average reader. Methods of construction of nomograms are discussed in L. J. Henderson's book on blood[6] and in an admirable little book in French by Frechet and Rouillet[7] and in other books, such as those by Swett,[8] Davis[9] and Allcock and Jones.[10]

[6] L. J. Henderson, "Blood, a study in general physiology," Yale University Press, New Haven, Conn., 1928.

[7] M. Frechet, and H. Rouillet. "Nomographie," Armand Colin, Paris, 1928.

[8] G. W. Swett, "Construction of Alignment Charts," John Wiley and Sons, Inc., New York, N. Y., 1928.

[9] D. S. Davis, "Empirical Equations and Nomography," McGraw-Hill Book Company, Inc., New York, N. Y., 1943.

[10] H. J. Allcock, and J. R. Jones, "The Nomogram," 2nd ed., Pitman, N. Y., 1932.

DEPARTMENT OF PHYSICAL CHEMISTRY
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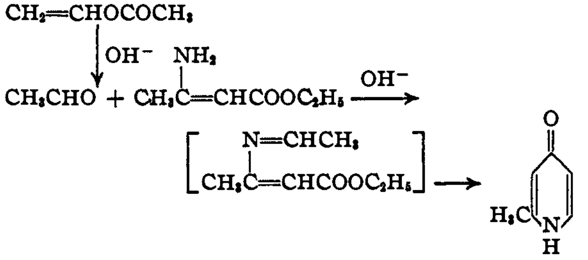
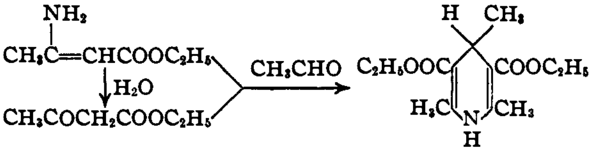
BOSTON, MASS.
RECEIVED APRIL 3, 1945

Condensation of Vinyl Acetate with Ethyl β-Aminocrotonate

BY JOHN A. KING

Although the instability of aliphatic aldimines is well known,[1] it was hoped that by slow generation of the aldehyde *in situ*, under mild condensing conditions, it might be possible to prepare ethyl β-ethylideneaminocrotonate which then, in the reaction mixture or subsequently, could be cyclized to 2-methyl-4-pyridone. The slow generation of acetaldehyde under condensing conditions was accomplished by the use of vinyl acetate in an aqueous alkaline medium but neither the intermediate ethylideneaminocrotonate nor the pyridone was obtained. Instead there was formed dihydrocollidine dicarboxylic ester, probably via a Hantzsch synthesis[2] from the aldehyde, the amino ester and acetoacetic ester produced by hydrolysis of some of the amino ester.





Although Collie[3] prepared this ester from ethyl β-aminocrotonate and acetaldehyde, he used warm sulfuric acid as the condensing agent and noted that the reactants did not condense if the acid catalyst were omitted.

Experimental

A mixture of ethyl β-aminocrotonate (12.9 g., 0.10 mole), vinyl acetate (17.2 g., 0.20 mole), potassium carbonate (27.6 g., 0.20 mole) and water (100 cc.) was allowed to stand for three weeks at room temperature in a stoppered flask, by which time all the water-insoluble reactants had disappeared and a semi-solid precipitate had formed. This semi-solid material (12.3 g., 92% yield, crude) was recrystallized four times from aqueous ethanol to give a nicely crystalline solid, m. p. 130°. When this was mixed with a sample of dihydrocollidine dicarboxylic ester, m. p. 129–130°, prepared from acetaldehyde ammonia and ethyl acetoacetate by the procedure of Hantzsch,[2] the mixture melted at 129–130°.

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[1] After this work was done the elegant synthesis of aldimines by Campbell, Sommers and Campbell, THIS JOURNAL, **66**, 82 (1944), was published.

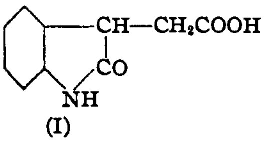
[2] Hantzsch, *Ann.*, **215**, 8 (1882).

[3] Collie, *ibid.*, **226**, 314 (1884).

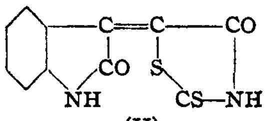
The Reduction of Ethyl Oxindole-3-glyoxalate under Clemmensen Conditions

BY WARD C. SUMPTER, MARION MILLER AND LAURA NELL HENDRICK

In 1923 Gränacher and Mahal[1] prepared a compound which they designated as oxindoleacetic acid (I) from β-rhodanal oxindole (II) by reduction and subsequent hydrolysis of the reduction product.

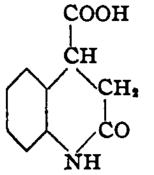


(I)

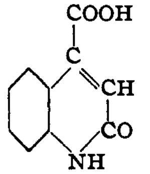


(II)

Subsequently Aeschlimann[2] found that Gränacher's "oxindole-acetic acid" was in reality 2-keto-1,2,3,4-tetrahydroquinoline-4-carboxylic acid (III) a fact later recognized by Gränacher and Kouniniotis[3] and confirmed by Hill, Schultz and Lindwall.[4] Aeschlimann found that compound III could be prepared quite readily by the reduction of 2-quinolone-4-carboxylic acid (IV) which in turn was prepared by condensing isatin with malonic acid[2,5] or by the action of alkali on acetylisatin.[2,6]



(III)



(IV)

In 1941 Horner[7] prepared ethyl oxindole-3-glyoxalate (V) by condensing ethyl oxalate and

[1] Gränacher and Mahal, *Helv. Chim. Acta*, **6**, 467 (1923).

[2] Aeschlimann, *J. Chem. Soc.*, 2902 (1926).

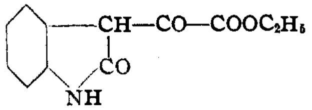
[3] Gränacher and Kouniniotis, *Helv. Chim. Acta*, **11**, 1241 (1928).

[4] Hill, Schultz and Lindwall, THIS JOURNAL, **52**, 769 (1930).

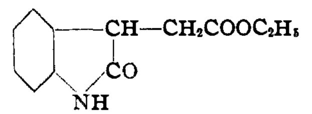
[5] Borsche and Jacobs, *Ber.*, **47**, 354 (1914).

[6] Camps, *Arch. Pharm.*, **237**, 687 (1889).

[7] Horner, *Ann.*, **548**, 117 (1941).



(V)



(VI)

oxindole. Horner reduced compound V with zinc amalgam and hydrochloric acid and obtained a product melting at 217° which he designated as "oxindoleacetic acid" (II). When the reduction was accomplished by the use of zinc amalgam and acetic acid the product was VI (the ethyl ester of I), m. p. 95°.

In view of the fact that Gränacher's "oxindoleacetic acid" and Horner's product had essentially the same melting point and that Gränacher's product had been shown by Aeschlimann to be III it was suspected that Horner's "oxindoleacetic acid" was also compound III.

To investigate this point the experimental work of Horner in preparing V and reducing it with zinc amalgam and hydrochloric acid was repeated. The product was found to be identical with a sample of compound III prepared according to the procedure of Aeschlimann. The identity was established by melting point methods and by the conversion of both samples to the ethyl ester of III (m. p. and mixed m. p. 155°).

Further the reduction of oxindole-3-glyoxylic ester (V) by zinc amalgam and acetic acid was repeated. It appeared that if the product of this reduction was the ethyl ester of oxindoleacetic acid (VI) compound III should result when VI was treated with hydrolytic agents through the opening of the five membered ring of the resulting oxindoleacetic acid and subsequent closure of the six membered ring giving III. It was found that VI is in fact converted into III by refluxing with aqueous hydrochloric acid.

It has been reported[8] that the reduction of α-keto acids and esters under Clemmensen conditions always results in the formation of α-hydroxy acids and esters. The reduction of ethyl oxindole-3-glyoxalate under Clemmensen conditions constitutes an exception to this rule since in both cases reported herein the carbonyl group of compound V is reduced to the methylene group in the formation of compounds III and VI.

Experimental

Ethyl Oxindole-3-glyoxalate (V).—This compound was prepared as described by Horner[7]; m. p. 187°.

2-Keto-1,2,3,4-tetrahydroquinoline-4-carboxylic Acid (III).—A. The compound was prepared by reducing V with zinc amalgam and hydrochloric acid as described by Horner[7]; colorless needles from water, m. p. 218°.

B. The compound was prepared by the procedure of Aeschlimann; colorless needles, m. p. 218°. A mixture of samples prepared by procedures A and B showed no depression in melting point.

Ethyl Ester of 2-Keto-1,2,3,4-tetrahydroquinoline-4-carboxylic Acid.—This compound was prepared by heating samples of III with absolute alcohol containing a few drops of sulfuric acid. Samples of III prepared by procedures A and B yielded identical samples of the ester; m. p. and mixed m. p., 155°.

Ethyl Ester of Oxindoleacetic Acid (VI).—2.5 grams of ethyl oxindole-3-glyoxalate (V) was refluxed with 10 g. of zinc amalgam and 50 cc. of 50% acetic acid until the resulting solution was decolorized. The solution was filtered and extracted with ether. The ether extract was shaken with saturated sodium carbonate solution until all acetic acid was neutralized. The ether extract was dried over sodium sulfate and the ether removed. The resinous residue was purified by crystallization from aqueous alcohol from which it separated as colorless needles; m. p. 95° as reported by Horner.

2-Keto-1,2,3,4-tetrahydro-quinoline-4-carboxylic Acid by the Hydrolysis of VI.—Three-tenths gram of compound VI was heated for one hour under reflux with a mixture of 6 cc. of concentrated hydrochloric acid and 30 cc. of water. The resulting solution was cooled, the precipitate collected and purified by crystallization from hot water. The product was obtained as colorless needles; m. p. 218°. The melting point of mixtures of this product with samples of III prepared by procedure B was also 218°.

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BOWLING GREEN, KENTUCKY
RECEIVED MARCH 12, 1945

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[8] Martin, "The Clemmensen Reduction," page 159 of "Organic Reactions," Vol. I, Roger Adams, Editor, John Wiley and Sons, New York, N. Y., 1942.

Methacrylic Esters of Glucose and Other Carbohydrates[1]

BY R. H. TREADWAY AND E. YANOVSKY

Recently methacrylic anhydride became available for research purposes. Although methacrylic esters of lower aliphatic alcohols have been of technical importance for some time, none has been prepared with methacrylic anhydride. Properties of methacrylic esters of the starch group of carbohydrates (glucose, maltose, dextrin, and starch) prepared by us are described here.

Preparation and Properties of Glucose Pentamethacrylate.—Thirty grams of glucose was stirred into 150 g. of pyridine at 65°. Methacrylic anhydride (192 g.) was added gradually. This amount is 50% more than that required for penta substitution. The sugar dissolved entirely in about three hours, but stirring and heating were continued for another half hour. The solution was then poured into stirred cold water. The sirup which separated was washed with water several times and then dissolved in warm alcohol. On cooling, twenty grams of fine needle-shaped white crystals of glucose pentamethacrylate separated. The substance was soluble in alcohol, acetone, benzene, chloroform, and other organic solvents, but insoluble in aliphatic hydrocarbons. After two recrystallizations, a constant melting point was attained, 115° (cor.). The specific rotation for a 4% solution in absolute alcohol was $[\alpha]^{25}\mathrm{D}$ +87.3°.

Anal. Calcd. for $C_{26}H_{32}O_{11}$: C, 60.0; H, 6.2. Found: C, 59.8; H, 6.1. Calcd. for $C_6H_7O_6(CH_2{=}C(CH_3){-}CO{-})_5$: methacrylyl, 66.4. Found by saponification: methacrylyl, 66.4.

Solutions of glucose pentamethacrylate in chloro-
