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SYNTHESIS OF METHYL 2-*O*- AND 3-*O*-α-D-TALOPYRANOSYL-α-D-MANNOPYRANOSIDE*

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ABSTRACT

Methyl 3,4,6-tri-*O*-benzyl-2-*O*-[6-*O*-(*tert*-butyldiphenylsilyl)-α-D-mannopyranosyl]-α-D-mannopyranoside (**2**) was synthesized by treatment of methyl 3,4,6-tri-*O*-benzyl-2-*O*-α-D-mannopyranosyl-α-D-mannopyranoside with *tert*-butylchlorodiphenylsilane in the presence of imidazole. Isopropylidenation, followed by oxidation with pyridinium chlorochromate, and stereoselective reduction with sodium borohydride, converted **2** into methyl 3,4,6-tri-*O*-benzyl-2-*O*-[6-*O*-(*tert*-butyldiphenylsilyl)-2,3-*O*-isopropylidene-α-D-talopyranosyl]-α-D-mannopyranoside (**5**). Treatment of **5** with a molar solution of tetrabutylammonium fluoride in dry oxolane produced a diol which, on *O*-de-isopropylidenation followed by catalytic hydrogenolysis, afforded the disaccharide glycoside methyl 2-*O*-α-D-talopyranosyl-α-D-mannopyranoside. Synthesis of methyl 3-*O*-α-D-talopyranosyl-α-D-mannopyranoside was accomplished by a similar reaction-sequence. The structures of the final disaccharides, and of various other intermediates, were established by ^{1}H- and ^{13}C-n.m.r. spectroscopy.

INTRODUCTION

The pathway for the biosynthesis of the mannose 6-phosphate recognition-marker on the oligosaccharide portion of lysosomal enzymes consists of the sequential action of two enzymes, UDP-*N*-acetylglucosamine: glycoprotein α-*N*-acetylglucosamine-1-phosphotransferase[2] and α-*N*-acetylglucosamine-1-phosphodiester *N*-acetylglucosaminidase[3]. The first enzyme catalyzes the transfer of α-GlcNAc 1-phosphate to 6-hydroxyl groups situated on the mannose residues of high-mannose type oligosaccharides in lysosomal enzymes, and the second removes the outer α-GlcNAc residues to generate phosphomanno esters.

In our laboratory[4], we have initiated a program to establish the specificity of these enzymes with the aid of synthetic methyl mannobiosides. According to our

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findings, methyl 2-*O*-α-D-mannopyranosyl-α-D-mannopyranoside acts as a better acceptor than methyl α-D-mannopyranoside, whereas methyl 3-*O*-α-D-mannopyranosyl-α-D-mannopyranoside showed the least activity. These observations enhanced our interest in the synthesis of modified disaccharides of these two isomeric methyl mannobiosides for further study of this enzyme. We now describe the first synthesis of the title disaccharides, which may also serve as useful model compounds for structural studies of oligosaccharides by n.m.r. spectroscopy.

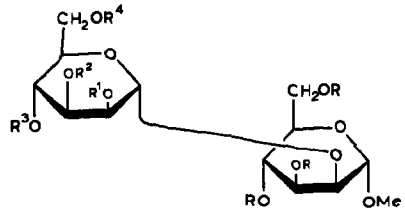
RESULTS AND DISCUSSION

Synthesis of *p*-nitrophenyl α-D-talopyranoside and 1-thio-α-D-talopyranoside[5] had been achieved directly by the reaction of α-D-talopyranose pentaacetate with *p*-nitrophenol or *p*-nitrobenzenethiol. However, in general, a talopyranoside is prepared either by inverting the 2-hydroxyl group of the corresponding galactoside or the 4-hydroxyl group of the corresponding mannoside derivative[6–8]. Very recently, Fleet *et al.*[9] reported the use of benzyl 6-*O*-(*tert*-butyldiphenylsilyl)-2,3-*O*-isopropylidene-α-D-mannopyranoside for procurement of the corresponding talopyranoside derivative. Our strategy was based upon the use of a similar technique, whereby the *tert*-butyldiphenylsilyl (Me_3CPh_2Si) group[10] was used as a protecting group for the primary hydroxyl group.

The starting material, namely, methyl 3,4,6-tri-*O*-benzyl-2-*O*-α-D-mannopyranosyl-α-D-mannopyranoside (**1**) and methyl 2,4,6-tri-*O*-benzyl-3-*O*-α-D-mannopyranosyl-α-D-mannopyranoside (**9**), were obtained as described earlier[4]. Direct acetonation of **1** gave a mixture of methyl 3,4,6-tri-*O*-benzyl-2-*O*-(2,3-*O*-isopropylidene-α-D-mannopyranosyl)-α-D-mannopyranoside and methyl 3,4,6-tri-*O*-benzyl-2-*O*-(2,3:4,6-di-*O*-isopropylidene-α-D-mannopyranosyl)-α-D-mannopyranoside, the latter being the major product. The monoacetal was obtained by selective hydrolysis[11] with 80% acetic acid at room temperature, but the yield was poor. Therefore, we preferred to protect the primary hydroxyl group of compound **1** before proceeding with acetonation.

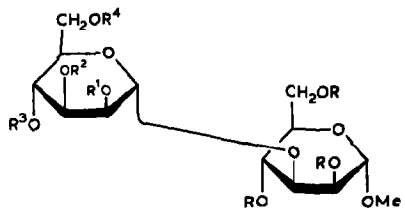
Treatment[10] of **1** (ref. 4) in *N,N*-dimethylformamide with *tert*-butylchlorodiphenylsilane in the presence of imidazole gave, exclusively, compound **2** in 94% yield. The ^{13}C-n.m.r. spectrum of **2** showed complete absence of a C-6 signal in the region of 60–63 p.p.m., confirming that selective silylation of **1** yields only the 6-*O*-substituted derivative **2**. Exposure of **9** to *tert*-butylchlorodiphenylsilane under identical conditions afforded compound **10** in 94.8% yield.

Isopropylidenation[7] of **2** afforded the 2,3-acetal **3** in 79.7% yield. The ^{13}C-n.m.r. spectrum of **3** exhibited a resonance for the acetal carbon atom at 109.22 p.p.m., and the chemical shifts for the isopropylidene methyl groups were separated by 1.68 p.p.m., supporting the presence of a five-membered ring[12] in **3**. Also, the upfield shift of the C-1′ signal (from 100.82 to 98.40 p.p.m.) due to the β-effect, further supports formation of the 2,3-*O*-isopropylidene group in **3**. Subjected to isopropylidenation[7] under identical conditions, compound **10** produced **11** in 76.5%

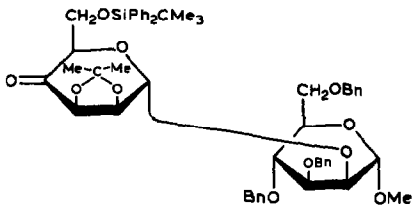


	R	R^1	R^2	R^3	R^4
1	Bn	H	H	H	H
2	Bn	H	H	H	Me_3CPh_2Si
3	Bn	Ip		H	Me_3CPh_2Si

Bn = $PhCH_2$, Ip = $Me_2C<$



	R	R^1	R^2	R^3	R^4
9	Bn	H	H	H	H
10	Bn	H	H	H	Me_3CPh_2Si
11	Bn	Ip		H	Me_3CPh_2Si



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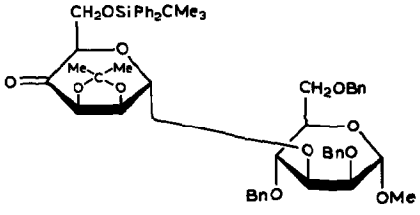

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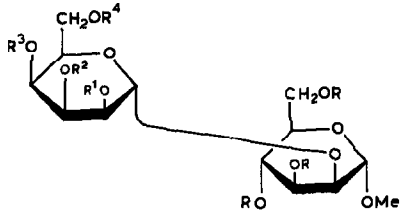
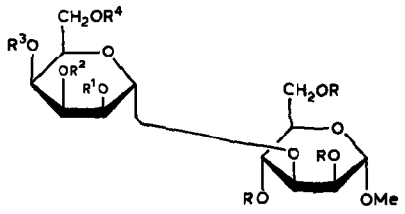


	R	R^1	R^2	R^3	R^4
5	Bn	Ip		H	Me_3CPh_2Si
6	Bn	Ip		H	H
7	Bn	H	H	H	H
8	H	H	H	H	H



	R	R^1	R^2	R^3	R^4
13	Bn	Ip		H	Me_3CPh_2Si
14	Bn	Ip		H	H
15	Bn	H	H	H	H
16	H	H	H	H	H

yield. The structure assigned the latter compound was also supported by its ^{13}C-n.m.r. spectrum.

Oxidation[13] of acetals **3** and **11** with pyridinium chlorochromate in the presence of 3Å molecular sieves gave the ketones **4** and **12**, respectively. When the oxidation was conducted in the absence of the sieves, the reaction was incomplete, even after a week and using a 20-fold excess of the reagent. The i.r. spectra of **4** and **12** showed a complete absence of any hydroxyl group and the presence of a carbonyl peak at 1739 cm^{-1}. The presence of a C-4′ signal at 201.9 p.p.m. in the spectrum of **4**, and at 202.44 p.p.m. in that of **12** further supports the presence of a carbonyl group in compounds **4** and **12**. Reduction of **4** and **12** resulted in hydride-

ion attack from the less-hindered face of the carbonyl group, to produce the talopyranosyl derivatives **5** and **13**, respectively, in almost quantitative yields. The structures assigned **5** and **13** were supported by their ^{1}H- and ^{13}C-n.m.r. spectra.

Treatment[10] of compounds **5** and **13** with a molar solution of tetrabutylammonium fluoride in dry oxolane proceeded satisfactorily, to give diols **6** and **14**, respectively, in >90% yields. Removal of the isopropylidene group afforded the disaccharide derivatives **7** (from **6**) and **15** (from **14**). The spectra ^{1}H- and ^{13}C-n.m.r. of **7** and **15** were in accord with the structures assigned.

Catalytic hydrogenolysis of **7** and **15** produced the title disaccharides **8** and **16**, respectively. The structures of **8** and **16** were confirmed by ^{1}H- and ^{13}C-n.m.r. spectroscopy.

Comments on the ^{13}C-n.m.r. assignments. — The ^{13}C-n.m.r. chemical-shifts of the title disaccharides, along with those for methyl α-D-mannopyranoside and methyl α-D-talopyranoside, are listed in Table I. In order to ensure that small chemical-shift differences between different compounds are real and not artifacts of slightly different, chemical-shift-referencing procedures, all of the chemical shifts listed in Table I were determined at 25.2 MHz, using the same referencing procedure for each. The assignments for methyl α-D-mannopyranoside and methyl α-D-talopyranoside are taken from the literature[14–17], and those for **8** and **16** are based on those reported for methyl α-D-mannopyranoside and methyl α-D-talopyranoside.

From the data given in Table I, the following important observations were made. First, $^1J_{CH}$ values for all of the anomeric carbon atoms were found to lie between 171.9 and 172.9 Hz, in agreement with the empirical rule of Bock *et*

TABLE I

25.2-MHz, ^{13}C-N.M.R. CHEMICAL SHIFTS[a] IN D_2O AT 25°

Atom	*Compound*			
	α-D-*Man-1→OMe*	α-D-*Tal-1→OMe*	**8**	**16**
C-1	101.9	102.39	100.35	101.79
$^1J_{CH}$ (Hz)	—	171.6	172.9	171.9
C-2	71.0	70.89	79.62	70.65
C-3	71.7	66.38	71.24	79.57
C-4	67.9	70.50	68.01	67.12
C-5	73.6	72.38	73.52	73.72
C-6	62.1	62.57	61.95	61.92
OMe	56.2	55.90	55.91	55.86
C-1′			104.00	103.93
$^1J_{CH}$ (Hz)			172.1	172.8
C-2′			70.99	71.10
C-3′			66.18	66.28
C-4′			70.69	70.65
C-5′			73.17	73.11
C-6′			62.78	62.57

[a]In p.p.m. downfield from external Me_4Si.

al.[18] for the α-D anomeric configuration. Second, the chemical shift of the carbinol carbon atom of the methyl α-D-mannopyranoside residue, to which the α-D-talopyranosyl group is linked, was found to be significantly deshielded due to the α-effect, and these signals could be readily differentiated from other signals of ring-carbon atoms. The (1→2) and (1→3) nature of the interglycosidic linkage in **8** and **16**, respectively, was supported by the presence of the deshielded signal due to the glycosidation shift[19] for C-2 (79.62 p.p.m.) in **8** and C-3 (79.57 p.p.m.) in **16**. Third, the signal for C-1, on talopyranosylation at O-2 or O-3, was shielded (β- or γ-effect) by 1.55 and 0.11 p.p.m., respectively. Fourth, the signal for C-1′ was deshielded by 1.61 p.p.m. for **8** and 1.54 p.p.m. for **16**, relative to the C-1 signal for methyl α-D-talopyranoside.

EXPERIMENTAL

General methods. — These were the same as those already described[4].

*Methyl 3,4,6-tri-O-benzyl-2-O-[6-O-(*tert*-butyldiphenylsilyl)-α-D-mannopyranosyl]-α-D-mannopyranoside* (**2**). — A solution of compound **1** (1 g, 1.6 mmol) and imidazole (327 mg, 4.8 mmol) in *N,N*-dimethylformamide (10 mL) was treated with *tert*-butylchlorodiphenylsilane (660 mg, 2.4 mmol) for 2 h at room temperature, and then poured into ice–water. The product was extracted with chloroform, and the extract was washed successively with water, saturated aqueous sodium hydrogencarbonate, and water, dried (anhydrous sodium sulfate), and evaporated to dryness. The syrupy material was purified by chromatography on a column of silica gel, with elution with 9:1 chloroform–acetone, to give **2** in 94% yield (1.3 g); $[\alpha]_D$ +27.5° (*c* 1.04, chloroform); ^{1}H-n.m.r. data ($CDCl_3$): δ 1.05 (s, 9 H, -CMe_3), 3.2 (s, 3 H, OMe), 5.03 (s, 1 H, H-1), and 7.1–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.2 (-*C*Me_3), 26.81 (-C*Me*$_3$), 54.57 (O*C*H_3), 64.98 (C-6′), 79.96 (C-2), 99.82 (C-1), and 100.82 (C-1′).

Anal. Calc. for $C_{50}H_{60}O_{11}$ Si: C, 69.42; H, 6.99. Found: C, 69.66; H, 6.87.

*Methyl 3,4,6-tri-O-benzyl-2-O-[6-O-(*tert*-butyldiphenylsilyl)-2,3-O-isopropylidene-α-D-mannopyranosyl]-α-D-mannopyranoside* (**3**). — To a suspension of **2** (1.5 g) in dry acetone (15 mL) were added 2,2-dimethoxypropane (15 mL) and *p*-toluenesulfonic acid monohydrate (300 mg). The mixture was stirred for 0.5 h at room temperature, the acid neutralized with a few drops of triethylamine, and the solution evaporated. Several additions and evaporations of toluene gave a syrup which was purified by chromatography on a column of silica gel, with elution with 4:1 (v/v) hexane–ethyl acetate, to give **3** (1.25 g, 79.7%); $[\alpha]_D$ +21.0° (*c* 1.4, chloroform); t.l.c. in 3:2 hexane–ethyl acetate: R_F 0.5; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.07 (s, 9 H, -CMe_3), 1.35 and 1.47 (s each, 2 × 3 H, isopropylidene methyls), 3.2 (s, 3 H, OMe), and 7.1–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.24 (-*C*Me_3), 26.23 and 27.91 (>C*Me*$_2$), 26.83 (-C*Me*$_3$), 54.61 (O*C*H_3), 64.5 (C-6′), 79.91 (C-2), 98.4 (C-1′), 99.85 (C-1), and 109.22 (>*C*Me_2).

Anal. Calc. for $C_{53}H_{64}O_{11}$Si: C, 70.32; H, 7.13. Found: C, 70.03; H, 7.15.

*Methyl 3,4,6-tri-*O*-benzyl-2-*O*-[6-*O*-(*tert*-butyldiphenylsilyl-2,3-*O*-isopropylidene-α-*D*-talopyranosyl]-α-*D*-mannopyranoside* (**5**). — A solution of compound **3** (1.15 g, 1.27 mmol) in dichloromethane (25 mL) containing 3A powdered molecular sieves and pyridinium chlorochromate (1.37 g, 6.35 mmol) was stirred overnight at room temperature. Diethyl ether (50 mL) was added, the mixture stirred for 5 min, the solids were removed by filtration, and the filtrate was evaporated. The syrupy material was purified by chromatography on a column of silica gel, eluting with 6:1 hexane–ethyl acetate, to give **4** in 65.4% yield (0.75 g); $[\alpha]_D$ +43.7° (*c* 1.9, chloroform); t.l.c. (3:2 hexane–ethyl acetate): R_F 0.55; ν_{max}^{film} 1730 cm^{-1} (carbonyl): ^{1}H-n.m.r. data ($CDCl_3$): δ 1.03 (s, 9 H, -CMe_3), 1.33 (s, 6 H, isopropylidene methyls), 3.26 (s, 3 H, OMe), and 7.2–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.25 (-*C*Me_3), 25.64 (>C*Me*$_2$), 26.79 (>C*Me*$_2$ + -C*Me*$_3$), 54.61 (O*Me*), 63.05 (C-6′), 80.0 (C-2), 97.92 (C-1′), 99.25 (C-1), 111.02 (*C*Me_2), and 201.90 (C-4′).

To a solution of **4** (0.6 g, 0.67 mmol) in 95% ethanol (15 mL) was added sodium borohydride (0.255 g, 6.7 mmol), the mixture was stirred at 0°, and the reaction was monitored by t.l.c. After 1 h, the mixture was evaporated to a white solid residue which was dissolved in chloroform (100 mL), and the solution was repeatedly washed with water until the aqueous layer became neutral, dried (anhydrous sodium sulfate), and evaporated, to give pure **5** (0.53 g) in 88.2% yield; $[\alpha]_D$ +29.6° (*c* 0.9, chloroform); t.l.c. in 3:2 hexane–ethyl acetate: R_F 0.47; the i.r. spectrum showed the absence of a carbonyl group and the presence of a hydroxyl group; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.03 (s, 9 H, -CMe_3), 1.07 and 1.23 (s each, 2 × 3 H, isopropylidene methyls), 3.17 (s, 3 H, OMe), and 7.1–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.19 (-*C*Me_3), 25.44 and 25.84 (>C*Me*$_2$), 26.81 (-C*Me*$_3$), 54.41 (O*Me*), 63.33 (C-6′), 80.11 (C-2), 98.6 (C-1′), 100.14 (C-1), and 109.07 (>*C*Me_3).

Anal. Calc. for $C_{53}H_{64}O_{11}Si$: C, 70.32; H, 7.13. Found: C, 70.48; H, 7.09.

*Methyl 3,4,6-tri-*O*-benzyl-2-*O*-(2,3-*O*-isopropylidene-α-*D*-talopyranosyl)-α-*D*-mannopyranoside* (**6**). — A solution of **5** (904 mg, 1 mmol) in dry oxolane (10 mL) was treated with a 1M solution of tetrabutylammonium fluoride in THF (1.1 mL) for 45 min at room temperature. The mixture was evaporated, and the residue was purified by chromatography on a column of silica gel, with elution with 9:1 chloroform–acetone, to give **6** in 90% yield (0.6 g); $[\alpha]_D$ +51.4° (*c* 0.9, chloroform); t.l.c. in 4:1 chloroform–acetone: R_F 0.22; ^{1}H-n.m.r. data ($CDCl_3$); δ 1.37 and 1.53 (s each, 2 × 3 H, isopropylidene methyls), 3.33 (s, 3 H, OMe), and 7.1–7.4 (m, 15 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 25.4 and 25.8 (>C*Me*$_2$), 54.92 (O*Me*), 63.0 (C-6′), 79.31 (C-2), 98.87 (C-1′), 99.3 (C-1), and 109.18 (*C*Me_2).

Anal. Calc. for $C_{37}H_{46}O_{11}$: C, 66.65; H, 6.95. Found: C, 66.98; H, 6.92.

*Methyl 3,4,6-tri-*O*-benzyl-2-*O*-α-*D*-talopyranosyl-α-*D*-mannopyranoside* (**7**). — A mixture of **6** (0.7 g) with 65% acetic acid (25 mL) was stirred for 1 h at 60°, cooled, and evaporated. Several additions and evaporations of toluene gave a thick syrup which was purified by chromatography on a column of silica gel, with elution

with 9:1 (v/v) chloroform–methanol, to give **7** (0.6 g, 91.2%); $[\alpha]_D$ +58.3° (*c* 1.1, methanol); t.l.c. (9:1 chloroform–methanol): R_F 0.26; ^{1}H-n.m.r. data (Me_2SO-d_6): δ 3.25 (s, 3 H, OMe) and 7.1–7.4 (m, 15 H, aromatic); ^{13}C-n.m.r. data (Me_2SO-d_6): δ 54.19 (OMe), 60.74 (C-6′), 65.03 (C-3′), 78.65 (C-2), 99.13 (C-1), and 102.32 (C-1′).

Anal. Calc. for $C_{34}H_{42}O_{11}$: C, 65.16; H, 6.76. Found: C, 64.98; H, 7.02.

Methyl 2-O-α-D-talopyranosyl-α-D-mannopyranoside (**8**). — A solution of **7** (0.5 g) in glacial acetic acid (50 mL) was hydrogenolyzed in the presence of 10% Pd–C (250 mg) for 2 days, the suspension filtered, the filtrate evaporated, and the residue purified by chromatography on a column of silica gel, with elution with 13:6:1 (v/v/v) chloroform–methanol–water, to give amorphous **8** in 76.7% yield (240 mg); $[\alpha]_D$ +85.4° (*c* 1.3, methanol); t.l.c. in 13:6:1 chloroform–methanol–water: R_F 0.23; ^{1}H-n.m.r. data (D_2O): δ 3.8 (s, 3 H, OMe), 5.43 (s, 1 H, H-1), and 5.53 (s, 1 H, H-1′); for ^{13}C-n.m.r. data see Table I.

Anal. Calc. for $C_{13}H_{24}O_{11} \cdot 2\ H_2O$: C, 39.79; H, 7.19. Found: C, 39.43; H, 7.07.

Methyl 2,4,6-tri-O-benzyl-3-O-[6-O-(tert-butyldiphenylsilyl)-α-D-mannopyranosyl]-α-D-mannopyranoside (**10**). — Compound **10** was prepared from **9** (1 g, 1.6 mmol) as described for **2**. Purification by chromatography on a column of silica gel gave pure **10** in 94.8% yield (1.31 g); $[\alpha]_D$ +28.9° (*c* 1.2, chloroform); t.l.c. in 4:1 (v/v) hexane–ethyl acetate: R_F 0.39; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.03 (s, 9 H, -CMe_3), 3.2 (s, 3 H, OMe), 5.07 (s, 1 H, H-1), and 7.1–7.7 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.17 (-*C*Me_3), 26.80 (-C*Me*$_3$), 54.63 (O*Me*), 65.06 (C-6′), 78.16 (C-3), 98.49 (C-1), and 101.51 (C-1′).

Anal. Calc. for $C_{50}H_{60}O_{11}Si$: C, 69.42; H, 6.99. Found: C, 69.17; H, 7.05.

Methyl 2,4,6-tri-O-benzyl-3-O-[6-O-(tert-butyldiphenylsilyl)-2,3-O-isopropylidene-α-D-mannopyranosyl]-α-D-mannopyranoside (**11**). — Isopropylidenation of **10** (1 g), as described for **3**, gave **11** (0.8 g, 76.5%); $[\alpha]_D$ +7.0° (*c* 0.7, chloroform); t.l.c. in 3:2 (v/v) hexane–ethyl acetate: R_F 0.5; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.03 (s, 9 H, -CMe_3), 1.3 and 1.43 (s each, 2 × 3 H, isopropylidene methyls), 3.2 (s, 3 H, OMe), and 7.2–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.25 (-*C*Me_3), 25.94 and 27.73 (>C*Me*$_2$), 26.84 (-C*Me*$_3$), 54.61 (O*Me*), 64.54 (C-6′), 78.18 (C-3), 98.42 (C-1), 99.30 (C-1′), and 109.23 (>*C*Me_2).

Anal. Calc. for $C_{53}H_{64}O_{11}Si$: C, 70.32; H, 7.13. Found: C, 70.24; H, 7.14.

Methyl 2,4,6-tri-O-benzyl-3-O-[6-O-(tert-butyldiphenylsilyl)-2,3-O-isopropylidene-α-D-talopyranosyl]-α-D-mannopyranoside (**13**). — Oxidation of **11** (3 g), as described for the preparation of **4**, furnished **12** in 66.8% yield (2 g); $[\alpha]_D$ +26.4° (*c* 0.9, chloroform); t.l.c. in 3:2 (v/v) hexane–ethyl acetate: R_F 0.57; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.03 (s, 9 H, -CMe_3), 1.3 and 1.33 (s each, 2 × 3 H, isopropylidene methyls), 3.23 (s, 3 H, OMe), and 7.2–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.20 (-*C*Me_3), 25.49 and 26.75 (>C*Me*$_2$), 26.75 (-C*Me*$_3$), 54.62 (O*Me*), 63.27 (C-6′), 78.71 (C-3), 98.46 (C-1), 99.12 (C-1′), 111.21 (>*C*Me_2), and 202.44 (C-4′).

Compound **12** (2 g) was treated with sodium borohydride, as described for **5**, to furnish **13** in quantitative yield; $[\alpha]_D$ +18.4° (*c* 2.9, chloroform); t.l.c. in 3:2 (v/v) hexane–ethyl acetate: R_F 0.5; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.05 (s, 9 H, -CMe_3), 1.33 and 1.5 (s each, 2 × 3 H, isopropylidene methyls), 3.17 (s, 3 H, OCH_3), and 7.2–7.8 (m, 25 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 19.24 (-*C*Me_3), 25.20 and 25.81 (>C*Me*$_2$), 26.88 (-C*Me*$_3$), 54.50 (O*Me*), 63.51 (C-6′), 78.54 (C-3), 98.66 (C-1), 99.75 (C-1′), and 109.23 (>*C*Me_2).

Anal. Calc. for $C_{53}H_{64}O_{11}Si$: C, 70.32; H, 7.13. Found: C, 70.01; H, 7.22.

*Methyl 2,4,6-tri-*O*-benzyl-3-*O*-(2,3-*O*-isopropylidene-α-*D*-talopyranosyl)-α-*D*-mannopyranoside* (**14**). — Treatment of compound **13** (1.81 g) with a molar solution of tetrabutylammonium fluoride, as described for the preparation of **6**, furnished compound **14** (1.24 g) in 93% yield; $[\alpha]_D$ +29.9° (*c* 1.6, chloroform); t.l.c. in 4:1 (v/v) chloroform–acetone: R_F 0.22; ^{1}H-n.m.r. data ($CDCl_3$): δ 1.33 and 1.5 (s each, 2 × 3 H, isopropylidene methyls), 3.33 (s, 3 H, OMe), and 7.2–7.4 (m, 15 H, aromatic); ^{13}C-n.m.r. data ($CDCl_3$): δ 25.09 and 25.83 (>C*Me*$_2$), 54.76 (O*Me*), 62.89 (C-6′), 77.67 (C-3), 98.52 (C-1), 99.41 (C-1′), and 109.27 (>*C*Me_2).

Anal. Calc. for $C_{37}H_{46}O_{11}$: C, 66.65; H, 6.95. Found: C, 66.81; H, 6.99.

*Methyl 2,4,6-tri-*O*-benzyl-3-*O*-α-*D*-talopyranosyl-α-*D*-mannopyranoside* (**15**). — Cleavage of the acetal group of compound **14** (1 g), exactly as described for **6** (to give **7**), afforded compound **15** in 70% yield (0.66 g); $[\alpha]_D$ +59.4° (*c* 1.3, methanol); t.l.c. in 9:1 (v/v) chloroform–methanol: R_F 0.27; ^{1}H-n.m.r. data (Me_2SO-d_6): δ 3.3 (s, 3 H, OMe) and 7.2–7.4 (m, 15 H, aromatic); ^{13}C-n.m.r. data (Me_2SO-d_6): δ 54.11 (O*Me*), 60.62 (C-6′), 65.13 (C-3′), 77.83 (C-3), 97.37 (C-1), and 103.02 (C-1′).

Anal. Calc. for $C_{34}H_{42}O_{11}$: C, 65.16; H, 6.76. Found: C, 64.90; H, 6.88.

*Methyl 3-*O*-α-*D*-talopyranosyl-α-*D*-mannopyranoside* (**16**). — Hydrogenolysis of compound **15** (0.5 g), as described for **7** (to give **8**), furnished amorphous **16** (0.24 g, 80.3%); $[\alpha]_D$ +120.8° (*c* 0.7, methanol); t.l.c. in 13:6:1 (v/v/v) chloroform–methanol–water: R_F 0.22; ^{1}H-n.m.r. data (D_2O): δ 3.9 (s, 3 H, OMe), 5.63 (s, 1 H, H-1), and 5.68 (s, 1 H, H-1′); for ^{13}C-n.m.r. data see Table I.

Anal. Calc. for $C_{13}H_{24}O_{11} \cdot H_2O$: C, 41.71; H, 7.00. Found: C, 41.92; H, 6.69.

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