

of stachyose was received through the further kindness of Prof. Hérissé, and was found to react as expected.

A contribution from the Chemical Laboratory of the Bureau of Food and Drugs of the New York City Department of Health, 125 Worth St., New York City.

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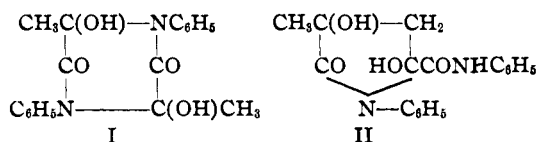
The Dimerization of Pyruvic Anilide

BY JOHN V. SCUDI

Continuing a study¹ of condensation reactions of alpha ketoamides it was observed that pyruvic anilide did not condense with a series of active methylene compounds or substituted benzaldehydes under Knoevenagel² conditions. Quantitative yields of dimeric pyruvic anilide³ were precipitated. This preferential condensation of pyruvic anilide with itself directed attention toward the structure of the dimer.

Wohl and Lips⁴ revised the structure of Bischoff and Walden⁵ and suggested a diketopiperidine (I). They demonstrated that the anilide hydrogens were involved in the dimerization, since *n*-methylpyruvic anilide did not dimerize. Their structure was based largely upon the stability of the compound to hydrolysis.

Since benzoylformanilide does not dimerize, one of the methyl hydrogen atoms is involved in the dimerization, and while the dimer is stable to acid hydrolysis, it shows the lability characteristic of aldols in alkaline media. The dimer dissolved in cold 10% sodium hydroxide with regeneration of the monomeric pyruvic anilide. This was demonstrated by oxime formation. The alkaline solution was boiled for five minutes. Two molecules of aniline were obtained and the pyruvic acid was isolated as the hydrazone. For these reasons, and the extensive analogies reported,^{1,6} structure II seemed more probable.



The dimer, treated with dry hydrogen chloride

- (1) Scudi and Lindwall, *THIS JOURNAL*, **57**, 1646, 2302 (1935).
- (2) Knoevenagel, *Ann.*, **281**, 25 (1894); **288**, 321 (1895); *Ber.*, **31**, 2588 (1898); **37**, 4464 (1904).
- (3) Nef, *Ann.*, **270**, 267 (1892).
- (4) Wohl and Lips, *Ber.*, **40**, 2313 (1907).
- (5) Bischoff and Walden, *Ann.*, **279**, 79 (1894).
- (6) (a) De Jong, *Rec. trav. chim.*, **20**, 91 (1901); (b) Bashour and Lindwall, *THIS JOURNAL*, **57**, 178 (1935).

in alcohol, lost a molecule of water, and a single ethoxyl group was introduced into the compound (III). Upon treatment with concentrated sulfuric acid in boiling acetic anhydride, two molecules of water were lost, and a single acetyl group was introduced (IV). This is evidence of an unsymmetrical structure of the dimer.

In analogy with condensation products of benzoylformanilide^{1,6a} the structure of III is probably 1-phenyl-2-ethoxyl-2-formanilide-4-hydroxy-4-methylpyrrolidone-5. The structure of IV may be either the 1-phenyl-2-formanilide-4-acetyl-4-methylpyrrolin-2-one-5, or the 2-acetyl derivative with the appropriate double bond shift. These structures have not been definitely established but since the problem is being discontinued, it was decided to report these data.

Experimental

Pyruvic Anilide.—Lactanilide was prepared in excellent yields according to the method of Bischoff and Walden⁵ and the crude product used directly. To 165 g. of crude lactanilide dissolved in one liter of 20% acetic acid, 88 g. of sodium bichromate, and 89 ml. of concentrated sulfuric acid were added. The reaction mixture was allowed to stand for thirty minutes at room temperature, was quenched to 0° and diluted to 3 liters. The product,³ recrystallized from slightly acidulated water, was obtained in 30–45% yields: m. p. 104°; the phenylhydrazone³ melted at 170–171°, and the oxime⁷ at 143°.

Anal. Calcd. for C₉H₉O₂N: N, 8.59. Found: N, 8.46, 8.66.

Dimeric Pyruvic Anilide (II).—Five drops of diethylamine was added to 5 g. of pyruvic anilide in 20 ml. of acetone. Solidification occurred within thirty minutes. The product was filtered off, washed with dilute acetone and recrystallized from 50% aqueous alcohol: white needles, m. p. 208–209°. The product was identical with that obtained by the methods of Nef³ or Wohl and Lips.⁴ The yields averaged 90–95% and became quantitative upon working up filtrates. No other condensation product could be isolated. Dimerization occurred in the presence of molecular amounts of the following active methylene compounds and benzaldehydes: acetophenone, ethyl cyanoacetate, ethyl acetoacetate, nitromethane, diethyl malonate, benzaldehyde, *p*-hydroxybenzaldehyde, and anisaldehyde.

Anal. Calcd. for C₁₈H₁₈O₄N₂: N, 8.59. Found: N, 8.31.

Alkaline Hydrolysis of II.—Treatment of II in cold 10% sodium hydroxide with hydroxylamine hydrochloride gave the oxime of pyruvic anilide. The identity of this substance was confirmed by comparison with an authentic sample.⁷

One gram of II was warmed carefully to a boil in 15 ml. of 10% sodium hydroxide under a reflux condenser, and

- (7) Ponzio and de Paolini, *Gazz. chim. ital.*, **57**, 653 (1927).

boiled for five minutes. The reaction was cooled, and the aniline was shaken out with ether and isolated as the hydrochloride. The yield was 0.79 g. or 100% of the theoretical; *lit.* p. 191^b. An excess of phenylhydrazine hydrochloride was added to the alkaline solution, acetic acid was added to slight acidity, and the reaction mixture was allowed to stand for twelve hours. This gave 0.28 g. of the phenylhydrazone of pyruvic acid, or 28%, melting at 186° with decomposition.

The Ethoxyl Derivative III.—Three grams of II was suspended in 75 ml. of absolute alcohol and dry hydrogen chloride was bubbled through the suspension until the dimer dissolved and no further hydrogen chloride was absorbed (about three hours). The alcoholic solution was evaporated to the point of crystallization. The product, white needles from 60% alcohol, melted at 198°. The yield of 1.5 g. or 50% is low due to hydrolytic side reac-

tions since aniline hydrochloride equivalent to 0.75 g. of dimer was isolated.

Anal. Calcd. for $C_{20}H_{20}O_2N_2$: C, 71.42; H, 5.95; N, 8.33. Found: C, 71.04; H, 5.97; N, 8.47.

The Acetyl Derivative IV.—Three-tenths ml. of concentrated sulfuric acid was added to 1.0 g. of II in 10 ml. of boiling acetic anhydride. The reaction was warmed at the boil for one minute then cooled and the acetic anhydride decomposed with dilute caustic. The tarry product recrystallized from 50% alcohol gave 0.7 g. or 70% of small yellow needles melting 148–150°. (The dimer may be crystallized unchanged from boiling acetic anhydride.)

Anal. Calcd. for $C_{27}H_{18}O_2N_2$: C, 71.85; H, 5.38; N, 8.38. Found: C, 71.86; H, 4.88; N, 8.52.

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COMMUNICATIONS TO THE EDITOR

SOLANINE-S

Sir:

The alkaloid of *Solanum auriculatum* has been identified as solanine-s [Anderson and Briggs, *J. Chem. Soc.*, (in press)] previously isolated only from *S. sodomaeum* [Oddo and Colombano, *Gazz. chim. ital.*, (i), **35**, 27 (1905); Romeo, *ibid.*, (ii), **35**, 579 (1905); Soldaini, *Boll. Chim. Farm.*, **44**, 769, 808, 843 (1905); see also Oddo and Caronna, *Ber.*, **69B**, 283 (1936) and intermediate papers by Oddo and co-workers]. Analyses of this alkaloid and its derivatives now obtained, however, correspond with formulas $C_{44}H_{75}O_{18}N$ and $C_{26}H_{43}O_8N$ for solanine-s and solanidine-s, respectively, rather than with the formulas $C_{64}H_{96}O_{18}N_2 \cdot H_2O$ and $C_{18}H_{31}ON$ suggested by Oddo. The formula now suggested for solanidine-s is supported by the work of Rochelmeyer [*Arch. Pharm.*, **274**, 543 (1936)], who has found that solanidine-s yields methylcyclopentenophenanthrene on selenium dehydrogenation, pyrrole bases on zinc dust distillation and a molecular compound with digitonin, thus indicating that solanidine-s, like solanidine-t, possesses a sterol structure, a fact which does not support Oddo's formula for the aglucone.

Anal. Calcd. for (solanine) $C_{44}H_{75}O_{18}N$: C, 58.34; H, 8.28; N, 1.54. Found: C, 58.38; H, 8.17; N, 2.21, 2.15. Calcd. for (solanidine) $C_{26}H_{43}O_8N$: C, 74.82; H, 10.31; N, 3.35. Found:* C, 74.57, 74.91; H, 10.43, 10.31; N, 3.96, 3.75. Calcd. for $C_{26}H_{43}O_8N \cdot C_6H_5O_7N_3$ (solanidine picrate): C, 59.44; H, 7.12; N, 8.67. Found:* C, 60.18; H, 7.11; N, 8.83.

Recently, Saiyed and Kanga [*Proc. Indian Acad. Sci.*, **4A**, 255 (1936)] have isolated from the fruit of *Solanum xanthocarpum* a glucosidic alkaloid, solancarpine, $C_{44}H_{77}O_{19}N$, hydrolyzed by dilute sulfuric acid to solancarpidine, $C_{26}H_{43}O_8N$, glucose, rhamnose and probably galactose. The formula of solancarpine differs only from that now suggested for solanine-s by H_2O while the formula of solancarpidine is the same as that proposed for solanidine-s. The melting points of the alkaloids and their derivatives also approximate closely to those already recorded for solanine-s and its derivatives and further derivatives now prepared.

It would appear, therefore, from the following comparison of melting points that solancarpine is identical with solanine-s or at least that solancarpidine is identical with solanidine-s.

The decomposition point of solanine-s and those of some of the salts of solanidine-s vary consider-

(* Analyses by Dr. Wejler.