this Laboratory[8] for the synthesis of acetals of galactose, we have obtained the crystalline dimethyl acetal of *d*-glucose. A study of the behavior of this substance under conditions of glucoside formation is in progress and should be of interest since the dimethyl acetal is a probable intermediate in this reaction.

Experimental

d-**Glucose Dimethyl Acetal Pentaacetate.**—Glucose diethyl mercaptal pentaacetate[9] (20 g.) was dissolved in 200 cc. of absolute methanol and 24 g. of finely powdered cadmium carbonate added. A solution of 65 g. of mercuric chloride in 160 cc. of absolute methanol was then added and the mixture was heated to its boiling point under vigorous mechanical stirring and refluxed for seven hours. At the end of this period the mixture was filtered and the residue was washed with a small amount of methanol. The filtrate was poured into a mixture of chloroform (300 cc.) and water (300 cc.) and the chloroform layer was washed with water (seven times) until free of chlorides. The sirup obtained on solvent removal from the dried chloroform extract was dissolved in ether and brought to crystallization by the addition of heptane to incipient opalescence. Crystallization was completed on standing overnight at ice box temperature; yield 3 g.; m. p. 71–72°; spec. rot. (20°) + 12° (*c*, 2.2; $CHCl_3$).[10] Further recrystallization from a warm mixture of equal parts of ether and heptane did not alter these constants.

Anal. Calcd. for $C_6H_7O_5(OCH_3)_2(CH_3CO)_5$: OCH_3, 14.22; CH_3CO, 11.48 cc. 0.1 *N* NaOH per 100 mg. Found: OCH_3, 14.45; CH_3CO, 11.57 cc.; S, absent.

d-**Glucose Dimethyl Acetal.**—Glucose dimethyl acetal pentaacetate (8.5 g.) was dissolved in 10 cc. of absolute methanol, 0.5 cc. of 0.4 *N* sodium methylate was added to the cold solution and the mixture kept at ice-box temperature for five hours. At the end of this period ether was added to incipient opalescence and the mixture was maintained at ice-box temperature. At the end of one hour a crystalline product separated that was removed by filtration and recrystallized from a mixture of equal parts of ether and methanol; yield 3.5 g.; m. p. 94–95°; spec. rot. (20°) + 15° (*c*, 3.1; H_2O). Further recrystallization did not alter these constants.

Anal. Calcd. for $C_6H_{12}O_6(OCH_3)_2$: C, 42.47; H, 8.02; OCH_3, 27.44. Found: C, 42.18; H, 7.78; OCH_3, 27.64.

We are indebted to Mr. Howard S. Clark for assistance in the analytical determinations.

Summary

1. The synthesis in crystalline form of *d*-glucose dimethyl acetal and of its pentaacetate is reported.

Columbus, Ohio Received February 14, 1938

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[8] M. L. Wolfrom, L. J. Tanghe, R. W. George and S. W. Waisbrot, This Journal, **60**, 132 (1938). Since the present manuscript was submitted to the Editor, we have noted the publication of H. A. Campbell and K. P. Link [*J. Biol. Chem.*, **122**, 635 (1938)] in which the dimethyl acetal of galactose was synthesized by the same general method.

[9] W. Schneider and J. Sepp, *Ber.*, **51**, 220 (1918); M. L. Wolfrom, This Journal, **51**, 2188 (1929).

[10] All specific rotations are recorded to the D-line of sodium light. *c* is the concentration in grams per 100 cc. of solution.

[Contribution from the College of Pharmacy of the University of California]

The Substitution of Iodine in Enols by Means of Iodine and Hydrogen Peroxide. The Preparation of Ethyl α-Iodoacetoacetate, *sym*-Iodoacetylacetone and α-Iodotetronic Acid

By W. D. Kumler

The use of hydrogen peroxide and iodine to form triiodophenol in practically quantitative yields[1] indicated that hydrogen peroxide might be of use for the synthesis of iodo enols. Iodo enols were prepared readily in good yields in this manner from ethyl acetoacetate, acetylacetone and tetronic acid. The reaction in alcohol with the calculated amounts of iodine and hydrogen peroxide was slow at room temperature but rapid at 70°.

Ethyl α-iodoacetoacetate was prepared by Genvresse[2] and by Schönbrodt[3] and α-iodotetronic acid was made by Wolff and Fertig.[4] Ethyl α-iodoacetoacetate decomposes upon distillation under reduced pressure, so a comparison of the boiling points is not a sure means of identification. α-Iodotetronic acid liberates iodine vapors at a temperature considerably lower than the point at which the compound melts with vigorous decomposition. The temperature of melting (or decomposition) depends upon the rate of heating so the behavior on heating is not a positive means of identification. However, the iodine analysis and equivalent weights of the compounds indicate that they are mono iodo derivatives and their chemical behavior leaves little doubt that the iodine is in the α-position. All of the compounds oxidize iodide quantitatively

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[1] Marsh, *J. Chem. Soc.*, 3164 (1927).

[2] Genvresse, *Ann. chim. phys.*, [6] **24**, 65 (1891).

[3] Schönbrodt, *Ann.*, **253**, 178 (1889).

[4] Wolff and Fertig, *ibid.*, **312**, 164 (1900).

to iodine. Wolff and Fertig found this true of α-iodotetronic acid. Ethyl α-bromoacetoacetate oxidizes iodide but the γ-bromo compound does not. Similar behavior would be expected for the α- and γ-iodo compounds.

In the bromination of ethyl acetoacetate in ether solution the α-compound is formed first and this rapidly rearranges to the γ-compound and a second bromine atom is introduced with the resulting formation of the α,γ-compound. If the γ- instead of the α-compounds are produced in our experiments, then it seems likely that another atom of iodine could be introduced in the α-position. Attempts to introduce more than one equivalent of iodine into each of the parent compounds failed.

Kharasch, Sternfeld and Mayo[5] recently have concluded that peroxides or oxygen as well as hydrogen bromide are necessary for the rearrangement of ethyl α-bromoacetoacetate and they suggest a chain mechanism involving bromine atoms. In this connection it is interesting that ethyl α-iodoacetoacetate does not rearrange in the presence of hydrogen peroxide. This is probably due to the fact that hydrogen iodide cannot exist in appreciable concentrations in the presence of peroxides while hydrogen bromide can.

These iodo enols decompose with the liberation of iodine. Heat and water accelerate the decomposition. α-Iodotetronic acid is the most stable of the three compounds and *sym*-iodoacetylacetone is the least stable.

Experimental

All reactions were carried out at about 70°.

Ethyl α-Iodoacetoacetate.—Ten grams of Eastman ethyl acetoacetate was dissolved in 10 ml. of 95% ethyl alcohol; 9.76 g. of U. S. P. iodine was added in five or six portions together with 10 ml. of 30% hydrogen peroxide ("Superoxol"), likewise in small portions. When the color from one portion of the iodine had disappeared another portion was added together with some hydrogen peroxide until all of the iodine had combined. The solution was shaken twice with 30 ml. of water and the ethyl α-iodoacetoacetate dried over anhydrous sodium sulfate; yield 90%.

Anal. Calcd. for $C_6H_8O_3I$: I, 49.6. Found: I, 50.0.

α-Iodotetronic Acid.—Two grams of tetronic acid was dissolved in 12 ml. of absolute alcohol and 2.54 g. of U. S. P. iodine was added in five portions together with 5 ml. of 30% hydrogen peroxide. When all of the iodine had reacted the solution was evaporated to dryness *in vacuo* at about 45°; yield 95% of the crude compound. The residue was recrystallized twice from ethyl acetate. A white solid was obtained which evolved iodine vapors at 160° and melted with decomposition at from 170–175° depending upon the rate of heating.

Anal. Calcd. for $C_4H_3O_3I$: equiv. wt., 226; I, 53.8. Found: equiv. wt., 225; I, 53.7.

***sym*-Iodoacetylacetone.**—Five grams of Eastman acetylacetone was dissolved in 5 ml. of 95% ethyl alcohol; 6.35 g. of U. S. P. iodine was added in five portions together with 7 ml. of 30% hydrogen peroxide likewise in small portions. The solution was shaken twice with 20 ml. of water and the *sym*-iodoacetylacetone was dried over anhydrous sodium sulfate; yield 80%.

Anal. Calcd. for $C_5H_2O_2I$: I, 56.2. Found: I, 55.7.

Summary

A convenient method has been developed for making α-iodo enols using iodine and hydrogen peroxide. Ethyl α-iodoacetoacetate, α-iodotetronic acid and a new compound *sym*-iodoacetylacetone have been prepared by this method.

SAN FRANCISCO, CALIF. RECEIVED NOVEMBER 24, 1937

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[5] Kharasch, Sternfeld and Mayo, THIS JOURNAL, **59**, 1655 (1937).