[CONTRIBUTION FROM THE STERLING CHEMISTRY LABORATORY OF YALE UNIVERSITY]

A New Thiazane Synthesis

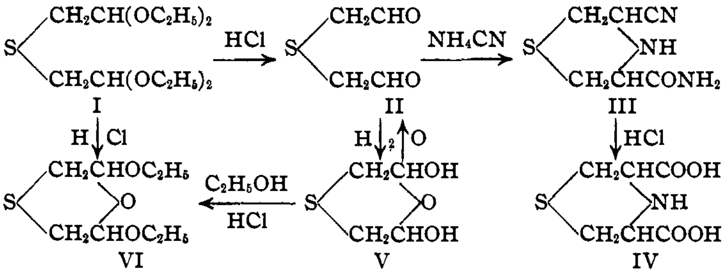
BY ROBERT D. COGHILL

For the purposes of some other research it was desired to obtain a sample of thiazane-3,5-dicarboxylic acid (IV). As this represents a new type of thiazane derivative it was necessary to devise a method of entering the series. It was found possible to do this by means of Strecker's well-known cyanohydrin synthesis.

Acetalyl sulfide (I) was prepared by a modification of Fischer's[1] method. In passing it should be mentioned that this substance is apparently what Curtius[2] prepared and described as mercaptoacetal. The acetalyl sulfide can be hydrolyzed by means of dilute hydrochloric acid to thiodiacetaldehyde (II). This aldehyde cannot be isolated as such but apparently exists in solution in equilibrium with 3,5-dihydroxythioxane (V), which is very reminiscent of the relationship existing between succinic dialdehyde and furan. In this case the 3,5-dihydroxythioxane can be isolated by concentrating the solution. The diethyl acetal of this substance, 3,5-diethoxythioxane (VI), can also be prepared from acetalyl sulfide as noted by Clarke and Smiles.[3]

When a solution of thiodiacetaldehyde is treated with ammonium cyanide, a somewhat complicated reaction sets in, the net result of which is the formation of the amide of 3-nitrilothiazane-5-carboxylic acid (III). Whether the Strecker reaction proceeds with the open chain form of the aldehyde, or whether the ammonium cyanide reacts with the dihydroxythioxane, is problematical. At first thought it seems unreasonable that only one of the nitrile groups should be hydrolyzed during the Strecker reaction, but somewhat similar reactions are not unknown in the chemical literature, and as this substance is quite insoluble and precipitates from the reaction mixture over a period of twenty-four hours, solubility considerations may well be the governing factors.

The nitriloamide resulting from the Strecker reaction can be transformed into the desired thiazane-3,5-dicarboxylic acid by means of concentrated hydrochloric acid. The synthesis can be represented as follows



Experimental

Acetalyl Sulfide.—This substance was prepared from bromoacetal and potassium sulfide as described by Fischer,[1] except that the reaction, instead of being autoclaved, was refluxed overnight. The yield was 75%. When potassium hydrosulfide was used instead of the sulfide, hydrogen sulfide was evolved copiously and acetalyl sulfide was obtained as above, except in smaller yield. Curtius[2] describes the product of this latter reaction as mercaptoacetal.

Thiodiacetaldehyde and 3,5-Dihydroxythioxane.—Twenty-six grams of acetalyl sulfide was vigorously shaken with 100 cc. of 0.5% hydrochloric acid at a temperature of 40–50° until solution was practically complete. The material now gave a very strong, nearly blue color to Schiff's reagent. A small amount of norite was then added and the solution filtered. The filtrate was evaporated to a volume of 50 cc. *in vacuo* at room temperature and then cooled in an ice-bath. The material separated as white needles, a second crop bringing the yield to 11.8 g., or nearly the theoretical. For analysis the material was dried in a vacuum desiccator over sulfuric acid.

Anal. Calcd. for $C_4H_8O_3S$: S, 23.5. Found: S, 22.9.

3,5-Dihydroxythioxane melts at 73° and is soluble in water at room temperature. Its solution imparts a deep bluish purple color to Schiff's reagent, entirely different from the color given by other aldehydes. When placed on the skin it imparts a deep brown stain impossible to remove. It has a very characteristic odor. When its solution is treated with saturated salt solutions or a trace of alkali, or even when the solid is kept in the dry state, it polymerizes or condenses to a water insoluble material. Due to this property it was always used in dilute aqueous solution just after hydrolysis from the acetal.

When warmed with alcohol and a trace of hydrochloric acid, it is transformed quantitatively into 3,5-diethoxythioxane, VI.

The Amide of 3-Nitrilothiazane-5-carboxylic Acid.—Fifty-three grams of acetalyl sulfide was hydrolyzed as above with 300 cc. of 0.5% hydrochloric acid. After

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[1] Fischer, *Ber.*, **42**, 1070 (1909).

[2] Curtius and Kyriacou, *J. prakt. Chem.*, [2] **95**, 370 (1917).

[3] Clarke and Smiles, *J. Chem. Soc.*, **95**, 992 (1909).

filtration of the hydrolysate it was concentrated *in vacuo* at room temperature to a volume of 100 cc. To the cooled concentrate was then added 11.2 g. of liquid hydrogen cyanide and the mixture was allowed to stand for ten minutes, after which an aqueous solution of 7.0 g. of ammonia was added slowly with stirring. The solution was then placed in the ice-box overnight. The reaction product was filtered off and recrystallized from 95% alcohol, in which it is sparingly soluble, to yield a crop of yellow needles. The yield is 17 g. or 50%. It melts with decomposition at 192°.

Anal. Calcd. for $C_6H_9ON_3S$: C, 42.1; H, 5.25; N, 24.5; S, 18.7. Found: (Schoeller) C, 42.2; H, 5.44; N, 23.5; S, 18.7.

This substance is insoluble in cold water and all organic solvents tried except boiling alcohol, but soluble in concentrated hydrochloric or sulfuric acid. When boiled with concentrated sodium hydroxide it gives off exactly two-thirds of its nitrogen as ammonia. When boiled with 0.05 *N* sodium hydroxide, one-third of the nitrogen appears as ammonia in twenty minutes. The second nitrogen is much slower to hydrolyze, only half of it appearing as ammonia in two hours. This behavior, coupled with its high insolubility, is interpreted as confirming the assigned structure.

Thiazane-3,5-dicarboxylic Acid.—Ten grams of the above nitriloamide was refluxed for three hours with concentrated hydrochloric acid. At the end of that time it was evaporated to dryness on a water-bath, taken up in water and made *just* alkaline to Congo red with ammonia, whereupon the thiazane-3,5-dicarboxylic acid came out in white needles which can be recrystallized from water and which contain one mole of water of crystallization. The yield was 6 g. or 56%. When heated it first decrepitates then melts with decomposition at 253–254°.

Anal. Calcd. for $C_6H_9O_4NS \cdot H_2O$: H_2O, 8.6; C, 34.5; H, 5.26; N, 6.7; S, 15.3. Found: (Schoeller) H_2O, 8.7; C, 34.4; H, 5.35; N, 6.3; S, 15.3.

Summary

A new application of the Strecker reaction, ring closure, has been used to enter the thiazane series.

Thiazane-3,5-dicarboxylic acid has been synthesized by means of this method. This substance can serve as a starting point for the synthesis of many new thiazane derivatives.

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[CONTRIBUTION FROM THE FOREST PRODUCTS LABORATORY,[1] FOREST SERVICE, U. S. DEPARTMENT OF AGRICULTURE]

White Oak Holocellulose[2]

BY CARROLL D. BIRD AND GEO. J. RITTER

Holocellulose, the carbohydrate fraction in wood freed of its extraneous materials, has proved within the last three years a promising material for the study of the composition of wood.[3,4] It is similar in composition to the wood fraction, "skelettsubstanz,"[5] that is isolated by means of an aqueous solution of pyridine and chlorine dioxide.

Since the results on holocellulose from maple[3] and spruce[4] were published, others have been collected on the holocellulose from white oak. They are considered in the present paper.

Materials Used.—White oak sawdust (60–80 mesh) was used in this study. It was first extracted consecutively with alcohol, alcohol–benzene solution, and hot water to remove extraneous materials.

Alcohol–pyridine solution, consisting of 85 parts of 95% alcohol and 15 parts of pyridine (by volume), was used as the solvent.

A bleach solution was employed that was made by dissolving commercial chlorinated lime in distilled water. The supernatant liquor was removed from any undissolved residue by filtration and diluted so as to contain 1.6% of available chlorine. It was cooled to 10° and was made just acid to litmus by means of acetic acid immediately before using.

Isolation of Holocellulose.—The method developed by Ritter and Kurth[3] was employed for the isolation of holocellulose. Briefly, it consists of repeated alternate treatments of the wood with gaseous chlorine and alcohol–pyridine solution.

Four chlorinations were required to remove the maximum amount of lignin from the wood before carbohydrates began dissolving as was shown by determining[6] the lignin content of a control sample. In general, at this stage of delignification about 1.0% of lignin still remained in the residue. The residual lignin was removed by means of the bleaching solution at 10°.

Physical Properties of White Oak Holocellulose.—Unbleached white oak holocellulose is grayish tan in color; the bleached material is light-cream. It can be bleached

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(1) Maintained at Madison, Wis., in coöperation with the University of Wisconsin.

(2) To be presented before the Cellulose Division of the American Chemical Society at Chapel Hill, N. C., April 12, 1937.

(3) G. J. Ritter and E. F. Kurth, *Ind. Eng. Chem.*, **25**, 1250 (1933).

(4) E. F. Kurth and G. J. Ritter, THIS JOURNAL, **56**, 2720 (1934).

(5) E. Schmidt, K. Meinel and W. Jandebeur, *Cellulosechem.*, **13**, 129 (1932).

(6) G. J. Ritter and J. H. Barbour, *Ind. Eng. Chem., Anal. Ed.*, **7**, 238 (1935).