ably from that reported for the formation of cellulose in the cotton boll.[2]

The pattern of label distribution in the celluloses from the ethanolic and non-ethanolic cultures was similar; that is, the distribution of label was confined to positions 1, 3 and 4, with the major proportion located at position 1. For this reason the addition of ethanol to the culture medium is clearly advantageous where it is desired to produce optimum yields of isotopically labeled cellulose from D-glucose-1-C^{14} by *Acetobacter xylinum.*

Acknowledgment.—The authors are grateful to Dr. H. S. Isbell for the supply of glucose-1-C^{14} and to Dr. S. Abraham for the randomly labeled glucose used for analysis as shown in Table I.

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[CONTRIBUTION FROM THE BEN MAY LABORATORY FOR CANCER RESEARCH, UNIVERSITY OF CHICAGO]

Benzylidene-L-iditols

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RECEIVED NOVEMBER 2, 1953

The acid-catalyzed reaction of L-iditol with benzaldehyde gave two acetals, a 2,3,4,5-di-*O*-benzylidene and a tri-*O*-benzylidene derivative.

A number of three-carbon dioses and trioses were needed in this Laboratory to study the steric requirements for the substrates of some enzymes involved in anaerobic glycolysis. It was thought that L-iditol might give access to the substances of the L-series, if suitable acetals or ketals were easily obtainable; this procedure would obviate the laborious preparation of L-mannitol.[1]

A 2,4:3,5-di-*O*-methylene-L-iditol[2] is the only well characterized acetal of iditol. The acid-catalyzed condensation of D-iditol with benzaldehyde has been reported to give a tribenzylidene derivative, $[\alpha]_D - 6°$ in acetone,[3] m.p. 224–228°.[4] Its enantiomorph, melting at 224–228°,[4] 242°[5] or 249°,[6] has been similarly prepared from L-iditol. Some doubt has recently been cast[7] on the possible existence of triacetals of iditol. A dimorphic tribenzylidene-L-iditol, $[\alpha]_D + 5.2°$ in chloroform, can indeed be synthesized. The wide range of melting points recorded in the literature is explained by the unusual melting phenomenon of this substance. It melted at 226–228° or 252–254° depending on the isolation procedure; the melting point of either form would, after a few days, be found in between those extreme values. The favored ring forms of this compound[8] are 1,3:2,5:4,6 as in mannitol[9] or 1,3:2,4:5,6 as in talitol.[7]

A dibenzylidene-L-iditol, melting at 192°[10] or below 190°,[6] has been reported as a by-product in the preparation of the triacetal. This compound (I) can now be prepared in good yield as the major product of the condensation; it was, however, found difficult to separate it by crystallization from the triacetal formed in the reaction. This substance was dimorphic also, m.p. 207–208° or 229–231°; the latter form did not give an appreciable depression of the melting point on admixture with the lower melting form of the tribenzylidene derivative. It was not sufficiently soluble to permit a reading of its rotation.

This dibenzylideneiditol (I) did not reduce periodate. Its ditoluenesulfonate ester was quite resistant to the exchange reaction with sodium iodide or lithium aluminum hydride under usual conditions. A more drastic procedure gave the expected diiodo derivative II which could be reduced to the dimorphic 1,6-dideoxydibenzylidene-L-iditol (III). Replacement of the acetal groups by acetolysis and subsequent catalytic deacetylation gave 1,6-dideoxy-L-iditol identified by conversion to its known[2] dimethylene acetal. By analogy with the latter compound, the dibenzylidene derivative may have the structure 2,4:3,5.

A small amount of triacetal was in every case formed during the preparation of the diacetal. Some diacetal was always isolated from the preparation of the triacetal.

Experimental

The melting points were determined in evacuated capillaries and corrected. The optical rotations were determined in alcohol-free chloroform, *c* being the concentration in g./100 ml. of solution; the tube length was 1 dm. The microanalyses were performed, unless otherwise specified, by Mr. W. Saschek.

2,3,4,5-Di-*O*-benzylidene-L-iditol Diacetate (Ia).—A solution of 1.86 g. of crystalline L-iditol[11] in 4 ml. of 6 *N* hydrochloric acid was shaken for a few hours with 2.20 g. (2.0 mol. eq.) of benzaldehyde. After standing overnight at room temperature the reaction mixture had set to a gel. The cake was broken, transferred to a filter, washed with dilute ammonium hydroxide, water and dried over calcium hydride *in vacuo*. The white mass (3.12 g.) was then dissolved in 10.0 ml. of pyridine and treated with 10.0 ml.

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of acetic anhydride; the solution was left at room temperature for 40 hours. The reaction mixture was then poured with stirring into 125 ml. of ice-water, the precipitate was collected, washed and dried. It was then extracted with 200 ml. of hot methanol which failed to dissolve 0.25 g. (8%) of tribenzylideneiditol. Colorless needles (3.11 g., 68%) crystallized out, m.p. 193–196°; recrystallization from ethanol raised the melting point to 196–198°, $[\alpha]^{25}_{D}$ −21.8° (*c* 0.87).

Anal. Calcd. for $C_{24}H_{26}O_8$ (442.45): C, 65.09; H, 5.92. Found: C, 64.88; H, 5.60.

2,3,4,5-Di-*O*-benzylidene-L-iditol (I).—One gram of the diacetate Ia was suspended in a solution of 5 mg. of sodium in 25 ml. of absolute methanol. The mixture was shaken for an hour. The solution was left for an additional hour, after which the crystalline precipitate was filtered, washed and dried. Recrystallization from methanol and acetone–hexane gave colorless needles, m.p. 207–208° or 229–231°.

Anal. Calcd. for $C_{20}H_{22}O_6$ (358.38): C, 67.02; H, 6.19. Found: C, 66.95; H, 6.22.

Its di-*p*-toluenesulfonate (Ib) was prepared in 90% yield by the usual procedure. It crystallized from acetone–hexane or ethyl acetate–hexane in colorless prisms, m.p. 138–140°, $[\alpha]^{28}_{D}$ +21.4° (*c* 1.40).

Anal. Calcd. for $C_{34}H_{34}O_{10}S_2$ (666.74): C, 61.24; H, 5.14; S, 9.62. Found: C, 61.35; H, 5.22; S, 9.61.

L-Iditol 1,6-Dibenzoate 2,3,4,5-Tetraacetate.—A solution of 107 mg. of dibenzylideneiditol (I) in 1.0 ml. of pyridine was treated with 92 mg. of benzoyl chloride and the mixture left at room temperature for two days, during which it set to a gel. The mass was then triturated with 8 ml. of water, filtered, washed and dried (150 mg.). The substance gelified in all solvents tried. It was then suspended in 25.0 ml. of acetolyzing solution[12] and left at room temperature for 36 hours. Ice-water (200 ml.) was then added, and the crystalline precipitate was washed and dried. It crystallized from ether–hexane in colorless needles (90 mg.), m.p. 152–154°, $[\alpha]^{25}_{D}$ +2.4° (*c* 2.07).

Anal. Calcd. for $C_{28}H_{30}O_{12}$ (558.52): C, 60.21; H, 5.41. Found: C, 60.20; H, 5.47.

1,6-Dideoxy-1,6-diiodo-2,3,4,5-di-*O*-benzylidene-L-iditol (II).—Two grams of pure di-*p*-toluenesulfonate (Ib) was refluxed (bath temperature 160°), under anhydrous conditions, for 200 minutes with a solution of 2.00 g. of dry sodium iodide in 30 ml. of freshly distilled acetic anhydride.[13] The brown solution was cooled and poured into 230 ml. of ice-cold water. Filtration of this suspension yielded a gel that was dried to a colorless powder (1.74 g.). Crystallization of this material from ethyl acetate gave colorless needles (0.71 g.), m.p. 211–212° (dec.). An intractable gel (1.11 g.) remained in the mother liquors.

Anal. Calcd. for $C_{20}H_{20}O_4I_2$ (578.20): I, 43.90. Found: I, 43.30.

1,6-Dideoxy-2,3,4,5-di-*O*-benzylidene-L-iditol (III).—A suspension of II (0.69 g.) in a solution of 0.275 g. of barium in 70 ml. of dry methanol was hydrogenated in the presence of 0.2 g. of Raney nickel. The absorption of hydrogen came to an end (68 ml. at 29° (755 mm.)) after 2 hours. The solution was then filtered and concentrated until crystals began to separate. The mixture was left overnight in the refrigerator. The product was recrystallized from acetone–hexane as colorless needles (0.345 g.), m.p. 176–177°. A sublimation at 135° under high vacuum gave colorless needles, m.p. 231–233°, $[\alpha]^{33}_{D}$ +1.6° (*c* 1.28).

Anal. Calcd. for $C_{20}H_{22}O_4$ (326.37): C, 73.60; H, 6.79. Found: C, 73.41; H, 6.87.

1,6-Dideoxy-L-iditol Tetraacetate (IV).—The preceding substance III (0.275 g.) was treated with 10.0 ml. of acetolyzing solution[12] at room temperature for 18 hours. The mixture was then poured onto 40 g. of crushed ice. The colorless crystals obtained (65 mg.) were recrystallized from cyclohexane in colorless prisms, m.p. 139–141°, $[\alpha]^{21}_{D}$ −8.3° (*c* 2.16).

Anal. Calcd. for $C_{14}H_{22}O_8$ (318.32): C, 52.82; H, 6.97. Found[14]: C, 53.21; H, 7.00.

1,6-Dideoxy-2,4:3,5-di-*O*-methylene-L-iditol.[2]—Forty-five mg. of IV was treated with 3.0 ml. of a 0.1 *N* solution of sodium in methanol. After 6 hours, the solution was acidified and evaporated to dryness. The sirupy residue was dissolved in 2.0 ml. of a mixture of equal volumes of concentrated hydrochloric acid and formalin. The dry residue left after evaporation in a desiccator was washed with water, crystallized from acetone–hexane and sublimed under high vacuum at 125°; colorless needles (15 mg.), m.p. 211–213°, $[\alpha]^{21}_{D}$ +34.4° (*c* 1.16).

Tri-*O*-benzylidene-L-iditol.—A solution of 3.64 g. of crystalline L-iditol[11] in 7.0 ml. of 12 *N* hydrochloric acid was shaken overnight with 7.0 ml. of benzaldehyde. The reaction mixture was then processed as in the case of the diacetal I. The crude acetal (7.81 g.) was suspended in a solution of acetic anhydride (5.0 ml.) in pyridine (10.0 ml.). A white powder was obtained by following the procedure previously described and crystallized from acetone. Colorless needles (6.00 g., 67%) were obtained, m.p. 254–256°. Sublimation of this material at 170° under high vacuum gave colorless crystals, m.p. 226–228°, $[\alpha]^{25}_{D}$ +5.2° (*c* 0.77). The latter substance gave the high melting form by recrystallization from acetone.

The mother liquors were evaporated to dryness and the residue extracted with 200 ml. of hot methanol. 2,3,4,5-Di-*O*-benzylidene-L-iditol diacetate (Ia) (2.06 g., 23%) identical with the product previously characterized was isolated.

Dibenzylidene-L-iditol Diacetate.—A solution of tribenzylidene-L-iditol (0.160 g.) in pure dioxane (50 ml.) was hydrogenated in the presence of 16 mg. of palladium black. The absorption of gas, which was linear with time, was interrupted after 4.5 hours (18.5 ml. at 19° and 758 mm.). The mixture was filtered, evaporated and dried. The residue (0.150 g.) was dissolved in a solution of acetic anhydride (1.5 ml.) in pyridine (3.0 ml.) and left at room temperature for 36 hours. It was then poured into 70 ml. of ice-water. The semi-crystalline precipitate was separated, washed with water, dried and crystallized from ethanol. Some starting material (29 mg., 18%) failed to dissolve. Colorless needles (0.115 g., 72%) separated and were recrystallized from ether–hexane, m.p. 182–184°, $[\alpha]^{29}_{D}$ −33.4° (*c* 0.75).

Anal. Calcd. for $C_{24}H_{26}O_8$ (442.45): C, 65.09; H, 5.92. Found: C, 65.16; H, 5.81.

This investigation was supported by grants from the American Cancer Society, as recommended by the Committee on Growth of the National Research Council, and the Jane Coffin Childs Memorial Fund for Medical Research.

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[13] W. T. Haskins, R. M. Hann and C. S. Hudson, THIS JOURNAL, **64**, 137 (1942). The tosyloxy–iodine exchange was limited to 22% after heating for 24 hours at 95° in acetonylacetone.

[14] Microanalysis performed by Micro-Tech Laboratories, Skokie, Ill.