with basic alumina.

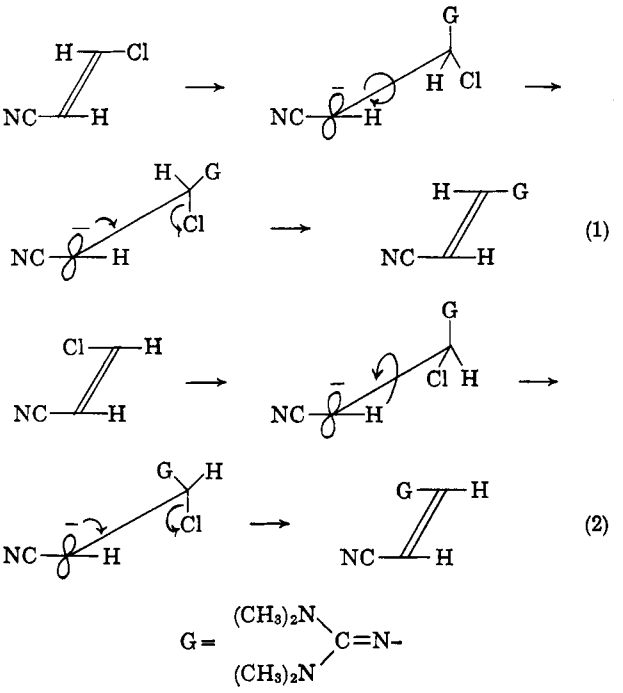
(1) V. Migrdichian, "The Chemistry of Organic Cyanogen Compounds," Reinhold Publishing Corp., New York, N. Y., 1947.

(2) It has been shown[3] that the magnitude of the spin–spin splitting constant falls between 11 and 18 c.p.s. for *trans* olefinic protons and between 6 and 14 c.p.s. for *cis* olefinic protons. When values for a pair of isomers fall outside the range of overlap, structural assignments may be made with reasonable certainty.

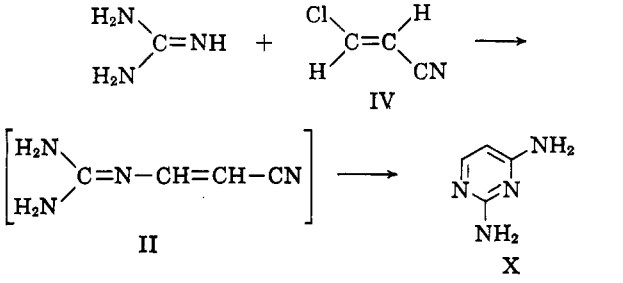
(3) L. M. Jackman, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," Pergamon Press Ltd., London, 1959, p. 85.

(4) F. Scotti and E. J. Frazza, *J. Org. Chem.*, **29**, 1800 (1964).

(5) E. L. Eliel, "Stereochemistry of Carbon Compounds," McGraw-Hill Book Co., Inc., New York, N. Y., 1962, p. 349.



An attempt to synthesize the parent cyanovinylguanidine II from IV and guanidine was unsuccessful; the only product isolated was 2,4-diaminopyrimidine (X). Apparently addition–elimination occurred and was followed by cyclization to the aromatic system.



Experimental[6]

trans-2-(2-Cyanovinyl)-1,1,3,3-tetramethylguanidine (VII).—To a solution of 0.59 g. (5.0 mmoles) of 1,1,3,3-tetramethylguanidine in 5 ml. of benzene was slowly added 0.22 g. (2.5 mmoles) of *trans*-3-chloroacrylonitrile.[4] After 16 hr. at room temperature, the crystals, m.p. 202–205°, of tetramethylguanidine hydrochloride which separated were removed by filtration. The filtrate was concentrated under reduced pressure to a solid, which upon recrystallization from ether yielded 0.15 g. (37%) of an off-white solid, m.p. 89–90.5°. Two recrystallizations from ether afforded the analytical sample as long colorless prisms, m.p. 90–91°, λ_{max}^{KBr} 4.55 μ, and λ_{max}^{MeOH} 298 mμ (ϵ 26,600). The n.m.r. spectrum ($CDCl_3$) showed doublets at τ 2.48 and 5.27 (J = 14 c.p.s., one proton each) and a singlet at 7.07 (12 protons).

Anal. Calcd. for $C_8H_{14}N_4$: C, 57.80; H, 8.49; N, 33.71. Found: C, 57.44; H, 8.31; N, 33.44.

trans-2-(2-Cyanovinyl)-1,1,3,3-tetramethylguanidine Hydrochloride (IX).—An ethereal solution of 1.0 g. (6.0 mmoles) of *trans*-2-(2-cyanovinyl)-1,1,3,3-tetramethylguanidine was acidified with ethereal hydrogen chloride. The precipitate was collected and recrystallized from acetone to yield 0.53 g. (43%) of cream-colored crystals, m.p. 185–187°. An additional recrystallization afforded the analytical sample as long regular prisms, m.p. 187–188°, λ_{max}^{KBr} 4.50 μ, and λ_{max}^{MeOH} 258 mμ (ϵ 27,000). The n.m.r. spectrum (DMSO-d_6) showed doublets at τ 2.33 and 4.25 (J = 14 c.p.s., one proton each) and a singlet at 6.88 (12 protons).

Anal. Calcd. for $C_8H_{15}ClN_4$: C, 47.41; H, 7.41; Cl, 17.53; N, 27.65. Found: C, 47.20; H, 7.41; Cl, 17.31; N, 27.15.

cis-2-(2-Cyanovinyl)-1,1,3,3-tetramethylguanidine (VIII). A.—To a cold, stirred solution of 14.7 g. (0.13 mole) of 1,1,3,3-tetramethylguanidine in 100 ml. of benzene was added dropwise under nitrogen a solution of 5.5 g. (0.065 mole) of *cis*-3-chloroacrylonitrile.[4] The mixture was stirred at room temperature for 16 hr., the tetramethylguanidine hydrochloride which separated was removed, and the solution was concentrated under reduced pressure to a brown, oily solid. Three recrystallizations from ether yielded 3.1 g. (29%) of regular prisms, m.p. 53–56°, λ_{max}^{KBr} 4.55 μ, and λ_{max}^{MeOH} 299 mμ (ϵ 23,400). The n.m.r. spectrum ($CDCl_3$) showed doublets at τ 2.88 and 5.78 (J = 7 c.p.s., one proton each) and a singlet at 7.10 (12 protons). The melting point was depressed to 48–53° upon admixture with the *trans* isomer VII.

Anal. Calcd. for $C_8H_{14}N_4$: C, 57.80; H, 8.49; N, 33.71. Found: C, 57.48; H, 8.57; N, 33.34.

B.—To a cold, stirred solution of 1.7 g. (0.033 mole) of propiolonitrile[7] in 40 ml. of benzene was added dropwise under nitrogen a solution of 3.8 g. (0.033 mole) of 1,1,3,3-tetramethylguanidine in 30 ml. of benzene. The mixture was stirred at room temperature for 16 hr. and filtered. The filtrate was concentrated under reduced pressure to a brown tar. Two recrystallizations from ether yielded 0.25 g. (4.5%) of long colorless prisms, m.p. 55–59°.

Anal. Calcd. for $C_8H_{14}N_4$: C, 57.80; H, 8.49; N, 33.71. Found: C, 57.80; H, 8.57; N, 33.93.

The n.m.r. spectrum of the compound was identical with that of the product of method A.

Isomerization of *cis*- to *trans*-2-(2-Cyanovinyl)-1,1,3,3-tetramethylguanidine.—A mixture of 0.12 g. of *cis*-2-(2-cyanovinyl)-1,1,3,3-tetramethylguanidine, 0.2 g. of activated alumina, and 50 ml. of ether was heated under reflux for 5 hr. and filtered. The filtrate was concentrated under reduced pressure to 0.12 g. of liquid which crystallized on standing to a pale yellow solid, m.p. 84–85°. The melting point was not depressed upon admixture with *trans*-2-(2-cyanovinyl)-1,1,3,3-tetramethylguanidine. The n.m.r. spectrum of the product was identical with that of VII prepared above.

2,4-Diaminopyrimidine (X).—To a cold, stirred suspension of 3.0 g. (0.05 mole) of guanidine[8] in 150 ml. of acetonitrile was added dropwise a solution of 2.2 g. (0.025 mole) of *trans*-3-chloroacrylonitrile in 60 ml. of acetonitrile. The brown mixture was stirred overnight at room temperature and filtered. The filtrate was concentrated under reduced pressure to 3.5 g. of a brown solid, which was extracted with chloroform. Concentration of the chloroform solution left 0.45 g. of a tan solid, m.p. 122–140°. Three recrystallizations from isopropyl alcohol–hexane afforded colorless microcrystals, m.p. 147–149° (lit.[9] m.p. 149–150°). The ultraviolet spectrum of the compound, λ_{max}^{MeOH} 284 mμ (ϵ 6400), was identical with that of authentic 2,4-diaminopyrimidine.

(6) Melting points were determined in a Hershberg apparatus and are uncorrected. Microanalyses were performed by Mr. L. M. Brancone and staff. Ultraviolet and n.m.r. spectra were determined by Mr. W. Fulmor and staff.

(7) C. Moureu and J. C. Bongrand, *Ann. chim.* (Paris), [9] **14**, 47 (1920).

(8) W. Marckwald and F. Struwe, *Chem. Ber.*, **55**, 457 (1922).

(9) J. P. English and J. W. Clapp, U. S. Patent 2,416,617 (1947).

The Preparation of 2-Methyl-1-phenylbenzimidazole 3-Oxide

JOHN W. SCHULENBERG AND S. ARCHER

Sterling-Winthrop Research Institute, Rensselaer, New York

Received October 26, 1964

Several years ago we prepared 2-chloro-2′-nitro-N-phenylacetanilide (I) and hydrogenated it with platinum in ethanol. A hydrochloride was obtained in good yield. On the basis of analytical results, mechanistic considerations, and the absence of a carbonyl