997. *Glycosides. Part III.*[1] *Synthetic Proof for the Structure of Sophorose* (2-O-β-D-*Glucopyranosyl*-D-*glucose*).

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Unambiguous syntheses of sophorose and of methyl β-sophoroside prove that sophorose is 2-*O*-β-D-glucopyranosyl-D-glucose.

SOPHOROSE, the disaccharide obtained by hydrolysis of kæmpferol sophoroside,[2,3] a pigment occurring in the pod of *Sophora japonica* L., and of stevioside,[4] the sweet principle of *Stevia rebaudiana* Bertoni, is considered to be 2-*O*-β-D-glucopyranosyl-D-glucose (Ia). The structure is based on the production from sophorose of glucosazone rather than a disaccharide osazone,[5,6] on the methylation work of Rabaté,[5] on the periodate oxidation

[1] Part II, *J.*, 1962, 4214.
[2] Rabaté and Charaux, *Bull. Soc. Chim. biol.*, 1938, **20**, 454; Rabaté and Dussy, *ibid.*, 1938, **20**, 459, 467.
[3] Freudenberg, Knauber, and Cramer, *Ber.*, 1951, **84**, 144.
[4] Vis and Fletcher, jun., *J. Amer. Chem. Soc.*, 1956, **78**, 4709.
[5] Rabaté, *Bull. Soc. chim. France*, 1940, **7**, 565.
[6] Freudenberg and Soff, *Ber.*, 1936, **69**, 1245.

studies of Clancy,[7] and on the observation that the disaccharide is hydrolysed by almond emulsin.[2] None of the reported chemical syntheses of the disaccharide provides structural proof. The work of Freudenberg and Soff [6] (carried out before the isolation of the disaccharide from natural sources), in which 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide was condensed with methyl 4,6-*O*-benzylidene-α-D-glucopyranoside, gave a compound which was identified with the natural product [3] by comparison of the α-acetobromo-derivatives, while in later extensions [8] of the same synthesis free sophorose was obtained. However, this synthetic route must be dubbed ambiguous. On the other hand, Gakhokidze [9] condensed 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide with 1,3,4,6-tetra-*O*-acetyl-D-glucopyranose (probably the β-anomer [10]), and obtained a compound whose physical constants did not agree with those of sophorose. The present syntheses provide synthetic proof for the structure of the disaccharide.

1,2-*O*-isopropylidene-D-glucofuranose was benzylated [11] to give 3,5,6-tri-*O*-benzyl-1,2-*O*-isopropylidene-D-glucofuranose (II). The latter was treated with benzyl alcohol containing 1% hydrogen chloride, and the resulting crude product was acetylated with acetic anhydride–pyridine to give crystalline benzyl 2-*O*-acetyl-3,5,6-tri-*O*-benzyl-α-D-glucofuranoside (III; R = Ac) in 25% yield. Deacetylation [12] gave syrupy benzyl 3,5,6-tri-*O*-benzyl-α-D-glucofuranoside (III; R = H), which, on methylation followed by hydrogenation, gave crystalline 2-*O*-methyl-D-glucose (72% yield), thus proving that the free hydroxyl group was at the 2-position of the glucose residue. The proton magnetic resonance spectrum * of (III; R = Ac) showed a doublet ($J \sim 6$ c./sec.) at τ 4·67 for the anomeric hydrogen, thus establishing [13] the α-configuration for the compounds (III; R = Ac) and (III; R = H). During the preparation of (III; R = Ac) much dibenzyl ether was formed, presumably from the action of the acid on benzyl alcohol.[14]

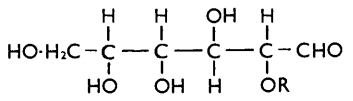
2,3,4,6-Tetra-*O*-acetyl-α-D-glucopyranosyl bromide condensed with benzyl 3,5,6-tri-*O*-benzyl-α-D-glucofuranoside (III; R = H) under the usual Koenigs–Knorr reaction conditions,[15] which are well known to give the β-D-glucopyranose. The crystalline condensation product (III; R = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl) was hydrogenated to give crystalline 2-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-D-glucose (Ib). The latter on deacetylation [12] gave crystalline sophorose, identical (m. p. and mixed m. p., infrared spectrum) with the natural product. The synthetic material was further characterised by conversion into crystalline octa-*O*-acetyl-β-sophorose, which was identical (m. p. and mixed m. p., infrared spectrum) with an authentic specimen. The overall yield of sophorose was 15%, based on (III; R = H).

In another approach to sophorose, 2,4,6-tri-*O*-acetyl-3-*O*-benzyl-α-D-glucopyranosyl bromide [16] was condensed with benzyl alcohol to give benzyl 2,4,6-tri-*O*-acetyl-3-*O*-benzyl-β-D-glucopyranoside (IV; R = Ac) in good yield. Deacetylation [12] gave crystalline benzyl 3-*O*-benzyl-β-D-glucopyranoside (IV; R = H). The latter condensed with benzaldehyde in the presence of zinc chloride to give the benzylidene compound (V; R = H), which crystallised as the monohydrate. Methylation of (V; R = H) with methyl sulphate

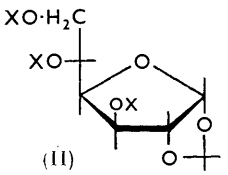
* The spectrum was measured in carbon tetrachloride solution (20%) with an AEI model RS2 spectrometer operating at 60 Mc./sec.; we thank Dr. R. A. Y. Jones for assistance with the interpretation.

[7] Clancy, *J.*, 1960, 4213.
[8] Coxon and Fletcher, jun., *J. Org. Chem.*, 1961, **26**, 2892; Schmidt in "Methods in Carbohydrate Chemistry," Academic Press Inc., New York, 1962, Vol. 1, p. 349.
[9] Gakhokidze, *J. Gen. Chem. U.S.S.R.*, 1941, **11**, 117 (*Chem. Abs.*, 1941, **35**, 5467).
[10] Lemieux and Huber, *Canad. J. Chem.*, 1953, **31**, 1040.
[11] Weygand and Trauth, *Ber.*, 1952, **85**, 57.
[12] Zemplén, *Ber.*, 1926, **59**, 1258.
[13] Abraham, Hall, Hough, and McLauchlan, *J.*, 1962, 3699.
[14] Meisenheimer, *Ber.*, 1908, **41**, 1421.
[15] For reviews see Evans, Reynolds, and Talley, *Adv. Carbohydrate Chem.*, 1951, **6**, 27; Haynes and Newth, *ibid.*, 1955, **10**, 207; Conchie, Levvy, and Marsh, *ibid.*, 1957, **12**, 157.
[16] Finan and Warren, *J.*, 1962, 3089.

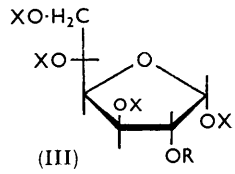
and alkali gave the crystalline methyl ether (V; R = Me), which, on hydrogenation, gave crystalline 2-*O*-methyl-D-glucose, thus proving the position of the benzylidene grouping. The benzylidene compound (V; R = H) in chloroform was treated with calcium sulphate to remove the water of crystallisation, and was then condensed with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide under the usual conditions for the Koenigs–Knorr reaction.[15] The condensation product (V; R = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl) failed to crystallise; it was hydrogenated to give the crystalline tetra-*O*-acetylsophorose derivative (Ib), identical with the product obtained earlier by way of the furanoside intermediate (III; R = H).



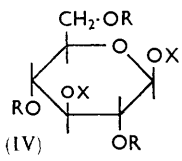
(I) (a : R = β-D-glucopyranosyl)
(b : R = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)



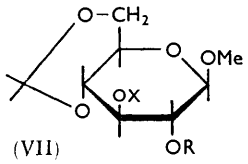
(II)



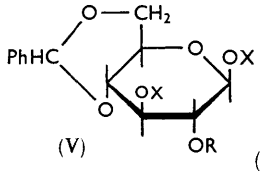
(III)



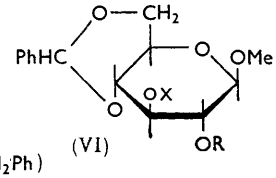
(IV)



(VII)



(V)



(VI)

(X = CH_2Ph)

For the synthesis of methyl β-sophoroside, 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide was condensed with methyl 3-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside [1] (VI; R = H) under the usual Koenigs–Knorr reaction conditions.[15] The product (VI; R = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl) could not be freed from unchanged starting material (VI; R = H). Accordingly, the crude material was hydrogenated and then treated with sodium methoxide in methanol.[12] The resulting product was chromatographed on " Biodeminrolit " mixed-bed ion-exchange material. Elution with methanol gave crystalline methyl β-D-glucopyranoside, arising from (VI; R = H). Elution with 50% aqueous methanol gave crystalline methyl β-sophoroside.

In another approach to methyl β-sophoroside, methyl 3-*O*-benzyl-β-D-glucopyranoside [1] was condensed with acetone in the presence of anhydrous zinc chloride to give syrupy methyl 3-*O*-benzyl-4,6-*O*-isopropylidene-β-D-glucopyranoside (VII; R = H). The latter was methylated to give the syrupy methyl ether (VII; R = Me), which, on treatment with dilute sulphuric acid at room temperature followed by hydrogenation, gave crystalline methyl 2-*O*-methyl-β-D-glucopyranoside. Condensation of 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide with the isopropylidene compound (VII; R = H) under the usual conditions for the Koenigs–Knorr reaction [15] gave the crystalline disaccharide derivative (VII; R = 2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl). Removal of the protecting groups from the latter by, in turn, hydrogenation, treatment with dilute sulphuric acid at room temperature, and deacetylation gave crystalline methyl β-sophoroside.

Finally, methyl β-sophoroside was treated with dilute sulphuric acid at room temperature to give a high yield (88%) of crystalline sophorose.

Experimental

M. p.s are uncorrected. Specific rotations were measured at 22—24°. The light petroleum used had b. p. 40—60°. The alumina used was kept under ethyl acetate for 24 hr., washed with water, then with methanol, and dried at 150° for 4 hr. The calcium sulphate used was "Hi-Drite" (Hi-Drite Ltd., London). "Biodeminrolit" refers to the mixed-bed ion-exchange material (B.D.H.).

3,5,6-*Tri*-O-*benzyl*-1,2-O-*isopropylidene*-D-*glucose* (II).—1,2-*O*-Isopropylidene-D-glucofuranose (30 g.), powdered sodium hydroxide (37 g.), and benzyl chloride (270 ml.) were heated (steam-bath) with vigorous stirring. After 1 hr. more sodium hydroxide (37 g.) was added. After 7 hr. the mixture was cooled, diluted with water (250 ml.), and extracted with ether. The extract was washed with water, dried (Na_2SO_4), and evaporated under reduced pressure; excess of benzyl chloride distilled at 85°/15 mm., followed by dibenzyl ether (b. p. 83—84°/0·05 mm.). The residual syrup was chromatographed on alumina (benzene as eluant) giving 3,5,6-tri-*O*-benzyl-1,2-*O*-isopropylidene-D-glucose (52 g., 78%) as a pale brown oil, $[\alpha]_D$ −35° (*c* 1 in $CHCl_3$) (lit.,[11] −34·7°).

Benzyl 3,5,6-*Tri*-O-*benzyl*-α-D-*glucofuranoside* (III; R = H).—3,5,6-Tri-*O*-benzyl-1,2-*O*-isopropylidene-D-glucose (20 g.) in benzyl alcohol (400 ml.) containing hydrogen chloride (1% w/w) was heated on the steam-bath for 4 hr. After cooling, the mixture was diluted with ether (400 ml.), washed with saturated aqueous sodium hydrogen carbonate and water, and dried (Na_2SO_4). Evaporation of the solvent under reduced pressure left a syrup which was chromatographed on alumina. Elution with acetone–ether (1 : 3) gave an oil (8 g.) which was taken up in pyridine (200 ml.) and treated with acetic anhydride (120 ml.) at room temperature for 24 hr. The mixture was poured into water and extracted with chloroform. The extract was dried (Na_2SO_4) and evaporated to give *benzyl* 2-O-*acetyl*-3,5,6-*tri*-O-*benzyl*-α-D-*glucofuranoside* (6 g., 25%), prisms (from chloroform–light petroleum), m. p. 53—54°, $[\alpha]_D$ +57° (*c* 1 in $CHCl_3$) (Found: C, 74·0; H, 6·5. $C_{36}H_{38}O_7$ requires C, 74·2; H, 6·5%), $\nu_{max.}$ 1730 (C=O of acetate), 1495, 735, and 695 cm.$^{-1}$ (benzyl ether).

The acetate (5·8 g.) was treated with sodium methoxide (from 0·1 g. sodium) in methanol (200 ml.) at room temperature for 12 hr. The solution was passed through a column of "Biodeminrolit" (5 g.) and was then concentrated under reduced pressure to give *benzyl* 3,5,6-*tri*-O-*benzyl*-α-D-*glucofuranoside* (5 g.) as a syrup, $[\alpha]_D$ +36° (*c* 1·2 in $CHCl_3$) (Found: C, 75·4; H, 6·7. $C_{34}H_{36}O_6$ requires C, 75·6; H, 6·7%), $\nu_{max.}$ 3450 (OH), 1492, 730, and 695 cm.$^{-1}$ (benzyl ether).

Methylation of Benzyl 3,5,6-*Tri*-O-*benzyl*-α-D-*glucofuranoside*.—To a mixture of the glucoside (0·96 g.) and powdered sodium hydroxide (1 g.) in tetrahydrofuran (20 ml.), a solution of methyl sulphate (0·7 ml.) in tetrahydrofuran (20 ml.) was added dropwise with stirring at 45°. The mixture was warmed to 70° during 1 hr. and stirred at this temperature for 12 hr. After cooling, water (40 ml.) was added and the mixture extracted with ether. The extract was dried (Na_2SO_4) and evaporated to a syrup which was chromatographed on alumina. Elution with ether gave benzyl 3,5,6-tri-*O*-benzyl-2-*O*-methyl-α-D-glucofuranoside (0·8 g.), a syrup, $[\alpha]_D$ +70° (*c* 0·8 in $CHCl_3$). Without further purification this was taken up in ethyl acetate (50 ml.) and hydrogenated over 10% palladium–charcoal at atmospheric pressure. When hydrogen uptake (120 ml., approx. 4 mol.) had ceased, the mixture was filtered. Evaporation gave 2-*O*-methyl-D-glucose (0·25 g., 72%), m. p. and mixed m. p. 156°.

Benzyl 3-O-*Benzyl*-β-D-*glucopyranoside* (IV; R = H).—2,4,6-Tri-*O*-acetyl-3-*O*-benzyl-α-D-glucopyranosyl bromide[16] (10 g.), benzyl alcohol (30 ml.), and silver carbonate (8 g.) in anhydrous ether (100 ml.) were stirred in darkness at room temperature for 12 hr. The mixture was filtered and the filtrate was evaporated, excess of benzyl alcohol distilling at 52°/0·1 mm. The residue gave *benzyl* 2,4,6-*tri*-O-*acetyl*-3-O-*benzyl*-β-D-*glucopyranoside* (10 g., 80%), needles (from ethanol), m. p. 99—100°, $[\alpha]_D$ −50° (*c* 1 in $CHCl_3$) (Found: C, 63·9; H, 6·1. $C_{26}H_{30}O_9$ requires C, 64·2; H, 6·2%).

Treatment of this product (5 g.) with 0·05% sodium methoxide in methanol at room temperature for 12 hr. gave *benzyl* 3-O-*benzyl*-β-D-*glucopyranoside* (3·5 g., 92%), needles (from ethanol), m. p. 69—70°, $[\alpha]_D$ −47° (*c* 0·8 in $CHCl_3$) (Found: C, 65·5; H, 7·15. $C_{20}H_{24}O_6,C_2H_5OH$ requires C, 65·0; H, 7·4%).

Benzyl 3-O-*Benzyl*-4,6-O-*benzylidene*-β-D-*glucopyranoside* (V; R = H).—Benzyl 3-*O*-benzyl-β-D-glucopyranoside (3 g.), benzaldehyde (20 g.), and anhydrous zinc chloride (3 g.) were stirred

at room temperature for 2·5 hr. Light petroleum was added and the mixture was poured into ice–water. The resulting solid was recrystallised from ethanol, giving *benzyl* 3-O-*benzyl*-4,6-O-*benzylidene*-β-D-*glucopyranoside* (2·1 g., 56%) as needles, m. p. 127—128°, $[\alpha]_D$ −53° (*c* 1 in $CHCl_3$) (Found: C, 69·1; H, 6·2. $C_{27}H_{28}O_6,H_2O$ requires C, 69·5; H, 6·4%), $\nu_{max.}$ (in $CHCl_3$) 3500 (OH), 3450, 3280, and 1645 cm.$^{-1}$ (water). The chloroform solution on drying over calcium sulphate had $\nu_{max.}$ 3540 cm.$^{-1}$ (OH), but no water bands.

Methylation of Benzyl 3-O-*Benzyl*-4,6-O-*benzylidene*-β-D-*glucopyranoside*.—To a mixture of the benzyl glucoside (0·5 g.) and powdered sodium hydroxide in acetone (10 ml.), methyl sulphate (0·2 ml.) in acetone (10 ml.) was added dropwise with stirring at 45°. The mixture was warmed to 60° during 1 hr. and stirred at this temperature for 3 hr. After cooling, water (20 ml.) was added and the mixture extracted with ether. The extract was dried (Na_2SO_4) and evaporated, giving *benzyl* 3-O-*benzyl*-4,6-O-*benzylidene*-2-O-*methyl*-β-D-*glucopyranoside* (0·38 g., 74%) as needles (from ethanol), m. p. 125°, $[\alpha]_D$ −68° (*c* 1 in $CHCl_3$) (Found: C, 72·7; H, 6·9. $C_{28}H_{30}O_6$ requires C, 72·7; H, 6·5%).

This product (0·3 g.) in ethyl acetate (50 ml.) was hydrogenated over 10% palladium–charcoal at atmospheric pressure. When hydrogen uptake (52 ml., approx. 4 mol.) had ceased, the mixture was filtered. Evaporation of the filtrate gave 2-*O*-methyl-D-glucose (0·1 g., 80%), prisms (from ethanol), m. p. and mixed m. p. 156—157°.

2-O-(2,3,4,6-*Tetra*-O-*acetyl*-β-D-*glucopyranosyl*)-D-*glucose* (Ib).—(*a*) A mixture of benzyl 3,5,6-tri-*O*-benzyl-α-D-glucofuranoside (2·8 g.), calcium sulphate (5 g.), and silver carbonate (1 g.) in chloroform (12 ml.) was stirred at room temperature for 1 hr. After the addition of iodine (0·1 g.), 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (2 g.) in chloroform (12 ml.) was added during 1·5 hr., and the mixture was stirred in darkness for a further 24 hr. The mixture was filtered through Celite and the filtrate was evaporated to a syrup which was chromatographed on alumina. Elution with acetone–ether (1 : 3) gave *benzyl* 2-O-(2,3,4,6-*tetra*-O-*acetyl*-β-D-*glucopyranosyl*)-3,5,6-*tri*-O-*benzyl*-α-D-*glucofuranoside* (1·3 g.), needles (from ethanol), m. p. 108—109°, $[\alpha]_D$ +44° (*c* 0·5 in $CHCl_3$) (Found: C, 65·9; H, 6·2. $C_{48}H_{54}O_{15}$ requires C, 66·2; H, 6·2%).

This product (1 g.) in ethyl acetate (50 ml.) was hydrogenated over 10% palladium–charcoal. When hydrogen uptake (106 ml., approx. 4 mol.) had ceased, the mixture was filtered. Evaporation of the filtrate gave 2-O-(2,3,4,6-*tetra*-O-*acetyl*-β-D-*glucopyranosyl*)-D-*glucose* (0·4 g., 15% overall), needles (from ethanol), m. p. 176—177°, $[\alpha]_D$ +14° (*c* 0·8 in MeOH) (Found: C, 46·85; H, 6·1. $C_{20}H_{30}O_{15}$ requires C, 47·1; H, 5·9%), $\nu_{max.}$ (in Nujol) 3400—3200br (OH bonded), 1745—1730br (C=O of acetate), 905 cm.$^{-1}$ (β-glucopyranoside).

(*b*) Benzyl 3-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside (1·35 g.) was condensed with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (1 g.) under the same conditions as in (*a*). The resulting syrup was chromatographed on alumina. Elution with acetone–ether (1 : 3) gave benzyl 3-*O*-benzyl-4,6-*O*-benzylidene-2-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-β-D-glucopyranoside (0·5 g.), a syrup, which without further purification was taken up in ethyl acetate (50 ml.) and hydrogenated over 10% palladium–charcoal at atmospheric pressure. When hydrogen uptake (60 ml., approx. 4 mol.) had ceased, the mixture was filtered. Evaporation gave 2-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-D-glucose (0·1 g., 6·5% overall), m. p. 176—177° undepressed on admixture with the material prepared by method (*a*).

Sophorose.—2-*O*-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl)-D-glucose (0·38 g.) was treated with 2% sodium methoxide in methanol at room temperature for 12 hr. The solution was passed through a column of " Biodeminrolit " (5 g.). Elution with 50% aqueous methanol (200 ml.) gave 2-*O*-β-D-glucopyranosyl-D-glucose (sophorose) (0·14 g., 55%), which crystallised as the *monohydrate*, needles, m. p. 196—197° (Found: C, 40·2; H, 6·4. $C_{12}H_{22}O_{11},H_2O$ requires C, 40·0; H, 6·6%) undepressed on admixture with a specimen of the natural product.

A mixture of sophorose (0·8 g.) and sodium acetate (2 g.) in acetic anhydride (10 ml.) was heated at 120° for 2 hr. The mixture was poured into water and extracted with chloroform. Working up in the usual way gave octa-*O*-acetyl-β-sophorose (0·45 g.), needles (from ethanol), m. p. 191—192°, undepressed on admixture with an authentic specimen.

Methyl 3-O-*Benzyl*-4,6-O-*isopropylidene*-β-D-*glucopyranoside* (VII; R = H).—Methyl 3-*O*-benzyl-β-D-glucopyranoside [16] (4 g.) and zinc chloride (4 g.) in acetone (200 ml.) were heated under reflux for 12 hr. After cooling, the mixture was poured with vigorous stirring into aqueous sodium hydrogen carbonate containing crushed ice. The mixture was filtered and the filtrate was extracted with chloroform. The extract was dried (Na_2SO_4) and evaporated to a

syrup (2·8 g.) which was treated with acetic anhydride–pyridine at room temperature for 12 hr. Working up in the usual way gave *methyl* 2-O-*acetyl*-3-O-*benzyl*-4,6-O-*isopropylidene*-β-D-*glucopyranoside* (2·5 g.), a colourless syrup, $[\alpha]_D$ +5·4° (*c* 0·5 in $CHCl_3$) (Found: C, 62·6; H, 7·1. $C_{19}H_{26}O_7$ requires C, 62·3; H, 7·1%).

The acetate (2·4 g.) was treated with 0·5% sodium methoxide in methanol at room temperature for 12 hr. The solution was passed through a column of " Biodeminrolit " (5 g.). Evaporation under reduced pressure gave methyl 3-O-*benzyl*-4,6-O-*isopropylidene*-β-D-*glucopyranoside* (2 g., 45% overall), a colourless syrup, $[\alpha]_D$ −22·5° (*c* 1·2 in $CHCl_3$) (Found: C, 62·8; H, 7·4. $C_{17}H_{24}O_6$ requires C, 62·95; H, 7·4%).

Methylation of Methyl 3-O-*Benzyl*-4,6-O-*isopropylidene*-β-D-*glucopyranoside*.—To a mixture of the glucoside (0·4 g.) and powdered sodium hydroxide (0·4 g.) in tetrahydrofuran (10 ml.), methyl sulphate (0·3 ml.) in tetrahydrofuran (10 ml.) was added dropwise with stirring at 45°. The mixture was warmed to 70° during 1 hr. and was stirred at this temperature for 12 hr. After cooling, water (20 ml.) was added and the mixture extracted with ether. The extract was dried (Na_2SO_4) and evaporated to a syrup which was chromatographed on alumina. Elution with ether gave methyl 3-*O*-benzyl-4,6-*O*-isopropylidene-2-*O*-methyl-β-D-glucopyranoside (0·35 g.), a syrup, $[\alpha]_D$ −25° (*c* 0·5 in $CHCl_3$) (no OH bands in the infrared spectrum). Without further purification, this product was dissolved in methanol (30 ml.), N-sulphuric acid (5 ml.) was added, and the resulting solution was left at room temperature until the specific rotation was constant (24 hr.). After neutralisation (barium carbonate), the solution was concentrated to a syrup (0·26 g.), $[\alpha]_D$ −50° (*c* 1 in $CHCl_3$), which was taken up in ethyl acetate (50 ml.) and hydrogenated over 10% palladium–charcoal at atmospheric pressure. When hydrogen uptake (17 ml., approx. 1 mol.) had ceased, the mixture was filtered. Evaporation gave methyl 2-*O*-methyl-β-D-glucopyranoside (0·15 g., 63% overall), m. p. and mixed m. p. 95°.

Methyl β-*Sophoroside*.—(*a*) A mixture of methyl 3-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside [1] (1·3 g.), calcium sulphate (2·5 g.), and silver carbonate (0·5 g.) was stirred at room temperature for 1 hr. After the addition of iodine (0·1 g.), 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (1 g.) in chloroform (6 ml.) was added during 1 hr. and the mixture was stirred in darkness for a further 24 hr. The mixture was filtered through Celite and the filtrate was evaporated to a syrup which was chromatographed on alumina. Elution with acetone–ether (1 : 3; 100 ml.) gave material (A; 0·8 g.) which consisted of condensation product contaminated with some methyl 3-*O*-benzyl-4,6-*O*-benzylidene-β-D-glucopyranoside. Further elution with the acetone–ether gave some of the latter (0·75 g.) pure.

Material (A) was dissolved in ethyl acetate (50 ml.) and hydrogenated over 10% palladium–charcoal at atmospheric pressure until hydrogen uptake (117 ml.) ceased. The resulting syrup (0·5 g.) was treated with 0·05% sodium methoxide in methanol (200 ml.) at room temperature for 12 hr. The solution was chromatographed on a column of " Biodeminrolit " (5 g.). The initial eluate gave methyl β-D-glucopyranoside (0·2 g.), m. p. and mixed m. p. 105°. Elution with 50% aqueous methanol (250 ml.) gave *methyl* 2-O-(β-D-*glucopyranosyl*)-β-D-*glucopyranoside* (*methyl* β-*sophoroside*) (0·15 g., 12% overall), needles (from aqueous methanol), m. p. 189—190°, $[\alpha]_D$ −28° (*c* 0·2 in H_2O) (Found: C, 43·4; H, 7·1. $C_{13}H_{24}O_{11}$ requires C, 43·8; H, 6·7%).

(*b*) Methyl 3-*O*-benzyl-4,6-*O*-isopropylidene-β-D-glucopyranoside (0·8 g.) condensed with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (1 g.) under the same conditions as in (*a*). The crude reaction product was chromatographed on alumina. Elution with acetone–ether (1 : 3, 90 ml.) gave *methyl* 3-O-*benzyl*-4,6-O-*isopropylidene*-2-O-(2,3,4,6-*tetra*-O-*acetyl*-β-D-*glucopyranosyl*)-β-D-*glucopyranoside* (0·3 g.), needles (from methanol), m. p. 140—141°, $[\alpha]_D$ −31·5° (*c* 0·7 in $CHCl_3$) (Found: C, 57·2; H, 6·5. $C_{31}H_{42}O_{16}$ requires C, 56·9; H, 6·4%). Further elution with the acetone–ether gave unchanged methyl 3-*O*-benzyl-4,6-*O*-isopropylidene-β-D-glucopyranoside (0·55 g.), $[\alpha]_D$ −22° (*c* 1 in $CHCl_3$), infrared spectrum identical with that of an authentic specimen.

The condensation product (0·2 g.) in ethyl acetate (50 ml.) was hydrogenated over 10% palladium–charcoal at atmospheric pressure; one mole (approx.) of hydrogen (7 ml.) was taken up. The resulting syrup (0·14 g.), $[\alpha]_D$ −10° (*c* 1·4 in $CHCl_3$), was dissolved in chloroform–methanol (50% v/v; 20 ml.), 2N-sulphuric acid (1 ml.) added, and the mixture shaken for 18 hr. at room temperature. The neutralised (barium carbonate) solution gave a syrup (0·1 g.) which was treated with 1% sodium methoxide in methanol (50 ml.) at room temperature for 12 hr. The solution was chromatographed on a column of " Biodeminrolit " (5 g.). Elution

with 50% aqueous methanol (75 ml.) gave methyl β-sophoroside (0·04 g., calc. 5·5% overall), m. p. 188—189° undepressed with the product prepared by method (*a*).

Hydrolysis of Methyl β-Sophoroside.—The glycoside (0·025 g.) was dissolved in methanol (10 ml.), 6N-sulphuric acid (2 ml.) added, and the mixture was set aside at room temperature. The specific rotation had changed from −28° (initial) to +18° (constant) after 52 hr. The neutralised (barium carbonate) solution was evaporated to give sophorose (0·021 g., 88%), m. p. 196—197° undepressed on admixture with an authentic specimen.

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