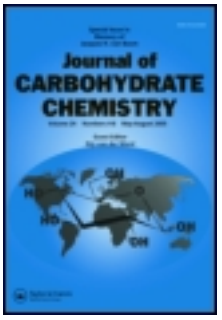

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Action of Base on Methyl 6-Thio- (and 6-Deoxy-) 2-O-Methanesulfonyl-α-d-Glucopyranoside Derivatives[1]

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ACTION OF BASE ON METHYL 6-THIO- (AND 6-DEOXY-) 2-*O*-METHANESULFONYL-α-D-GLUCOPYRANOSIDE DERIVATIVES[1]

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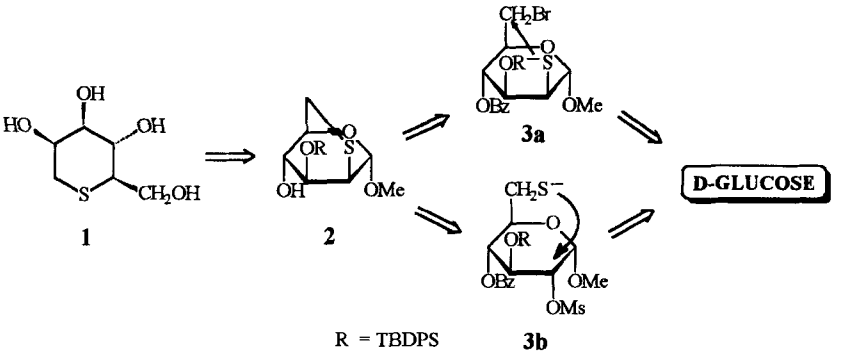
ABSTRACT

Treatment of methyl 4-*O*-benzoyl-3-*O*-*tert*-butyldiphenylsilyl-2-*O*-methanesulfonyl-6-thio-α-D-glucopyranoside (**8**) and its 6-deoxy analogue (**11**) with methanolic sodium methoxide, afforded methyl 2,3-anhydro-mannopyranoside derivatives as a consequence of an $O_3 \rightarrow O_4$ TBDPS rearrangement. When the protecting group at C-3 was 2-methoxyethoxy methyl ether only deacylation and methanolysis of the methanesulfonyl group occurred.

INTRODUCTION

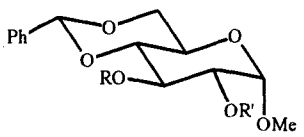
In recent years our group has paid much attention to the synthesis of thioanalogues of some potent glycosidase inhibitors,[3] structurally characterized as polyhydroxypiperidines, pyrrolidines and indolizidines. In 1993 we reported on the synthesis of 1-deoxythiomannojirimycin (**1**) from a suitable D-glucose derivative[4] (see retrosynthesis in Scheme 1), through a bicycle key-intermediate **2**, by introduction of a sulfide function between C-2 and C-6, with a previous inversion of configuration at C-2 (via intermediate **3a**, Scheme 1) in D-glucose. In order to shorten the synthesis of **1**, avoiding the inversion step at C-2, we attempted the synthesis of **2** by promoting a C-6 → C-2 cyclization (via intermediate **3b**, Scheme 1).[2]



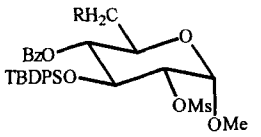
Scheme 1

RESULTS AND DISCUSSION

Methyl 4,6-*O*-benzylidene-α-D-glucopyranoside,[5] was transformed in a regioselective manner into its 2-*O*-methanesulfonyl derivative **4**, by application of the method described by Munavu *et al.*[6]. Silylation of **4** with *tert*-butyldiphenylsilyl chloride afforded the corresponding derivative **5**, which upon treatment with NBS yielded methyl 4-*O*-benzoyl-6-bromo-3-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (**6**). Reaction of **6** with potassium thioacetate proceeded with a hightly regioselective nucleophilic displacement at the C-6 position to give the 6-*S*-acetyl-6-thio derivative (**7**) as was shown by its spectroscopic data.

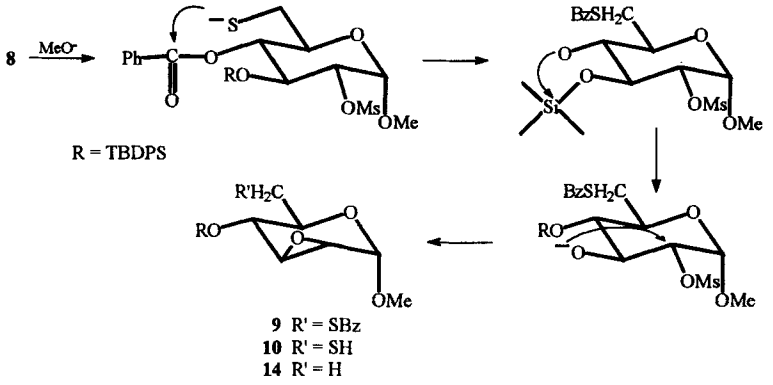


4 R = H; R' = Ms
5 R = TBDPS; R' = Ms
15 R = MEM; R' = Ms
20 R = H, R' = Tf



6 R = Br
7 R = SAc
8 R = SH

Treatment of **7** with methanolic sodium methoxide under mild conditions, in order to obtain the bicyclic intermediate **2** (via **3b**, see Scheme 1), was unsuccessful and only the corresponding de-*S*-acylation product **8** was obtained. When **8** was subsequently treated with the same base under stronger conditions, the methyl 2,3-anhydro-6-*S*-benzoyl-4-*O*-*tert*-butyldiphenylsilyl-6-thio-α-D-mannopyranoside (**9**) and its debenzoylated derivative **10**, were isolated in high overall yield. The coupling patterns showed by H-2,3 in the ^{1}H NMR spectra



Scheme 2

of **9** and **10**, were identical to those found by Sinclair[7] for 2,3-anhydro-α-D-mannopyranoside derivatives, where coupling with the corresponding vicinal protons (H-1,4, respectively) was not observed.

Formation of **9** and **10** from **8**, could be explained as indicated in Scheme 2. Thus, the mercaptide ion promotes an $O_4 \rightarrow S_6$ benzoyl migration, leaving an alkoxide ion at C-4, which caused the subsequent $O_3 \rightarrow O_4$ TBDPS rearrangement, through a pentacoordinate silicon intermediate. The so formed alkoxide ion at C-3 displaces the mesylate group at C-2, yielding **9**. Finally, basic hydrolysis of the thiobenzoate at C-6 afforded the thiol **10**. Silicon migration in polyols has been reported previously: 1,3-*O*,*O*[8] and 1,2-*O*,*O*-TBDPS rearrangements[9] have been known since 1987, and pentacoordinate silicon anions have been postulated as intermediates in the closely related 1,2-*O*,*O*-*t*-butyldimethylsilyl group migrations under basic catalysis.[10] On the other hand, formation of 2,3-anhydro sugars by internal nucleophilic displacements is a well documented process in the field of carbohydrate chemistry.[11]

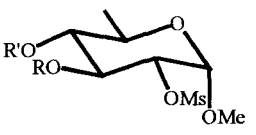
In order to check whether the mercaptide ion has an influence on the above migration processes, methyl 4-*O*-benzoyl-3-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (**11**) was synthesized by Raney-Ni desulfurization of **7**. When **11** was treated with methanolic sodium methoxide at room temperature for 2 days, three products were isolated: the product of a simple benzoate methanolysis (**12**), the $O_3 \rightarrow O_4$ TBDPS rearrangement product (**13**), and the 2,3-anhydro sugar derivative **14**. This result seems to indicate that the thiolate anion at C-6 has no influence on the migration of TBDPS group. We concluded that TBDPS is inappropiate for the protection of hydroxyl group at C-3, owing to

its tendency to rearrange in this case, and to the consequent epoxidation, which prevents the formation of the key bicyclic intermediate **2**.

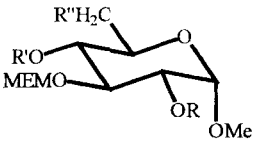
In order to avoid the formation of the 2,3-anhydro derivative, the hydroxyl group at C-3 was protected as its 2-methoxyethoxymethyl ether, because it neither affects, by steric hindrance, the reactivity of the neighbour groups, nor rearranges, and can be selectively cleaved. Therefore, we synthesized methyl 4,6-*O*-benzylidene-2-*O*-methanesulfonyl-3-*O*-(2-methoxyethoxymethyl)-α-D-glucopyranoside (**15**) from **4**. Reaction of **15** with NBS gave **16**, which upon treatment with potassium thioacetate yielded methyl 6-*S*-acetyl-4-*O*-benzoyl-2-*O*-methanesulfonyl-3-*O*-(2-methoxyethoxymethyl)-6-thio-α-D-glucopyranoside (**17**). Treatment of **17** with base was first performed under similar conditions as those described for **7**, to yield the deacylated derivative **18**, in this case as a result of the easy hydrolysis of the benzoate and the thioacetate groups. When **18** was treated with sodium methoxide under stronger conditions, only the methanolysis of 2-*O*-methanesulfonyl group occurred to give methyl 3-*O*-(2-methoxyethoxymethyl)-6-thio-α-D-glucopyranoside (**19**). In order to force the cyclization **18** → **2**, the former compound was treated with $NaCH_2SOCH_3$ in dry DMSO; after 30 min at room temperature no reaction occurred and after 2 h at 85 °C, an extensive decomposition of **18** was observed.

A final attempt was tried by changing the methanesulfonyloxy group with a better leaving group such as trifluoromethanesulfonyloxy. Consequently, methyl 4,6-*O*-benzylidene-2-*O*-trifluoromethanesulfonyl-α-D-glucopyranoside (**20**) was prepared from methyl 4,6-*O*-benzylidene-α-D-glucopyranoside in good yield. Compound **20** was sufficiently stable to be characterized but subsequent protection of the hydroxyl group at C-3 with MEM chloride resulted in its total decomposition.

The structures of all compounds were determined on the basis of their analytical and spectroscopic data, including some COSY and ^{13}C-^{1}H-correlated spectra.



11 R = TBDPS; R' = Bz
12 R = TBDPS; R' = H
13 R = H; R' = TBDPS



16 R = Ms; R' = Bz; R" = Br
17 R = Ms; R' = Bz; R" = SAc
18 R = Ms; R' = H; R" = SH
19 R = R' = H; R" = SH

EXPERIMENTAL

General methods. Melting points were determined with a Gallenkamp apparatus and are uncorrected. Solutions were dried over $MgSO_4$ before concentration under reduced pressure. The ^1H and ^{13}C NMR spectra were recorded with Bruker AMX-300, AM-300 and ARX-400 spectrometers for solutions in $CDCl_3$ (internal Me_4Si). IR spectra were recorded with a Perkin-Elmer 782 instrument. Mass spectra with Hewlett-Packard HP-5988-A and Fisons mod. Platform II and VG Autospec-Q mass spectrometers. Optical rotations were measured for solutions in $CHCl_3$ (1-dm tube) with a Jasco DIP-370 polarimeter. TLC was performed on precoated Silica 60 F_{254} aluminium sheets (E. Merck) and detection by charring with H_2SO_4. Flash chromatography and column chromatography were performed on silica gel Merck (60, 230-400) and (7734), respectively. The noncrystalline compounds, for which elemental analyses were not obtained were shown to be homogeneous by chromatography and characterised by NMR and HRMS.

Methyl 4,6-*O*-Benzylidene-2-*O*-methanesulfonyl-α-D-glucopyranoside (4). To a stirred solution of methyl 4,6-*O*-benzylidene-α-D-glucopyranoside[5] (28.2 g, 0.1 mol) in dry methanol (250 mL) was added dibutyltin oxide (26.14 g, 105 mmol) and the suspension was heated for 2 h under reflux, then concentrated to afford the 2,3-dibutylstannylene derivative as a syrup which was dried under vacuum over P_2O_5 overnight. To a cooled (ice-water) and stirred solution of the above syrup in dry 1,4-dioxane (150 mL), a solution of methanesulfonyl chloride (8.18 mL, 105 mmol) in the same solvent (50 mL) was added dropwise. The mixture was left at room temperature for 20 h. TLC (1:1 EtOAc-hexane) then revealed a main faster running compound. The mixture was filtered and the filtrate concentrated. Flash chromatography (1:4 → 1:1 EtOAc-hexane) of the residue gave crystalline **4** (31.6 g, 88%), mp 131-132°; $[\alpha]_D^{29}$+62° (*c* 2.5). [Lit.[12] mp 133-134°; $[\alpha]_D^{26}$ +73° (*c* 1.38)]. NMR data: ^1H, δ 7.51-7.37 (m, 5 H, Ph), 5.52 (s, 1 H, C*H*Ph), 4.93 (d, 1 H, $J_{1,2}$ 3.8 Hz, H-1), 4.48 (dd, 1 H, $J_{2,3}$ 9.5 Hz, H-2), 4.29 (dd, 1 H, $J_{5,6e}$ 4.5 Hz, H-6*e*), 4.18 (dt, 1 H, H-3), 3.84 (dt, 1 H, H-5), 3.72 (t, 1 H, $J_{5,6a} = J_{6a,6e} = 10$ Hz, H-6*a*), 3.49 (t, 1 H, $J_{3,4} = J_{4,5} = 9.3$ Hz, H-4), 3.44 (s, 3 H, OMe), 3.12 (s, 3 H, Ms) and 2.97 (d, 1 H, $J_{3,OH}$ 3 Hz, OH-3); ^{13}C, δ 136.84, 129.47, 128.44, and 126.33 (CH*Ph*), 102.12 (*C*HPh), 98.59 (C-1), 81.39 (C-4), 79.36 (C-2), 68.79 (C-6), 68.65 (C-3), 61.96 (C-5), 55.81 (OMe), and 38.35 (Ms). Mass spectrum (LSIMS): *m/z* 361.09636 (M^++1). For $C_{15}H_{21}O_8S$ 361.09572 (deviation -1.8 ppm).

Methyl 4,6-*O*-Benzylidene-3-*O*-*tert*-butyldiphenylsilyl-2-*O*-methanesulfonyl-α-D-glucopyranoside (5). To a stirred solution of **4** (1.8 g, 5 mmol) in dry DMF (40 mL) were added imidazole (0.36 g, 5. 3 mmol), 4-dimethylaminopyridine (120 mg, 1 mmol), and *tert*-butylchlorodiphenylsilane (1.36 mL, 5.25 mmol) under argon, and the reaction mixture heated at 65° for 20 h. TLC (1:1 EtOAc-hexane) then revealed the presence of a faster-running compound. Water (50 mL) was added and the solution extracted with ether (3 x 100 mL), and the ethereal extracts washed with water (3 x 20 mL) and then concentrated. Flash chromatography (1:4 EtOAc-hexane) of the residue afforded crystalline **5** (2.25 g, 75%), mp 139-140°; $[\alpha]_D^{28}$ +70.5° (*c* 1.1); ν_{max}^{KBr} 3075 and 3047 (C-H, aromatic), 743 and 701 cm^{-1} (aro matic). NMR data: ^1H, δ 7.60-6.84 (m, 15 H, 3 Ph), 5.09 (d, 1 H, $J_{1,2}$ 4 Hz, H-1), 5.03 (s, 1 H, C*H*Ph), 4.65 (dd, 1 H, $J_{2,3}$ 9 Hz, H-2), 4.29 (t, 1 H, $J_{3,4}$ 9 Hz, H-3),), 4.17 (dd, 1 H, $J_{5,6e}$ 3.5, $J_{6a,6e}$ 9.1 Hz, H-6*e*), 3.67 (dt, 1 H, H-5), 3.62 (t, 1 H, $J_{5,6a}$ 9.7 Hz, H-6*a*), 3.55 (t, 1 H, $J_{4,5}$ 9.1 Hz, H-4), 3.39 (s, 3 H, OMe), 2.85 (s, 3 H, Ms), and 0.96 (s, 9 H, C*M*e); ^{13}C, δ 136.31, 135.62, 134.25, 132.74, 129.56, 129,46, 128.89, 127.85, 127.45, 127.39, and 126.50 (3 Ph), 101.98 (*C*HPh), 98.55 (C-1), 81.88 (C-4), 79.28 (C-2), 70.38 (C-3), 68.77 (C-6), 62.03 (C-5), 55.74 (OMe), 38.33 (Ms), 26.82 (C*Me*$_3$), and 19.79 (*C*Me$_3$). Mass spectrum (LSIMS): *m/z* 599.21327 (M^++1). For $C_{31}H_{39}O_8SSi$ 599.21349 (deviation 0.4 ppm).

Methyl 4-*O*-Benzoyl-6-bromo-3-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (6). To a stirred solution of **5** (12.43 g, 20.8 mmol) in dry CCl_4 (200 mL) were added NBS (4.06 g, 22.8 mmol) and $BaCO_3$ (16 g, 81.2 mmol) and the mixture refluxed for 1/2 h. TLC (1:3 EtOAc-hexane) then revealed the presence of a new compound with higher mobility. The reaction mixture was filtered and the filtrate washed with 10% aqueous sodium thiosulfate, 10% aqueous sodium hydrogen carbonate, brine, and then concentrated. Column chromatography (1:4 EtOAc-hexane) of the residue gave crystalline **6** (11.42 g, 81%), mp 148-149°; $[\alpha]_D^{27}$ +81° (*c* 1); ν_{max}^{KBr}3075 and 3019 (C-H, aromatic), 1730 (C=O, benzoate), and 704 cm^{-1} (aromatic). NMR data: ^1H, δ 7.78-7.25 (m, 15 H, 3 Ph), 5.22 (dd, 1 H, $J_{3,4}$ 9, $J_{4,5}$ 5.5 Hz, H-4), 5.20 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.69 (dd, 1 H, $J_{2,3}$ 9.2 Hz, H-2), 4.43 (t, 1 H, H-3), 3.88 (m, 1 H, H-5), 3.41 (bs, 4 H, H-6,OMe), 3.36 (m, 1 H, H-6'), 2.43 (s, 3 H, Ms), and 0.82 (s, 9 H, C*Me*$_3$); ^{13}C, δ 165.66 (PhCO), 136.10, 135.88, 133.49, 133.22, 131.94, 130.04, 129.93, 129.80, 129.15, 128.22, and 127.74 (CO*Ph*), 97.13 (C-1), 78.43 (C-2), 74.50 (C-3), 70.77 (C-4), 69.49 (C-5), 55.87 (OMe), 37.94 (Ms), 31.68 (C-6),

26.71 (C*Me*$_3$), and 19.43 (*C*Me$_3$). Mass spectrum (CI, CH_4): *m/z* (refered to ^{81}Br) 661 (3, M^++1-H_2O), 636 (100, M^++1-CO-Me), 578 (14%, M^++1-CO-Me-C_4H_{10}), 525 (25, M^++1-2Ph), 447 (33, M^++1-2Ph-PhH), and 105 (63, $PhCO^+$).

Methyl 6-*S*-Acetyl-4-*O*-benzoyl-3-*O*-*tert*-butyldiphenylsilyl-2-*O*-methanesulfonyl-6-thio-α-D-glucopyranoside (7). To a stirred solution of **6** (1.85 g, 2.73 mmol) in dry DMF (15 mL) was added potassium thioacetate (0.6 g, 5.2 mmol) portionwise, under argon, and the mixture left at room temperature for 1 h. TLC (1:3 EtOAc-hexane) then revealed a new compound of slightly lower mobility. The solvent was evaporated and the residue in CH_2Cl_2 washed with brine and water, then concentrated. Column chromatography (1:4 EtOAc-hexane) of the residue gave 7 (1.24 g, 85%) as a syrup; $[\alpha]_D^{26}$ +116° (*c* 1.3); ν_{max}^{film} 3075 and 3036 (C-H, aromatic), 1730 (C=O, benzoate), 1696 (C=O, thioacetate), and 705 cm^{-1} (aromatic). NMR data: ^{1}H, δ 7.84-7.25 (m, 15 H, 3 Ph), 5.24 (t, 1 H, $J_{3,4} = J_{4,5}$ = 9 Hz, H-4), 5.10 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.65 (dd, 1 H, $J_{2,3}$ 9 Hz, H-2), 4.39 (t, 1 H, H-3), 3.72 (dt, 1 H, H-5), 3.33 (s, 3 H, OMe), 3.24 (dd, 1 H, $J_{5,6}$ 3, $J_{6,6'}$ 14 Hz, H-6), 2.80 (dd, 1 H, $J_{5,6'}$ 9 Hz, H-6'), 2.38 (s, 3 H, Ms), 2.25 (s, 3 H, SAc), and 0.82 (s, 9 H, CMe$_3$); ^{13}C, δ 194.83 (S*C*OMe), 165.93 (*C*OPh), 136.09, 135.91, 133.37, 133.26, 131.96, 130.03, 129.91, 129.73, 129.60, 128.17, and 127.72 (3 Ph), 97.08 (C-1), 78.55 (C-2), 74.98 (C-3), 70.82 (C-4), 68.82 (C-5), 55.56 (OMe), 37.87 (Ms), 30.80 (C-6), 30.42 (SCO*Me*), 26.72 (C*Me*$_3$), and 19.44 (*C*Me$_3$). Mass spectrum (LSIMS): *m/z* 673.19789 (M^++1). For $C_{33}H_{41}O_9S_2Si$ 673.19613 (deviation -2.6 ppm).

Treatment of 7 with sodium methoxide. To a stirred solution of 7 (670 mg, 1 mmol) in dry methanol (15 mL), 1 M methanolic sodium methoxide (3 mL) was added dropwise, and the mixture maintained at room temperature for 1.5 h. TLC (1:1 ether-hexane) then showed the absence of 7 and the presence of a faster-running product. The mixture was neutralised with acetic acid, concentrated and the residue extracted with ether. The combined extracts were washed with water and concentrated to give a residue that was chromatographed (1:2 → 1:1 ether-hexane) to afford methyl 4-*O*-benzoyl-3-*O*-*tert*-butyldiphenylsilyl-2-*O*-methane sulfonyl-6-thio-α-D-glucopyranoside (**8**, 350 mg, 56%) as a syrup; $[\alpha]_D^{27}$ +75° (*c* 1); ν_{max}^{film} 3075 and 3047 (C-H, aromatic), 2583 (S-H), 1729 (C=O, benzoate), and 703 cm^{-1} (aromatic). NMR data: ^{1}H, δ 7.79-7.27 (m, 15 H, 3 Ph), 5.30 (t, 1 H, $J_{3,4} = J_{4,5}$ = 9 Hz, H-4), 5.18 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.69 (dd, 1 H, $J_{2,3}$ 9.5 Hz, H-2), 4.44 (t, 1 H, H-3), 3.75 (ddd, 1 H, H-5), 3.40

(s, 3 H, OMe), 2.66 (ddd, 1 H, $J_{5,6}$ 7.5, $J_{6,6'}$ 13.5 Hz, H-6), 2.50 (ddd, 1 H, $J_{5,6'}$ 2.7 Hz, H-6'), 2.43 (s, 3 H, Ms), 1.80 (dd, 1 H, $J_{6,SH}$ 6.5, $J_{6',SH}$ 10.3 Hz, SH-6), and 0.83 (s, 9 H, CMe_3); ^{13}C, δ 165.64 (*C*OPh), 136.08, 135.89, 133.39, 133.31, 131.90, 129.98, 129.89, 129.73, 129.28, 128.18, 127.70, and 127.69 (3 Ph), 97.15 (C-1), 78.54 (C-2), 74.60 (C-3), 70.79 (C-4), 69.99 (C-5), 55.74 (OMe), 37.83 (Ms), 26.68 (CMe_3), 26.40 (C-6), and 19.41 (CMe_3). Mass spectrum (LSIMS): *m/z* 631.17846 (M^++1). For $C_{31}H_{39}O_8S_2Si$ 631.18556 (deviation 11.3 ppm).

Treatment of 8 with sodium methoxide. To a stirred solution of **8** (380 mg, 0.61 mmol) in dry methanol (5 mL), 3 M methanolic sodium methoxide (1 mL) was added, and the mixture maintained at room temperature for 21 h, then refluxed for 30 min. TLC (1:1 ether-hexane) then showed the absence of **8** and the presence of two new faster-running products. The mixture was neutralised with acetic acid, concentrated and the residue extracted with ether. The combined extracts were washed with water and concentrated to give a residue that was chromatographed (1:3 ether-hexane) to afford first methyl 2,3-anhydro-4-*O*-*tert*-butyldiphenylsilyl-6-thio-α-D-mannopyranoside (**10**, 200 mg, 76%) as a syrup; $[\alpha]_D^{26}$ +57° (*c* 1); ν_{max}^{film} 3075 and 3046 (C-H, aromatic), 2580 (S-H), and 703 cm^{-1} (aromatic). NMR data: ^1H, δ 7.75-7.41 (m, 10 H, 2 Ph), 4.84 (s, 1 H, H-1), 3.79 (d, 1 H, $J_{4,5}$ 9 Hz, H-4), 3.69 (dt, 1 H, H-5), 3.56 (s, 3 H, OMe), 3.28 (d, 1 H, $J_{2,3}$ 3.6 Hz, H-3), 3.05 (d, 1 H, H-2), 2.73 (ddd, 1 H, $J_{5,6}$ 2.3, $J_{6,6'}$ 13.5 Hz, H-6), 2.33 (dt, 1 H, $J_{5,6'}$ 8 Hz, H-6'), 1.50 (dd, 1 H, $J_{6,SH}$ 9.5, $J_{6',SH}$ 7.2 Hz, SH-6), and 1,13 (s, 9 H, CMe_3); ^{13}C, δ 135.93, 135.87, 133.10, 132.69, 130.24, 130.20, 128.01, and 127.97 (2 Ph), 96.20 (C-1), 70.74 (C-5), 66.98 (C-4), 55.98 (OMe), 55.51 (C-3), 50.12 (C-2), 27.03 (CMe_3), 26.92 (C-6), and 19.39 (CMe_3). Mass spectrum (CI, CH_4): *m/z* 413 (21%, M^++1-H_2O), 399 (23, M^++1-MeOH), 381 (21, M^++1-MeOH-H_2O), 373 (16, M^++1-C_4H_{10}), 341 (21, M^++1-MeOH-C_4H_{10}), and 321 (100, M^++1-MeOH-PhH).

Anal. Calcd for $C_{23}H_{30}O_4SSi$: C, 64.14; H, 7.02; S, 7.45. Found: C, 64.36; H, 6.85; S, 7.78.

Eluted second was syrupy 6-*S*-benzoyl derivative of **10** (**9**, 70 mg, 20%); $[\alpha]_D^{26}$ +76° (*c* 1); ν_{max}^{film} 3075 and 3003 (C-H, aromatic), 1693 (C=O, *S*-benzoate) and 707 cm^{-1} (aromatic). NMR data: ^1H, δ 8.15-7.38 (m, 15 H, 3 Ph), 4.78 (s, 1 H, H-1), 3.84 (dt, 1 H, H-5), 3.66 (d, 1 H, $J_{4,5}$ 10 Hz, H-4), 3.49 (s, 3 H, OMe), 3.22 (d, 1 H, $J_{2,3}$ 3.6 Hz, H-3), 2.99 (d, 1 H, H-2), 2.95 (dd, 1 H, $J_{5,6}$ 2, $J_{6,6'}$ 13.5 Hz, H-6), 2.41 (dd, 1 H, $J_{5,6'}$ 10 Hz, H-6'), and 1.08 (s, 9 H,

CMe_3); ^{13}C, δ 172.14 (*C*OPh), 135.93, 133.86, 133.29, 132.60, 130.29, 130.18, 129.43, 128.56, 128.09, and 127.96 (3 Ph), 96.03 (C-1), 68.99 (C-5), 67.78 (C-4), 55.94 (OMe), 55.56 (C-3), 50.15 (C-2), 42.43 (C-6), 27.10 (CMe_3), and 19.41 (CMe_3). Mass spectrum (EI): *m/z* 518 (1%, M^+-O), 373 (16, M^+-C_4H_8-Bz), 213 (100, $Ph_2Si{=}OMe^+$), and 135 (97, PhSi OCH_2^+).

Anal. Calcd for $C_{30}H_{34}O_5SSi$: C, 67.38; H, 6.41; S, 6.00. Found: C, 67.65; H, 6.75; S, 6.13.

Methyl 4-*O*-Benzoyl-3-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (11). A solution of 7 (1 g, 1.5 mmol) in dry ethanol (20 mL) was refluxed with Raney-Ni (9 g) for 1 h. TLC (1:2 EtOAc-hexane) then revealed the presence of a faster-running compound. The catalyst was filtered off and washed with ethanol. The combined filtrate and washings concentrated and the residue chromatographed (1:4 EtOAc-hexane) to afford crystalline **11** (0.8 g, quantitative), mp 75-77° (from hexane); $[\alpha]_D^{23}$ +71.5° (*c* 1.4); ν_{max}^{KBr} 3075 and 3048 (C-H, aromatic), 1730 (C=O, benzoate), 710 and 686 cm^{-1} (aromatic). NMR data: ^1H, δ 7.79-7.26 (m, 15 H, 3 Ph), 5.16 (t, 1 H, $J_{3,4} = J_{4,5}$ = 10 Hz, H-4), 5.09 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.67 (dd, 1 H, $J_{2,3}$ 9 Hz, H-2), 4.41 (t, 1 H, H-3), 3.78 (dq, 1 H, H-5), 3.34 (s, 3 H, OMe), 2.41 (s, 3 H, Ms), 1.14 (d, 3 H, $J_{5,6}$ 6.5 Hz, H-6,6,6), and 0.83 (s, 9 H, CMe_3); ^{13}C, δ 165.58 (*C*OPh), 136.06, 135.88, 133.47, 133.09, 132.13, 129.85, 129.76, 129.62, 128.08, and 127.61 (3 Ph), 97.21 (C-1), 78.98 (C-2), 76.89 (C-3), 70.80 (C-4), 65.41 (C-5), 55.54 (OMe), 37.82 (Ms), 26.69 (CMe_3), 19.42 (CMe_3), and 17.62 (C-6). Mass spectrum (CI, CH_4): *m/z* 564 (100%, M^+-2-MeOH), 540 (10, M^+-1-C_4H_9), 521 (3, M^+-Ph), 503 (8, M^++1-MsOH), and 419 (12, M^+-1-C_4H_9-$PhCO_2$).

Anal. Calcd for $C_{31}H_{38}O_8SSi$: C, 62.18; H, 6.40; S, 5.35. Found: C, 61.76; H, 6.35; S, 5.18.

Treatment of 11 with sodium methoxide. To a stirred solution of **11** (740 mg, 1.24 mmol) in dry methanol (5 mL), 1 M methanolic sodium methoxide (3 mL) was added, and the mixture maintained at room temperature for 2 days. TLC (1:2 EtOAc-hexane) then showed the absence of **11** and the presence of three new products. The mixture was neutralised with acetic acid, concentrated and the residue extracted with dichloromethane. The extracts were washed with water, then concentrated. Column chromatography (1:4 EtOAc-hexane) of the residue gave first syrupy methyl 2,3-anhydro-4-*O*-*tert*-butyldiphenylsilyl-6-deoxy-α-D-

mannopyranoside (**14**, 19 mg, 24%); $[\alpha]_D^{27}$ +74° (*c* 1); ν_{max}^{film} 3052 and 3016 (C-H, aromatic), 703 and 691 cm^{-1} (aromatic). NMR data: ^1H, δ 7.70-7.34 (m, 10 H, 2 Ph), 4.74 (s, 1 H, H-1), 3.66 (dq, 1 H, H-5), 3.57 (d, 1 H, $J_{4,5}$ 9 Hz, H-4), 3.43 (s, 3 H, OMe), 3.20 (d, 1 H, $J_{2,3}$ 3.5 Hz, H-3), 2.98 (d, 1 H, H-2), 1,09 (s, 9 H, CMe_3), and 1.05 (d, 3 H, $J_{5,6}$ 6 Hz, H-6,6,6); ^{13}C, δ 136.01, 133.52, 133.02, 130.06, and 127.87 (2 Ph), 96.12 (C-1), 69.76 (C-5), 65.59 (C-4), 55.95 (OMe), 55.56 (C-3), 50.18 (C-2), 27.07 (CMe_3), 19.45 (CMe_3), and 18.40 (C-6). Mass spectrum (CI, CH_4): *m/z* 397 (5%, M^+-1), 381 (11, M^+-1-O), 367 (22, M^+-1-CH_2O), 339 (9, M^+-1-C_4H_{10}), and 323 (100, M^+-1-O-C_4H_{10}).

Anal. Calcd for $C_{23}H_{30}O_4Si$: C, 69.31; H, 7.59. Found: C, 69.25; H, 7.35.

A second fraction was collected and rechromatographed (1:4 ether-hexane) to yield first methyl 4-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (**13**, 53 mg, 10%) as a syrup; $[\alpha]_D^{27}$ +28.5° (*c* 0.4); ν_{max}^{film} 3560 (OH), and 704 cm^{-1} (aromatic). NMR data: ^1H, δ 7.75-7.69 and 7.47-7.41 (2 m, 10 H, 2 Ph), 4.99 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.57 (dd, 1 H, $J_{2,3}$ 9.5 Hz, H-2), 4.08 (t, 1 H, $J_{3,4}$ 9.5 Hz, H-3), 3.51 (dq, 1 H, $J_{4,5}$ 9 Hz, H-5), 3.32 (s, 3 H, OMe), 3.26 (t, 1 H, H-4), 2.82 (s, 3 H, Ms), 2.16 (s, 1 H, HO-3), 1.18 (d, 3 H, $J_{5,6}$ 6 Hz, H-6,6,6), and 1,06 (s, 9 H, CMe_3); ^{13}C, δ 136.11, 135.55, 134.08, 132.94, 130.19, 130.11, 128.18, and 128.02 (2 Ph), 97.42 (C-1), 79.01 (C-2), 77.42 (C-4), 73.76 (C-3), 66.47 (C-5), 55.37 (OMe), 38.54 (Ms), 27.09 (CMe_3), 19.72 (CMe_3), and 17.60 (C-6). Mass spectrum (CI, CH_4): *m/z* 445 (15%, M^++1-H_2O-MeOH), 437 (3, M^++1-C_4H_{10}), 419 (10, M^+ +1-C_4H_{10}-H_2O), 261 (20), and 143 (100, $C_6H_{11}O_2Si^+$).

Eluted second was syrupy 3-*O*-*tert*-butyldiphenylsilyl-6-deoxy-2-*O*-methanesulfonyl-α-D-glucopyranoside (**12**, 150 mg, 28%); $[\alpha]_D^{23}$ +110° (*c* 1.2); ν_{max}^{film} 3547 (OH), 3076 and 3050 (C-H, aromatic), and 705 cm^{-1} (aromatic). NMR data: ^1H, δ 7.75-7.74, 7.68-7.62, and 7.47-7.38 (3 m, 10 H, 2 Ph), 4.76 (d, 1 H, $J_{1,2}$ 4 Hz, H-1), 4.19 (dd, 1 H, $J_{2,3}$ 10 Hz, H-2), 4.01 (dd, 1 H, $J_{3,4}$ 8.3 Hz, H-3), 3.79 (dq, 1 H, $J_{4,5}$ 9.3 Hz, H-5), 3.42 (s, 3 H, OMe), 3.24 (dd, 1 H, H-4), 2.96 (s, 3 H, Ms), 1.84 (bs, 1 H, HO-4), 1.19 (d, 3 H, $J_{5,6}$ 6 Hz, H-6,6,6), and 1,05 (s, 9 H, CMe_3); ^{13}C, δ 136.26, 135.32, 134.48, 131.99, 130.24, 130.11, 128.23, and 127.98 (2 Ph), 97.55 (C-1), 79.22 (C-2), 78.90 (C-4), 71.83 (C-3), 67.27 (C-5), 55.55 (OMe), 38.25 (Ms), 27.19 (CMe_3), 19.64 (CMe_3), and 17.99 (C-6). Mass spectrum (CI, CH_4): *m/z* 445 (16%, M^++1-H_2O-MeOH), 437 (11, M^++1-C_4H_{10}), 419 (4, M^++1-C_4H_{10}-H_2O), 261 (100), and 143 (45, $C_6H_{11}O_2Si^+$).

Methyl 4,6-*O*-Benzylidene-2-*O*-methanesulfonyl-3-*O*-(2-methoxyethoxymethyl)-α-D-glucopyranoside (15). To a stirred and cooled (ice-water) solution of **4** (3.6 g, 10 mmol) in dry THF (20 mL) was added NaH (70% oil dispersion, 410 mg, 12 mmol) under argon. The mixture was left for 1 h, and then 2-methoxyethoxymethyl chloride (1.4 mL, 12 mmol) was added dropwise. After 1 h, TLC (1:2 EtOAc-hexane) then revealed the presence of a slower-running compound. The reaction mixture was quenched by addition of ether saturated with water, concentrated and the residue partitioned into dichloromethane-water. The organic phase was separated, washed with water and concentrated. Flash chromatography (1:4 EtOAc-hexane) of the residue afforded crystalline **15** (4.24 g, 89%), mp 71-72°; $[\alpha]_D^{27}$ +48° (*c* 1.2); ν_{max}^{KBr} 3032 and 3015 (C-H, aromatic), 756 and 699 cm^{-1} (aromatic). NMR data: ^1H, δ 7.47-7.33 (m, 5 H, Ph), 5.51 (s, 1 H, C*H*Ph), 4.97 (d, 1 H, $J_{1,2}$ 3.7 Hz, H-1), 4.91 and 4.86 (2 d, 2 H, J 7 Hz, $OCH_2O(CH_2)_2OCH_3$), 4.48 (dd, 1 H, $J_{2,3}$ 9.5 Hz, H-2), 4.29 (dd, 1 H, $J_{5,6}$ 4.5, $J_{6,6'}$ 10 Hz, H-6), 4.24 (t, 1 H, $J_{3,4}$ 9.5 Hz, H-3), 3.87 (dt, 1 H, $J_{4,5} = J_{5,6'} = 10$ Hz, H-5), 3.73 (t, 1 H, H-6'), 3.68 (m, 2 H, $OCH_2OCH_2CH_2OCH_3$), 3.54 (t, 1 H, H-4), 3.45 (s, 3 H, OMe), 3.32 (m, 2 H, $OCH_2OCH_2CH_2OCH_3$), 3.21 (s, 3 H, $OCH_2O(CH_2)_2OCH_3$), and 3.09 (s, 3 H, Ms); ^{13}C, δ 137.02, 129.56, 128.33, and 126.22 (Ph), 101.84 (*C*HPh), 98.56 (C-1), 96.33 ($OCH_2O(CH_2)_2OCH_3$), 81.56 (C-4), 78.56 (C-2), 72.54 (C-3), 71.58 ($OCH_2OCH_2CH_2OCH_3$), 68.88 (C-6), 67.60 ($OCH_2OCH_2CH_2OCH_3$), 62.32 (C-5), 58.98 ($OCH_2OCH_2CH_2OCH_3$), 55.75 (OMe), and 38.35 (Ms). Mass spectrum (CI, CH_4): *m/z* 417 (15%, M^++1-MeOH), 373 (100, M^++1-$CH_3O(CH_2)_2OH$), 165 (34, $C_{10}H_{13}O_2^+$), and 89 (62, MEM^+).

Anal. Calcd for $C_{19}H_{28}O_{10}S$: C, 50.88; H, 6.29; S, 7.15. Found: C, 50.82; H, 6.32; S, 7.14.

Methyl 4-*O*-Benzoyl-6-bromo-6-deoxy-2-*O*-methanesulfonyl-3-*O*-(2-methoxyethoxymethyl)-α-D-glucopyranoside (16). Compound **15** (3.7 g, 8.26 mmol) was treated with NBS (1.62 g, 9 mmol) and $BaCO_3$ (6.5 g, 33 mmol) in dry CCl_4 (75 mL) as compound **5** for 1 h. TLC (1:2 EtOAc-hexane) then revealed the presence of a new compound with lower mobility. After conventional workup, column chromatography (1:3 EtOAc-hexane) of the resulting residue gave syrupy **16** (4.3 g, quantitative; $[\alpha]_D^{25}$ +33° (*c* 1.1); ν_{max}^{film} 3064 and 3035 (C-H, aromatic), 1730 (C=O, benzoate), and 712 cm^{-1} (aromatic). NMR data: ^1H, δ 8.08-8.03 and 7.63-7.41 (2 m, 5 H, Ph), 5.19 (dd, 1 H, $J_{3,4}$ 9, $J_{4,5}$ 10 Hz, H-4), 5.06 (d, 1 H, $J_{1,2}$ 3.5 Hz,

H-1), 4.75 (s, 2 H, $OCH_2O(CH_2)_2OCH_3$), 4.53 (dd, 1 H, $J_{2,3}$ 10 Hz, H-2), 4.25 (t, 1 H, H-3), 4.05 (ddd, 1 H, $J_{5,6}$ 3, $J_{5,6'}$ 7.5 Hz, H-5), 3.52 (s, 3 H, OMe), 3.55-3.35 (m, 4 H, OCH_2OCH_2 CH_2OCH_3,6,6'), 3.18 (s, 3 H, $OCH_2O(CH_2)_2OCH_3$), 3.22-3.11 (m, 2 H, $OCH_2OCH_2CH_2O$ CH_3), and 3.09 (s, 3 H, Ms); ^{13}C, δ 165.21 (*C*OPh), 133.87, 130.02, 129.00, and 128.33 (Ph), 97.63 (C-1), 97.26 ($OCH_2O(CH_2)_2OCH_3$), 78.34 (C-2), 75.24 (C-3), 72.84 (C-4), 71.37 ($OCH_2OCH_2CH_2OCH_3$), 69.33 (C-5), 68.14 ($OCH_2OCH_2CH_2OCH_3$), 58.86 (OCH_2OCH_2 CH_2OCH_3), 55.97 (OMe), 38.33 (Ms), and 31.19 (C-6). Mass spectrum (LSIMS): *m/z* 527.05518 (M^++1, referred to ^{79}Br). For $C_{19}H_{28}BrO_{10}S$ 527.05866 (deviation 6.6 ppm).

Methyl 6-*S*-Acetyl-4-*O*-benzoyl-2-*O*-methanesulfonyl-3-*O*-(2-methoxyethoxy methyl)-6-thio-α-D-glucopyranoside (17). Compound **16** (4.2 g, 8 mmol) was treated with potassium thioacetate (1.82 g, 16 mmol) in dry DMF (50 mL) as compound **6**. After conventional workup, flash chromatography (1:4 → 1:2 EtOAc-hexane) of the resulting residue gave syrupy **17** (2.78 g, 67%); $[\alpha]_D^{27}$ +50° (*c* 1); ν_{max}^{film} 3066 (C-H, aromatic), 1730 (C=O, benzoate), and 713 cm^{-1} (aromatic). NMR data: ^1H, δ 8.09-8.06, 7.62-7.56, and 7.49-7.43 (3 m, 5 H, Ph), 5.17 (dd, 1 H, $J_{3,4}$ 9, $J_{4,5}$ 10 Hz, H-4), 4.97 (d, 1 H, $J_{1,2}$ 3.6 Hz, H-1), 4.73 (s, 2 H, $OCH_2O(CH_2)_2OCH_3$), 4.49 (dd, 1 H, $J_{2,3}$ 10 Hz, H-2), 4.20 (t, 1 H, H-3), 3.93 (ddd, 1 H, $J_{5,6}$ 3, $J_{5,6'}$ 8.5 Hz, H-5), 3.53-3.40 (m, 2 H, $OCH_2OCH_2CH_2OCH_3$), 3.45 (s, 3 H, OMe), 3.27 (dd, 1 H, $J_{6,6'}$ 14 Hz, H-6), 3.17 (s, 3 H, $OCH_2O(CH_2)_2OCH_3$), 3.15-3.11 (m, 2 H, OCH_2 $OCH_2CH_2OCH_3$), 3.08 (s, 3 H, Ms), 2.91 (dd, 1 H, H-6'), and 2.28 (s, 3 H, SAc); ^{13}C, δ 194.39 (*S*COMe), 165.24 (*C*OPh), 133.48, 129.89, 129.77, and 128.55 (Ph), 97.26 (C-1), 96.87 ($OCH_2O(CH_2)_2OCH_3$), 78.26 (C-2), 74.89 (C-3), 72.84 (C-4), 71.07 ($OCH_2OCH_2CH_2$ OCH_3), 68.55 (C-5), 67.78 ($OCH_2OCH_2CH_2OCH_3$), 58.58 ($OCH_2OCH_2CH_2OCH_3$), 55.42 (OMe), 37.98 (Ms), 30.24 (SCO*Me*), and 30.06 (C-6). Mass spectrum (LSIMS): *m/z* 521.11621 (M^+-1). For $C_{21}H_{29}O_{11}S_2$ 521.11513 (deviation -2.1 ppm).

Treatment of 17 with sodium methoxide. To a stirred solution of **17** (1.3 g, 2.5 mmol) in dry methanol (15 mL), 1.4 M methanolic sodium methoxide (7 mL) was added dropwise, and the mixture maintained at room temperature for 2 days. TLC (1:1 EtOAc-hexane) then showed the absence of **17** and the presence of a slower-running product. After workup as above, flash chromatography (9:1 EtOAc-hexane) afforded methyl 2-*O*-methane sulfonyl-3-*O*-(2-methoxyethoxymethyl)-6-thio-α-D-glucopyranoside (**18**, 830 mg, 88%) as a syrup; $[\alpha]_D^{28}$ +200° (*c* 1); ν_{max}^{film} 3421 (OH). NMR data: ^1H, δ 5.01 (d, 1 H, $J_{1,2}$ 3.7 Hz, H-1),

4.98 and 4.86 (2 d, 2 H, J 7.2 Hz, $OCH_2O(CH_2)_2OCH_3$), 4.52 (dd, 1 H, $J_{2,3}$ 10 Hz, H-2), 4.00-3.92 (m, 2 H, $OCH_2OCH_2CH_2OCH_3$, H-5), 3.88 (dd, 1 H, $J_{3,4}$ 8.4 Hz, H-3), 3.78 (m, 1 H, $OCH_2OCH_2CH_2OCH_3$), 3.64 (m, 2 H, $OCH_2OCH_2CH_2OCH_3$), 3.54 (s, 3 H, OMe), 3.51 -3.43 (m, 3 H, H-4,6,6'), 3.46 (s, 3 H, $OCH_2O(CH_2)OCH_3$), 3.14 (s, 3 H, Ms), and 2.94 (dd, 1 H, $J_{6,SH}$ 8.5, $J_{6',SH}$ 14 Hz, SH); ^{13}C, δ 97.45 (C-1), 97.34 ($OCH_2O(CH_2)_2OCH_3$), 82.24 (C-3), 78.23 (C-2), 72.49 (C-4), 71.56 ($OCH_2OCH_2CH_2OCH_3$), 69.70 (C-5), 68.10 ($OCH_2OCH_2CH_2OCH_3$), 59.01 ($OCH_2OCH_2CH_2OCH_3$), 55.58 (OMe), 41.86 (C-6), and 38.43 (Ms). Mass spectrum (LSIMS): *m/z* 377.09589 (M^++1). For $C_{12}H_{25}O_9S_2$ 377.09400 (deviation -5.0 ppm).

Treatment of **18** (215 mg, 0.6 mmol) with 2.4 M sodium methoxide in dry methanol (4 mL) under reflux for 4 h gave, after usual workup (*vide supra*) and column chromatography (20:1 chloroform-methanol), methyl 3-*O*-(-2-methoxyethoxymethyl)-6-thio-α-D-glucopyranoside (**19**, 14 mg, 10%) as a syrup; $[\alpha]_D^{27}$ +186° (*c* 0.2); ν_{max}^{film} 3441 cm^{-1} (OH). NMR data: ^1H, δ 4.92 and 4.86 (2 d, 2 H, J 7.5 Hz, $OCH_2O(CH_2)_2OCH_3$), 4.71 (d, 1 H, $J_{1,2}$ 2.5 Hz, H-1), 3.89-3.81 (m, 2 H, H-5,6), 3.76 (dt, 1 H, J 4.2, J 11, $OCH_2OCH_2CH_2OCH_3$), 3.60-3.55 (m, 5 H, H-2,3,$OCH_2OCH_2CH_2OCH_3$ and $OCH_2OCH_2CH_2OCH_3$), 3.49-3.37 (m, 2 H, H-4,6'), 3.45 (s, 3 H, $OCH_2O(CH_2)_2OCH_3$), and 2.83 (dd, 1 H, $J_{6,SH}$ 8.5, $J_{6',SH}$ 14 Hz, SH); ^{13}C, δ 99.09 (C-1), 97.26 ($OCH_2O(CH_2)_2OCH_3$), 85.33 (C-3), 71.71 (C-4), 71.61 ($OCH_2OCH_2CH_2OCH_3$), 71.42 (C-2), 69.54 (C-5), 67.76 ($OCH_2OCH_2CH_2OCH_3$), 59.04 ($OCH_2OCH_2CH_2OCH_3$), 55.38 (OMe), and 41.86 (C-6). Mass spectrum (CI, CH_4): *m/z* 299 (1%, M^++1), 281 (1.5, M^++1-H_2O), 249 (9, M^++1-H_2O-MeOH), 161 (84, M^++1-H_2O-MeOH-$C_4H_8O_2$), and 89 (100, MEM^+).

Anal. Calcd for $C_{11}H_{22}O_7S$: C, 44.28; H, 7.43; S, 10.75 Found: C, 44.56; H, 7.32; S, 10.64.

Methyl 4,6-*O*-Benzylidene-2-*O*-trifluoromethanesulfonyl-α-D-glucopyranoside (**20**). To a stirred solution of methyl 4,6-*O*-benzylidene-α-D-glucopyranoside (1.41 g, 5 mmol) in dry methanol (15 mL) was added dibutyltin oxide (1.26 g, 5.05 mmol) and the suspension was heated for 2 h under reflux, then concentrated to afford the 2,3-dibutylstannylene derivative as a syrup that was dried under vacuum over P_2O_5 overnight. To a cooled (ice-water) and stirred solution of the above syrup and triethylamine (0.7 mL, 5.5 mmol) in dry 1,4-dioxane (10 mL), trifluoromethanesulfonyl anhydride (0.83 mL, 5.05 mmol) was added dropwise under argon. The mixture was left at room temperature for 20 h. TLC (1:1 EtOAc-

hexane) then revealed a main faster running compound. The mixture was concentrated and flash chromatographed (1:4 EtOAc-hexane) to yield syrupy **20** (1.41 g, 68%); $[\alpha]_D^{26}$+71° (*c* 1); ν_{max}^{film} 3440 (OH), 3070 and 3040 (C-H, aromatic), 740 and 700 cm^{-1} (aromatic). NMR data: ^1H, δ 7.51-7.32 (m, 5 H, Ph), 5.54 (s, 1 H, C*H*Ph), 4.97 (d, 1 H, $J_{1,2}$ 3.8 Hz, H-1), 4.70 (dd, 1 H, $J_{2,3}$ 9.4 Hz, H-2), 4.32 (dd, 1 H, $J_{5,6e}$ 4.8, $J_{6a,6e}$ 10.2 Hz, H-6*e*), 4.27 (t, 1 H, $J_{3,4}$ 9.4 Hz, H-3), 3.87 (dt, 1 H, $J_{5,6a}$ 10 Hz, H-5), 3.75 (t, 1 H, $J_{4,5}$ 10.3 Hz, H-4), 3.54 (bt, 1 H, H-6*a*), and 3.48 (s, 3 H, OMe); ^{13}C, δ 136.84, 129.47, 128.44, and 126.33 (CH*Ph*), 102.12 (*C*HPh), 98.59 (C-1), 81.39 (C-4), 79.36 (C-2), 68.79 (C-6), 68.65 (C-3), 61.96 (C-5), 55.81 (OMe), and 38.35 (Ms). Mass spectrum (LSIMS): *m/z* 361.09636 (M^++1). For $C_{15}H_{21}O_8S$ 361.09572 (deviation -1.8 ppm).

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