sideration of the configurations of some of the compounds studied. According to the generalization of Bertrand the favorable configuration for oxidation by *A. xylinum* is a *cis* arrangement of two secondary hydroxyl groups adjacent to a primary alcohol grouping. In Table I there are two pairs of *d*- and *l*-forms, namely, *d*- and *l*-arabitol and *d*- and *l*-α-mannoheptitol (since *d*-α-galaheptitol is the enantiomorph of *d*-α-mannoheptitol). In each of these pairs, only the *d*-form is oxidized readily.

For the four and higher carbon sugar alcohols the configuration which is oxidized readily is OH OH / C—C—CH_2OH / H H and its mirror image is either not oxidized at all or only at a slow rate. It seems possible that *A. suboxydans* is more specific than *A. xylinum* because, while both organisms require *cis* arrangement of the two hydroxyl groups indicated above, *A. xylinum* acts when the *cis* pair is above or below (*e. g.*, sorbitol (above) and *l*-arabitol (below)), whereas *A. suboxydans* does not act if the *cis* hydroxyls are below (*e. g.*, *l*-arabitol (no action) and *d*-arabitol (oxidized)). The behavior of *l*-fucitol must be studied further before deciding what generalization may apply to the alcohols derived from the methylose sugars.

We are indebted to Dr. W. D. Maclay for preparing many of the rare sugar alcohols used in the present investigation. Further investigations of the biochemical oxidations are under way in the Division of Chemistry of the National Institute of Health.

Summary

The oxidizing action of *Acetobacter suboxydans* on a considerable number of sugar alcohols and related carbohydrate derivatives has been tested in a preliminary survey. The present results indicate a specific relationship between configuration of the substrate and oxidizing attack. Perseitol is oxidized to perseulose, which is obtained as the crystalline sugar in nearly quantitative yield. *d*-Arabitol is oxidized to *d*-xylulose, but *l*-arabitol is not attacked. *l*-Rhamnitol is not oxidized, but *l*-fucitol gives a reducing substance in large amount, presumably a new ketose. *d*-α-Glucoheptitol readily yields what is presumably *l*-glucoheptulose. The study is being continued.

WASHINGTON, D. C. RECEIVED MARCH 24, 1938

[CONTRIBUTION FROM THE CELLULOSE DEPARTMENT, CHEMICAL FOUNDATION, BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH, INC.]

The Dimolar Tosylation of β-Methylcellobioside: α-Cellobiomethylose

BY JACK COMPTON

In a previous communication[1] it has been shown that the unimolar tosylation of α- and β-methylglucosides in pyridine solution with tosyl chloride, followed by acetylation, results in the formation of 6-tosyl-triacetyl-α-methylglucoside in 36% yield and 6-tosyl-triacetyl-β-methylglucoside in 41% yield, respectively. Extension of this reaction to other alkylglycosides may serve as a convenient method for obtaining the ω-desoxy sugars, since the tosyl group in the primary position may be replaced by an iodo group[2] which is reduced easily.

The present investigation is concerned with the relative reactivity of the primary hydroxyl groups in β-methylcellobioside as shown by treatment in pyridine solution with tosyl chloride. Also, in applying the general procedure suggested above for the production of ω-desoxy sugars, a new disaccharide (cellobiomethylose) has been obtained in crystalline form.

The dimolar tosylation of β-methylcellobioside in pyridine solution with tosyl chloride, followed by acetylation, resulted in formation of 6,6′-ditosylpentaacetyl-β-methylcellobioside in 67% yield. The structure of this compound may be considered proved since it is identical with that obtained by Helferich, Bohn, and Winkler,[3] upon tosylating 2,3,4,2′,3′-pentaacetyl-β-methylcellobioside which in turn was prepared from 6,6′-ditrityl-pentaacetyl-β-methylcellobioside. In comparison with α- and β-methylglucosides, under comparable conditions, it may be stated that the primary hydroxyl groups in β-methylcellobioside, are considerably more reactive.

Reduction of 6,6′-diiodopentaacetyl-β-methylcellobioside, obtained by treating 6,6′-ditosylpentaacetyl-β-methylcellobioside with sodium io-

(1) J. Compton, THIS JOURNAL, **60**, 395 (1938).

(2) J. W. H. Oldham and J. K. Rutherford, *ibid.*, **54**, 366 (1932).

(3) B. Helferich, E. Bohn, and S. Winkler, *Ber.*, **63**, 989 (1930).

dide in acetone solution,[3] yielded pentaacetyl-β-methylcellobiomethyloside which upon deacetylating yielded β-methylcellobiomethyloside. Acetolysis of pentaacetyl-β-methylcellobiomethyloside resulted in the formation of hexaacetyl-α-cellobiomethylose which upon deacetylation yielded the new disaccharide α-cellobiomethylose.

A comparison of the rate of acetolysis of tetraacetyl-β-methylglucoside and heptaacetyl-β-methylcellobioside with triacetyl-β-methylglucomethyloside and hexaacetyl-β-methylcellobiomethyloside (Fig. 1) shows the latter sugar derivatives to be converted more easily to the α-acetates. It has been observed previously in this Laboratory that in general ω-desoxy sugars (hexomethyloses) are hydrolyzed easily and are more reactive than the corresponding hexoses. The acetolysis curves given in Fig. 1 are complicated due to the rapidity of the consecutive reactions: cleavage of the glycosidic methoxyl, acetylation, and rearrangement to the α-acetate. The complex nature of this reaction, however, is shown by its taking place in a step-wise manner only in the case of heptaacetyl-β-methylcellobioside (II).

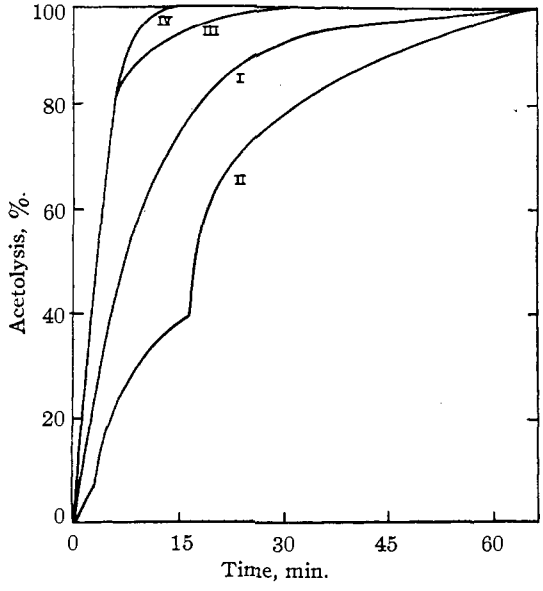

Fig. 1.—Comparison of the rates of acetolysis of tetraacetyl-β-methylglucoside (I) and heptaacetyl-β-methylcellobioside (II) with triacetyl-β-methylglucomethyloside (III) and hexaacetyl-β-methylcellobiomethyloside (IV).

Experimental[4]

Dimolar Tosylation of β-Methylcellobioside Followed by Acetylation to Yield 6,6′-Tosyl-pentaacetyl-β-methylcellobioside.—Two grams of β-methylcellobioside was dissolved in 30 cc. of dry pyridine and to the ice-cold solution 2.5 g. (2.1 moles) of tosyl chloride dissolved in 20 cc. of dry pyridine was added over a period of fifteen minutes with rapid stirring. After standing for two hours at 0°, the mixture was removed from the ice-bath and allowed to stand for twenty-four hours at room temperature. At the end of this time the solution was again cooled to 0° and 14 cc. of acetic anhydride added with constant shaking. The mixture was then allowed to stand for one hour at 0° and overnight at room temperature. At the end of the acetylation period the solution was cooled to 0° in an ice-bath and 5 cc. of water added with vigorous stirring. After standing for thirty minutes, the solution was poured, with stirring, into 400 cc. of ice water. The amorphous product separating was removed by filtration, thoroughly washed with ice water and dried in a vacuum desiccator over calcium chloride. The product when dissolved in absolute ethyl alcohol crystallized in long needles upon cooling. Pure material was obtained after the second recrystallization from ethyl alcohol: m. p. 161–162°; yield 3.3 g.; sp. rot., −1.07° (*c*, 3.705; $CHCl_3$).

Anal. Calcd. for $C_{37}H_{46}O_{20}S_2$: C, 50.78; H, 5.30; OCH_3, 3.65. Found: C, 50.85; H, 5.00; OCH_3, 3.43.

The yield of 6,6′-ditosyl-pentaacetyl-β-methylcellobioside indicated that approximately 67.3% of the β-methylcellobioside was preferentially esterified in the primary positions when treated with two moles of tosyl chloride. Helferich, Bohn, and Winkler,[3] upon tosylating 2,3,4,2′,3′-pentaacetyl-β-methylcellobioside in pyridine solution, obtained a product, m. p. 160–162°, sp. rot. (21°), −2.5° ($CHCl_3$).

Preparation of 6,6′-Diiodo-pentaacetyl-β-methylcellobioside.—6,6′-Diiodopentaacetyl-β-methylcellobioside was prepared from 6,6′-ditosyl-pentaacetyl-β-methylcellobioside (1.6 g.), dissolved in acetone (20 cc.) containing sodium iodide (1.6 g.), according to the procedure of Helferich, Bohn, and Winkler:[3] yield 1.08 g.; m. p. 218–219°; sp. rot. −7.5° (*c*, 3.75; $CHCl_3$).

The product obtained by Helferich gave a melting point 216–219°; sp. rot. (17°), −7.5° ($CHCl_3$).

Pentaacetyl-β-methylcellobiomethyloside.—6,6′-Diiodopentaacetyl-β-methylcellobioside (4.0 g.) was dissolved in 45 cc. of 75% acetic acid heated to 80°. A trace of chloroplatinic acid was then added, followed by the portion-wise addition of 10 g. of zinc dust over a period of twenty minutes with vigorous stirring. The excess zinc was removed by filtration at the end of this time and the clear filtrate concentrated under diminished pressure to a solid crystalline mass. After grinding with water in a mortar, the solid residue was removed by filtration, thoroughly washed with water and dried. Pure material was obtained after the second recrystallization from methyl alcohol; m. p. 214–215°; yield 1.6 g.; sp. rot. −35.2° (*c*, 3.75; $CHCl_3$).

Anal. Calcd. for $C_{28}H_{34}O_{14}$: C, 51.65; H, 6.41; OCH_3, 5.80. Found: C, 51.78; H, 6.30; OCH_3, 5.81.

β-Methylcellobiomethyloside.—Pentaacetyl-β-methylcellobiomethyloside (1.25 g.) was deacetylated in methyl alcohol (50 cc.) with barium methylate according to the procedure described by Isbell.[5] After the second re-

(4) All specific rotations herein reported were determined at 23° with the D-line of sodium light.

(5) H. S. Isbell, *Bur. Standards J. Research*, 1179 (1930).

crystallization from absolute ethyl alcohol pure material was obtained, m. p. 198–199°; yield 0.8 g.; sp. rot. −29.8° (*c*, 3.752; water).

Anal. Calcd. for $C_{13}H_{24}O_9$: C, 48.12; H, 7.46; OCH_3, 9.54. Found: C, 48.07; H, 8.04; OCH_3, 9.96.

The substance did not reduce hot Fehling's solution, but gave a strong orcinol–hydrochloric acid test for hexomethyloses.

Hexaacetyl-α-cellobiomethylose.—Pentaacetyl-β-methylcellobiomethyloside (1.18 g.) was dissolved in 4 cc. of glacial acetic acid–acetic anhydride (1:1) solution containing 0.2 cc. of concentrated sulfuric acid. The mixture was allowed to stand at room temperature for fifty minutes (Fig. 1) and then poured with stirring into 100 cc. of ice-cold sodium bicarbonate solution. The product was removed by filtration, thoroughly washed with water and the dried product recrystallized from methyl alcohol. After the second recrystallization from methyl alcohol pure material was obtained; m. p. 236–237°; yield 0.9 g.; sp. rot. +41.1° (*c*, 3.328; $CHCl_3$).

Anal. Calcd. for $C_{24}H_{34}O_{15}$: C, 51.22; H, 6.09; $COCH_3$, 10.67 cc. 0.1 *N* NaOH per 100 mg. Found: C, 51.21; H, 5.36; $COCH_3$, 10.43 cc.

α-Cellobiomethylose.—With slight modification hexaacetyl-α-cellobiomethylose was deacetylated according to the procedure of Zemplén, Gerecs, and Hadácsy[6] for the deacetylating of octaacetylcellobiose.

Hexaacetyl-α-cellobiomethylose (1.0 g.) was suspended in 5 cc. of methyl alcohol and 0.9 cc. of methyl alcohol containing 1% sodium methylate added. The mixture was shaken at room temperature for one hour and the resulting clear solution filtered, whereupon crystallization began. The product was removed by filtration, washed with methyl alcohol and dried. After the second recrystallization from methyl alcohol, pure material was obtained: m. p. 205–206°; yield 0.4 g.; sp. rot. +59.0° ⟶ +18.9° (2 hours) (*c*, 3.075; water).

Anal. Calcd. for $C_{12}H_{22}O_9$: C, 46.42; H, 7.15. Found: C, 46.48; H, 7.24.

The substance strongly reduces hot Fehling's solution and has little or no taste.

(6) G. Zemplén, A. Gerecs, and I. Hadácsy, *Ber.*, **69**, 1827 (1936).

Method Used in Determining Acetolysis Rates.—The acetolysis mixture was prepared in essentially the same manner as the transforming mixture described by Hann and Hudson.[7]

One cubic centimeter of concentrated sulfuric acid was added to 20 cc. of a (1:1) mixture of glacial acetic acid–acetic anhydride cooled to 0°. The sample was weighed accurately into a volumetric flask, dissolved in the acetolysis mixture and the optical rotation observed at regular intervals of time. The reaction was allowed to proceed at room temperature until a constant rotation was obtained. At the end of this time the α-acetates of the sugars could be isolated by pouring the acetolysis mixtures into ice water and working up in the usual manner. Results obtained are given in Fig. 1.

Summary

1. The dimolar tosylation of β-methylcellobioside in pyridine solution with tosyl chloride, followed by acetylation, results in the formation of 6,6′-ditosyl-pentaacetyl-β-methylcellobioside in 67% yield.

2. The new disaccharide α-cellobiomethylose has been synthesized by the following series of reactions: 6,6′-ditosyl-pentaacetyl-β-methylcellobioside ⟶ 6,6′-diiodopentaacetyl-β-methylcellobioside ⟶ pentaacetyl-β-methylcellobiomethyloside ⟶ hexaacetyl-α-cellobiomethylose ⟶ α-cellobiomethylose. The three last named compounds and β-methylcellobiomethyloside were obtained in crystalline form.

3. The rates of acetolysis of the ω-desoxy sugars, triacetyl-β-methylglucomethyloside and pentaacetyl-β-methylcellobiomethyloside, are found to be considerably greater than the sugar derivatives, tetraacetyl-β-methylglucoside and heptaacetyl-β-methylcellobioside.

YONKERS, N. Y. RECEIVED FEBRUARY 26, 1938

(7) R. M. Hann and C. S. Hudson, THIS JOURNAL, **56**, 2465 (1934).