

Sebacic Acid (XIX).—Following the procedure of Johnson,²⁴ 198 mg. (1 mmole) was oxidized in the presence of 1.5 ml. of bromine, 4.2 g. of sodium hydroxide, 20 ml. of water and 15 ml. of dioxane during a period of one hour to give 170 mg. (84%) of crude dibasic acid, m.p. 124–128°. One recrystallization from 3 ml. of water sufficed to give pure sebacic acid as shiny plates, m.p. 133–134° (reported m.p. 134°).

***n*-Eicosane.**—2-(*n*-Hexadecyl)-thiophene (1.15 g.) was desulfurized by heating under reflux with 15 g. of Raney nickel and 100 ml. of dioxane for 16 hours. The catalyst was removed by filtration and the filtrate concentrated to yield 0.70 g. of fine white powder, m.p. 36.5–37.0°, n_{D}^{20} 1.4354 (reported m.p. 38°, n_{D}^{20} 1.434).

5-Eicosanol.—Desulfurization of 6.75 g. of 2-(*n*-penta-decyl)-thienone with 90 g. of Raney nickel furnished 5.74 g. (90%) of the alcohol, m.p. 51–52° after one crystallization from acetone. *Anal.* Calcd. for C₂₀H₄₂O: C, 80.46; H, 14.18. Found: C, 80.63; H, 13.94.

5-Eicosanone.—The alcohol obtained above (1.37 g.) was oxidized at 25–35° with 2.04 g. of chromium trioxide in 20 ml. of glacial acetic acid to yield 1.25 g. (91.2%) of white powder, m.p. 51–52° (m.m.p. with 5-eicosanol 46–48°, reported²⁵ m.p. 53–54° (uncor.)).

4-Methyloctane.—Redistilled 2-butanoylthiophene¹⁰ (20.0 g.), b.p. 141–142° (41 mm.), n_{D}^{20} 1.5426, in 100 ml. of anhydrous ether was added over a period of 1 hr. to the Grignard reagent prepared from 3.50 g. of magnesium, 25.0 g. of methyl iodide and 100 ml. of ether. Stirring and gentle refluxing was continued for 1 hour. The reaction

(24) W. S. Johnson, C. D. Gutsche and D. Offenbauer, *THIS JOURNAL*, **68**, 1648 (1946).

(25) F. C. Whitmore, L. H. Sutherland and J. N. Cosby, *ibid.*, **64**, 1360 (1940).

mixture was decomposed with ice-cold dilute hydrochloric acid, the organic phase carefully washed free of acid, dried and concentrated to a yellow sirup. This oil (16.6 g., 73%) was divided into three parts:

Part I, 6.00 g., was distilled at reduced pressure; no material distilled in the expected range (140–175°). However a straw-colored oil came over between 215–265°. Upon redistillation the boiling point was 220–245° (28 mm.), n_{D}^{20} 1.5663–1.5666. Three grams of this oil was heated under reflux for 6 hr. with 40 g. of Raney nickel in 175 ml. of 95% alcohol. Isolation in the usual manner furnished 2.05 g. (82%, based on dimer) of colorless oil, n_{D}^{20} 1.4551. Two redistillations at atmospheric pressure yielded constant boiling material, b.p. 263–266° (740 mm.), n_{D}^{20} 1.4496–1.4500. *Anal.* Calcd. for C₁₈H₃₈: C, 84.95; H, 15.05; mol. wt., 254. Found: C, 85.16; H, 14.89; mol. wt., 230 (Rast).

Part II, 4.00 g., was desulfurized immediately using 20.0 g. of Raney nickel yielding a colorless oil, b.p. 178–180° (740 mm.), n_{D}^{20} 1.4317; reported constants for 4-methyl-octanol-4 are^{26,27} b.p. 178° (760 mm.), n_{D}^{20} 1.4301.

Part III, 4.00 g., was heated to 100° for 30 minutes with oxalic acid, then freed of oxalic acid and water by washing and drying. The oil thus remaining was relatively unstable (n_{D}^{20} 1.5035) and immediately desulfurized with 20 g. of Raney nickel to furnish a sulfur-free hydrocarbon, b.p. 138–142° (739 mm.), n_{D}^{20} 1.4050–1.4092; reported²⁸ for 4-methyloctane, b.p. 142° (771 mm.), n_{D}^{20} 1.4063.

(26) O. R. Quayle and K. O. Smart, *ibid.*, **66**, 935 (1944).

(27) L. Clarke, *ibid.*, **34**, 680 (1912).

(28) *J. Research Natl. Bur. Standards*, **52**, 59 (1954), Res. Paper No. 2773.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, INSTITUTE OF POLYMER RESEARCH, POLYTECHNIC INSTITUTE OF BROOKLYN]

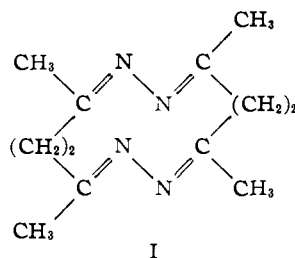
Azo Compounds.¹ Investigation of the Structure of the Products from the Reaction of Acetylacetone and Hydrazine

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The reaction of hydrazine hydrate and acetylacetone in the absence of solvent and added catalyst has been shown to yield as a major product a basic six-membered ring structure II which is an associated dimer, rather than structure I previously suggested for this product. (Reaction of hydrazine hydrate and acetylacetone in acetic acid gave principally III and IV.) II has been converted to III and IV in the presence of a palladium catalyst. Catalytic hydrogenation of the high-boiling compound in acid media with a mixture of platinum oxide and 10% palladium-on-charcoal as catalysts or in neutral medium with Raney nickel gave IV. Reaction of II with hydrogen cyanide gave VI and further confirms the proposed structure of VI obtained previously by a modified procedure.

The synthesis of compound I, a 12-membered ring, has been reported by a number of investigators.^{3,4,5a} Since this compound appeared to be convertible to a cyclic azo compound, a potential biradical source by hydrogenation and oxidation, we attempted to prepare I as starting material. Attempted conversion of the alleged 12-membered ring to the cyclic azo compound revealed, however, that the major product from the reaction of hydrazine hydrate and acetylacetone without sol-



vent was an associated dimethyldihydropyridazine. Gray³ described the preparation of compound I by reaction of hydrazine hydrate and acetylacetone and reported an analysis and a molecular weight but gave no melting point. Blaise⁴ reported a dimeric solid compound from the same reaction and a melting point but did not characterize the product further. Blaise also reported that the reaction of acetylacetone and hydrazine in dilute hydrochloric acid solution gave the alleged dimer I. In

(1) This is the eighteenth in a series of papers concerned with the preparation and decomposition of azo compounds. For the seventeenth paper in this series, see C. G. Overberger, H. Biletch, P. Huang and H. M. Blatter, *J. Org. Chem.*, **20**, 1717 (1955).

(2) This paper comprises a portion of a thesis presented by Norman R. Byrd in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Graduate School of the Polytechnic Institute of Brooklyn.

(3) T. Gray, *J. Chem. Soc.*, **79**, 682 (1901).

(4) E. E. Blaise, *Compt. rend.*, **170**, 1324 (1920).

(5) (a) B. G. Zimmerman and H. L. Lochte, *THIS JOURNAL*, **60**, 2456 (1938); (b) A. Smith and H. N. McCoy, *Ber.*, **35**, 2169 (1902).

acetic acid solution, he reported that octane-3,6-dione and hydrazine gave a mixture of a diethyl tetrahydropyridazine derivative corresponding to IV with ethyl groups instead of methyl and 3,6-diethylpyridazine.

Zimmerman and Lochte^{5a} also reported a product from the reaction of acetylacetone with hydrazine hydrate which they isolated as a high boiling viscous oil which was not further characterized. They, however, compared this compound with Gray's³ reported product. They also reported the 3,6-dimethylpyridazine and a linear polymeric solid product from the reaction. Smith and McCoy^{5b} described the reaction of acetylacetone and excess hydrazine hydrate to give a linear product, $\text{NH}_2\text{N}=\text{C}(\text{CH}_3)(\text{CH}_2)_2(\text{CH}_3)\text{C}=\text{N}=\text{C}(\text{CH}_3)(\text{CH}_2)_2(\text{CH}_3)\text{C}=\text{N}\text{NH}_2$, which on treatment with carbon dioxide in alcohol gave a product which they compared with Gray's dimeric compound.

In our hands the reaction of acetylacetone with hydrazine hydrate with no solvent or in ethyl alcohol solution gave two products—a low boiling and a high boiling fraction which were interconvertible. Only the high boiling fraction is characterized here, as a dimethyldihydropyridazine. The experimental results indicate that there is a facile equilibrium with the high boiling fraction being more stable thermodynamically. The low boiling compound can be obtained on slow distillation by displacement of the equilibrium and it is suggested that it is a six-ring tautomer. This equilibrium could be followed by changes in refractive index and infrared spectrum. The reaction in acetic acid as a solvent confirmed the results of Blaise with the diethyl derivative, that is, a 9% yield of IV was obtained and a 20% yield of the aromatized compound III.

The evidence which led us to the conclusion that the major reaction product was not the 12-membered ring (I) but rather an associated dimer of a dimethyldihydropyridazine is summarized as follows: Molecular weight data⁶ obtained on compound II indicated that it was associated even in a solvent such as water. Data on the molecular weight of II by a cryoscopic procedure using water as a solvent are described in the Experimental section. It is apparent that at low concentrations of the high boiling compound, values indicating monomeric material are obtained, whereas at high molar concentrations dimeric association begins to play a major role.

Oxidation of the high boiling compound by the method of Bacchetti⁷ with 15% hydrogen peroxide gave a 50% yield of III, the known 3,6-dimethylpyridazine. A more satisfactory way of establishing the 6-membered ring structure of II, however, was by treatment of II in cyclohexene or benzene as the solvent in the presence of palladium to give III in high yield plus a small amount of IV. This method could also be carried out at room temperature although lower yields were obtained.

Catalytic hydrogenation of the high-boiling compounds in acid media with a mixture of platinum oxide and 10% palladium-on-charcoal as catalyst

or in neutral medium with Raney nickel gave IV. Attempts to reduce II directly to VII under more rigorous conditions failed and products resulting from hydrogenolysis of the N-N bond were indicated. This was also the result on attempted hydrogenation of IV to VII under more forcing conditions. It was not possible to reduce either the high or low-boiling compound with sodium and alcohol to give either IV or VII. On the other hand, III was reduced with sodium and ethanol according to the procedure of Paal and Koch^{8a} to give VII which was useful for comparison purposes.

Reaction of the high-boiling compound II with benzoyl chloride gave a benzoate V which melted at 184–184.5° dec. Since the benzoate of 1-amino-2,5-dimethylpyrrole has been reported⁹ to melt at 184–185°, it could not be eliminated as a possible structure for this compound. A mixed melting point of V with the benzoate of 1-amino-2,5-dimethylpyrrole was depressed and a comparison of their infrared spectra showed differences. The structure of the benzoate of the pyrrole derivative has been established elsewhere. This evidence strongly indicates that the structure of the high-boiling compound was not that of an N-aminopyrrole and supports the six-membered ring structure. An infrared spectrum of V showed absorption at 2.90 and 3.07 μ strongly indicative of an NH group. However, it should be recognized that the structure of V as indicated in the diagram should be regarded as tentative. Thus it is possible that the benzoate can be represented by another tautomer of V. Determination of the molecular weight⁶ of V in acetone as a solvent, indicated association in that there were changes in molecular weight with changes in the concentration of the solute.

Reaction of the high-boiling and low-boiling isomers with liquid hydrogen cyanide by the method of Overberger and Berenbaum¹⁰ gave identical products, compound VI. This compound was identical with a product previously reported¹¹ obtained by the reaction of acetylacetone with hydrazine sulfate and sodium cyanide followed by the addition of hydrogen cyanide to the intermediate 3,6-dimethyl-3-cyano-2,4,5-trihydropyridazine. Since a number of other methods have been described here which establish the structure of II, the high-boiling product, as a 6-membered ring, the comparison of the product obtained by the addition of hydrogen cyanide to both the low-boiling and high-boiling compounds with this previously reported material established the structure of VI prepared by the procedure described in reference 11. Oxidation of VI with neutral potassium permanganate in acetone resulted in loss of nitrogen and a 43% yield of VIII, a logical product to be expected from the hypothetical biradical $\text{CH}_4(\text{CN})\dot{\text{C}}(\text{CH}_2)_2\dot{\text{C}}(\text{CN})\text{CH}_3$ obtained from decomposition of the unstable azo compound derived from VI. An infrared spectrum revealed no unsaturation, strongly indicating structure VIII.

(8) (a) C. Paal and C. Koch, *Ber.*, **37**, 4382 (1904); (b) C. Paal and J. Ueber, *ibid.*, **36**, 497 (1903).

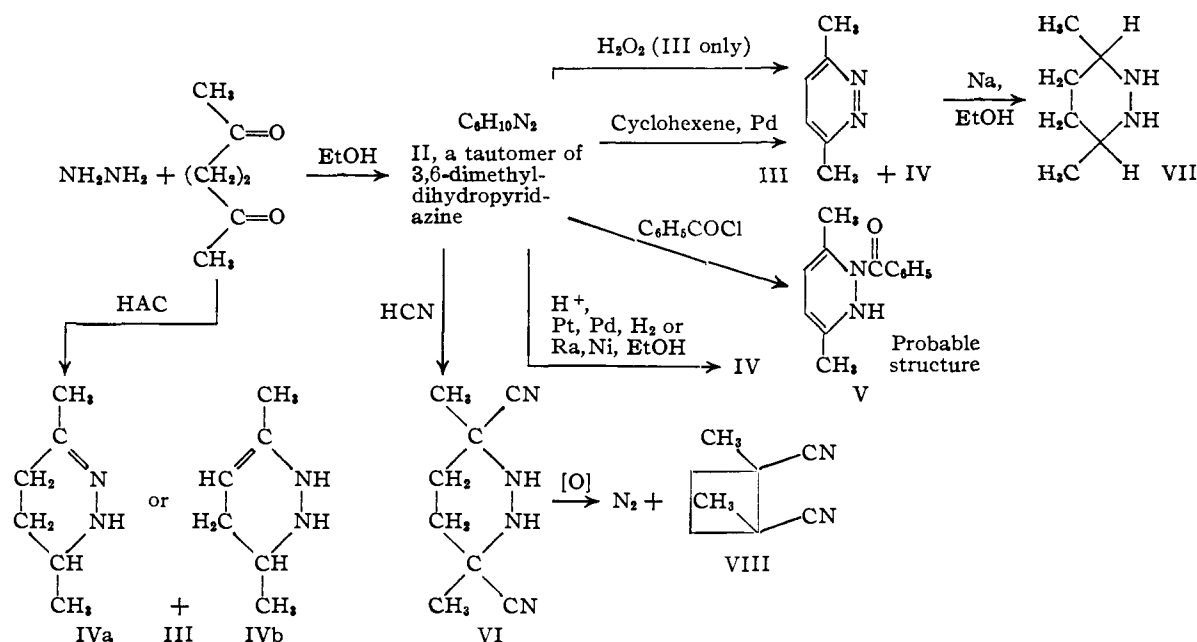
(9) C. G. Overberger, L. C. Palmer, B. S. Marks and N. R. Byrd, *THIS JOURNAL*, **77**, 4100 (1955).

(10) C. G. Overberger and M. B. Berenbaum, *ibid.*, **73**, 2618 (1951).

(11) C. G. Overberger, T. B. Gibbs, Jr., S. Chibnik, P. Huang and J. J. Monagle, *ibid.*, **74**, 3290 (1952).

(6) W. Swietoslowski, "Ebulliometric Measurements," Reinhold Publishing Corp., New York, N. Y., 1945.

(7) T. Bacchetti, *Gazz. chim. ital.*, **80**, 783 (1950).



All of the preceding reactions are outlined in the diagram.

Experimental¹²

Preparation of Dihydropyridazine (II).—The method used was a modification of that described by Gray,³ who carried out the reaction at room temperature, allowed the reaction mixture to stand for one hour and then extracted with ether. Here the reaction was carried out at a higher temperature, and the time of standing and temperature of heating were critical for optimum results. Since the structure of the product is controversial, some detail of its preparation seems justified.

To 114 g. (1 mole) of acetonylacetone (purified by distillation under nitrogen, b.p. 88° (20 mm.)), cooled by a water-bath and under a nitrogen atmosphere, was added 50 g. (1 mole) of 64% hydrazine hydrate. The rate of addition was such that the temperature remained between 30–35°. The addition took approximately one hour. The reaction mixture was left standing for another 1.5 hours at room temperature, the reflux condenser was attached and then the solution heated to 90° for 20 minutes, cooled and extracted with four 150-ml. portions of ether. A pasty solid usually separated, Dry Ice^{5b} was added to the flask until the solution was cold and the mixture then placed on the steam-bath for another 20 minutes. The ether extract was thoroughly dried under nitrogen over anhydrous potassium carbonate. After removal of the solvent a cloudy, yellow oil, 110 g., was distilled through a modified Claisen unit. This unit allowed rapid distillation with some fractionation. Distillation gave 100 g. (90.7%) of a clear, almost colorless, viscous oil, b.p. 115° (1.5 mm.), n_D^{20} 1.5340, d_4^{24} 1.0771, pK_b in water, 9.387; K_b 2.44 × 10⁻¹⁰. When cooled to Dry Ice temperatures it solidified to a pasty solid, m.p. 48–50°. Recrystallization from ether-petroleum ether (b.p. 35–60°), gave transparent, square crystals, m.p. 52–53°, ϵ_{max} 3958, λ_{max} 250 m μ in cyclohexane; ϵ_{max} 4291, λ_{max} 245 in ethanol; infrared absorptions, 3.0 μ , NH stretching; 3.23 μ ; 3.4 μ possible CH₂ stretching; 6.15 μ , C=N or NH bending; literature values: 73%, 160–175° (20 mm.), solid reported but no m.p.;³ 114–115° (2 mm.), no yield^{5a}; 155–156° (10 mm.), m.p. 52–53°.⁴

*Anal.*¹³ Calcd. for C₈H₁₀N₂: C, 65.41; H, 9.15; N, 25.43. Found: C, 65.15; H, 9.06; N, 25.24.

The picrate was prepared from an ether solution of picric acid, as orange crystals, m.p. 115° dec.

(12) All melting points are corrected. All distillations were carried out under nitrogen.

(13) Analyses by Dr. F. Schwarzkopf, Queens, N. Y.; Dr. K. Ritter, Basel, Switzerland.

Anal. Calcd. for C₁₂H₁₂N₂O₇: C, 42.48; H, 3.86; N, 20.64. Found: C, 42.38; H, 3.85; N, 20.30.

The lower boiling compound could be obtained from the high boiling compound by slow vacuum distillation, b.p. 50° (1.4 mm.), m.p. 32–33°, n_D^{20} 1.5155. On standing the refractive index gradually changed from 1.5155 to 1.5331. Analysis of this compound was carried out within several hours after distillation.

Anal. Calcd. for C₈H₁₀N₂: C, 65.41; H, 9.15; N, 25.43. Found: C, 65.34; H, 9.17; N, 25.26.

Effect of solvents on Reaction between Acetonylacetone and Hydrazine Hydrate. (a) **Reaction in Alcoholic Solution.**—The reaction in alcohol proceeded as in the absence of solvent to yield 72% of II.

(b) **Reaction in Acetic Acid Solution.**—To a solution of 500 ml. of glacial acetic acid and 114 g. (1 mole) of acetonylacetone was added, dropwise and with no external cooling, 100 g. (1 mole) of a 50% hydrazine hydrate solution. The temperature rose slowly to 60° and the color changed to deep purple. When all the hydrazine was added, a condenser was substituted for the dropping funnel and the solution was refluxed for 30 minutes. The reaction mixture was then cooled to room temperature and a major portion of the acetic acid removed under reduced pressure. The remaining solution was made alkaline with sodium hydroxide and the solution extracted with five 150-ml. portions of methylene chloride. The extract was dried over anhydrous potassium carbonate, the solvent removed, and the brown oil residue, 90 g., was distilled. One fraction gave 10.4 g. (9%) of 3,6-dimethyltetrahydropyridazine, b.p. 30° (2 mm.), n_D^{20} 1.4718, picrate m.p. 107–108°; a mixed melting point with an analytical sample, obtained from the hydrogenation experiment which follows, melted at 107–108°. A second fraction, 21.7 g. (20%), was 3,6-dimethylpyridazine, b.p. 52° (1 mm.), picrate m.p. 163–165°. Recrystallization from ethanol gave yellow crystals, m.p. 164–165°; a mixed melting point with an analytical sample, obtained from the oxidation experiment described below, melted at 164–165°.

Equilibration of Dihydropyridazines. (a) **Rapid Distillation of II.**—From 19 g. (0.17 mole) of high-boiling compound II, n_D^{20} 1.5331, distilled rapidly through the modified Claisen unit described in the first experiment, there was obtained 13.5 g. (71.7%) of high-boiling compound, b.p. 116° (1.5 mm.), n_D^{20} 1.5332.

(b) **Slow Redistillation of High-boiling Compound.**—The redistillation of 193 g. (1.75 moles) of high-boiling compound was effected through a glass-spiral, heated column. A slow rate of distillation was used and fractions were taken throughout an 18-hour period in order to ensure equilibration. Fraction 1, 16 g., had a refractive index n_D^{20}

1.5185 (after 90 minutes it was n_D^{20} 1.5291); fraction 2, 31 g., n_D^{20} 1.5161; fraction 3, 44 g., n_D^{20} 1.5151 (after 70 minutes, n_D^{20} 1.5228); fraction 4, 23.5 g., n_D^{20} 1.5151 and fraction 5, 60 g. The boiling point of all fractions was 48–50° (1–1.4 mm.), with a total of 174.5 g. (90.2%) of low-boiling compound obtained.

Hydrogen Peroxide Oxidation of II. 3,6-Dimethylpyridazine (III).—The general method employed was that described by references 7 and 8a. To a solution of 11 g. (0.1 mole) of II in 20 ml. of distilled water heated on a steam-bath, was added 45.2 g. (0.2 mole) of 15% hydrogen peroxide dropwise. When all the peroxide had been added, any excess was decomposed with ferrous sulfate and the aqueous solution extracted with methylene chloride. The extract was dried over anhydrous potassium carbonate and the solvent removed under reduced pressure. The dark red liquid residue, 10 g., was distilled to give 5 g. (46%) of 3,6-dimethylpyridazine, b.p. 66° (2.5 mm.), picrate m.p. 164–165°. A mixed melting point with an analytical sample, prepared as in the disproportionation below, melted at 163–165°.

Disproportionation Reaction of II on Palladium.—II, 40 g. (0.36 mole), was dissolved in 250 ml. of cyclohexene and 3 g. of 10% palladium-on-charcoal was added. Vigorous bubbling always resulted and the system was refluxed for 23 hours, the catalyst removed by filtration and the solvent removed at reduced pressure to give 40 g. of a light amber liquid residue. Vacuum distillation gave two fractions: the first, 3.1 g. (7.6%) of 3,6-dimethyltetrahydropyridazine, b.p. 74° (11 mm.), n_D^{20} 1.4758, picrate m.p. 108–110°; mixed melting point with an analytical sample, prepared under the hydrogenation experiment above, m.p. 107–109°; the second, 30.1 g. (77.2%) was 3,6-dimethylpyridazine, b.p. 89.5° (8 mm.), which solidified on cooling to give a crystalline mass, m.p. 32–33° (b.p. 64° (2 mm.)), m.p. 34–35° from direct reaction of acetylacetone and hydrazine^{8a}; 105° (18 mm.) from hydrogen peroxide oxidation of 3,6-dimethyl-3-cyano-2,4,5-trihydropyridazine⁷; 180° (760 mm.), no yield, from decarboxylation and oxidation of 3,6-dimethyl-4,5-dicarbethoxytetrahydropyridazine^{8a}. By carefully melting the crystals and placing the melt on a refractometer without jarring or scratching, it was possible to obtain the refractive index before the melt solidified; n_D^{20} 1.5032. The same results were obtained when benzene was used in place of cyclohexene. The reaction could be carried out at room temperature to give a 10% yield of V.

Anal. Calcd. for $C_8H_{12}N_2$: C, 66.63; H, 7.45; N, 25.91. Found: C, 66.84; H, 7.45; N, 25.88.

The picrate was prepared from an ether solution of picric acid, yellow crystals, m.p. 164–165°, lit.^{7,8a} 164°.

Anal. Calcd. for $C_{12}H_{11}N_5O_7$: C, 42.73; H, 3.28; N, 20.76. Found: C, 42.85; H, 3.41; N, 20.67.

The low boiling compound gave similar products under the same conditions.

Hydrogenation of Dihydropyridazines. Formation of a 3,6-Dimethyltetrahydropyridazine (IV). (a) Hydrogenation of II in Acid Media.—II, 11 g. (0.1 mole), was hydrogenated with 0.5 g. of platinum oxide (pre-reduced) and 0.3 g. of 10% palladium-on-charcoal in 80 ml. of anhydrous methanol in a Parr apparatus. Dry hydrogen chloride was introduced for five minutes before hydrogenation. After 1.5 hours at room temperature and 3 atmospheres pressure, 81.5% of hydrogen (calculated for one double bond), was absorbed. Heating the apparatus to 60° resulted in no further absorption. The catalyst was removed by filtration, the solvent removed, the solution made basic with potassium hydroxide and extracted with three 50-ml. portions of ether. The ether solution was dried over anhydrous potassium carbonate and the solvent removed under reduced pressure. The dark red liquid residue, 10 g., was distilled to give 3.6 g. (32%) of a clear, slightly yellow liquid, b.p. 65° (11 mm.), n_D^{20} 1.4730, d_4^{24} 0.9311.

Anal. Calcd. for $C_8H_{12}N_2$: C, 64.23; H, 10.78; N, 24.97. Found: C, 64.01; H, 10.68; N, 25.29.

The picrate was prepared from an ether solution of picric acid to give yellow crystals, m.p. 108–109°. Recrystallization from benzene gave a m.p. 110–111°.

Anal. Calcd. for $C_{12}H_{11}N_5O_7$: C, 42.22; H, 4.43; N, 20.52. Found: C, 42.31; H, 4.53; N, 20.51.

(b) Hydrogenation of II under Neutral Conditions.—II, 11 g. (0.1 mole), in 50 ml. of ethanol with 0.5 teaspoon of

W-5 Raney nickel catalyst was hydrogenated at 3.5 atmospheres and 80° for seven hours. Removal of solvent under reduced pressure and distillation of 11 g. of a deep amber liquid residue gave 5.23 g. (46.6%) of the same 3,6-dimethyltetrahydropyridazine as described above, b.p. 61° (10 mm.), n_D^{20} 1.4742. A picrate was prepared as before, m.p. 110–111°. A mixed melting point with the sample prepared by the previous reduction melted at 108–110°. The lower boiling constituent could be hydrogenated to give a similar product with a 5% rhodium-on-alumina catalyst.

Reduction of 3,6-Dimethylpyridazine. Formation of 3,6-Dimethylhexahydropyridazine (VII).—The method used was essentially that of Paal and Koch.^{8a} After removal of the ether extract under reduced pressure, 10 g. of a yellow residue was distilled to give 4 g. (35%) of 3,6-dimethylhexahydropyridazine, b.p. 48° (5.5 mm.), n_D^{20} 1.4575, d_4^{24} 0.8912; lit.^{8a} 180° (760 mm.), no yield.

Anal. Calcd. for $C_8H_{14}N_2$: C, 63.10; H, 12.35; N, 24.53. Found: C, 62.94; H, 12.25; N, 24.29.

Benzylation of II (V).—A benzoate was prepared in the usual manner¹⁴ with pyridine. From 2 g. (0.018 mole) of II there was obtained 1 g. (27.7%) of a tan powder, m.p. 170–174° dec. Recrystallization from 85% ethanol gave 0.95 g. (24.6%) of white crystals, m.p. 184–184.5° dec. A mixed melting point with the benzoate of 1-amino-2,5-dimethylpyrrole,⁹ m.p. 184–184.5, was depressed 30° and their infrared spectra were not identical.

Anal. Calcd. for $C_{12}H_{14}N_2O$: C, 72.86; H, 6.58; N, 13.07. Found: C, 72.92; H, 6.70; N, 12.97.

Addition of Hydrogen Cyanide to the High Boiling Compound. Formation of 3,6-Dimethyl-3,6-dicyano-1,2,4,5-tetrahydropyridazine (VI).—The method used was similar to that described in reference 11. With 11 g. (0.1 mole) of II, 50 ml. of liquid hydrogen cyanide and no catalyst, after 43 hours there was obtained 16.3 g. (99.2%) of slightly pink crystalline material, m.p. 90–96° (gas evolution). Recrystallization two times from a benzene-ether solution gave a m.p. 103.5–104.5° (gas evolution), lit.¹¹ m.p. 99–99.9°. A mixed melting point with a sample prepared according to the method reported in reference 11 gave a m.p. 102–104° (gas evolution). The infrared spectra of the two compounds were identical. Addition of hydrogen cyanide to the low boiling compound gave the same product.

Permanganate Oxidation of 3,6-Dimethyl-3,6-dicyano-1,2,4,5-tetrahydropyridazine. Formation of 1,2-Dimethyl-1,2-dicyanocyclobutane (VIII).—To 11 g. (0.07 mole) of 3,6-dimethyl-3,6-dicyano-1,2,4,5-tetrahydropyridazine dissolved in 50 ml. of acetone and cooled to 0°, was added slowly 15 g. (0.1 mole) of potassium permanganate dissolved in acetone. After all the permanganate had been added, the solution was kept at room temperature for 7 hours. The reaction mixture was filtered and the solvent removed to leave a yellow oil which was chilled in Dry Ice to give 4 g. of a pasty yellow solid, m.p. 40–48°. Recrystallization two times from an ether-Skelly A solution gave white, flaky crystals, m.p. 87–88°. An analytical sample was recrystallized twice from an ether-Skelly A solution to give a m.p. 90–90.8°. An infrared spectrum showed only a nitrile group with no other unsaturation; $C\equiv N$ frequency, 4.45 μ .¹⁵

Anal. Calcd. for $C_8H_{10}N_2$: C, 71.60; H, 7.51; N, 20.88. Found: C, 71.80; H, 7.69; N, 20.90.

Molecular Weight Determinations. (a) Determination of Molecular Weight of II in Water.—Using a cryoscopic method and 20 g. of water with varying concentrations of compound, it was found that the molecular weight varied with the concentration.

(b) Determination of Molecular Weight of Monobenzoyl Derivative (V) of II in Acetone.—Using an ebullioscopic method as described by Swietoslawski⁶ with acetone as a solvent, and a K_b for acetone of 2.29, as determined for this system,¹⁶ it was demonstrated that the molecular weight varied with the concentration. At a concentration of 0.01 molal, based on the monomer, the molecular weight was 211; 0.01 molal, 220.6; 0.02 molal, 359.3; 0.03 molal, 392.9 (monomer, 214; dimer, 428).

Acknowledgment.—We wish to gratefully ac-

(14) R. L. Shriner and R. C. Fuson, "Identification of Organic Compounds," John Wiley and Sons, Inc., 3rd Edition, New York, N. Y., 1948, p. 177.

(15) R. F. Kiston and T. H. Griffith, *Anal. Chem.*, **24**, 334 (1952).

(16) Determined by M. Lapkin for this apparatus.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, POLYTECHNIC INSTITUTE OF BROOKLYN]

Cyclic Sulfones. VI. Synthesis and Reactions of 4-Hydroxythiaepane 1,1-Dioxide¹

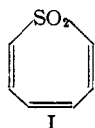
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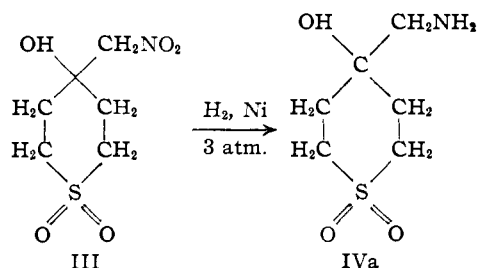
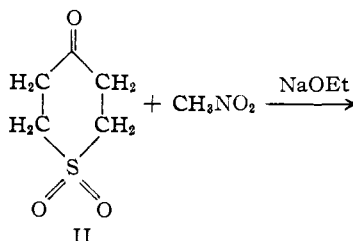
Reaction of tetrahydro-1,4-thiapyrone with diazomethane gave a 42% yield of 4-ketothiaepane (VIII) and a 40% yield of the oxide IX. Reaction of tetrahydro-1,4-thiapyrone 1,1-dioxide with diazomethane gave only the oxide, V, and none of the seven-membered ring. Treatment of 4-aminomethyltetrahydrothiapyran 1,1-dioxide-4-ol (IVa) with nitrous acid gave 4-oxothiaepane 1,1-dioxide (VI) in low yield and V in 67% yield. VIII was converted to the corresponding carbinol and then oxidized and acetylated to give 4-acetoxythiaepane 1,1-dioxide (XIII). Other reactions of this acetate are also described.

The synthesis of thiaepin or thiaepin 1,1-dioxide (I) is of interest because it represents a case in which the concept that $(2 + 4N)$ or 6π -electrons are necessary for aromatic resonance,³ can be examined for a sulfur system, although planarity is unlikely. A knowledge of the degree of aromatic character of this compound would be of considerable theoretical interest. This paper reports the preparation of key intermediates for the synthesis of thiaepin and thiaepin 1,1-dioxide.

The proposed synthesis of thiaepin 1,1-dioxide used tetrahydro-1,4-thiapyrone 1,1-dioxide⁴ (II) as the starting material. An initial attempt at ring enlargement using the procedure described by Kohler, *et al.*,⁵ with diazomethane resulted in the isolation of a small amount of the oxide V and none of the desired 4-ketothiaepane 1,1-dioxide (VI). An alternate route for ring enlargement was the method of Tiffeneau, *et al.*,⁶ which required as the key step the diazotization of 4-aminomethyltetra-



hydrothiapyran 1,1-dioxide-4-ol (IVa). The compound was conveniently prepared by the condensation of nitromethane with the keto sulfone II with sodium ethoxide to give 4-nitromethyltetrahydrothiapyran 1,1-dioxide-4-ol (III) in 71% yield. Catalytic reduction of the nitro alcohol in methanol with hydrogen at 3 atmospheres gave the amino alcohol IVa in 88% yield while a similar reduction in acetic acid gave the acetate salt IVb in an 86% yield. Diazotization of IVb in 10% glacial acetic acid gave as the major product the oxide V in a 67% yield, characterized as the glycol, while 4-



ketothiaepane 1,1-dioxide (VI) was obtained as a side product in a 13.6% yield. Attempts to alter the course of the reaction by increasing the acidity of the solvent, for example, the use of 20, 40% glacial acetic acid and 50% sulfuric acid failed. An attempt to prepare 4-nitromethyltetrahydrothiapyran-4-ol by a condensation of VII with nitromethane with sodium ethoxide gave the sodium salt of the nitro alcohol which on acidification gave only starting material.

Repetition of the diazomethane type ring enlargement on tetrahydro-1,4-thiapyrone⁴ using barium oxide⁷ as the basic catalyst for the decomposition of nitrosomethylurethan proved successful. There was obtained as a colorless liquid 4-ketothiaepane (VIII) in a 42% yield, characterized by the formation of its 2,4-dinitrophenylhydrazone. The

(1) This is the sixth in a series of papers concerned with cyclic sulfones. For the previous paper in this series, see C. G. Overberger, R. A. Gadea, J. A. Smith and I. C. Kogon, *THIS JOURNAL*, **76**, 2075 (1953).

(2) This paper comprises part of a thesis presented by Arthur Katchman in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the graduate school of the Polytechnic Institute of Brooklyn.

(3) E. Huckel, *Z. Elektrochem.*, **43**, 752 (1937).

(4) E. A. Fehnel and M. Carmack, *THIS JOURNAL*, **70**, 1813 (1948).

(5) F. P. Kohler, M. Tishler, H. Potter and H. T. Thompson, *ibid.*, **61**, 1057 (1939).

(6) M. Tiffeneau, E. Weill and B. Tchoubar, *Compt. rend.*, **205**, 54 (1937).

(7) The use of barium oxide in the ring expansion of the sulfide was suggested by Dr. H. J. Dauben, Univ. of Washington, Seattle. There are a number of indications that electron withdrawing groups favor the oxide in the reaction of diazomethane with ketones although steric factors may also be operative. Thus cyclohexanone gives a ketone:oxide ratio of ca. 4 (Kohler, *et al.*, *THIS JOURNAL*, **61**, 1057 (1939)); 2-chlorocyclohexanone gives a ketone:oxide ratio of no greater than about 1:1 and probably much less [D. Gutsche, *ibid.*, **71**, 3513 (1949) and unpublished observations]. In work presented by Dr. Gutsche last summer the ketone:oxide ratio was measured for a number of ketones of the general type 2-(*p*-R-phenyl)-cyclohexanone and was found to be 3.45 when R is hydrogen, 5.45 when R is methoxyl and 2.65 when R is chloro. It would seem therefore that electron withdrawing substituents which have strong inductive effects on the carbonyl dipole do favor oxide formation.