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Conversion of D-Glucofuranose to L-*arabino*-Hexofuranoside[1]

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Solvolysis of 2,3-di-O-benzyl-5-O-mesyl-6-O-trityl-D-glucofuranose (IV) was carried out under an oxide ring migration, affording methyl 2,3-di-O-benzyl-α-L-altrofuranoside (XVIIIa) and its β-anomer (XVIIIb) in a ratio of 1:2.2.

Behaviors of activated carbon centers to nucleophilic attack of bases with intramolecular participation of a near-located oxygen atom are one of the interesting problems in carbohydrate chemistry. In 1936, Levene and Compton[3] reported that 2,3-O-isopropylidene--5-O-tosyl-L-rhamnofuranose (I) was solvolyzed by sodium methoxide and converted into methyl 6-deoxy-2,3-O-isopropylidene-β-D-allofuranoside (II) through an epoxyaldehyde intermediate (III) under an oxide ring migration,[4] as shown in Chart 1. 6-Deoxy-D-allofuranose thus obtained was utilized for the synthesis of some new nucleosides[4] or an antibiotic sugar,[5] but application of this rearrangement reaction to other sugar derivatives has not been attempted so far. The present work was undertaken to ascertain whether

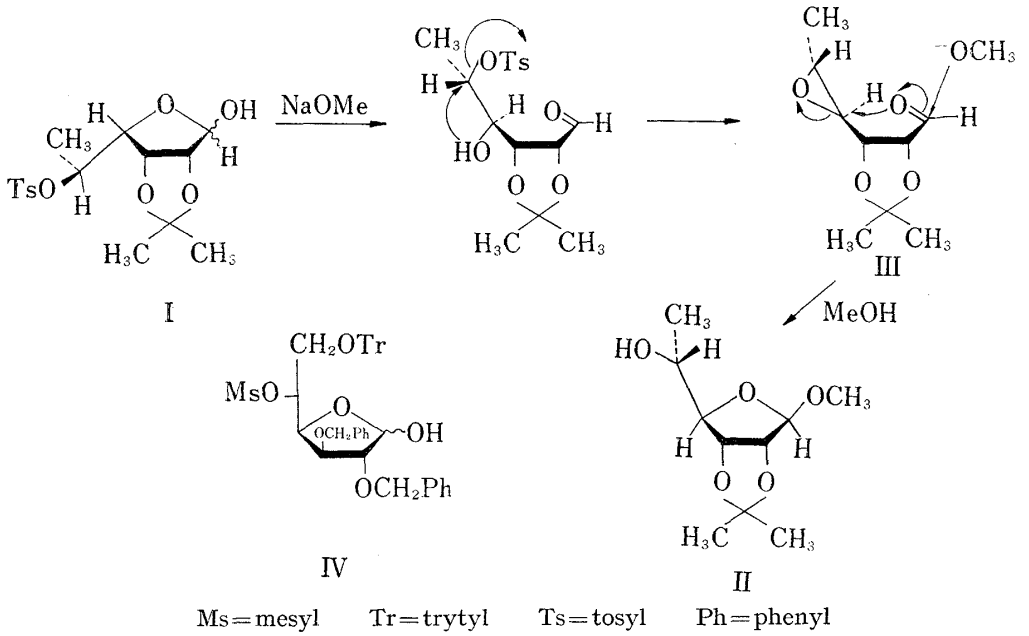

Chart 1

or not this rearrangement reaction is generally applicable to other sugar derivatives. First, we attempted solvolysis of 2,3-di-O-benzyl-5-O-mesyl-6-O-trityl-D-glucofuranose (IV); because it would be considered that the L-*arabino*-hexofuranoside obtainable from IV by

1) A preliminary communication has been published: T. Iwashige, H. Saeki, *Chem. Pharm. Bull.* (Tokyo), **15**, 132 (1967).
2) Location: *Hiromachi, Shinagawa-ku, Tokyo.*
3) P.A. Levene and J. Compton, *J. Biol. Chem.*, **116**, 169 (1936).
4) E.J. Reist, L. Goodman, R.R. Spencer, and B.R. Baker, *J. Am. Chem. Soc.*, **80**, 3962 (1958).
5) J.S. Brimacombe, M. Stacey, and L.C.N. Tucker, *J. Chem. Soc.*, **1964**, 5391.

analogous rearrangement might be expected as an important intermediate for the synthesis of L-*arabino*-aldoses. In order to prepare IV, 3-O-benzyl-1,2-O-isopropylidene-α-D-glucofuranose[6] (V), easily derived from D-glucose, was used as the starting material.

First, we undertook the most direct possible route to prepare IV as follows: Tritylation of V,[7] followed by mesylation with methanesulfonyl chloride in pyridine afforded 3-O-benzyl-1,2-O-isopropylidene-5-O-mesyl-6-O-trityl-α-D-glucofuranose (VI), mp 160—161°, in a fair yield. However, it was found that attempted methyl glycosidation of VI under removal of the 1,2-isopropylidene group with acids in methanol was not successful, giving an unseparable complex reaction mixture.

We next attempted to change the order of blocking of these O-functions of V and treatment of V with phosgene in pyridine gave 3-O-benzyl-1,2-O-isopropylidene-α-D-glucofuranose 5,6-carbonate (VII), mp 119—120°, $[\alpha]_D^{18}$ −53°. Methanolysis of VII with 1.2% methanolic sulfuric acid under removal of the 1,2-O-isopropylidene group was successful, affording an anomeric mixture of methyl 3-O-benzyl-D-glucofuranosides 5,6-carbonates which was separated by column chromatography on silica gel to a crystalline α-anomer (VIIIa) of mp 62—63°, $[\alpha]_D^{29}$ +93°, and a syrupy β-anomer (VIIIb) of $[\alpha]_D^{30}$ −61.2°. VIIIa and VIIIb were benzylated with benzyl chloride and silver oxide in dimethylformamide,[8] yielding the corresponding syrupy methyl 2,3-di-O-benzyl-D-glucofuranoside 5,6-carbonates; α-anomer (IXa), $[\alpha]_D^{27}$ −97.5°, and β-anomer (IXb), $[\alpha]_D^{27}$ −52.5°. Successive hydrolysis of IXa and IXb with aqueous acetone solution of 0.33N barium hydroxide afforded the corresponding methyl 2,3-di-O-benzyl-D-glucofuranosides; α-anomer (Xa) as a waxy solid and β-anomer (Xb) as prisms of mp 59—61°.

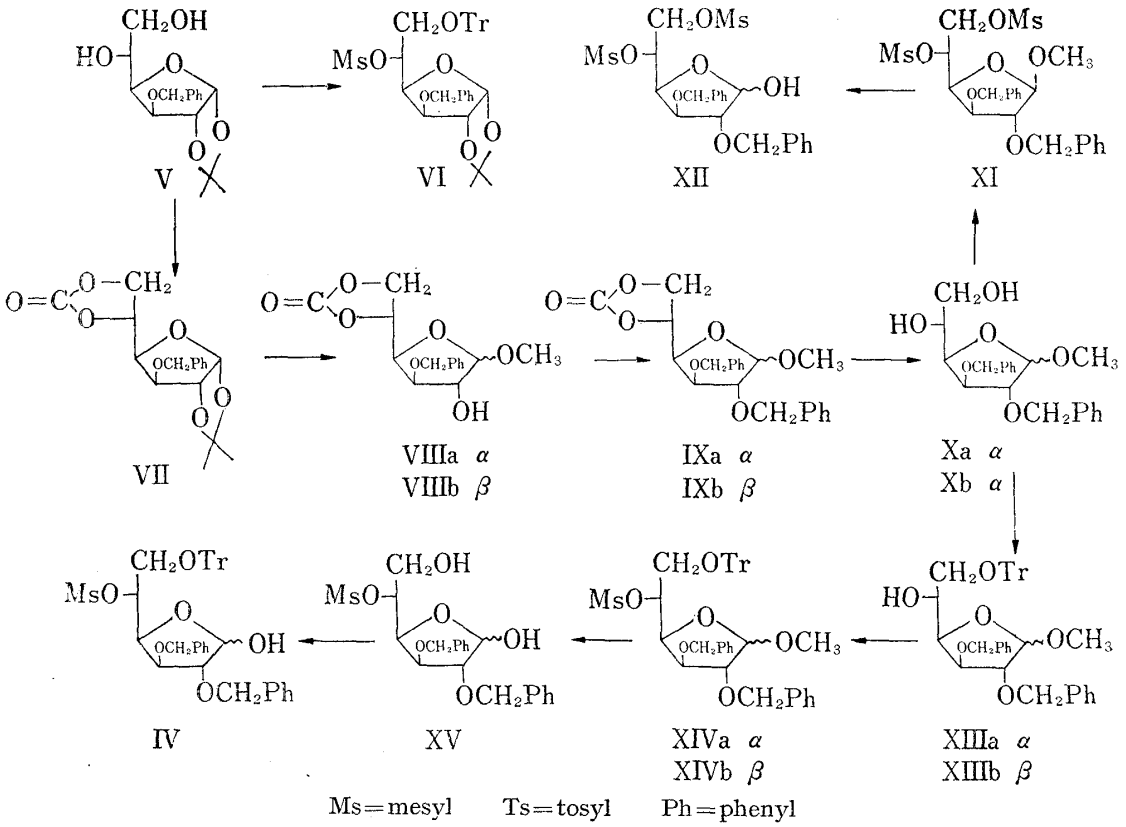

Chart 2

6) A.S. Meyer and T. Reichstein, *Helv. Chim. Acta*, **29**, 156 (1946).
7) R.E. Gramera, R.M. Bruce, S. Hirase, and R.L. Whistler, *J. Org. Chem.*, **28**, 1401 (1963).
8) R. Kuhn, I. Löw, and H. Trischman, *Chem. Ber.*, **90**, 203 (1957).

Direct dimesylation of the 5- and 6-O-functions of Xb was undertaken and a syrupy dimesylate (XI) was obtained.[9] Hydrolysis of XI in aqueous acetone solution of sulfuric acid at 60° gave a syrupy 2,3-di-O-benzyl-5,6-di-O-mesyl-D-glucofuranose (XII). A preliminary attempt on solvolysis of XII with bases did not give any satisfactory result, and was not further pursued.

Tritylation of methyl 2,3-di-O-benzyl-β-D-glucofuranoside (Xb), followed by mesylation of the resulting tritylated compound (XIIIb) with methanesulfonyl chloride in pyridine gave a syrupy methyl 2,3-di-O-benzyl-5-O-mesyl-6-O-trityl-β-D-glucofuranoside (XIVb), $[\alpha]_D^{28}$ +4.7°, whose hydrolysis in aqueous acetone solution of sulfuric acid at 60° resulted in the formation of 2,3-di-O-benzyl-5-O-mesyl-D-glucofuranose (XV), mp 101—105° and 108—109° (two crystal forms). Similar treatment of the α-anomer (Xa) also gave the same 5-O-mesyl compound (XV). Partial tritylation of XV thus obtained[10] was carried out in dimethylformamide in the presence of silver oxide, yielding the objective 2,3-di-O-benzyl-5-O-mesyl-6-O-trityl-D-glucofuranose (IV), mp 119—121°, $[\alpha]_D^{20}$ +23.3°.

Solvolysis of IV was carried out at room temperature by treatment with 1—2 moles of sodium methoxide in methanol. The resulting reaction mixture was chromatographed on silica gel and afforded a small amount of a crystalline substance (XVI), mp 98—99.5°, $[\alpha]_D^{20}$ +16.1°, and a syrupy fraction (XVII) corresponding to the anomeric mixture of the expected methyl 2,3-di-O-benzyl-6-O-trityl-L-altrofuranosides in 50.3% yield. Elementary analysis of XVI showed its molecular formula as $C_{39}H_{36}O_5$. The infrared spectrum of XVI exhibited no absorption corresponding to a hydroxyl, carbonyl, or sulfonate group, and its NMR spectrum did not indicate the presence of a methoxyl group or a mesyl group. Based on these data, XVI might be formulated as 1,5-anhydro-2,3-di-O-benzyl-6-O-trityl-α-L-idofuranose. Formation of XVI would be illustrated as an attack of the hemiacetal hydroxyl group of IV on the carbon at the 5-position under removal of the mesyl group. Consequently, XVI would be an idose derivative having an inverted configuration at the 5-position of IV, although there is no certain chemical proof on its configuration.

The syrupy fraction of methyl 2.3-di-O-benzyl-6-O-trityl-L-altrofuranosides (XVII) was difficult to be separated into each anomer by a chromatographic procedure. This fraction was further treated with an aqueous acetone solution of acetic acid and the resulting detritylated mixture was chromatographed on silica gel, yielding methyl 2,3-di-O-benzyl-α-L-altrofuranoside (XVIIIa) as a syrup of $[\alpha]_D^{20}$ −55.8° in 25.8% yield and its β-anomer (XVIIIb) as a glassy amorphous solid of $[\alpha]_D^{20}$ +55.5° in 46.9% yield.

As for these structural assignments, both XVIIIa and XVIIIb were oxidized with lead tetraacetate in benzene to give the corresponding methyl 2,3-di-O-benzyl-α-L-*arabino*-pentodialdo-1,4-furanoside (XIXa) and its β-anomer (XIXb), respectively. The structures of XIXa and XIXb were confirmed by comparison of their semicarbazones, mp 121—124° for XIXa and mp 154—156° for XIXb, with the authentic samples[11] synthesized by oxidation of the corresponding methyl 2,3-di-O-benzyl-L-arabinofuranosides (XXa and XXb). Further additional proof was given by reduction of the dialdo α derivative (XIXa) with sodium borohydride, followed by tritylation to give the identical methyl 2,3-di-O-benzyl-5-O-trityl-α-L-arabinofuranoside (XXIa), mp 80—81°, $[\alpha]_D^{27}$ −41.2°, with the one derived from L-arabinose.[11]

9) As a by-product of this mesylation of Xb, a syrupy halide, corresponding to a monomesyl monochloride, $C_{22}H_{27}O_7SCl$, was separated. Further study on its structure was not made due to scarcity of the sample.

10) Partial blocking of the 6-O-function of XV with a tetrahydropyranyl group was also investigated; and 2,3-di-O-benzyl-5-O-mesyl-6-O-tetrahydropyranyl-D-glucofuranose was obtained as a syrup in a lower yield, while formation of the possible 1,6-O-disubstituted substance was also observed.

11) These synthetic data will be given in the following paper. Identifications with these authentic samples were made by means of infrared and NMR spectrometry, mixed melting point, and thin-layer chromatography.

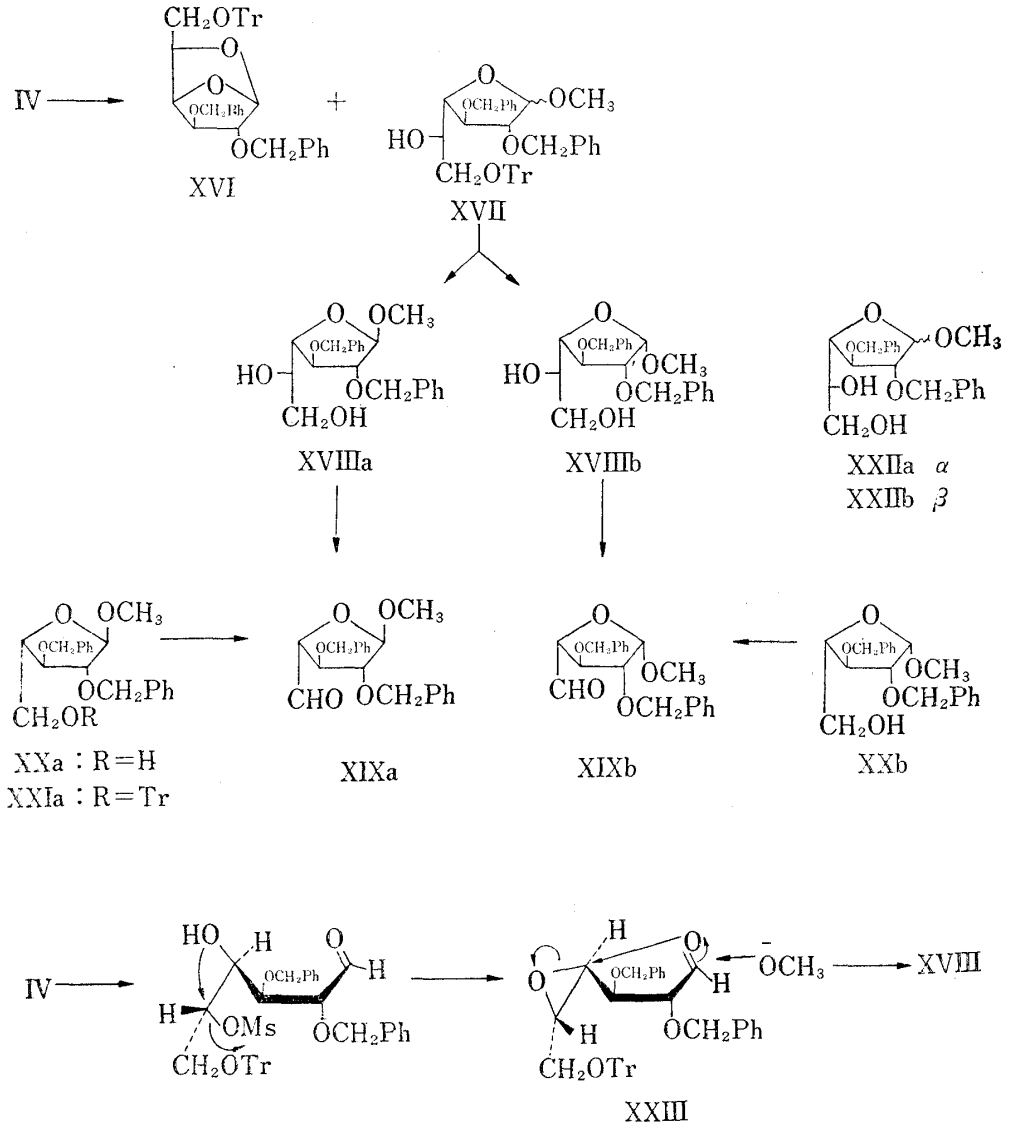

Chart 3 [Ms=mesyl, Tr=trytyl, Ts=tosyl, Ph=phenyl]

On the other hand, neither the rearrangement product (XVIIIa) nor its anomer (XVIIIb) was identical with the corresponding methyl 2,3-di-O-benzyl-α-D-galactofuranoside (XXIIa), mp 83—85°, and its β-anomer (XXIIb), mp 89—91°, synthesized from D-galactose.[11] Based on these facts, these rearrangement products (XVIIIa and XVIIIb) were designated as methyl 2,3-di-O-benzyl-α-L-altrofuranoside and its β-anomer, respectively, although direct comparison with the samples synthesized by an unequivocal route has not been accomplished.

The detritylated reaction mixture described above was trifluoroacetylated in acetonitrile,[12] and analysed by gas chromatography, using a column packed with 1.5% SE-30 on Chromosorb-W, indicating that the ratio of the α-altrofuranoside (XVIIIa) and its β-anomer (XVIIIb) was 1 to 2.2, as shown in Fig. 1. The predominance of the β-anomer (XVIIIb) was also coincident with the yield of each component resulting from the chromatographic separation of the reaction mixture.

Finally, it was concluded that the rearrangement observed in the rhamnofuranose derivative (I) is also applicable to the glucofuranose derivative (IV) without any substantial effect on the configuration or substitution of 2- and 3-hydroxyl groups. An analogous possible

12) M. Vilkas, Hiu-I-Jan, G. Boussac, and M-C. Bonnard, *Tetrahedron Letters*, **1966**, 1441.

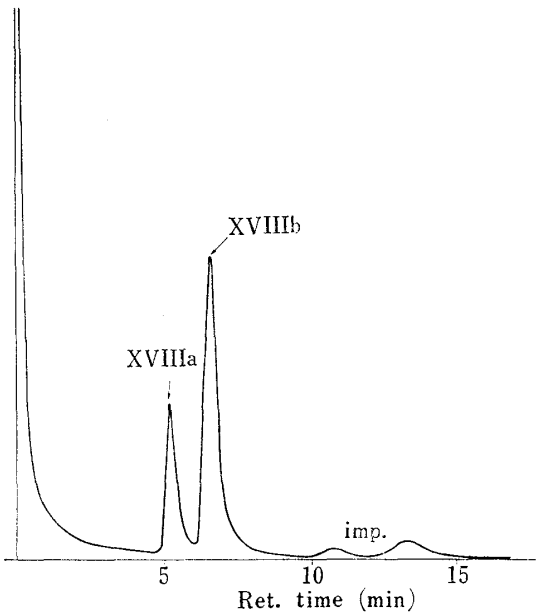

Fig. 1.

Column: 1.5% SE-30 on Chromosorb-W(60/80), 1.5 m, diameter 4 mm, U-shaped stainless steel column
Column temp.: 203°

mechanism for this conversion is depicted by IV→XXIII→XVIII in Chart 3. However, there is no coincidence concerning the component of these reaction products. It was reported[4] that the conversion of I to II was effected in 60% yield, β-D-allofuranoside (II) predominating, and, consequently, the conversion of I to II should proceed under a stereospecificity in the β-attack of a methoxide ion on the epoxyaldehyde (III), avoiding the α-side hindered by the isopropylidene group. On the other hand, in the case of IV, analogous conversion occurred under nonstereospecificity to give both anomers (XVIIIa and XVIIIb), the latter forming predominantly, which corresponds to a β-attack of a methoxide ion to the presumed epoxyaldehyde intermediate (XXIII) based on a concerted pathway from a rather hindered side. Therefore, it may be considered that the attack of a methoxide ion on XXIII will be oriented freely or under other possible factors, different from the case of the intermediate (III) rigidly fixed by the isopropylidene group. Further work in this field is in progress.

Experimental

Melting points are not corrected. Infrared spectra were taken on a Perkin-Elmer Model 21 and proton magnetic resonance spectra (NMR) on a Varian A-60 with Me_4Si as an internal standard. The removal of solvents *in vacuo* was accomplished by a rotating flash evaporator at 20—30 mm and usually at 35—50°. Plates for thin-layer chromatography were prepared with Silica Gel G (E. Merck AG). Visualization of spots was effected by spraying a solution of NH_4VO_3 in 50% H_2SO_4, followed by heating.

3-O-Benzyl-1,2-O-isopropylidene-5-O-mesyl-6-O-trityl-α-D-glucofuranose (VI)——To an ice-cooled solution of 14.8 g of 3-O-benzyl-1,2-O-isopropylidene-6-O-trityl-α-D-glucofuranose[7] in 110 ml of pyridine was added dropwise 4.1 ml of MsCl at below 12° with stirring, and the mixture was allowed to stand for 72 hr, at room temperature. The resulting mixture was diluted with 110 ml of $CHCl_3$ and washed successively with ice-water, dil. $NaHCO_3$ solution, and H_2O. The $CHCl_3$ layer was dried over anhyd. $MgSO_4$ and evaporated *in vacuo*. To the residue was added 15 ml of toluene and was evaporated *in vacuo*. The residue obtained by repeating this procedure for the removal of pyridine was digested with 100 ml of MeOH, giving 13.3 g (78.7%) of crude crystals which were recrystallized from MeOH containing a small amount of $CHCl_3$ to 11.0 g of VI as rods, mp 160—161°. *Anal.* Calcd. for $C_{36}H_{38}O_8S$: C, 68.55; H, 6.07; S, 7.20. Found: C, 68.43; H, 6.00; S. 7.41.

3-O-Benzyl-1,2-O-isopropylidene-α-D-glucofuranose 5,6-Carbonate (VII)——Crude syrupy 3-O-benzyl-1,2-O-isopropyridene-α-D-glucofuranose[6] (V) (33 g), dissolved in 100 ml of dry pyridine, was treated with phosgene with vigorous stirring at 0° for 1 hr, and then dry N_2 was passed through the mixture for 30 min. To this mixture 500 ml of $CHCl_3$ was added to dissolve the precipitated mass and then the $CHCl_3$ solution was washed successively with 200 ml of ice-water, 200 ml of dil. $NaHCO_3$ solution, and H_2O, dried over anhyd. $MgSO_4$, and evaporated *in vacuo* to give a viscous brown syrup which crystallized on digestion with MeOH. Recrystallization from MeOH gave 25.5 g of the carbonate (VII), mp 119—120°, $[\alpha]_D^{28}$ −53° (c=3.7, $CHCl_3$). IR (Nujol, cm^{-1}) 1760 (C=O). *Anal.* Calcd. for $C_{17}H_{20}O_7$: C, 60.71; H, 5.99. Found: C, 60.34; H, 5.96.

Methyl 3-O-Benzyl-α-D-glucofuranoside 5,6-Carbonate (VIIIa) and Its β-Anomer (VIIIb)——A solution of 21 g of VII dissolved in 375 ml of warm MeOH was cooled, conc. H_2SO_4 (4.5 ml) was added slowly, and the mixture was kept at 45° for 5 hr. The mixture was neutralized with $BaCO_3$, filtered, and evaporated to dryness *in vacuo*. The residue was extracted with $CHCl_3$ and the extract was evaporated *in vacuo* to give 19.4 g of an anomeric mixture of VIIIa and VIIIb as a pale-yellow syrup. IR (liquid, cm^{-1}) 3500 (OH).

This mixture was dissolved in $CHCl_3$ and adsorbed on a column (diam. 5 cm) of silica gel (540 g) packed in $CHCl_3$. The column was first washed with $CHCl_3$ (3 liter) and then eluted with MeOH-$CHCl_3$ (1:99 v/v)

(5.4 liter, fractions 1—18). Each fraction was checked by thin-layer chromatography (MeOH–$CHCl_3$ 2:98 v/v). Removal of the solvent from fractions 3—9 afforded 6.81 g (35%) of the α-anomer (VIIIa) as a colorless syrup and, from fractions 11—18, 12.27 g (62.1%) of the β-anomer (VIIIb) as a colorless syrup. The α-anomer was crystallized from EtOH–petr. ether at 0°, but not the β-anomer. The analytical sample of VIIIa had mp 62—63°, $[\alpha]_D^{29}$ +93.3° (c=2.7, MeOH). NMR ($CDCl_3$, τ), 6.50 (singlet, $-OCH_3$, 3H); 4.95 (doublet, J=5 cps, anomeric proton, 1H). *Anal.* Calcd. for $C_{15}H_{18}O_7$: C, 58.06; H, 5.85. Found: C, 57.69: H, 5.89. The analytical sample of VIIIb was a viscous syrup, $[\alpha]_D^{30}$ −61.2° (c=3.3, MeOH). NMR ($CDCl_3$, τ), 6.60 (singlet, OCH_3, 3H); 5.09 (singlet, anomeric proton, 1H). *Anal.* Found: C, 57.79; H, 6.05.

Methyl 2,3-Di-O-benzyl-α-D-glucofuranoside 5,6-Carbonate (IXa) and Its β-Anomer (IXb)——A mixture of 10.8 g of VIIIb, 14.8 ml of benzyl bromide, 60 ml of dimethyl formamide and 20 g of Ag_2O was shaken at room temperature for 5 days. After the solid was filtered off, the filtrate was evaporated at 80—100° under a reduced pressure (2—5 mm) to give a brown syrup which was dissolved in $CHCl_3$ and filtered. The product obtained by removal of the solvent contained a small amount of benzyl bromide and benzyl alcohol. Therefore, to remove these impurities, the syrupy product was acetylated with Ac_2O–pyridine in the usual manner. The acetylated viscous syrup thus obtained was chromatographed on 480 g of silica gel. After removal of the impurities (benzyl bromide and benzyl acetate) by washing with benzene, the columm was eluted with AcOEt–benzene (1:9 v/v). Evaporation of the solvent gave 12.0 g (85%) of IXb as a colorless syrup, $[\alpha]_D^{27}$ −52.5 (c=3.2, $CHCl_3$). The infrared spectra of this syrup (IXb) showed no hydroxyl band. *Anal.* Calcd. for $C_{22}H_{24}O_7$: C, 66.00; H, 6.05. Found: C, 65.71; H, 6.18.

Benzylation of VIIIa as for IXb afforded IXa as a colorless syrup, $[\alpha]_D^{27}$ +97.5° (c=3.3, $CHCl_3$) in 75% yield. *Anal.* Found: C, 65.15; H, 6.00.

Methyl 2,3-Di-O-benzyl-α-D-glucofuranoside (Xa) and Its β-Anomer (Xb)——To a mixture of 10.0 g of IXb and 200 ml of 0.33N $Ba(OH)_2$ solution, was added acetone until the precipitated oil dissolved. The mixture was refluxed for 30 min and the solid formed on addition of Dry Ice was filtered off. The residue obtained by evaporation of the solvent *in vacuo* from the filtrate was extracted with $CHCl_3$. Removal of the solvent from the extract afforded 9.3 g of a crude syrup of Xb which crystallized slowly on standing. Recrystallization from ether yielded 8.2 g (88% yield) of Xb as silky needles of mp 59—61°, $[\alpha]_D^{27}$ −59.3° (c=2.7, $CHCl_3$). *Anal.* Calcd. for $C_{21}H_{26}O_6$: C, 67.36; H, 7.00. Found: C, 67.15; H, 6.73.

Hydrolysis of IXa as for Xb afforded Xa as a waxy solid, $[\alpha]_D^{19}$ +75.3° (c=3.4, $CHCl_3$). *Anal.* Found: C, 67.22; H, 7.08.

Methyl 2,3-Di-O-benzyl-5,6-di-O-mesyl-β-D-glucofuranoside (XI) and 2,3-Di-O-benzyl-5,6-di-O-mesyl-D-glucofuranose (XII)——As decribed for VI, 3.0 g of Xb was treated with 2.4 g of MsCl in 12 ml of pyridine. The resulting product was chromatographed on 150 g of silica gel and fractions eluted with AcOEt–benzene (1:9 v/v) was evaporated, giving 3.1 g (73% yield) of XI as a colorless syrup, $[\alpha]_D^{28}$ −22.5° (c=3.0, $CHCl_3$). *Anal.* Calcd. for $C_{23}H_{30}O_{10}S_2$: C, 52.06; H, 5.70; S, 12.09. Found: C, 52.09; H, 5.63; S, 11.71.

The fast moving fraction eluted with benzene afforded a chlorine-containing syrup (0.7 g), $[\alpha]_D^{27}$ −43.2° (c=3.2, $CHCl_3$). *Anal.* Calcd. for $C_{22}H_{27}O_7SCl$: C, 56.10; H, 5.78. Found: C, 56.21; H, 5.86. The infrared spectrum of this syrup exhibited no hydroxyl band, and its NMR spectrum suggested the presence of one mesyl group and one chloro group.

A solution of 1.0 g of XI in 100 ml of 50% aqueous acetone containing 1.35 ml of conc. H_2SO_4 was kept at 50—60° for 20 hr. The cooled reaction mixture was neutralized with $BaCO_3$, filtered, and evaporated, giving 0.91 g of a pale-yellow syrup, which was chromatographed on 50 g of silica gel. Removal of the solvent from fractions eluted with AcOEt–benzene (1:9 v/v) gave 0.76 g of XII as a colorless syrup which was not purified further. *Anal.* Calcd. for $C_{22}H_{28}O_{10}S_2$: S, 12.42. Found: S, 12.84.

Methyl 2,3-Di-O-benzyl-5-O-mesyl-6-O-trityl-β-D-glucofuranoside (XIVb) and Its α-Anomer (XIVa)——A solution of 7.5 g of Xb and 6.8 g of trityl chloride in 30 ml of pyridine was kept at 50—60° for 112 hr. The cooled mixture was diluted with 120 ml of $CHCl_3$ and 120 ml of H_2O. After shaking the mixture, the separated $CHCl_3$ layer was washed with dil. $NaHCO_3$ solution and H_2O, and dried over anhyd. $MgSO_4$. Removal of the solvent *in vacuo* gave 14.3 g of a viscous syrup, which was dissolved in benzene and poured on a column of 600 g of silica gel, and the column was washed with benzene. The first component emerging from the column was 1.2 g of triphenylcarbinol and the next was 11.4 g (92% yield) of a trityl ether of Xb (XIIIb) containing a small amount of triphenylcarbinol. XIIIb was not obtained as an analytically and thin-layer chromatographically pure substance.

To an ice-cooled solution of 10.0 g of XIIIb thus obtained in 60 ml of pyridine was added dropwise 2.9 g of mesyl chloride and the mixture was allowed to stand at room temperature for 72 hr. The resulting mixture was shaken with 250 ml of $CHCl_3$ and 150 ml of ice-water, the separated $CHCl_3$ layer was washed with dil. $NaHCO_3$ solution and H_2O, and dried over anhyd. $MgSO_4$. Removal of the solvent *in vacuo* afforded 9.3 g of a very thick syrup which was chromatographed on 450 g of silica gel packed in benzene. The fast moving component with benzene was a small amount of triphenylcarbinol and the following was 7.8 g (74%) of XIVb as a syrup, $[\alpha]_D^{28}$ +4.7° (c=3.0, $CHCl_3$). IR (liquid, cm^{-1}) 1355, 1175 ($-OSO_2-$). NMR ($CDCl_3$, τ), 2.3—2.9 (multiplet, aromatic proton, 25H); 5.17 (broad singlet, anomeric proton, 1H); 6.85 (singlet, CH_3O-, 3H); 7.17 (singlet, CH_3SO_3-, 3H). *Anal.* Calcd. for $C_{41}H_{42}O_8S$: C, 70.87; H, 6.09; S, 4.61. Found: C, 70.89; H, 6.25; S, 4.52.

Tritylation of Xa as described for XIIIb, followed by mesylation afforded XIVa, as needles (from MeOH), mp 149—151°, $[\alpha]_D^{19}$ +66.8° (c=3.0, $CHCl_3$). IR (Nujol, cm^{-1}) 1345, 1160 (–OSO_2–). NMR ($CDCl_3$, τ), 2.4—2.9 (multiplet, aromatic proton, 25H); 5.28 (doublet, J=5 cps, anomeric proton, 1H); 6.67 (singlet, CH_3O–, 3H); 7.08 (singlet, CH_3SO_3–, 3H). *Anal.* Calcd. Found: C, 70.69; H, 6.08; S, 4.58.

2,3-Di-O-benzyl-5-O-mesyl-D-glucofuranose (XV)——To a solution of 7.5 g of XIVb in 750 ml of acetone was added slowly a mixture of 75 ml of conc. H_2SO_4 and 375 ml of H_2O, and the mixture was kept at 60° for 6 hr. The precipitate of triphenylcarbinol formed by dilution with 1.5 liter of H_2O was filtered off and the filtrate was concentrated *in vacuo* at below 45° until crystalline materials precipitated. After standing in an ice-bath for 1 hr, the resulting precipitate was collected, washed with H_2O, and dissolved in 230 ml of $CHCl_3$. The $CHCl_3$ solution was washed with dil. $NaHCO_3$ solution and H_2O, dried over anhyd. $MgSO_4$, and concentrated *in bvacuo* to a volume of about 15—25 ml After petr. ether was added to turbidity, the concentrate was allowed to stand in an ice-bath, giving 4.0 g of XV (84% yield), which formed two kinds of crystals, depending to its recrystallization condition; one of plates, mp 108—109°, $[\alpha]_D^{20}$ +7.4° (2 min) →+11.1° (2 hr) (c=3.6, $CHCl_3$), and the other of silky needles, mp 101—105° (softening at 98°), $[\alpha]_D^{20}$ +15.6° (2 min)→+9.7° (2 hr) (c=3.8, $CHCl_3$). The infrared spectra of these crystals in Nujol mull were different, but the NMR spectra in $CDCl_3$ were identical. IR ($CHCl_3$, cm^{-1}) 1350, 1170 (–OSO_2–). NMR ($CDCl_3$, τ) 6.97 (doublet, CH_3SO_3–, 3H). *Anal.* Calcd. for $C_{21}H_{26}O_8S$: C, 57.52; H, 5.98; S, 7.31. Found: C, 57.37; H, 6.06; S, 7.73 (plates), C, 57.14; H, 5.84; S, 7.56 (needles).

The same compound (XV) was also obtained by the analogous treatment of the α-anomer (XIVa).

2,3-Di-O-benzyl-5-O-mesyl-6-O-trityl-D-glucofuranose (IV)——To a solution of 20 g of XV and 15.10 g of trityl chloride in 125 ml of dimethyl formamide was added 17.05 g of Ag_2O. The mixture was shaken at room temperature for 5 days and filtered. The filtrate was evaporated *in vacuo* at below 45°. The residue was dissolved in $CHCl_3$ and filtered. The filtrate was evaporated *in vacuo* to give 36 g of a thick syrup, which was dissolved in benzene and poured on a silica gel column (1500 g, diam. 10 cm) packed in benzene. The column was first washed with benzene to remove triphenylcarbinol and then with a mixture of AcOEt–benzene (3:97 v/v) which afforded 12.5 g (40.1% yield) of a crude syrup of IV. The column was then eluted with AcOEt–benzene (3:7 or 2:3 v/v) to recover the unchanged XV (9 g). Recrystallization from MeOH gave 11.0 g (63.8% based on the changed material) of the analytical sample of IV, mp 119—121°, $[\alpha]_D^{20}$ +23.2° (c=2.4, $CHCl_3$). IV did not show mutarotation in $CHCl_3$. *Anal.* Calcd. for $C_{40}H_{40}O_8S$: C, 70.57; H, 5.92; S, 4.71. Found: C, 70.38; H, 5.76; S, 4.94.

Solvolysis of 2,3-Di-O-benzyl-5-O-mesyl-6-O-trityl-D-glucofuranose (IV) with MeONa——To a cooled solution of 3.15 g (4.6 mmole) of IV in 20 ml of abs. MeOH was added slowly 9.3 ml of 1N MeOH solution of NaOMe (9.3 mmoles) and the mixture was allowed to stand overnight at room temperature. The resulting precipitate (sodium mesylate) was filtered off and Dry Ice was added to the filtrate to destroy excess NaOMe. Evaporation of the solvent *in vacuo* was followed by extraction of the residue with $CHCl_3$, and the extract was evaporated *in vacuo* to give 2.91 g of a syrup which was chromatographed on silica gel column (diam. 34 mm, 140 g) packed in benzene. Elution with benzene (1.2 liter) gave 260 mg of 1,5-anhydro-2,3-di-O-benzyl-6-O-trityl-α-L-idofuranose (XVI), mp 98 —99.5°, $[\alpha]_D^{20}$ +16.1° (c=2.5, $CHCl_3$). *Anal.* Calcd. for $C_{39}H_{36}O_5$: C, 80.11; H, 6.21. Found: C, 80.06; H, 6.14.

The following elution with EtOAc–benzene (3:97 v/v) (600 ml) gave 1.54 g (50.3% yield) of a syrupy anomeric mixture of methyl 2,3-di-O-benzyl-6-O-trityl-L-altrofuranoside (XVII). *Anal.* Calcd. for $C_{40}H_{40}O_6$: C, 77.89; H, 6.53. Found: C, 77.61; H, 6.49.

Finally, elution with EtOAc–benzene (1:9 v/v) gave 700 mg of a syrupy mixture, whose infrared and NMR spectra suggested the presence of an aldehyde function.

In another run, the solvolysis was carried out, using one equivalent of NaOMe, and 256 mg of XVI, 1.40 g (39.7% yield) of XVII, and 1.3 g of an unidentified mixture were obtained.

A solution of 2.23 g of XVII thus obtained in a mixture of 85 ml of AcOH, 35 ml of H_2O, and 15 ml of acetone was warmed on a boiling water bath for 1 hr. The cooled reaction mixture was diluted with 40 ml of H_2O and kept in an ice-box for 1 hr. The resulting precipitate (triphenylcarbinol) was filtered off and the filtrate was evaporated *in vacuo* to dryness, giving 1.4 g of an amorphous residue which was chromatographed on 60 g of silica gel. The column was first washed with $CHCl_3$ to remove triphenylcarbinol (0.2 g) and unidentified acetylated materials (0.2 g), and successively with 35-ml portions of a mixture of EtOAc–hexane (2:3 v/v). The fractions 9—17 gave, after evaporation, 344 mg (25.8% yield) of methyl 2,3-di-O-benzyl-α-L-altrofuranoside (XVIIIa) as a syrup of $[\alpha]_D^{20}$ −55.8° (c=2.7, $CHCl_3$), and the fractions 18—46 gave 629 mg (46.9% yield) of its β-anomer (XVIIIb) as a glassy powder of $[\alpha]_D^{20}$ +55.5° (c=2.7, $CHCl_3$). *Anal.* Calcd. for $C_{21}H_{26}O_6 \cdot \frac{1}{4}H_2O$: C, 66.56; H, 7.05. Found C, 66.50; H, 6.94 (XVIIIa): C, 66.59; H, 7.08 (XVIIIb).

Methyl 2,3-Di-O-benzyl-α-L-*arabino*-pentodialdo-1,4-furanoside (XIXa), Its β-Anomer (XIXb) and Their Semicarbazones——To a solution of 200 mg of XVIIIb in 3 ml of dry benzene, 315 mg of $Pb(AcO)_4$ was added. After the mixture was kept at 50—55° for 15 min, a small amount of ethylene glycol was dropped until excess of $Pb(AcO)_4$ was consumed, and then filtered. The filtrate was evaporated *in vacuo* at below 50° to give 180 mg of a crude syrup of XIXb which formed a crystalline semicarbazone in aqueous MeOH. Recrystallization from EtOH afforded the semicarbazone of XIXb as needles of mp 154—156°, $[\alpha]_D^{20}$ +20.1° (c=2.1, $CHCl_3$). *Anal.* Calcd. for $C_{21}H_{25}O_5N_3$: C, 63.14; H, 6.31; N, 10.52. Found: C, 62.86; H, 6.37; N, 10.69.

The α-anomer (XVIIIa) was oxidized with $Pb(AcO)_4$ as described for XVIIIb to give XIXa which was characterized as its semicarbazone of mp 121—124°, $[\alpha]_D^{20}$ −46.4° (c=1.1, $CHCl_3$). *Anal.* Found: C, 63.18; H, 6.22; N, 10.28.

These semicarbazones of XIXa and XIXb were identified with the authentic samples[11] by means of mixed mp, and infrared and NMR spectrometry.

Methyl 2,3-Di-O-benzyl-6-O-trityl-α-L-arabinofuranoside (XXIa)——Fifty mg of XIXa were treated with 10 mg of $NaBH_4$ in 1.5 ml of EtOH at room temperature for 1.5 hr. After addition of a small amount of AcOH, the mixture was concentrated and diluted with 10 ml of benzene. The benzene solution was washed with H_2O, dried over anhyd. $MgSO_4$, and evaporated *in vacuo*. Treatment of the residue with trityl chloride in pyridine at 100° for 2 hr afforded XXIa, mp 80—81°, which was identified with the synthetic sample[11] by means of mixed mp, and infrared and NMR spectrometry.

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