The hydrochloride crystallized from ethyl acetate and ether. The colorless crystals melted at 164–166° (dec.).

Anal. Calcd. for $C_9H_{12}ClN$: C, 63.71; H, 7.13. Found: C, 63.62, 63.89; H, 7.13, 7.36.

A mixture melting point with the stereoisomeric hydrochloride (m. p. 153.5–156.5°) was 94–104° (dec.).

The benzoyl derivative crystallized from dilute ethanol, m. p. 119–120°.

Anal. Calcd. for $C_{16}H_{15}NO$: N, 5.90. Found: N, 6.07.

A mixture melting point with the A-benzoyl derivative (m. p. 122–123.5°) showed a 20–30° depression.

(2-Phenylcyclopropyl)-dimethylamine.—Following general directions[10] for the methylation of primary amines, 10.2 g. of a 40% aqueous formaldehyde solution was added to a cooled solution of 5 g. of 2-phenylcyclopropylamine A in 13.2 g. of 90% formic acid, and the mixture was refluxed overnight. The cooled reaction mixture was treated with 5.5 cc. of concentrated hydrochloric acid, the solution was evaporated under reduced pressure, the residue was made alkaline with a 50% potassium hydroxide solution, and the amine extracted into ether. After drying over potassium hydroxide and distillation of the ether, the colorless amine boiled at 70–70.5° (1.3–1.5 mm.).

The hydrochloride was prepared in dry ether solution and weighed 2.0 g. (27%). After recrystallization from ethyl acetate–ether, the colorless crystals showed m. p. 187–189° (dec.).

Anal. Calcd. for $C_{11}H_{16}ClN$: C, 66.82; H, 8.16. Found: C, 66.85, 66.93; H, 8.20, 8.22.

(2-Phenylcyclopropyl)-methylamine.—A solution of 5 g. of 2-phenylcyclopropylamine A and 4.3 g. of benzaldehyde in 10 cc. of absolute ethanol was refluxed for three hours, the solvent was stripped under reduced pressure, and the benzal derivative distilled once. The colorless oil boiled at 170–172° (2 mm.). It was not purified further. The yield was 6 g. (70%).

A mixture of 6 g. of (2-phenylcyclopropyl)-benzalamine and 7.7 g. of methyl iodide was heated in a sealed tube at 95° for seven hours. The dark red viscous reaction product was boiled with 75 cc. of 95% ethanol for four hours, the solvent was removed under reduced pressure, the base was liberated with 40% potassium hydroxide solution and extracted with ether. The extract was dried over potassium hydroxide, the ether evaporated, and the amine distilled. The colorless mobile distillate, obtained in a yield of 25%, boiled at 88–90° (1.5 mm.).

The colorless **hydrochloride** crystallized from ethanol–ether, m. p. 99–124.5°. Repeated recrystallizations did not narrow this melting point range.

Anal. Calcd. for $C_{10}H_{14}ClN$: N, 7.63. Found: N, 7.53.

1-Phenyl-3,4-dihydro-3,4-cyclopropanoisoquinoline.—A solution of 5 g. of N-(2-phenylcyclopropyl)-benzamide A in 100 cc. of dry toluene was refluxed with 5 g. of phosphorus pentoxide for twenty minutes. Another 5 g. of phosphorus pentoxide was added, and boiling was continued for forty minutes. The mixture was cooled, the toluene decanted, and the residue was decomposed with ice and slow warming until the ice was melted. The resulting solution was cleared, washed with ether, and made strongly alkaline with a 40% potassium hydroxide solution. The reaction product was extracted with four 75-cc. portions of benzene, and the solvent was evaporated. The oily residue solidified to pale brown prisms which were recrystallized from absolute ethanol. The yield was 21%, m. p. 109.5–110.5°.

Anal. Calcd. for $C_{16}H_{13}N$: C, 87.64; H, 5.97. Found: C, 88.17; H, 5.75.

The hydrochloride was hygroscopic. The **dilturate** consisted of yellow prisms which were recrystallized from water and melted at 137–140° with darkening, and decomposed at 156–161°.

Anal. Calcd. for $C_{20}H_{16}N_4O_5$: N, 14.28. Found: N, 14.04.

(10) Clarke, Gillespie and Weishaus, THIS JOURNAL, **55**, 4571 (1933).

Summary

Condensation of styrene with ethyl diazoacetate yields two stereoisomeric 2-phenylcyclopropanecarboxylic acids. The higher-melting member of this pair rearranges to the lower-melting one by way of their common chloride. Both acids have been degraded to the corresponding stereoisomeric 2-phenylcyclopropylamines by different modifications of the Curtius reaction. Secondary and tertiary amines in this series have been prepared, and the benzoyl derivative of the more readily accessible 2-phenylcyclopropylamine has been cyclized to a compound which probably is 1-phenyl-3,4-dihydro-3,4-cyclopropanoisoquinoline.

CHARLOTTESVILLE, VA. RECEIVED JANUARY 26, 1948

[CONTRIBUTION FROM THE CHEMISTRY LABORATORY, NATIONAL INSTITUTE OF HEALTH, U. S. PUBLIC HEALTH SERVICE]

Methyl 2,6-Anhydro-α-D-altroside and Other New Derivatives of Methyl α-D-Altroside[1]

BY DAVID A. ROSENFELD, NELSON K. RICHTMYER AND C. S. HUDSON

In continuation of earlier researches in this Laboratory on methyl α-D-altroside,[2] we now wish to describe a number of new crystalline derivatives of this glycoside. Our primary objective was the study of 6-desoxy-D-altrose (D-altromethylose), the corresponding L-form having been obtained previously as a sirup by Freudenberg and Raschig.[3] From methyl α-D-altroside, following the general procedure described by Haskins, Hann and Hudson,[4] we were successful in preparing, in crystalline form, methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside (I), methyl 2,3,4-tribenzoyl-6-iodo-6-desoxy-α-D-altroside (II), methyl 6-iodo-6-desoxy-α-D-altroside, and methyl 2,3,4-tribenzoyl-6-desoxy-α-D-altroside (III). However, our attempts to transform this last-named compound to the desired methyl 6-desoxy-α-D-altroside and to 6-desoxy-D-altrose have so far yielded only sirups. Gut and Prins[5] have also described these two com-

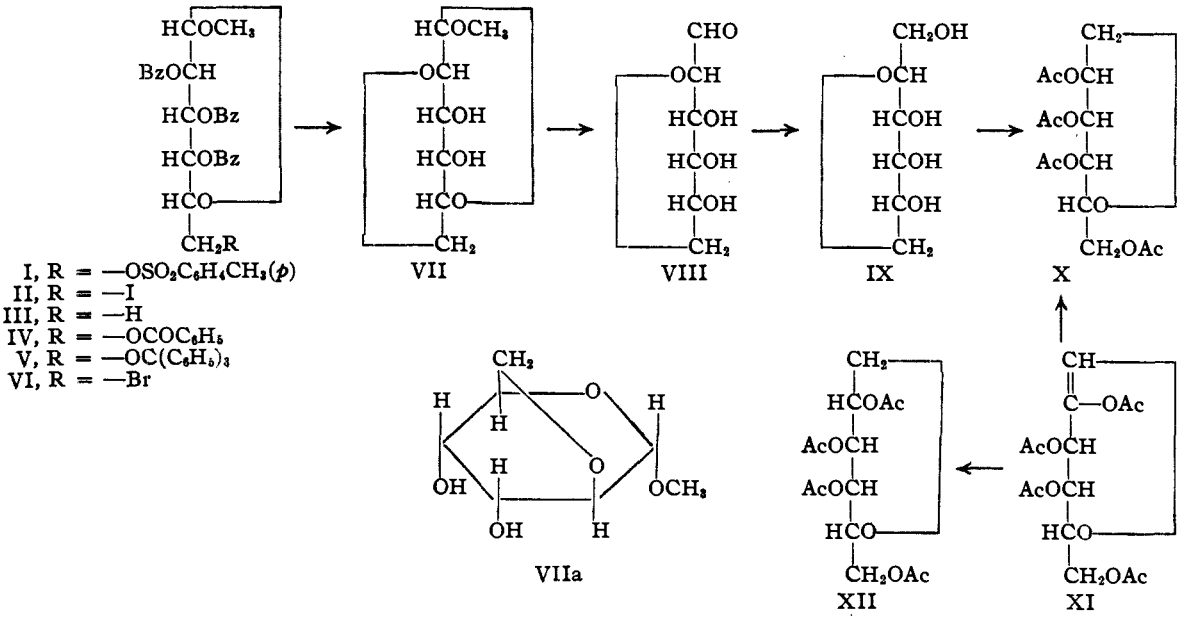
(1) Presented in part before the Division of Sugar Chemistry and Technology at the Atlantic City meeting of the American Chemical Society, April 14, 1947.

(2) N. K. Richtmyer and C. S. Hudson, THIS JOURNAL, **63**, 1727 (1941).

(3) K. Freudenberg and K. Raschig, *Ber.*, **62**, 373 (1929).

(4) W. T. Haskins, R. M. Hann and C. S. Hudson, THIS JOURNAL, **68**, 628 (1946).

(5) M. Gut and D. A. Prins, *Helv. Chim. Acta*, **29**, 1555 (1946).



pounds recently as sirups, as well as the triacetyl derivatives analogous to our crystalline tribenzoates. A sirupy D-altromethylose has been reported also by Iwadare.[6]

The reaction of methyl α-D-altroside with benzoyl chloride in pyridine readily yields the expected tetrabenzoyl derivative (IV). The reaction with one equivalent of triphenylchloromethane in pyridine, followed by benzoylation, produces methyl 2,3,4-tribenzoyl-6-trityl-α-D-altroside (V); the corresponding triacetyl derivative has also been crystallized. By removal of the triphenylmethyl residue from V, and subsequent tosylation of the free hydroxyl group, we have converted this trityl compound to the tosyl derivative (I). A second correlation has been achieved by the action of phosphorus pentabromide upon V, whereby the trityl ether group was replaced by a bromine atom, and the resulting methyl 2,3,4-tribenzoyl-6-bromo-6-desoxy-α-D-altroside (VI) was then reduced with hydrogen and Raney nickel to methyl 2,3,4-tribenzoyl-6-desoxy-α-D-altroside (III).

Haskins, Hann and Hudson[4] have shown that methyl 2,3,4-tribenzoyl-6-tosyl-α-D-mannoside is converted readily by an excess of warm sodium hydroxide to methyl 3,6-anhydro-α-D-mannoside. Under identical conditions, methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside (I) likewise undergoes debenzoylation and loss of the tosyl group to form an anhydride, which melts at 98° and has $[\alpha]^{20}D$ + 44.6° in water. In the sugars which are known to form a 3,6-anhydroglycopyranoside from a 6-substituted glycopyranoside, namely, D-glucose, D-mannose and D-galactose,[7] the hydroxyl group on carbon 3 is on the same side of the sugar ring as the side chain carbon 6, that is, on the left in the usual Fischer projection formula; in the D-altroside only the hydroxyl on carbon 2 can be written on the left. A 2,6-anhydro ring might thus be anticipated rather than a 3,6-anhydro ring, and the new compound was indeed proved to be methyl 2,6-anhydro-α-D-altropyranoside (VII and VIIa). The simplest method of distinguishing between a 2,6-ring and a 3,6-ring, assuming the original 1,5-ring to be intact, was to apply the method of periodate oxidation. A 3,6-anhydride would not be expected to react with sodium metaperiodate; our 2,6-anhydro compound, having two adjacent hydroxyl groups, consumed rapidly one equivalent of oxidant, and liberated neither formic acid nor formaldehyde.

Further proof of the structure of methyl 2,6-anhydro-α-D-altropyranoside (VII) was secured by a series of reactions which ruptured the 1,5-ring and left the 2,6-ring intact. The glycosidic methyl group was first removed by mild acid hydrolysis, and the resulting 2,6-anhydro-D-altrose (VIII) was reduced with hydrogen and Raney nickel to an anhydrohexitol (IX) which might be named 2,6-anhydro-D-altritol, but is preferably called 1,5-anhydro-D-talitol. While neither VIII nor IX has yet been obtained in crystalline form, the latter yielded a tetraacetyl derivative (X) which separated as prisms melting at 107°, and with $[\alpha]^{20}D$ −16.2° in chloroform. These data are in good agreement with those of the prismatic crystals of melting point 108° and $[\alpha]^{22}D$ −15.3° described by Freudenberg and Rogers.[8] Their compound, prepared by the catalytic hydrogenation of 2,3,4,-6-tetraacetyl-2-hydroxy-D-galactal (XI), could be either 2,3,4,6-tetraacetyl-1,5-anhydro-D-talitol

(6) K. Iwadare, *Bull. Chem. Soc. Japan*, **17**, 296 (1942); *C. A.*, **41**, 4457g (1947).

(7) See S. Peat's review of the chemistry of anhydro sugars in "Advances in Carbohydrate Chemistry," Vol. 2, Academic Press Inc., Publishers, New York, N. Y., 1946, pp. 37–77.

(8) W. Freudenberg and E. F. Rogers, THIS JOURNAL, **59**, 1604 (1937).

(X) or 2,3,4,6-tetraacetyl-1,5-anhydro-D-galactitol (XII), because the addition of hydrogen to the ethylenic linkage could give rise to either or both of these isomers. Our work identifies their compound as the D-talitol derivative (X) because only that one is possible if we start with a D-altrose derivative. The recent synthesis in this Laboratory of 2,3,4,6-tetraacetyl-1,5-anhydro-D-galactitol (XII),[9] which is quite different from the compound first described by Freudenberg and Rogers, and now by us, completes the series of compounds and correlates all three researches.

We have prepared the methyl 2,6-anhydro-α-D-altroside (VII) by the action of alkali not only upon the 6-tosyl derivative (I) but also upon the 6-bromo derivative (VI) and the 6-iodo derivative (II). Although the formation of methyl 3,6-anhydroglycosides from 6-bromo compounds has been reported previously,[10] we believe that this is the first time that a cyclic anhydride of a glycoside has been obtained from a 6-iodo compound. However, the reaction was accompanied by the formation of a highly colored solution with attendant low yield of the anhydro compound, and the reaction cannot be recommended for preparative purposes.

It will be interesting to learn whether the compound reported by Steiger and Reichstein[11] to be an isopropylidene derivative of a methyl anhydro-D-altroside, of melting point 132° and $[\alpha]^{18}D$ −43.0°, is the 3,4-isopropylidene derivative of methyl 2,6-anhydro-β(or α)-D-altroside.

Although methyl 2,6-anhydro-α-D-altropyranoside does not show the extreme sensitivity to acids that is shown by the 3,6-anhydro derivatives of methyl α-D-galactopyranoside[12] and methyl α-D-glucopyranoside,[13] and appears to be completely stable under ordinary conditions in the laboratory, it is hydrolyzed readily by *N* hydrochloric acid at 20°. We were unable to compare the rate of hydrolysis of methyl 2,6-anhydro-α-D-altropyranoside with that of methyl α-D-altropyranoside because D-altrose, the hydrolysis product of the latter, readily forms 1,6-anhydro-D-altrose (= D-altrosan<1,5>β<1,6>) in acid solution. However, sucrose is hydrolyzed about twenty-two times faster, and methyl α-D-glucopyranoside only about one-ninetieth as fast as methyl 2,6-anhydro-α-D-altroside under comparable conditions.

Experimental Part

Methyl α-D-altroside was prepared from methyl α-D-glucoside essentially as described in a preceding publication,[2] except that ethylene dichloride was used as a solvent whenever possible instead of the more expensive chloroform. The **methyl 2,3-ditosyl-4,6-benzylidene-α-D-glucoside**[14] which was used in our earlier study crystallized as needles melting at 147–148°. A new modification has since been obtained in large, chunky prisms which melt at 154–155°. The two forms have identical rotations, $[\alpha]^{20}D$ +11.8° in chloroform (*c*, 6). In contrast to the behavior of the two modifications of the corresponding derivative of methyl β-D-glucoside reported by Littmann and Hess,[14] either form of our compound can be obtained as desired by inoculating an ethylene dichloride solution of either form with the appropriate seed crystal.

Anal. Calcd. for $C_{28}H_{30}O_{10}S_2$: C, 56.93; H, 5.12. Found (155° form): C, 57.04; H, 5.28.

In the transformation of each 100 g. of ditosyl compound to the methyl 2,3-anhydro-4,6-benzylidene-α-D-alloside it was necessary to use 1500 ml. of ethylene dichloride and 450 ml. of methyl alcohol (including 0.85 mole of sodium methoxide) to maintain a homogeneous solution.

In our most recent preparations of methyl α-D-altroside we have found it unnecessary to isolate the methyl 2,3-ditosyl-4,6-benzylidene-α-D-glucoside, and considerable time may be saved by using a modified procedure. Thus, 100 g. of well-dried, crude methyl 4,6-benzylidene-α-D-glucoside was dissolved in 600 ml. of a "practical" grade of pyridine (dried over sticks of potassium hydroxide, and filtered) and 250 g. of *p*-toluenesulfonyl chloride was added. The reaction mixture, after three days at room temperature, was decomposed with ice and water, and the product extracted with ethylene dichloride. Pyridine was removed from this extract by washing with cold dilute sulfuric acid, and after further washing with water, aqueous sodium bicarbonate, and water, and drying with granular calcium chloride, the volume was adjusted to 1500 ml. The solution was cooled in the refrigerator and to it was added a cold solution of 450 ml. of methyl alcohol containing 1.4 moles of sodium methoxide (twice the theoretical amount required to effect detosylation and anhydride formation on the assumption that the starting material was all in the form of the ditosyl compound). The mixture was kept in the refrigerator for three days, with occasional shaking at first to prevent the separation of the liquid into two layers, and then allowed to stand at room temperature for two additional days. The solution was diluted with water, and the ethylene dichloride layer and extracts washed with water, dried over granular calcium chloride, and concentrated *in vacuo*. The crystalline anhydroalloside, filtered and washed with the aid of ether, weighed 70 g., representing 75% of the theoretical amount based on the 100 g. of methyl 4,6-benzylidene-α-D-glucoside.

The alkaline hydrolysis of the anhydroalloside to methyl 4,6-benzylidene-α-D-altroside and the subsequent mild acid hydrolysis to methyl α-D-altroside were then carried out as previously described.[2]

Methyl 2,3,4,6-Tetrabenzoyl-α-D-altroside (IV).—A solution of 5 g. of methyl α-D-altroside in 75 ml. of pyridine was cooled in an ice-bath, and to it was added 15 ml. of benzoyl chloride. After standing for twenty-four hours at room temperature, the mixture was poured into one liter of ice and water, and the precipitated gum was washed thoroughly by stirring with fresh portions of water several times during the course of the next few days. Crystals were first observed after the gum had stood under water in the refrigerator for about two months. The crystalline product weighed 7 g. and was recrystallized five times from ethyl alcohol as large, brilliant prisms; the m. p. was 94–96°, and $[\alpha]^{20}D$ +32.6° in chloroform (*c*, 4).

Anal. Calcd. for $C_{35}H_{30}O_{10}$: C, 68.84; H, 4.95. Found: C, 68.97; H, 4.94.

(9) H. G. Fletcher, Jr., and C. S. Hudson, THIS JOURNAL, **70**, 310 (1948).

(10) *E. g.*, that of the β-D-glucoside by E. Fischer and K. Zach [*Ber.*, **45**, 456 (1912)], that of the α-D-galactoside by F. Valentin [*Coll. Czechoslov. Chem. Commun.*, **4**, 371 (1932)], and that of the α-D-mannoside by F. Valentin [*ibid.*, **6**, 354 (1934)].

(11) M. Steiger and T. Reichstein, *Helv. Chim. Acta*, **19**, 1011 (1936).

(12) W. N. Haworth, J. Jackson and F. Smith, *J. Chem. Soc.*, 620 (1940).

(13) W. N. Haworth, L. N. Owen and F. Smith, *ibid.*, 88 (1941).

(14) H. Ohle and K. Spencker, *Ber.*, **61**, 2392 (1928); D. S. Mathers and G. J. Robertson, *J. Chem. Soc.*, 696 (1933); O. Littmann and K. Hess, *Ber.*, **67**, 524 (1934); H. Ohle and F. Just, *ibid.*, **68**, 601 footnote 5 (1935).

Methyl 2,3,4-Triacetyl-6-trityl-α-D-altroside.[15]—A mixture of 6.75 g. of methyl α-D-altroside and 13 g. of triphenylchloromethane in 50 ml. of pyridine was heated for three hours on the steam-bath, cooled, 25 ml. of acetic anhydride added, and the mixture allowed to stand for three days at room temperature. At the end of that time the flask contained a considerable number of large, colorless crystals which were removed by filtration, washed with pyridine, and recrystallized from a mixture of chloroform and pentane as prisms melting at 175°. The action of hot aqueous sodium hydroxide upon the compound liberated pyridine, which was recognized by its odor, and triphenylcarbinol, which was identified by its melting point and by a mixed melting point with an authentic specimen. These properties, together with analyses of the substance, indicate that it is the double compound of pyridine hydrochloride with triphenylcarbinol (probably present as an impurity in the triphenylchloromethane), melting at 174°, which was described by Helferich and Sieber.[16]

Anal. Calcd. for $C_{24}H_{22}ClNO$: C, 76.68; H, 5.90; Cl, 9.43; N, 3.73. Found: C, 76.69; H, 6.05; Cl, 9.57; N, 4.01.

The filtrate from the double compound was diluted with ice water and the precipitated solid extracted with chloroform. The chloroform solution was washed with 20% aqueous copper sulfate or cold, dilute sulfuric acid to remove the pyridine, then with water, aqueous bicarbonate, and water, dried with granular calcium chloride, and concentrated to a sirup which crystallized readily. The product weighed 9 g. It was recrystallized three times from chloroform by the addition of ether and isopentane, and then twice from alcohol. The elongated prisms melted at 165–166° after sintering a few degrees lower, and showed $[\alpha]^{20}D$ +44.8° in chloroform (*c*, 2).

Anal. Calcd. for $C_{32}H_{34}O_9$: C, 68.31; H, 6.09. Found: C, 68.55; H, 6.17.

Methyl 2,3,4-Tribenzoyl-6-trityl-α-D-altroside (V).—Ten grams of methyl α-D-altroside in 100 ml. of pyridine was heated for three hours with 15.8 g. of triphenylchloromethane, then cooled, and 27.4 ml. of benzoyl chloride added. After two days the mixture was decomposed by pouring into ice water. The next day the precipitated gum was extracted with chloroform, and the solution washed successively with water, cold dilute sulfuric acid, water, aqueous sodium bicarbonate, and water. This solution was dried with Drierite, filtered, and concentrated *in vacuo* to a sirup. The first crystalline material was obtained by fractional extraction of this sirup with ethyl alcohol; the radiating clusters of small needles melted about 96–98°, and were not very soluble in alcohol. When these crystals were found to be readily recrystallizable from ether, the several alcohol solutions and residue were combined and concentrated again to a sirup which was dissolved in ether and crystallized with the aid of isopentane. The product separated in large prisms, and weighed 29 g. The melting point of 83–85° with evolution of gas indicated solvent of crystallization; the material lost weight slowly at room temperature, and finally reached a constant weight, when heated at 70°, with a loss corresponding to one molecule of ether of crystallization.

Anal. Calcd. for $C_{47}H_{40}O_9 \cdot (C_2H_5)_2O$: ether, 9.01. Found: ether, 8.86.

Finally, the compound was purified by recrystallizing it from chloroform by the addition of absolute alcohol, from which it separated in small plates. After five recrystallizations the melting point was 139–140°, and the rotation, $[\alpha]^{20}D$, was +15.2° in chloroform (*c*, 4).

Anal. Calcd. for $C_{47}H_{40}O_9$: C, 75.38; H, 5.38. Found: C, 75.43; H, 5.49.

Methyl 2,3,4-Tribenzoyl-6-tosyl-α-D-altroside (I). (a) From Methyl α-D-Altroside.—A solution of 10 g. of methyl α-D-altroside in 150 ml. of pyridine was cooled in an ice-bath and stirred vigorously while a cold solution of 11 g. of *p*-toluenesulfonyl chloride (1.1 molecular equivalents) in 20 ml. of pyridine was added dropwise. The mixture was left for six hours at 20°, then 20 ml. (3.3 molecular equivalents) of benzoyl chloride was added and the mixture kept at 20° for an additional eighteen hours. Decomposition was effected by pouring the mixture into 2 liters of ice and water. The aqueous layer was decanted, and the gummy residue was triturated with water, twice with 200 ml. of 2% aqueous sodium bicarbonate solution, then three times with water, and drained as well as possible. The heavy gum was extracted twice with boiling ethyl alcohol, two 200-ml. portions usually being sufficient to dissolve the material. The solutions deposited about 7 g. (21%) of product melting at 144–146°; small additional amounts were obtained by reworking the mother liquors. A number of variations on this procedure failed to improve the yield, and no methyl 2,3,4,6-tetrabenzoyl-α-D-altroside could be isolated from the non-crystalline residues. The methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside was purified by several recrystallizations from alcohol; it formed acicular prisms which melted at 149–150° and showed $[\alpha]^{20}D$ +30.3° in chloroform (*c*, 3).

Anal. Calcd. for $C_{35}H_{32}O_{11}S$: C, 63.63; H, 4.88. Found: C, 63.77; H, 4.74.

(b) **From Methyl 2,3,4-Tribenzoyl-6-trityl-α-D-altroside (V).**—In order to correlate the 6-trityl derivatives with the 6-tosyl derivatives, the following experiment was performed. Five grams of the methyl 2,3,4-tribenzoyl-6-trityl-α-D-altroside was dissolved in 100 ml. of warm glacial acetic acid, the solution was cooled to room temperature, and 3 ml. of glacial acetic acid saturated with gaseous hydrobromic acid was added. After thirty minutes the mixture was poured into one liter of ice water, and extracted with chloroform; the chloroform solution was washed with aqueous bicarbonate and water, dried with Drierite, and concentrated *in vacuo* to a sirup. Upon the addition of methyl alcohol the sirup yielded 0.64 g. of triphenylcarbinol. The mother liquor was concentrated to a dry sirup, taken up in pyridine, and 5 g. of *p*-toluenesulfonyl chloride added. After three days at room temperature the reaction mixture was decomposed with ice and water, and the product extracted with chloroform, which was then washed, dried, and concentrated to a sirup in the usual manner. The product was crystallized with the aid of ether and pentane to yield 1.6 g. of the desired methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside; after two recrystallizations from ethyl alcohol the acicular prisms melted at 149–150° and showed $[\alpha]^{20}D$ +29.9° in chloroform (*c*, 2) in good agreement with the values reported in the preceding paragraph. A mixture of the two samples showed no depression in melting point.

Methyl 2,3,4-Tribenzoyl-6-iodo-6-desoxy-α-D-altroside (II).—A solution containing 5 g. of methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside and 5 g. of sodium iodide in 40 ml. of acetonylacetone was heated at 70° for eighteen hours. The precipitated sodium *p*-toluenesulfonate, filtered from the solution after cooling, weighed 1.4 g. (theory, 1.5 g.). The filtrate, upon dilution with water, deposited 4.8 g. of product which was recrystallized several times from acetone by the slow addition of water. The acicular prisms of the purified substance melted at 143–145°, and showed $[\alpha]^{20}D$ +2.5° in chloroform (*c*, 4).

Anal. Calcd. for $C_{28}H_{25}IO_8$: C, 54.56; H, 4.09. Found: C, 54.98; H, 4.27.

Methyl 6-Iodo-6-desoxy-α-D-altroside.—Debenzoylation of the preceding compound catalytically with barium methoxide, followed by removal of the barium ions by

(15) First prepared by Mr. Frank G. Young in this Laboratory during the summer of 1940.

(16) B. Helferich and H. Sieber, *Ber.*, **59**, 600 (1926). A double compound presumed to consist of pyridine and triphenylchloromethane, melting at 173–174°, has been described by C. A. Kraus and R. Rosen [THIS JOURNAL, **47**, 2744 (1925)]; the analyses, reported only for chlorine, are not sufficient to enable one to decide whether their compound was also identical with that of Helferich and Sieber.

precipitation with the equivalent amount of sulfuric acid, yielded almost the theoretical amount of methyl 6-iodo-6-desoxy-α-D-altroside. The product, recrystallized four times from chloroform by the addition of ether or isopentane, formed clusters of rectangular prisms melting at 105–106°. The $[\alpha]^{20}D$ value was +91.4° in chloroform (*c*, 1) and +79.3° in water (*c*, 1).

Anal. Calcd. for $C_7H_{13}IO_5$: C, 27.65; H, 4.31. Found: C, 27.76; H, 4.58.

Methyl 2,3,4-Tribenzoyl-6-bromo-6-desoxy-α-D-altroside (VI).—To a solution of 22.9 g. of methyl 2,3,4-tribenzoyl-6-trityl-α-D-altroside in 200 ml. of dry, alcohol-free chloroform was added a mixture of 12.2 g. of phosphorus tribromide and 7.2 g. of bromine in 200 ml. of chloroform, corresponding to a 50% excess of the amount of phosphorus pentabromide required for the reaction. After three hours the reaction mixture was decomposed with ice water, and the chloroform layer separated and washed successively with water, aqueous bicarbonate, water, aqueous thiosulfate, and water, dried with Drierite, and concentrated *in vacuo* to a sirup. The product crystallized readily upon the addition of methyl alcohol in a yield of 13.2 g. (76%); from the mother liquor, concentrated to a sirup and taken up in ether, was obtained 6.8 g. (85%) of triphenylcarbinol which had been formed by hydrolysis of the other cleavage product, triphenylbromomethane.

The methyl 2,3,4-tribenzoyl-6-bromo-6-desoxy-α-D-altroside was freed from a small amount of levorotatory material by six recrystallizations from hot methyl alcohol; the rotation $[\alpha]^{20}D \pm 0.0°$ in chloroform (*c*, 8; *l*, 4) was unchanged by eight additional recrystallizations from a mixture of chloroform and pentane. The product separated as prisms melting at 146–147°.

Anal. Calcd. for $C_{28}H_{25}BrO_8$: C, 59.06; H, 4.43. Found: C, 59.11; H, 4.46.

Methyl 2,3,4-Tribenzoyl-6-desoxy-α-D-altroside (III).—Five grams of powdered methyl 2,3,4-tribenzoyl-6-iodo-6-desoxy-α-D-altroside and 1 ml. of Raney nickel catalyst were suspended in 200 ml. of methyl alcohol containing 1.7 ml. of diethylamine, and the mixture was shaken with hydrogen at atmospheric pressure. The absorption of one equivalent of gas was complete in about fifty minutes. The catalyst was removed by filtration, and the filtrate was concentrated *in vacuo*. The crystalline residue was stirred with several portions of water to remove the diethylamine hydroiodide, and the residue was recrystallized from methyl alcohol in a yield of 2.7 g. After three additional recrystallizations the small, chunky prisms melted at 134–135° and showed $[\alpha]^{20}D$ −15.5° in chloroform (*c*, 3).

Anal. Calcd. for $C_{28}H_{26}O_8$: C, 68.56; H, 5.34; OCH_3, 6.33. Found: C, 68.69; H, 5.18; OCH_3, 6.32.

In the same manner, 5.0 g. of slightly impure methyl 2,3,4-tribenzoyl-6-bromo-6-desoxy-α-D-altroside yielded 3.0 g. of reduction product. After two recrystallizations from methyl alcohol the small, chunky prisms melted at 133–134°, and a mixture with the compound prepared from the iodo derivative melted at 133–135°; the specific rotation, however, was −19.6° in chloroform, and after twenty-five recrystallizations the substance still contained a small amount of more levorotatory impurity as shown by the value $[\alpha]^{20}D$ −17.3°.

Methyl 2,6-Anhydro-α-D-altropyranoside (VII). (a) **From Methyl 2,3,4-Tribenzoyl-6-tosyl-α-D-altroside (I).**—A mixture of 10 g. of methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside, 150 ml. of methyl cellosolve, and 67 ml. of 1 *N* sodium hydroxide (4.4 molecular equivalents) was heated on the steam-bath for one hour. The solution was cooled, neutralized with carbon dioxide, and concentrated *in vacuo* to dryness; a 50-ml. portion of ethyl acetate was added, and the mixture concentrated again to dryness. The product was removed from the mixture of solid sodium salts by extracting three times with 100-ml. portions of boiling anhydrous ethyl acetate. The extract, upon concentration *in vacuo*, left a sirup which crystallized after standing a few days. The average yield from a number of such experiments was 1.7 g. The methyl 2,6-anhydro-α-D-altroside was recrystallized first from acetone by the cautious addition of ether, and then from ethyl acetate, as large elongated prisms, melting, when pure, at 97–98°, and with $[\alpha]^{20}D$ +44.6° in water (*c*, 2).

Anal. Calcd. for $C_7H_{12}O_5$: C, 47.72; H, 6.87; OCH_3, 17.61. Found: C, 47.74; H, 6.97; OCH_3, 17.55.

(b) **From Methyl 2,3,4-Tribenzoyl-6-bromo-6-desoxy-α-D-altroside (VI).**—The catalytic debenzoylation of methyl 2,3,4-tribenzoyl-6-bromo-6-desoxy-α-D-altroside with sodium methoxide, unlike that of the analogous iodo compound, failed to yield a crystalline product. Accordingly, 50 ml. of an aqueous solution of such a preparation, containing about 2.6 g. of methyl 6-bromo-6-desoxy-α-D-altroside ($[\alpha]^{20}D$ about +80° in water), was heated for two hours on the steam-bath with 2.5 g. of sodium hydroxide. The light-brown solution was neutralized with carbon dioxide, decolorized with activated carbon, and concentrated *in vacuo* to dryness. The product was extracted with hot ethyl acetate, and 1.6 g. of methyl 2,6-anhydro-α-D-altroside was obtained; it was identified, after several recrystallizations, by its melting point, mixed melting point, and rotation.

(c) **From Methyl 6-Iodo-6-desoxy-α-D-altroside.**—A solution containing 2.2 g. of methyl 6-iodo-6-desoxy-α-D-altroside and 2.2 g. of sodium hydroxide in 35 ml. of water was heated on the steam-bath for two hours. The dark, reddish-brown solution was neutralized with carbon dioxide, treated with carbon, concentrated to dryness, and extracted with ethyl acetate as above. Evaporation of the ethyl acetate left 0.85 g. of a yellowish-red sirup which did not crystallize when inoculated with the expected 2,6-anhydro compound. The sirup was therefore acetylated with acetic anhydride and pyridine at room temperature. The product was isolated in the usual manner, yielding 1.5 g. of a sirup which crystallized when inoculated with the known diacetate of the 2,6-anhydro compound (see below). One recrystallization from chloroform by the addition of pentane produced 1.0 g. of yellowish prisms; the colored impurity was removed by a fractional recrystallization, and the diacetate was obtained as the characteristic colorless elongated prisms, identical in melting point and rotation with those described in the following paragraph.

Methyl 2,6-Anhydro-3,4-diacetyl-α-D-altroside.—Acetylation of the purest 2,6-anhydroaltroside (prepared from methyl 2,3,4-tribenzoyl-6-tosyl-α-D-altroside) with acetic anhydride and pyridine in the usual manner furnished the diacetate in practically quantitative yield. The product was recrystallized twice from chloroform by the addition of pentane, separating as elongated prisms of m. p. 100–101° and $[\alpha]^{20}D$ +32.5° in chloroform (*c*, 2). These values were unchanged by two additional recrystallizations.

Anal. Calcd. for $C_{11}H_{16}O_7$: C, 50.76; H, 6.20; OCH_3, 11.92. Found: C, 50.96; H, 6.53; OCH_3, 11.80.

Oxidation of Methyl 2,6-Anhydro-α-D-altroside with Sodium Metaperiodate.—To a solution of 0.5292 g. of the anhydro compound in 75 ml. of water was added 15 ml. of 0.4445 *M* sodium periodate solution, and the mixture diluted exactly to 100 ml. with water. The first rotation was observed twenty minutes after adding the reagent and was unchanged after four days; the value $[\alpha]^{20}D$ +113.5° was calculated for the expected oxidation product, the dialdehyde $C_7H_{10}O_5$. The first determination of the amount of reagent consumed showed that the reaction was complete at the end of forty-five minutes, and the value of 1.03 molecular equivalents of periodate had changed only to 1.07 molecular equivalents after four days. Neither formic acid nor formaldehyde could be detected in the reaction mixture.

Hydrolysis of Methyl 2,6-Anhydro-α-D-altroside with Hydrochloric Acid.—In 0.1 *N* hydrochloric acid at 20° there was no appreciable hydrolysis of the anhydroaltroside in nineteen hours; when the solution was heated in a

boiling water-bath, hydrolysis appeared to be complete within one hour. For a 2% solution of the anhydroaltroside in 0.01 *N* hydrochloric acid at 98°, the unimolecular velocity coefficient, calculated in minutes and decimal logarithms, was 0.0062; the time required for 50% hydrolysis was forty-nine minutes. Methyl α-D-glucoside in 0.1 *N* hydrochloric acid, other conditions being the same, yielded a unimolecular velocity coefficient of 0.00068; on the assumption that the rate is proportional to the acidity, this indicates that methyl 2,6-anhydro-α-D-altroside is hydrolyzed about ninety times as rapidly as methyl α-D-glucoside.

The hydrolysis of methyl 2,6-anhydro-α-D-altroside by 1 *N* hydrochloric acid at 20° was readily observed with the saccharimeter. A 4% solution required 2712 minutes for 50% hydrolysis, and the velocity coefficient was calculated to be 0.000111. An equimolecular solution of sucrose (7.8%) under the same conditions had a velocity coefficient of 0.00244 and the time required for 50% hydrolysis was 121 minutes. Hence, sucrose is hydrolyzed about 22 times as rapidly as an equimolecular solution of the anhydroaltroside.

The solutions obtained by the hydrolysis of the anhydroaltroside had a rotation, calculated as a 2,6-anhydro-D-altrose, of $[\alpha]^{20}D$ −21°. A few drops of solution restored the color to Schiff reagent within a few seconds; crystalline D-altrose restored the color slowly, and D-glucose not at all. In a separate experiment, using *N* sulfuric acid followed by neutralization with solid barium carbonate, we have been unable to obtain a crystalline 2,6-anhydroaltrose.

Hydrogenation of 2,6-Anhydro-D-altrose and the Isolation of Tetraacetyl-1,5-anhydro-D-talitol (X).—The solution obtained by the hydrolysis of several portions of methyl 2,6-anhydro-α-D-altroside (total weight 4.0 g.) with dilute hydrochloric acid were combined, neutralized to litmus with dilute sodium hydroxide, and concentrated *in vacuo* to 50 ml. The solution was transferred to the glass liner of a steel bomb, and hydrogenated, in the presence of 3 g. of Raney nickel, for six hours at 100° under a pressure of 1500 lb. per square inch. The solution no longer reduced Fehling solution. It was concentrated *in vacuo* to a dry sirup, and acetylated with 50 ml. of acetic anhydride and 50 ml. of pyridine. The acetylated product was isolated in the usual manner, and crystallized spontaneously from its concentrated ether solution. The yield was 5.5 g., or 73%. The tetraacetyl-1,5-anhydro-D-talitol thus obtained was recrystallized twice from ether, then twice from chloroform by the addition of pentane. The elongated prisms melted at 106–107°, and showed $[\alpha]^{20}D$ −16.2° in chloroform (*c*, 5); Freudenberg and Rogers[8] reported prisms of m. p. 108° and $[\alpha]^{23}D$ −15.31° in chloroform (*c*, 2).

Anal. Calcd. for $C_{14}H_{20}O_9$: C, 50.60; H, 6.07. Found: C, 50.62; H, 6.13.

The Specific Rotation of 1,5-Anhydro-D-talitol (IX).—The deacetylation of 2.4566 g. of tetraacetyl-1,5-anhydro-D-talitol by 0.5 ml. of 3% sodium methoxide in 50 ml. of methyl alcohol, followed by careful concentration of the solution in a desiccator over granular calcium chloride, yielded a sirup which in separate experiments we have been unable to crystallize. This sirup was dissolved and transferred quantitatively to a 25-ml. volumetric flask, and its rotation determined in a 4-dm. tube. Our value $[\alpha]^{20}D$ −11.4° in water (*c*, 4.85) is somewhat higher than the $[\alpha]^{23}D$ −7.34° reported by Freudenberg and Rogers for their sirup which was prepared in a different manner.

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Summary

Ten new crystalline derivatives of methyl α-D-altroside have been described. One of these, prepared by the action of alkali on the 6-tosyl, 6-bromo, or 6-iodo derivative, is methyl 2,6-anhydro-α-D-altropyranoside; this is a new type of anhydroglycoside, in contrast to the 3,6-anhydroglycosides of D-glucose, D-mannose, and D-galactose.

The acid hydrolysis of methyl 2,6-anhydro-α-D-altroside, followed by catalytic hydrogenation of the 2,6-anhydro-D-altrose, yields 1,5-anhydro-D-talitol; the crystalline tetraacetate of this substance has been identified with the product obtained previously by W. Freudenberg and K. F. Rogers by the catalytic hydrogenation of 2,3,4,6-tetraacetyl-2-hydroxy-D-galactal.

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[CONTRIBUTION FROM THE OREGON FOREST PRODUCTS LABORATORY AND THE DEPARTMENT OF CHEMISTRY, OREGON STATE COLLEGE]

The Constituents of Sierra Juniper Wood (*Juniperus occidentalis*, Hooker)

BY E. F. KURTH AND HOMER B. LACKEY*

Sierra Juniper is native to altitudes ranging from 3,000 to 11,000 feet in California, Oregon, Washington, and Western Idaho. It is a low, broadheaded tree, 20 to 65 feet high, with thick trunk and stout horizontal branches. The larger trees may reach a circumference of nine feet and an age of 2,000 years. The heartwood is pale reddish-brown and the sapwood is nearly white.

It appears that no previous investigation has been made of the extractive from this species. Because large numbers of the trees are found in proposed reclamation areas, it became advisable to ascertain the constituents of the extractives from the wood.

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Experimental

The material for the investigation was collected from trees felled for the purpose in the vicinity of Bend, Oregon, and included cross sections from the top and bottom of logs, stumpwood and rootwood. After the bark was removed, representative specimens of sapwood, heartwood, whole wood, stumpwood and rootwood were shredded separately in a Greundler Peerless Grinder. At the time of shredding, the moisture content of the wood was roughly 40 to 50%. For quantitative yield of extractive, samples of the shredded wood were room-dried to under 10% moisture content and then further ground in a Wiley mill to pass a 40-mesh standard U. S. sieve.