a potency of "considerably above 2,265,000 and somewhat below 3,400,000 International Units per gram." A similar biologic assay of crystals from oil No. 1364 made by A. D. Emmett of Parke, Davis and Company indicated that this preparation "probably has a value of 3,000,000 international units per gram."

5. The molecular weight of the vitamin isolated from ishinagi oil was determined (by freezing point lowering of purified cyclohexane) as 294, less than 3% above the weight corresponding to Karrer's formula. The rate of change in this solution indicates that the actual value is a little lower than 294.

6. The average of five analyses in our own laboratory is 83.28% carbon and 10.44% hydrogen, slightly below the Karrer theoretical 83.84% carbon and 10.56% hydrogen. Oxidation in analytical handling and difficulty in removal of final traces of solvent tend to give low results.

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[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, IOWA STATE COLLEGE]

The Ring Structure of Alpha-Methyl-*l*-sorboside

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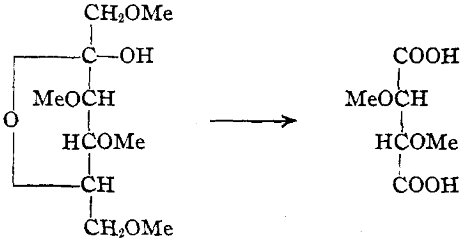
By employing mild conditions of glycoside formation Fischer[1] was able to isolate crystalline α-methyl-*l*-sorboside. This sorboside is the only one so far recorded in the literature. Arragon[2] has reported the preparation of two forms of tetramethyl-α-methyl-*l*-sorboside and of tetramethyl-*l*-sorbose, which can be obtained as colorless sirups.

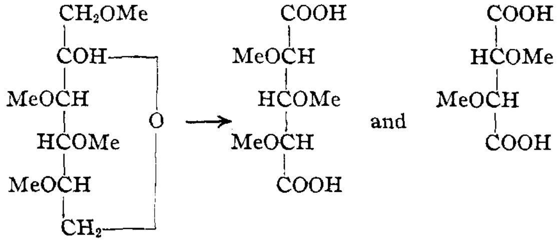
An attempt to ascertain the ring structure of α-methyl-*l*-sorboside by the usual procedures of methylation and oxidative degradation had been started prior to Arragon's publication. Optical rotations were taken in chloroform but were repeated in methanol in order to compare them with the rotations given by Arragon in this solvent. Confirmation of Arragon's rotations was obtained.

The tetramethyl-*l*-sorbose resulting from the hydrolysis of the tetramethyl-α-methyl-*l*-sorboside in hot 2% aqueous hydrochloric acid has been oxidized by concentrated nitric acid to *d*-dimethoxysuccinic acid. The latter product was obtained in good yield. No intermediate products of oxidation corresponding to those of fructose[3] have, as yet, been isolated. However, the presence of *d*-dimethoxysuccinic acid alone suffices for the certain allocation of the lactol ring if consideration of an ethylene oxide structure is foregone.

If the oxygen bridge engaged carbon 5, a large yield of *l*-dimethoxysuccinic acid (II) would be expected in the oxidation products of 1,3,4,6-tetramethylsorbose (I).



(I) 1,3,4,6-Tetramethylsorbose (II) *l*-Dimethoxysuccinic acid



(III) 1,3,4,5-Tetramethylsorbose (IV) Xylotrimethoxyglutaric acid (V) *d*-Dimethoxysuccinic acid

No *l*-dimethoxysuccinic acid could be isolated. If the oxygen bridge engaged carbon atom 6 (III) the oxidation products would be expected to yield xylotrimethoxyglutaric acid (IV) and *d*-dimethoxysuccinic acid (V). Probably due to an insufficient amount of material, no trimethoxyglutaric acid could be separated. *d*-Dimethoxysuccinic acid was, however, isolated in good yield. It is seen at once that the isolation of this product, since it asserts methylation of carbon atom 5, alone suffices for the elimination of the fura-

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[1] Fischer, *Ber.*, **28**, 1145 (1895).

[2] Arragon, *Bull. soc. chim. biol.*, **18**, 1336 (1936).

[3] Haworth, Hirst and Learner, *J. Chem. Soc.*, 1040 (1927).

nose structure. *d*-Dimethoxysuccinic acid must contain carbon atoms 4 and 5 since no other adjacent carbon atoms in the tetramethylsorbose can give rise to an acid of this configuration.

The presence of the *d*-dimethoxysuccinic acid was proved definitely by the preparation of its amide and methylamide. These are well-defined crystalline derivatives prepared by Haworth[4] as reference compounds in the sugar series.

If the evidence now advanced be accepted, a pyranoid configuration is indicated for tetramethyl-*l*-sorbose $[\alpha]^{28}\mathrm{D}$ +4.95° and hence also for α-methyl-*l*-sorboside and its derivatives.

In further characterization of α-methyl-*l*-sorboside the tetraacetate was prepared.[5] The glycosidic methyl group appears to be extremely stable in this derivative for even on standing over night in acetyl chloride saturated with hydrogen chloride gas only the starting material was recovered.

Experimental Part

α-Methyl-*l*-sorboside, m. p. 118°, $[\alpha]^{22}\mathrm{D}$ —88.9°, was prepared by the method of Fischer[1] as modified by Arragon.[6] This glycoside at 0.8% concentration in 0.017 *N* hydrochloric acid was 59% hydrolyzed in seventeen days when kept at a temperature of 30°. On standing for four days a solution of the pure glycoside in water gave no precipitate when tested with Fehling's solution.

Tetramethyl-α-methyl-*l*-sorboside was prepared according to the standard procedures for methylation,[7,8] the α-methyl-*l*-sorboside being methylated twice with dimethyl sulfate and then once with silver oxide and methyl iodide. The resulting sirup after distilling in a high vacuum gave a colorless liquid $[\alpha]^{32}\mathrm{D}$ −48.8° (*c* 0.8) in chloroform; $[\alpha]^{25}\mathrm{D}$ −32.1° (*c* 0.8) in methanol. Arragon[2] records $[\alpha]^{20}\mathrm{D}$ −31.5° in methanol.

Tetramethyl-*l*-sorbose was prepared by hydrolysis of a 10% solution of the tetramethyl-α-methyl-*l*-sorboside for one and one-half hours in 2% hydrochloric acid. On distilling in a high vacuum it gave a light yellow sirup $[\alpha]^{28}\mathrm{D}$ −10.2° (*c* 0.8) in chloroform; $[\alpha]^{28}\mathrm{D}$ +4.95° (*c* 0.8) in methanol. Arragon[2] records $[\alpha]^{30}\mathrm{D}$ +4.9° in methanol.

Oxidation of Tetramethyl-*l*-sorbose.—To 5 g. of colorless tetramethyl-*l*-sorbose was added 38.5 cc. of concentrated nitric acid (d. 1.42). The solution was heated carefully on a water-bath to 70°. At this temperature vigorous oxidation began and the solution was removed from the bath for a few minutes to prevent the reaction from becoming violent. After the initial reaction had subsided, the temperature of the bath was raised carefully to 95°, and the solution was kept at this temperature for two hours. At the end of this time reaction had ceased and a clear light yellow solution remained. The mixture was poured into three times its volume of water and the excess nitric acid removed by distilling at 40° (20 mm.) while water was added from time to time for six hours. The evaporation was continued, replacing water by methanol until one liter had distilled, after which the liquid was taken to dryness. The product was esterified by gentle refluxing in methanol for six hours; enough nitric acid remained to catalyze the reaction. When esterification was complete the nitric acid was neutralized by silver carbonate. The solution was evaporated to dryness and the residue extracted with ether. On evaporation of the ether a light yellow sirup remained which distilled at 1–2 mm. to give two fractions. The first fraction distilled at 120–125° and weighed 2.1 g.; the second fraction distilled at 125–135° and weighed 0.4 g.

Preparation of Amide and Methylamide.—A small quantity of the slightly yellow sirup from the first fraction was converted to the amide in dry methanol saturated at 0° with ammonia gas. On the basis of crude sirup a 50% yield was obtained of *d*-dimethysuccinamide[4] m. p. 270° $[\alpha]^{27}\mathrm{D}$ +96° in water (*c* 0.15). *Anal.* Calcd. for $C_6H_{12}O_4N_2$: N, 15.92. Found: N, 16.13. A further quantity of the first fraction dissolved in 10 cc. of dry methanol and saturated at 0° with methylamine, gave on evaporation a yield of about 60% of *d*-dimethoxysuccinomethylamide[4] m. p. 204°, $[\alpha]^{35}\mathrm{D}$ +130° in water (*c* 0.6). *Anal.* Calcd. for $C_8H_{10}O_4N_2$: N, 13.73. Found: N, 13.84. The second fraction of the distillate contained some *d*-dimethoxysuccinic acid and a small quantity of unidentifiable material.

α-Methyl-*l*-sorboside Tetracetate.—To 4 g. of α-methyl-*l*-sorboside dissolved in 25 cc. of dry pyridine was added 13 cc. of acetic anhydride. After standing overnight the mixture was poured into 500 cc. of ice water and extracted twice with 75-cc. portions of chloroform. The combined extract was washed successively with sodium bisulfate solution, sodium bicarbonate solution and water. The chloroform extract was dried over anhydrous sodium sulfate and the chloroform removed under diminished pressure. The sirup was crystallized from alcohol: yield 2.9 g., m. p. 88°, $[\alpha]^{25}\mathrm{D}$ −52.4° in chloroform (*c* 4.0). Arragon reports m. p. 88°, $[\alpha]^{20}_{578}$ −51.8° in methanol.

Summary

α-Methyl-*l*-sorboside can be methylated completely to a pentamethyl derivative, which on hydrolysis of the glycosidic methyl group yields a tetramethyl-*l*-sorbose ($[\alpha]^{28}\mathrm{D}$ + 4.95°). The oxidation of this latter compound by means of nitric acid resulted in the production of *d*-dimethoxysuccinic acid. The isolation of this acid is taken as sufficient evidence for the assumption of a normal pyranose structure in the tetramethyl-*l*-sorbose and hence also in the parent compounds α-methyl-*l*-sorboside and tetramethyl-α-methyl-*l*-sorboside.

Ames, Iowa Received July 15, 1937

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(4) Haworth and Jones, *J. Chem. Soc.*, 2349 (1927).

(5) Arragon, *Bull. soc. chim. biol.*, **17**, 831 (1935).

(6) Arragon, *Compt. rend.*, **199**, 1231 (1934).

(7) Haworth and Leitch, *J. Chem. Soc.*, 188 (1918).

(8) Purdie and Irvine, *ibid.*, 1021 (1903).