These compounds were not analyzed since they appear to be identical with the 3,4-diethylpiperidine (b. p. 193° at 720 mm.) and its derivatives (chloroplatinate, m. p. 159-160°; picrate, m. p. 107-108°) previously prepared by Koenigs and Bernhart.[8]

Summary

The reduction of ethyl propylidenemalonate with aluminum amalgam yields a mixture of substances from which there can be obtained the *dl* and the *meso* forms of β,γ-diethyladipic acid. These acids have been characterized and converted into the corresponding forms of 3,4-diethylcyclopentanone, 3,4-diethylcyclopentanone oxime, 4,5-diethylpiperidone-2, and 3,4-diethylpiperidine.

MINNEAPOLIS, MINNESOTA RECEIVED AUGUST 28, 1944

---

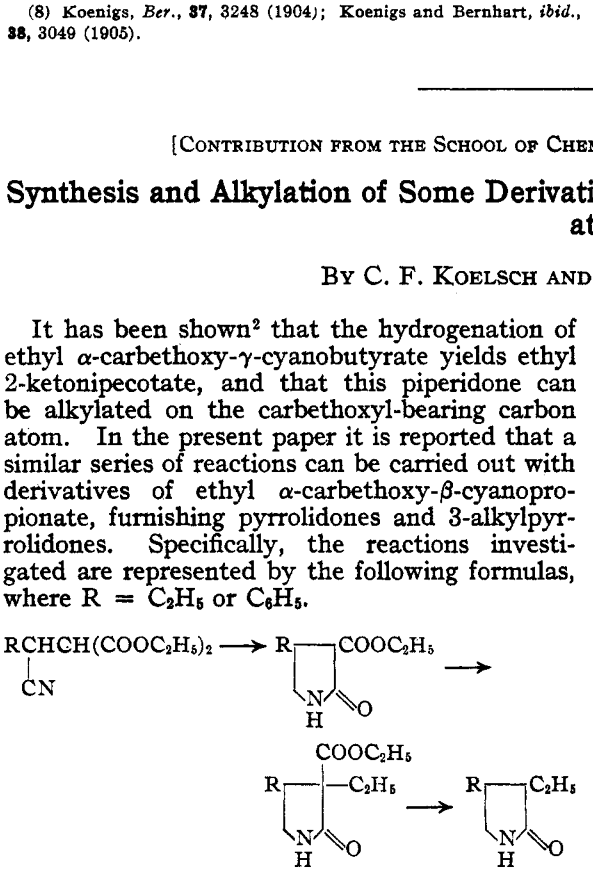
[8] Koenigs, *Ber.*, **37**, 3248 (1904); Koenigs and Bernhart, *ibid.*, **38**, 3049 (1905).

[CONTRIBUTION FROM THE SCHOOL OF CHEMISTRY OF THE UNIVERSITY OF MINNESOTA]

Synthesis and Alkylation of Some Derivatives of Ethyl 2-Ketopyrrolidine-3-carboxylate[1]

BY C. F. KOELSCH AND CHARLES H. STRATTON

It has been shown[2] that the hydrogenation of ethyl α-carbethoxy-γ-cyanobutyrate yields ethyl 2-ketonipecotate, and that this piperidone can be alkylated on the carbethoxyl-bearing carbon atom. In the present paper it is reported that a similar series of reactions can be carried out with derivatives of ethyl α-carbethoxy-β-cyanopropionate, furnishing pyrrolidones and 3-alkylpyrrolidones. Specifically, the reactions investigated are represented by the following formulas, where R = C_2H_5 or C_6H_5.



Sodium and butyl alcohol converts the products into pyrrolidines, but the yields obtainable are much inferior to those realized in the reduction of analogous piperidones.[3]

Experimental

Ethyl α-Carbethoxy-β-cyanovalerate.—A solution of 59 g. of sodium cyanide in 150 ml. of water and 300 ml. of alcohol was treated at below 10° with 66 g. of acetic acid and then added with stirring to 200 g. of ethyl propylidenemalonate. After it had been stirred for one hour, the mixture was diluted with water, acidified, and extracted with ether. Distillation gave 141 g. (62%) of product with b. p. 130-140° at 2.5 mm.

Anal. Calcd. for $C_{11}H_{17}NO_4$: C, 58.2; H, 7.5. Found: C, 58.3; H, 7.8.

Reduction of 13.1 g. of the cyanoester in 150 ml. of alcohol at 175° using Raney nickel and hydrogen at 100 atmospheres took place in less than one hour, and gave 5.2 g. (80%) of **4-ethylpyrrolidone-2**, b. p. 104-106° at 5 mm., m. p. 39-41°. This substance has been reported previously[4] as a liquid, b. p. 117-118° at 13 mm.

Anal. Calcd. for $C_6H_{11}NO$: C, 63.7; H, 9.7. Found: C, 63.2; H, 9.8.

Reduction of 35 g. of the cyanoester in 125 ml. of alcohol in the same way but at 100° gave 24.3 g. (85%) of **ethyl 4-ethyl-2-ketopyrrolidine-3-carboxylate,** colorless coarse needles from benzene-ligroin, m. p. 83-84.5°.

Anal. Calcd. for $C_9H_{15}NO_3$: C, 58.4; H, 8.0. Found: C, 58.6; H, 8.1.

Saponification of the pyrrolidone-ester with alcoholic potassium hydroxide and distillation of the resulting acid gave 4-ethylpyrrolidone-2 in a yield of 64%. Reduction of 3.8 g. of this pyrrolidone in 95 ml. of dry butyl alcohol with 7.7 g. of sodium gave 0.75 g. (22%) of **3-ethylpyrrolidine,** b. p. 122-132°, analyzed in the form of its **picrate,** yellow needles from alcohol, m. p. 102.5-103°.

Anal. Calcd. for $C_6H_{13}N + C_6H_3N_3O_7$: C, 43.9; H, 4.9. Found: C, 44.0; H, 5.2.

A solution of 0.3 mole of sodium ethoxide, 47.2 g. of ethyl 4-ethyl-2-ketopyrrolidine-3-carboxylate, and 47.5 g. of ethyl iodide in 200 ml. of absolute alcohol was boiled for one and one-half hours, and then most of the alcohol was distilled. The residue was diluted to 600 ml. with 20% aqueous calcium chloride and extracted with fifteen 100-ml. portions of ether. Distillation at 11 mm. gave 36 g. of product, b. p. 165-185°, and crystallization of the distillate from benzene-ligroin gave 20.3 g. (38%) of **ethyl 3,4-diethyl-2-ketopyrrolidine-3-carboxylate,** m. p. 76.5-77°.

Anal. Calcd. for $C_{11}H_{19}NO_3$: C, 62.0; H, 9.0. Found: C, 62.2; H, 9.2.

Saponification of 29.8 g. of the ester with alcoholic potassium hydroxide followed by distillation of the resulting acid gave 18 g. (91%) of **3,4-diethylpyrrolidone-2,** b. p. 138-142° at 10 mm., m. p. 16-18°.

Anal. Calcd. for $C_8H_{15}NO$: C, 68.0; H, 10.7. Found: C, 68.0; H, 10.8.

Reduction of 18 g. of 3,4-diethylpyrrolidone-2 in 300 ml. of dry butyl alcohol with 23 g. of sodium gave 1.6 g. (12%) of **3,4-diethylpyrrolidine,** b. p. 57° at 12 mm., analyzed in the form of its **picrate,** flat yellow needles from benzene, m. p. 116.5-117°.

Anal. Calcd. for $C_8H_{17}N + C_6H_3N_3O_7$: C, 47.2; H, 5.7. Found: C, 47.1; H, 6.0.

Ethyl α-Carbethoxy-β-cyano-β-phenylpropionate, m. p. 48° (reported[5] 48.5°) was obtained in yields of 90-94% when a solution of 20.2 g. of sodium cyanide and 23 g. of

---

[1] From the Ph.D. Thesis of Charles H. Stratton, September, 1943.

[2] Koelsch, THIS JOURNAL, **65**, 2458 (1943).

[3] Koelsch, *ibid.*, **65**, 2460 (1943).

[4] Guha-Sircar, *J. Indian Chem. Soc.*, **5**, 549 (1928).

[5] Bredt and Kallen, *Ann.*, **293**, 342 (1896).

acetic acid in 50 ml. of water and 100 ml. of alcohol was added with stirring to 86.5 g. of ethyl benzalmalonate, and the resulting mixture was kept in a refrigerator overnight.

Reduction of 67 g. of the cyanoester in 500 ml. of alcohol at 100° with Raney nickel and hydrogen at 100 atmospheres took place in less than one hour, and gave 40.5 g. (71%) of **ethyl 2-keto-4-phenylpyrrolidine-3-carboxylate,** colorless prisms from benzene–ligroin, m. p. 119–120.5°. At higher temperatures, or in more concentrated solutions, or in ether, lower yields were obtained.

Anal. Calcd. for $C_{13}H_{15}NO_3$: C, 67.1; H, 6.4. Found: C, 67.1; H, 6.4.

Saponification of the ester with alcoholic potassium hydroxide gave a difficultly soluble potassium salt, from which there was obtained **2-keto-4-phenylpyrrolidine-3-carboxylic acid,** colorless crystals from dilute alcohol, m. p. 127–131° with decomposition.

Anal. Calcd. for $C_{11}H_{11}NO_3$: C, 64.4; H, 5.4. Found: C, 64.5; H, 5.3.

Distillation of the acid gave 4-phenylpyrrolidone-2, b. p. 198–200° at 10 mm., m. p. 75–76° (reported, m. p. 60°,[6] 76–77°[7]).

Reduction of 3.9 g. of 4-phenylpyrrolidone-2 with sodium in butyl alcohol gave 3-phenylpyrrolidine, isolated as its picrate (1.05 g., 12%), m. p. 163.5° (reported 164°,[8] 166°).[9]

Ethyl 2-keto-4-phenylpyrrolidine-3-carboxylate formed a white sodio derivative, difficultly soluble in alcohol, that gave back the original ester when it was acidified. A mixture of 0.05 mole of sodium ethoxide, 10 g. of ethyl 2-keto-4-phenylpyrrolidine-3-carboxylate, 7.7 g. of ethyl iodide, and 50 ml. of absolute alcohol was boiled for one hour, then cooled and diluted with water. The product was crystallized from benzene–ligroin, giving 4.96 g. (44%) of **ethyl 3-ethyl-2-keto-4-phenylpyrrolidine-3-carboxylate,** colorless prisms, m. p. 118–119°.

Anal. Calcd. for $C_{15}H_{19}NO_3$: C, 69.0; H, 7.3. Found: C, 68.9; H, 7.3.

Saponification of the alkylated ester with aqueous alkali was comparatively slow; but when a solution of 5 g. of it and 10 g. of potassium hydroxide in methanol was boiled for thirty minutes and then cooled, a crystalline potassium salt was deposited. This was removed, dissolved in water, and acidified, giving 3.9 g. (87%) of **3-ethyl-2-keto-4-phenylpyrrolidine-3-carboxylic acid,** colorless plates from dilute alcohol, that melted with decomposition at 173° or lower depending on the rate of heating.

Anal. Calcd. for $C_{13}H_{15}NO_3$: C, 67.1; H, 6.4. Found: C, 67.2; H, 6.8.

Distillation of 3.9 g. of the acid under reduced pressure gave 1.92 g. (57%) of **3-ethyl-4-phenylpyrrolidone-2,** colorless crystals, m. p. 84–85°.

Anal. Calcd. for $C_{12}H_{15}NO$: C, 76.3; H, 7.9. Found: C, 76.4; H, 7.9.

A solution of 1.76 g. of 3-ethyl-4-phenylpyrrolidone-2 in 20 ml. of dry butyl alcohol was reduced with 1.5 g. of sodium. The basic product, **3-ethyl-4-phenylpyrrolidine,** b. p. approximately 140° at 15 mm., was obtained in poor yield.

Anal. Calcd. for $C_{12}H_{17}N$: C, 82.3; H, 9.7. Found: C, 82.2; H, 9.7.

The amine formed an oily benzoyl derivative. The **picrate,** yellow crystals from dilute alcohol, melted at 154–155°.

Anal. Calcd. for $C_{12}H_{17}N + C_6H_3N_3O_7$: C, 53.5; H, 5.0. Found: C, 53.8; H, 4.9.

Summary

Hydrogenation of ethyl α-carbethoxy-β-cyanovalerate and of ethyl α-carbethoxy-β-cyano-β-phenylpropionate furnished, respectively, ethyl 4-ethyl- and ethyl 4-phenyl-2-ketopyrrolidine-3-carboxylate. The sodio derivatives of these esters were ethylated, and the products were hydrolyzed and decarboxylated. The resulting pyrrolidones were reduced to pyrrolidines by treatment with sodium and butyl alcohol.

MINNEAPOLIS, MINNESOTA RECEIVED AUGUST 30, 1944

---

(6) Jackson and Kenner, *J. Chem. Soc.*, 1657 (1928).

(7) Winans and Adkins, THIS JOURNAL, **55**, 4167 (1933).

(8) Gitsels and Wibaut, *Rec. trav. chim.*, **59**, 1093 (1940).

(9) Späth, Wiss and Breusch, *Monatsh.*, **50**, 349 (1928).

[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF IOWA STATE COLLEGE]

Dibenzofuran. XXII. 1-Nitrodibenzofuran[1]

BY HENRY GILMAN AND JACK SWISS[2]

Dibenzofurans having a substituent in the 1-position are of more than ordinary interest as reference compounds in cyclization processes. Nitration of dibenzofuran gives largely 3-nitrodibenzofuran. A by-product of the nitration melted at 110° and was supposed to be the 2-nitro isomer[3] or possibly the 4-nitro isomer.[4] It was later[5] shown that the 110° product was a mixture in which was contained some 2-nitrodibenzofuran. More recently[6] a nitration product melting at 91–93° was designated as the 1-nitrodibenzofuran. Subsequently, this supposed compound was resolved by further crystallization to give "a pure mononitrobiphenylene oxide melting at 126–126.5°," and purportedly shown to be the 1-nitrodibenzofuran by comparison with the 2-, 3-, and 4-nitrodibenzofurans.[7]

We do not know the structure of the product melting at 126–126.5°. It may possibly be a mixture of isomers which is very difficult to resolve, but it is not 1-nitrodibenzofuran, which we have prepared by the following sequence of reactions and which melts at 120–121°. Hydrolysis of [B], followed by deamination via the diazonium reaction, gave 1-nitrodibenzofuran. The structure of [C] was established[8a] earlier by a series of reac-

---

(1) Paper XXI: Gilman and Thirtle, THIS JOURNAL, **66**, 858 (1944).

(2) Present address: Research Laboratories, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

(3) Borsche and Bothe, *Ber.*, **41**, 1940 (1908).

(4) Cullinane, *J. Chem. Soc.*, 2267 (1930).

(5) Gilman, Bywater and Parker, THIS JOURNAL, **57**, 885 (1935).

(6) Yamashiro, *J. Chem. Soc. Japan*, **57**, 714 (1936) [*C. A.*, **30**, 7575 (1936)].

(7) Yamashiro, *Bull. Chem. Soc. Japan*, **16**, 61 (1941) [*C. A.*, **35**, 5111 (1941)].

(8) (a) Gilman and Van Ess, THIS JOURNAL, **61**, 1365 (1939); (b) Gilman, Jacoby and Swislowsky, *ibid.*, **61**, 954 (1939).