g.). Recrystallization from methanol gave methyl 2,3,4,6-tetra-*O*-acetyl β-D-glucopyranoside, m.p. and mixed m.p. 104–105°, $[\alpha]^{27}\mathrm{D}$ $-22.2°$ in ethanol (c 2.7); literature values: m.p. 104–105[4,12] and $[\alpha]^{20}\mathrm{D}$ $-24.6°$ (ethanol),[13] $-27.2°$ (ethanol).[4]

Deacetylation of the methyl tetra-*O*-acetyl β-D-glucopyranoside by the Zemplén method[14] using catalytic amounts of sodium methoxide gave methyl β-D-glucopyranoside, m.p. and mixed m.p. 115–116°, $[\alpha]^{27}\mathrm{D}$ $-30.3°$ in water (c 2.0) (after recrystallization from methanol–ether); literature values: m.p. 110°,[15] 105°[16] and $[\alpha]^{15}\mathrm{D}$ $-32°$ (H_2O),[15] $-34.2°$ (H_2O).[16]

2. **Methyl β-Lactoside.**—Application of the above procedure to acetobromo lactose yielded the corresponding methyl β-lactoside, m.p. 205°, $[\alpha]^{25}\mathrm{D}$ $+1°$ in water (c 5.0). Inasmuch as the pure methyl β-lactoside showed $[\alpha]^{25}\mathrm{D}$ $+5.6°$ in water[5] it is believed that the compound above contained some of the α-anomer.

B. 1. **Methyl α-D-Mannopyranoside.**—To crystalline D-mannose (18.0 g.) was added 3% hydrogen chloride in methanol (15 ml.) and ethylene dichloride (30 ml.). The mixture was refluxed on the water-bath for 4 hours. During the course of the reaction a two-phase liquid system was formed, the lower layer of which soon turned to a solid crystalline mass. After being allowed to cool, the reaction mixture was filtered and washed with a little ice-cold methanol followed by ether. The crystalline methyl α-D-mannopyranoside (yield 9.7 g.) had m.p. and mixed m.p. 191–192°, $[\alpha]^{20}\mathrm{D}$ $+79.0°$ in water (c 1.0) (after recrystallization from 80% ethanol); literature values: m.p. 191–192°,[17] $[\alpha]^{20}\mathrm{D}$ $+79°$ (H_2O),[17] $+79.2°$ (H_2O).[18]

2. **Methyl β-L-Arabopyranoside.**—A mixture of 3% methanolic hydrogen chloride (70 ml.), ethylene dichloride (100 ml.) and L-arabinose (70 g.) was refluxed for 3 hours and allowed to stand overnight. The methyl β-L-arabopyranoside (yield 23.5 g.) was filtered off and washed with ethyl acetate and recrystallized from absolute ethanol, m.p. and mixed m.p. 166–168°, $[\alpha]^{19}\mathrm{D}$ $+235°$ in water (c 1.7); literature values: m.p. 169°[19] and 169–171°.[20]

Repeated recrystallization did not change the specific rotation which does not agree with the literature value ($[\alpha]^{20}\mathrm{D}$ $+245.5°$ in water).[19] As a further check on its purity a sample of the material ($[\alpha]\mathrm{D}$ $+235°$) was oxidized with periodic acid according to the procedure of Hudson and Jackson.[21] The D′-methoxydiglycolic aldehyde obtained had $[\alpha]^{20}\mathrm{D}$ $+123°$ (H_2O); Hudson and Jackson[21] reported $[\alpha]^{20}\mathrm{D}$ $+124°$ (H_2O) for this substance.

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The Condensation of D-Arabinose with Nitromethane in Aqueous Solution

BY JOHN C. SOWDEN AND ROBERT R. THOMPSON

RECEIVED MARCH 17, 1955

The condensation of nitromethane[1] and nitroethanol[2] with aldose sugars, as a step in the preparation of higher-carbon aldoses and ketoses, has been carried out previously in dry, alcoholic media. In most successful examples of the reaction, the solubility relationships between the reactants and the alcoholic solvent were such that the alkali-sensitive sugars dissolved and the resulting salts of the nitrodeoxyalditols precipitated as the condensation reaction progressed. While many of the aldose sugars condense satisfactorily with nitromethane in alkaline alcoholic media, others such as D-glucose react to only a minor extent.[3]

With a view to increasing the scope and utility of the nitroparaffin–sugar condensation, the reaction now is being studied in *aqueous* solution. The condensation of D-arabinose with nitromethane in aqueous alkali has been found to proceed rapidly and to an extent comparable with that observed in alcoholic media.

It seems likely that the use of aqueous reaction conditions will appreciably extend the applicability of the nitromethane and related syntheses in the sugar field. Further experiments are contemplated to generalize the above results.

Experimental

Solutions containing D-arabinose in 2 equivalents of 2 M nitromethane in 2 N aqueous sodium hydroxide were allowed to stand at room temperature for varying lengths of time and the resulting *aci*-nitroalcohols then were decomposed by adding the solutions to warm (50°), aqueous sulfuric acid.[1] Following deionization and concentration, D-mannose was precipitated from the resulting solutions as the phenylhydrazone. The relationship between the duration of the condensation reaction and the yield of D-mannose phenylhydrazone was as follows: 5 min., 15.4%; 15 min., 20.6%; 25 min., 21.6%; 1 hr., 18.4%; 2 hr., 17.8%. When the amount of the alkaline nitromethane solution was varied, a condensation reaction time of 15 minutes resulted in the following yields of D-mannose phenylhydrazone: 1 equiv., 16.9%; 2 equiv., 20.6%; 3 equiv., 17.6%.

D-Mannose phenylhydrazone was characterized by conversion to the known anhydro-O-tetraacetate,[4] m.p. 123–124°, $[\alpha]^{25}\mathrm{D}$ 12° in pyridine (c 3).

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Tetraacetates of D-Glucose and D-Galactose

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RECEIVED JANUARY 8, 1955

Helferich and Klein[2] first prepared 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose by removal of the trityl (triphenylmethyl) group from 1,2,3,4-tetra-*O*-acetyl-6-*O*-trityl-β-D-glucopyranose. The compound has proven to be very useful as an intermediate in the synthesis of disaccharides in the Königs–Knorr type reaction.[3] We wish to describe herein a new synthesis for 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose and the corresponding D-galactose derivative. This synthesis is made possible by the discovery[4] that mercuric acetate is an excellent reagent for replacing halogen in acetylated glycopyranosyl halides. The immediate precursors of the tetraace-

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(1) Corn Industries Research Foundation Associate (A. T.) and Fellow (M. I.).

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tates are obtained by the action of titanium tetrachloride on the 2,3,4-tri-*O*-acetyl-1,6-anhydro-β-D-glycopyranoses as described by Zemplén and coworkers.[5] 2,3,4-Tri-*O*-acetyl-1,6-anhydro-β-D-glucopyranose (levoglucosan triacetate) is readily available and is thus easily converted in good yield to 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose. A crystalline tetraacetate (m.p. 140–140.5°, $[\alpha]\text{D}$ +37° in chloroform) was obtained in the D-galactose structure. The fact that it did not form a trityl derivative as does 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose[2] and that it was recovered unchanged after solution in dilute aqueous alkali, offers strong presumptive evidence that an acetyl group had migrated to the sixth carbon atom. A migration from the fourth to the sixth carbon atom occurs readily in the D-glucopyranose structure in the presence of a trace of alkali or even in an aqueous solution in an alkaline glass container.[6] Table I lists the known tetraacetates of D-galactose.

TABLE I

TETRAACETATES OF D-GALACTOSE

Acetate position	Anomer	M.p., °C.	$[\alpha]^{25 \pm 5}\text{D}$ ($CHCl_3$)	Reference
2,3,4,6	α	133	+144°	7
	β	127–128	+ 23	8
2,3,5,6	β	71–73	− 18	9
2,3,4,5	Aldehydrol	162	+ 10[a]	10, 11
1,3,4,6	β	128	+ 12[b]	12
?	β	140–140.5	+ 37, +36[b]	This work

[a] Initial rotation in pyridine; chloroform-insoluble. [b] Ethanol solution.

Experimental

1,2,3,4-Tetra-*O*-acetyl-β-D-glucopyranose.—2,3,4-Tri-*O*-acetyl-α-D-glucopyranosyl chloride[5] (40 g.) was dissolved in 100 ml. of acetic acid containing 35 g. of mercuric acetate and kept at room temperature for 1.5 hr. The solution was then diluted with 250 ml. of chloroform and washed with water, saturated aqueous sodium bicarbonate solution, and water again, dried with anhydrous sodium sulfate and evaporated below 40° under reduced pressure to a sirup. The sirup was dissolved in ether and was crystallized by the addition of petroleum ether; yield 26.5 g., m.p. 121–123° cor. Pure material was obtained on further crystallization from chloroform–ether–petroleum ether, m.p. 125–127° cor., $[\alpha]^{29}\text{D}$ +10° (*c* 6, chloroform) in agreement with recorded[2] (128–129° cor., +12.1°) values for 1,2,3,4-tetra-*O*-acetyl-β-D-glucopyranose.

Tetra-*O*-acetyl-β-D-galactopyranose.—1,6-Anhydro-2,3,4-tri-*O*-acetyl-β-D-galactopyranose[13] (6 g.), which had been prepared by an adaptation of the method which Coleman, McCloskey and Kirby[14] had used for the corresponding D-glucose derivative, was dissolved in 100 ml. of U.S.P.[15] chloroform. To this solution was added 1 ml. of ethanol and a mixture of 10 ml. of titanium tetrachloride and 10 ml. of chloroform. A yellow precipitate was formed which redissolved upon heating the solution in an oil-bath at 100° for 45 min. After cooling, the solution was washed with ice and water, dried with sodium sulfate and evaporated under reduced pressure to a sirup. The sirup was dissolved in 20 ml. of acetic acid containing 2 g. of mercuric acetate and allowed to stand at room temperature for 1 hr. The solution was diluted with 75 ml. of chloroform and washed with water until free of acid. The chloroform solution was dried with anhydrous sodium sulfate and evaporated under reduced pressure at room temperature. The resulting sirup was dissolved in ether and brought to crystallization by the addition of petroleum ether; yield 1.0 g., m.p. 129–136°. The substance was purified by two recrystallizations from chloroform–ether; m.p. 140–140.5° cor., $[\alpha]^{30}\text{D}$ +37.4° (*c* 3.2, chloroform), $[\alpha]^{30}\text{D}$ +36° (*c* 1.9, ethanol); X-ray powder diffraction data: 10.78[16] m,[17] 8.41m, 7.06s, 6.45m, 5.97s, 5.37m, 5.06vs, 4.81m, 4.51w, 4.32m, 4.19m, 4.05w, 3.80w, 3.72s, 3.56w, 3.51s, 3.43w, 3.00vw, 2.94m, 2.85m.

Anal. Calcd. for $C_6H_8O_6(CH_3CO)_4$: C, 48.27; H, 5.79; CH_3CO, 11.48 ml. of 0.1 *N* NaOH per 100 mg. Found: C, 48.41; H, 6.10; CH_3CO, 11.60 ml.

The substance was recovered unchanged after treatment with pyridine and trityl chloride and also after solution in 0.001 *N* sodium hydroxide.

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(16) Interplanar spacing, Å., $CuK\alpha$ radiation.

(17) Relative intensity, estimated visually; vs, very strong; s, strong; m, medium; w, weak; vw, very weak.

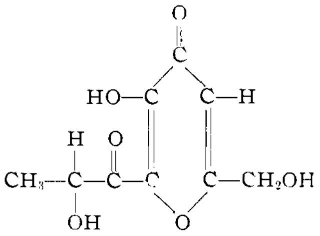
Kojic Acid in the Hoesch Reaction

BY L. L. WOODS[1]

RECEIVED AUGUST 16, 1954

Continuing a study of kojic acid[2,3] we have condensed lactonitrile with it under the conditions of the Hoesch reaction. A compound $C_9H_{10}O_6$ was obtained. The reactions described below prove this product to be 2-hydroxymethyl-5-hydroxy-6-(α-hydroxy propionyl)-4-pyrone (I).

Prolonged heating of the substance with water fails to hydrolyze it, indicating that it is not a lactic acid ester.[4] Only the monochloro derivative is obtained when the reaction product with thionyl chloride is recrystallized from water, which is to be expected from the proposed structure. The compound reacts with malonic acid to form a derived



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(1) The author expresses his thanks to the Research Corporation for its support of this project, to the Northern Regional Research Laboratory of the Department of Agriculture, Peoria, Illinois, for the kojic acid required to complete these experiments, to the Sadtler Research Laboratories, Philadelphia, Pa., for infrared spectrograms and to Dr. J. D. Edwards, Veterans' Administration Hospital, Houston, Texas, for additional infrared spectrograms and their interpretation.

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