removed by careful distillation at 60 mm. (b.p. 49°). The remaining product was distilled over a Widmer column at 150 mm. to give some $POCl_3$ (b.p. 60°) and the wanted product (b.p. 110°). The yield was 18 g. (76%), b.p. 153° (760 mm.), $n^{25}D$ 1.3420. *Anal.* Calcd. for $C_9ClF_{14}N_3$ (451.6): F, 58.90. Found: F, 58.28.

2,4-Bis-pentafluoroethyl-6-chloro-*s*-triazine (XXI) was obtained in analogy to the above procedure, refluxing 24 g. of XIX and 50 g. of $POCl_3$. The yield was 13 g. (77%), b.p. 125° (760 mm.), b.p. 84° (150 mm.), $n^{25}D$ 1.3538. *Anal.* Calcd. for $C_7ClF_{10}N_3$ (351.6): Cl, 10.09; F, 54.04; N, 11.95. Found: Cl, 10.50; F, 53.89; N, 11.92.

2,4-Bis-heptafluoropropyl-6-toluene-*p*-sulfonylhydrazino-*s*-triazine (XXIV).—To XXII (2.7 g., 0.006 mole) in 10 ml. of acetonitrile was added 2.2 g. of toluene-*p*-sulfonyl hydrazide (2.2 g., 0.012 mole). After 3 hours at room temperature the precipitated toluene-*p*-sulfonylhydrazide-HCl was filtered off and the filtrate was evaporated *in vacuo*. The residual XXIV was recrystallized from ligroin; yield 3.03 g. (83.5%), m.p. 109–111°. *Anal.* Calcd. for $C_{16}H_9F_{14}N_5SO_2$ (601.3): S, 5.33. Found: S, 5.33.

2,4-Bis-pentafluoroethyl-6-toluene-*p*-sulfonylhydrazino-*s*-triazine (XXIII).—An amount of 1.1 g. (0.0031 mole) of XXI in 10 ml. of acetonitrile was allowed to react by the above procedure with toluene-*p*-sulfonyl hydrazide (1.16 g., 0.0062 mole); yield of XXIII, 1.35 g. (85%), m.p. 109–113° after recrystallization from ligroin. *Anal.* Calcd. for $C_{14}H_9F_{10}N_5SO_2$ (501.3): Calcd.: S, 6.39. Found: S, 6.33.

COLUMBUS, OHIO

[CONTRIBUTION FROM THE STAMFORD LABORATORIES, RESEARCH DIVISION, AMERICAN CYANAMID CO.]

New Knowledge of Thioammeline

BY RICHARD P. WELCHER, DONALD W. KAISER AND V. P. WYSTRACH

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A reinvestigation of the chemistry of thioammeline has resulted in the improvement and extension of Rathke's procedure[1] for its preparation so that high yields of thioammeline and N-substituted thioammelines can be obtained. The amphoteric behavior of thioammeline has been clarified by determining the ionization constants of thioammeline hydrochloride and the sodium salt of thioammeline, and correlating their molecular spectra and structures. These results have led to the identification of the "yellow intermediate" as thioammeline hydrochloride. Several new N-substituted thioammelines and S-alkyl thioammelines were prepared. Among the latter, S-carboxymethylthioammeline is noteworthy for its anomalous infrared spectrum.

Introduction.—In his preparation of thioammeline[2] (4,6-diamino-*s*-triazine-2-thiol) from cyanoguanidine, ammonium thiocyanate and hydrochloric acid, Rathke[1a] first obtained a "yellow intermediate" which gave thioammeline on treatment with ammonium hydroxide. He reported the "yellow intermediate" as thioammeline thiocyanate, but did not actually characterize it.

While preparing thioammeline in this way, we found Rathke's surmise to be incorrect. The purpose of our investigation was to study the conditions and scope of this reaction, to examine in more detail the amphoteric nature of thioammeline, and to identify the "yellow intermediate."

Results and Conclusions.—Our study showed that Rathke's use[1] of two moles each of ammonium thiocyanate and hydrochloric acid in the preparation of thioammeline was unnecessary. We obtained a 74% yield of free thioammeline directly by using an approximately 1:1:1 molar ratio of cyanoguanidine, ammonium (or sodium) thiocyanate and hydrochloric acid. The use of excess acid gave a still higher yield of thioammeline, but it was mixed with thioammeline hydrochloride.

The scope of the reaction was extended too by using 3-substituted 1-cyanoguanidines. 1-Cyano-3-phenyl-, 1-cyano-3-dodecyl- and 1-cyano-3,3-dibutylguanidine gave high yields of the corresponding N-substituted thioammelines (4-amino-6-substituted-amino-*s*-triazine-2-thiols).[3]

Thioammeline can also be prepared in a non-aqueous system. Werner and Bell obtained thioammeline in 10% yield as a by-product in the preparation of guanidine thiocyanate by fusion of cyanoguanidine with two moles of ammonium thiocyanate.[4] Using a 1:1 molar ratio in this fusion process lowered the yield of guanidine thiocyanate[5] without raising the yield of thioammeline. We found that the use of a solvent such as methyl isobutyl ketone markedly changed the course of the reaction, giving 50–60% yields of thioammeline.[6]

To learn more about the amphoteric nature of thioammeline we prepared its hydrochloride[7] and its sodium salt. Both compounds can be readily titrated, with aqueous base and acid, respectively. As a base thioammeline has a pK_B of 10.2; as an acid thioammeline has a pK_A of 7.8. These values agree fairly well with the ionization constants determined spectrophotometrically in these laboratories[8] using a reported method.[9]

The infrared spectra of solid thioammeline, its salts and S-alkyl thioammelines (2-alkylthio-4,6-diamino-*s*-triazines) have been correlated with their structures. The S-alkyl thioammelines, which appear to have the structure Ia with three double bonds in the ring, show a characteristic sharp band of medium intensity near 810 cm.$^{-1}$. This ring structure will be referred to as the "normal"[10] triazine structure. The sodium salt of thioammeline, strongly resembling the S-alkyl thioammelines in its spectrum, is assigned the normal triazine structure Ib. Thioammeline itself, lacking

(1) (a) B. Rathke, *Chem. Ber.*, **18**, 3102 (1885); (b) **20**, 1059 (1887).

(2) J. Ponomareff, *Compt. rend.*, **80**, 1384 (1875).

(3) D. W. Kaiser and R. P. Welcher (to American Cyanamid Co.), U. S. Patent 2,820,033 (1958).

(4) E. A. Werner and J. Bell, *J. Chem. Soc.*, **117**, 1133 (1920).

(5) T. L. Davis and H. W. Underwood, THIS JOURNAL, **44**, 2595 (1922).

(6) R. P. Welcher and D. W. Kaiser (to American Cyanamid Co.), U. S. Patent 2,780,623 (1957).

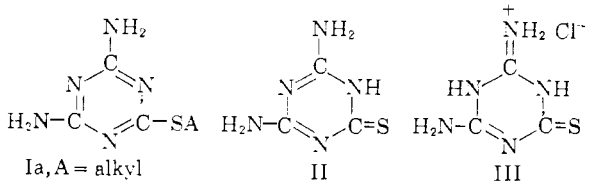
(7) P. Klason, *J. prakt. Chem.*, [2] **33**, 296 (1886).

(8) H. A. Strauss, R. C. Hirt and R. G. Schmitt, to be published.

(9) F. T. King and R. C. Hirt, *Appl. Spectros.*, **7**, 164 (1953).

(10) N. Colthup, to be published.

this band but having a sharp medium intensity band at 780 cm.$^{-1}$, is believed to have the "isotriazine" structure II with two double bonds in the ring. Thioammeline hydrochloride has a spectrum different from either of the above with a band at 750 cm.$^{-1}$. Its structure is believed to be III with two double bonds outside the ring. These assignments will be discussed in detail elsewhere.[10]



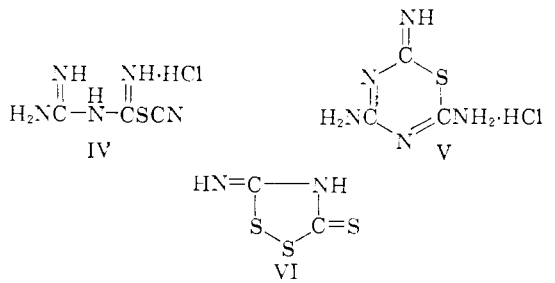
Ia, A = alkyl
Ib, A = Na

II III

The ultraviolet spectra of aqueous solutions of thioammeline and its salts have also been correlated with their structures, in the manner described for the oxygen analogs.[11] The results corroborate the above interpretation of the infrared data.

Both the hydrochloride and the sodium salt of thioammeline can be readily prepared, purified and reconverted to thioammeline. Accordingly, either salt provides a useful route to pure thioammeline. It is not usually necessary to remove all the tightly held water from the crystalline thioammeline sodium salt polyhydrate before use.

During this work we identified Rathke's "yellow intermediate" as thioammeline hydrochloride (III) by means of qualitative tests, analysis and spectroscopic results. Conceivable isomeric structures IV and V were ruled out by the infrared spectra.

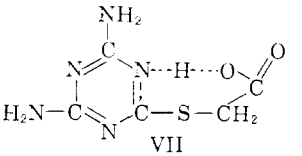


IV V VI

The identity of the impurity which gives the yellow color to the "yellow intermediate" has not been established. Although a trace of sulfur was found, there appeared to be another yellow substance present, slightly soluble in water. Rathke's statement[1b] that the impurity was isoperthiocyanic acid, structure VI[12], could not be confirmed.

S-Alkyl thioammelines,[13] the esters of the thioacid thioammeline, are conveniently prepared by alkylation of thioammeline in an alkaline medium.[14] S-Methyl-,[14] S-methallyl-[15] and S-carboxymethylthioammeline can be prepared in excellent yield from the sodium salt of thioammeline. For the preparation of S-2-cyanoethylthioammeline from thioammeline and acrylonitrile a catalytic amount of base is sufficient.

With the exception of S-carboxymethylthioammeline the infrared spectra of these compounds are normal. Surprisingly the spectrum of S-carboxymethylthioammeline shows unexpected isotriazine absorption together with the expected carboxylic acid absorption, but none of the expected normal triazine absorption. Its sodium salt[16] has the expected absorption of a normal triazine and a carboxylate ion. The anomalous spectrum of the S-carboxymethylthioammeline is ascribed to distortion of the electronic structure of the ring resulting from hydrogen bonding between a ring nitrogen and the acid hydrogen on the side chain, as shown in structure VII.



VII

Experimental

Materials.—A commercial grade of cyanoguanidine, m.p. 206–208°, was used without further purification.

3-Substituted 1-cyanoguanidines were prepared according to the published procedures.[17] **1-Cyano-3-phenylguanidine** melted at 201–202° after recrystallization from water (1 g./50 ml.). **1-Cyano-3-dodecylguanidine**, m.p. 78–81°, was used without further purification. **1-Cyano-3,3-dibutylguanidine** melted at 74–75° after recrystallization from hexane (1 g./5 ml.).

Preparation of Thioammelines. A. Aqueous Method.—A solution of 22 g. (0.26 mole) of cyanoguanidine and 21 g. (0.28 mole) of ammonium thiocyanate in 30 ml. of water was heated at 100° while 47 ml. (0.28 mole) of 6 *N* hydrochloric acid was added dropwise over a period of 1 hr. After 4.5 hr. additional heating the slurry was cooled to 20° and filtered. The white solid was washed with hot water to remove unreacted cyanoguanidine and dried at 100° to give 27.5 g. (74%) of **thioammeline.**

Anal. Calcd. for $C_3H_5N_5S$: C, 25.17; H, 3.52; N, 48.92; S, 22.39. Found: C, 25.21; H, 3.64; N, 49.19; S, 21.75, 22.52.

The effect of changing some of the conditions was briefly studied. Sodium thiocyanate, a small excess of cyanoguanidine or a shorter heating time could be used without affecting the result. A 1.1:1:1.5 molar ratio of cyanoguanidine, sodium thiocyanate and acid gave a mixture of thioammeline and its hydrochloride. After neutralization, the yield of thioammeline was 80%. Substitution of sulfuric acid or acetic acid gave lower yields, 45 and 8%, respectively. In the absence of acid the yield of thioammeline was only 7% after 11 hr.

Thioammeline dissolved slowly in cold 6 *N* sodium hydroxide, 6 *N* hydrochloric acid and 6 *N* sulfuric acid, and was slightly soluble in hot water. It did not melt below 350°.

N-PHENYLTHIOAMMELINE was prepared similarly in 69% yield from 40 g. (0.25 mole) of 1-cyano-3-phenylguanidine, 23 g. (0.28 mole) of sodium thiocyanate and 64 ml. (0.38 mole) of 6 *N* hydrochloric acid in 110 ml. of water containing a trace of Aerosol[18] OT wetting agent to facilitate wetting. The excess acid in the product was neutralized with ammonium hydroxide, and the product washed with water until chloride-free. It was soluble in cold dilute acid and dilute alkali, slightly soluble in hot water (1 g./400 ml.) and methanol, and insoluble in hot ethanol, acetonitrile, acetone, benzene and hexane; m.p. 287–288°.

Anal. Calcd. for $C_9H_9N_5S$: C, 49.30; H, 4.14; S, 14.62; N, 31.94. Found: C, 48.81; H, 4.35; S, 14.35; N, 32.06.

(11) R. C. Hirt and R. G. Schmitt, *Spectrochim. Acta*, **12**, 127 (1958).

(12) P. Klason, *J. prakt. Chem.*, [2] **38**, 366 (1888).

(13) A. W. Hofmann, *Chem. Ber.*, **18**, 2755 (1885).

(14) I. G. Farbenind, Akt.-Ges., French Patent 864,914 (1941); *C. A.*, **43**, P1444d (1949).

(15) H. A. Bruson (to the Resinous Products and Chemical Co.), U. S. Patent 2,258,130 (1941).

(16) P. E. Thompson, D. F. Walker and M. C. Dunn, *J. Am. Pharm. Assoc.*, **42**, 647 (1953).

(17) B. C. Redmon and D. E. Nagy (to American Cyanamid Co.), U. S. Patent 2,455,807 (1948).

(18) Reg. U. S. Patent Office, American Cyanamid Co.

N-Dodecylthioammeline was prepared in 60% yield from 1-cyano-3-dodecylguanidine as above. The product was soluble in hot methanol, ethanol (1 g./20 ml.), acetone and benzene, and insoluble in hot diethyl ether, hexane, acetonitrile and water; m.p. 196–197°.

Anal. Calcd. for $C_{15}H_{29}N_5S$: C, 57.84; H, 9.38; N, 22.49; S, 10.29. Found: C, 57.87; H, 9.20; N, 22.73; S, 10.06.

N,N,-Dibutylthioammeline was similarly prepared in 94% yield from 1-cyano-3,3-dibutylguanidine. It was soluble in hot methanol, ethanol, acetonitrile, acetone and benzene, and insoluble in hot water, diethyl ether and hexane; m. p. 219–220°.

Anal. Calcd. for $C_{11}H_{21}N_5S$: C, 51.73; H, 8.29; N, 27.43; S, 12.55. Found: C, 52.00; H, 8.16; N, 27.30; S, 12.62.

B. Non-aqueous Method.—A mixture of 22 g. (0.26 mole) of cyanoguanidine and 21 g. (0.28 mole) of ammonium thiocyanate in 100 g. of methyl isobutyl ketone was stirred at 110–120° for 6 hr. Ammonia was evolved throughout the reaction, and a precipitate of thioammeline appeared after 0.5 hr. The product was washed with methyl isobutyl ketone and hot water. Its infrared spectrum showed it to be pure thioammeline (55% yield). Other solvents such as ethylene glycol monoethyl ether and 1-butanol were also used successfully. The fate of the unrecovered cyanoguanidine was not investigated.

Salts of Thioammeline.—For the preparation of the **sodium salt of thioammeline**, 7 g. (0.049 mole) of thioammeline was dissolved in a hot solution of 2.2 g. (0.055 mole) of sodium hydroxide in 16 ml. of water. After hot filtration to remove a small amount of yellow solid the yellow solution was cooled to give large crystalline plates of the polyhydrate which became colorless on washing with cold 2% aqueous sodium hydroxide. Drying at 1 mm. pressure and 25° did not remove all the water. Prolonged drying above 100° caused the plates to change to a very finely divided crystalline powder, the anhydrous sodium salt.

The equivalent weight and acid ionization constant of the salt were determined by titrating an 0.002 molar aqueous solution with 0.0501 *N* hydrochloric acid using a Beckman model H-2 *p*H meter. The plot of *p*H *versus* volume was slightly asymmetrical with one sharp inflection at 4.9 ml. of acid, *p*H 4.75; equiv. wt. calcd. for $C_3H_4N_5SNa$, 165; found, 165. The half-equivalence point occurred at 2.45 ml., *p*H 7.8. At this point $pH \cong pK_A = 7.8$; $K_A = 1.6 \times 10^{-8}$. Titration of a more concentrated solution of the sodium salt (0.0165 molar) resulted in precipitation of thioammeline during the titration. The half-equivalence point was again at *p*H 7.8.

Thioammeline hydrochloride was prepared by dissolving 0.10 mole of the polyhydrated sodium salt of thioammeline in 350 ml. of 2.5 *N* hydrochloric acid and filtering the hot solution. The crystals obtained on cooling were dried and recrystallized from 270 ml. of 2 *N* hydrochloric acid, washed with cold solvent and dried at reduced pressure.

Anal. Calcd. for $C_3H_5N_5S.HCl$: Cl, 19.74. Found: Cl, 19.81.

Its equivalent weight and acid ionization constant were determined by titrating a 0.002 molar aqueous solution with 0.0500 *N* sodium hydroxide, using the *p*H meter. There was one sharp inflection at 4.55 ml. of base and *p*H 5.70; equiv. wt. calcd. for $C_3H_5N_5S.HCl$, 180; found, 181. The half-equivalence point occurred at 2.28 ml., *p*H 3.8. At this point $pH \cong pK_A = 3.8$; $K_A = 1.6 \times 10^{-4}$; $pK_B = 10.2$.

The use of water alone for recrystallization of thioammeline hydrochloride resulted in some hydrolysis to thioammeline.[1b]

Spectra of Thioammeline and Its Salts.—The ultraviolet spectra of these compounds in water solution are summarized as follows: For thioammeline the absorption band occurs at λ_{max} 282 mμ, ϵ_{max} 24300; for the sodium salt of thioammeline ϵ_{max} 21300 at λ_{max} 268 mμ; for thioammeline hydrochloride ϵ_{max} 24200 at λ_{max} 270 mμ.

The infrared spectra[19] showed the following principal absorptions, medium in intensity unless noted as strong (s): For thioammeline, 780(sharp), 950, 1200(s), 1300(s), 1485, 1535(s), 1595(s), 1700(s), 3150, 3370 and 3410 cm.$^{-1}$. For the sodium salt of thioammeline, 810(sharp), 1325, 1415, 1505(s), 1550, 1625, 3200, 3310 and 3400. For thioammeline hydrochloride, 955, 1165, 1190(s), 1525(s), 1585(s), 1650(s), 1695, 3100 and 3250.

Identity of Rathke's Yellow Intermediate.—The procedure of Rathke[1] was used: A solution of 4.0 g. (0.048 mole) of cyanoguanidine and 7.3 g. (0.096 mole) of ammonium thiocyanate in 75 ml. of water was stirred while 16 ml. (0.096 mole) of 6 *N* hydrochloric acid was added. The pink solution was heated on the steam-bath for 6.3 hr. with occasional stirring. The "yellow intermediate" began to precipitate after 0.5 hr. After cooling, the solid was filtered off, washed with two 10-ml. portions of water, and dried at reduced pressure.

The "yellow intermediate" gave a positive test for halogen with aqueous silver nitrate and a negative test for thiocyanate with aqueous ferric chloride. Its infrared spectrum was identical with that of thioammeline hydrochloride. The absence of isoperthiocyanic acid was shown by comparison with a sample prepared by the method of Klason,[12] having characteristic absorption peaks at 286 and 347 mμ. Its equivalent weight was determined by a *p*H titration as above. A small amount of yellow insoluble solid, probably sulfur, remained behind when the sample was dissolved.

Anal. Calcd. for $C_3H_5N_5S.HSCN$: equiv. wt., 202; S, 31.70; Cl, 0. Calcd. for $C_3H_5N_5S\cdot HCl$: equiv. wt., 180; S, 17.85; Cl, 19.74. Found: equiv. wt., 180; S, 17.9; Cl, 19.64.

A 100-g. portion of "yellow intermediate" was converted to thioammeline by dissolving it in hot water, adding ammonium hydroxide to *p*H 8, then acetic acid to *p*H 6, giving 76 g. of thioammeline (96% yield). If the "yellow intermediate" were thioammeline thiocyanate, the yield would have been 108%. The filtrate from the transformation gave no precipitate of lead thiocyanate when treated with lead acetate solution.

A 6-g. sample of the "yellow intermediate" was recrystallized from 120 ml. of 2 *N* hydrochloric acid after treatment with decolorizing charcoal. The colorless crystals of thioammeline hydrochloride were dried at 20 mm. pressure and 80°. Its infrared spectrum was the same as for the "yellow intermediate," but sharper.

Anal. Found: equiv. wt., 182; Cl, 19.48.

S-Alkyl Thioammelines.—To prepare **S-carboxymethylthioammeline** a solution of 9.5 g. (0.100 mole) of chloroacetic acid and 4.3 g. (0.108 mole) of sodium hydroxide in 75 ml. of water was added to a hot solution of 17 g. (0.100 mole) of the sodium salt of thioammeline in 50 ml. of water. The clear solution was heated at 85–90° for 1.8 hr., cooled, and acidified with 58 ml. (0.100 mole) of 1.7 *N* hydrochloric acid. The precipitate was washed with water and dried at 100° to give 19 g. of the desired product (94% yield). It was soluble in cold dilute ammonium hydroxide, and insoluble in hot water, acetonitrile, ethanol, acetone, benzene and hexane. When heated it decomposed at 235–245° without melting. Its infrared spectrum showed absorption at 775 (broad), but no absorption at 805 cm.$^{-1}$. There was also absorption assigned to carboxylic acid. Analysis for sulfur gave low results.

An 8.0-g. (0.04 mole) portion of the presumed S-carboxymethylthioammeline was converted to the sodium salt[16] with 80 ml. (0.04 mole) of 0.5 *N* sodium hydroxide. Extraction of the crude product with 25 ml. of hot 2:3 aqueous methanol gave 5.3 g. (60%) of the crystalline **sodium salt of S-carboxymethylthioammeline**. It was soluble in cold water and insoluble in hot methanol. Its infrared spectrum showed absorption at 800 (sharp) but no absorption at 775 cm.$^{-1}$; carboxylate ion absorption was seen, and no carboxylic acid. Its equivalent weight was found by *p*H titration, with endpoint at *p*H 3.2. At half-neutralization *p*H = $pK_A = 6.2$; $K_A = 6.3 \times 10^{-7}$.

Anal. Calcd. for $C_5H_6N_6O_2SNa$: equiv. wt. 223; C, 26.90; H, 2.71; N, 31.38; S, 14.36; Na, 10.32. Found: equiv. wt., 225; C, 27.25, 26.80; H, 2.99, 2.89; N, 31.26; S, 14.45; Na, 10.0.

The precipitate of S-carboxymethylthioammeline from the above titration of the sodium salt was dried at 110°. Its infrared spectrum showed absorption at 775 cm.$^{-1}$

(19) Copies of these spectra have been deposited as Document Number 5904 with the ADI Auxiliary Publications Project, Photoduplication Service, Library of Congress, Washington 25, D. C. A copy may be secured by citing the Document number and by remitting in advance $1.25 for photoprints, or $1.25 for 35 mm. microfilm, payable to: Chief, Photoduplication Service, Library of Congress.

again, and carboxylic acid, but no absorption at 805 cm.$^{-1}$. Analysis suggested the presence of difficulty removable water of hydration.

Anal. Calcd. for $C_5H_7N_5O_2S \cdot H_2O$: equiv. wt., 219; C, 27.39; H, 4.14; N, 31.95; O, 21.90; S, 14.63. Found: equiv. wt., 212; C, 27.93, 27.80; H, 4.22, 4.09; N, 32.21; O, 17.72, 17.45; S, 14.03.

To prepare **S-(2-cyanoethyl)thioammeline** a mixture of 28 g. (0.20 mole) of thioammeline, 120 ml. of water, 10 ml. (0.005 mole) of 0.5 *N* sodium hydroxide, 0.2 g. of cupric sulfate and 11 g. (0.20 mole) of acrylonitrile was heated at 82° for 1.5 *hr.*, then cooled. The yellowish crystalline product weighed 34 g. (87%). It was soluble in hot ethylene glycol monoethyl ether, 1:1 aqueous ethylene glycol monoethyl ether (1 g./19 ml.), slightly soluble in hot water, acetonitrile (1 g./150 ml.), methanol, ethanol and acetone, and insoluble in hot benzene; m.p. 248–250°. Its infrared spectrum showed the expected absorption at 806 cm.$^{-1}$, and an aliphatic nitrile, with no absorption at 775 cm.$^{-1}$, and had a strong resemblance to the spectrum of S-methylthioammeline.

Anal. Calcd. for $C_6H_8N_6S$: S, 16.34. Found: S, 16.06.

S-Methylthioammeline[13,14] was similarly prepared from the sodium salt of thioammeline and dimethyl sulfate in 94% yield. It was soluble in hot ethylene glycol monoethyl ether and hot 1:1 aqueous ethylene glycol monoethyl ether (1 g./40 ml.), slightly soluble in hot water, methanol, ethanol, acetone and acetonitrile, and insoluble in hot benzene, diethyl ether, hexane and chloroform; m.p. 270–272° dec.; sharp infrared absorption at 812 cm.$^{-1}$.

Anal. Calcd. for $C_4H_7N_5S$: N, 44.56. Found: N, 44.04 (by Kjeldahl method); N, 44.92, 45.11 (by pressure Kjeldahl method); use of the Dumas method consistently gave low values for nitrogen.

S-Methallylthioammeline[15] was prepared from the sodium salt of thioammeline and methallyl chloride, in 92% yield. It was soluble in hot acetone, diethyl ether, methanol, ethanol (1 g./3 ml.) and acetonitrile (1 g./25 ml.), slightly soluble in hot benzene and hexane, and insoluble in hot water, m.p. 132–132.5°; sharp infrared band at 808 cm.$^{-1}$.

Anal. Calcd. for $C_7H_{11}N_5S$: C, 42.62; H, 5.62; N, 35.51; S, 16.25. *Found:* C, 42.73; H, 5.66; N, 35.21; S, 16.03.

S-Benzylthioammeline, prepared in 93% yield from thioammeline and benzyl chloride by the reported procedure,[14] was soluble in hot acetone, methanol and ethanol (1 g./15 ml.), slightly soluble in hot acetonitrile, and insoluble in hot benzene and hexane; m.p. 171–172°; sharp infrared band at 805 cm.$^{-1}$.

Acknowledgments.—We express our thanks to Elspeth C. Eberlin, N. Colthup, R. C. Gore and J. E. Lancaster for their assistance in determining and interpreting the infrared spectra of these compounds, to R. C. Hirt and R. G. Schmitt for their similar assistance with the ultraviolet spectra, and to Elizabeth C. Grim and Patricia Lentz for analytical assistance.

STAMFORD, CONN.

[CONTRIBUTION NO. 1042 FROM THE DEPARTMENT OF CHEMISTRY, UNIVERSITY OF PITTSBURGH]

Chemistry of Pyrazine and Its Derivatives. III. The Synthesis of Carbinols by the Participation of Methylpyrazine in Aldol-type Condensations[1]

BY JOHN D. BEHUN[2] AND ROBERT LEVINE

RECEIVED APRIL 3, 1959

Several aldehydes and ketones have been condensed with pyrazylmethylsodium to give the corresponding pyrazylmethylcarbinols, $PzCH_2C(OH)RR^1$, in fair to excellent yields. Diphenylpyrazylmethylcarbinol was reductively cleaved with ethanolic potassium hydroxide to give methylpyrazine and benzhydrol while its reaction with potassium hydroxide in *t*-butyl alcohol gave methylpyrazine and benzophenone. Benzophenone was also reduced to benzhydrol (90.8%) by ethanolic potassium hydroxide. 1-Pyrazyl-2-phenyl-2-propanol, on reaction with ethanolic potassium hydroxide, was converted to a mixture of methylpyrazine, acetophenone, methylphenylcarbinol (A) and 1,5-diphenyl-3-methylpentane-1,5-dione (B). A mixture of A and B also was obtained when acetophenone was treated similarly.

In the previous paper[3] of this series, we reported that high yields of pyrazyl methyl ketones, $PzCH_2COR$, were obtained by the interaction of a series of aliphatic, aromatic and heterocyclic esters with pyrazylmethylsodium, which was prepared from methylpyrazine and sodium amide in liquid ammonia. The present paper is concerned with the results of a study involving aldol-type reactions between methylpyrazine and several aldehydes and ketones to give a series of carbinols containing the pyrazylmethyl radical.

Prior to our study, aldol-type condensations had been effected between a few aldehydes and ketones and methylpyrazine and 2,5-dimethylpyrazine. Thus, Franke[4] treated 2,5-dimethylpyrazine with several aromatic aldehydes in a bomb at 160–200° for eight hours using zinc chloride as the catalyst. Under these conditions, mono- and disubstituted olefinic products, which resulted from the dehydration of the initially-formed carbinols, were obtained in unreported yields. Also, Kitchen and Hanson[5] obtained a 38% yield of 2-pyrazylethanol by heating methylpyrazine with paraformaldehyde in a stainless steel autoclave for 4.5 hours at 165°. In addition Klein and Spoerri[6] found that the reaction of 2,5-dimethylpyrazine with methyllithium followed by the addition of propionaldehyde gave none of the expected carbinol and instead a 44% yield of the azomethine addition product, 2,3,6-trimethylpyrazine, was obtained. Furthermore, during the course of the present investigation, Zaugg, DeNet and Freifelder[7] reported the synthesis of diphenylpyrazylmethylcarbinol from methylpyrazine and benzophenone using sodium amide as the condensing agent. However, the reaction conditions employed were considerably different from those

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(2) This paper is based on part of the thesis presented by J. D. B. to the Graduate Faculty of the University of Pittsburgh in partial fulfillment of the requirements for the Ph.D. degree.

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