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Note

Preparation of some partially protected, α,α-trehalose-type disaccharides having the D-*altro* configuration

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For a synthetic project in the area of α,α-trehalose analogs, we required as a key intermediate an α-D-altropyranosyl α-D-altropyranoside wherein O-2, O-4, and O-6 in both moieties are temporarily protected and the C-3 atoms bear a functionality amenable to further modification, be it by nucleophilic displacement or by oxidation. Entry into the series of such D-*altro*,D-*altro* (1→1′)diglycoses had previously been achieved[1] by epoxide-opening reactions in 2,3-anhydro-4,6-*O*-benzylidene-α-D-mannopyranosyl 2,3-anhydro-4,6-*O*-benzylidene-α-D-mannopyranoside (**4**) and its α-D-*allo*,α-D-*allo* isomer **5**. These diepoxides are accessible by base treatment of suitable sulfonic esters derived from the parent, α,α-trehalose diacetal **1**. Thus, the diepoxide **4** is prepared[2] from the 2,2′-ditosylate **2** which, in turn, is obtainable by partial tosylation of **1**. The diepoxide **5** has been synthesized[2] from the tetra-*O*-mesyl analog of the 2,3,2′,3′-tetratosylate **3**. For the present work, we found it convenient to utilize, if possible, the latter ester (**3**), a supply of which had to be procured for a concurrent, independent study. Because fairly large quantities of the epoxides and sulfonic esters were needed, we first sought to improve some aspects of their preparation by procedural modifications.

Application to α,α-trehalose of the acetal-exchange method using α,α-dimethoxytoluene[3], on a 50-g scale, furnished the diacetal **1** in 94% yield in operations requiring one working day; a 78% yield had been reported[2] for a 120-h reaction using benzaldehyde and zinc chloride. Selective tosylation of **1** by use[4] of 1-tosylimidazole afforded the 2,2′-ditosylate **2** in ~50% yield. This was less than the 70% yield reported[2] for dimolar tosylation with tosyl chloride, but a shorter reaction-time was required (4.5 *vs.* 72 h). Chromatographic processing of the mother liquor was worth while only for isolating the corresponding 2-monotosylate (12% yield) and 2,3,2′-tritosylate (6.5% yield), which were formed as by-products and, as unsymmetrically derivatized compounds, are useful for a variety of synthetic

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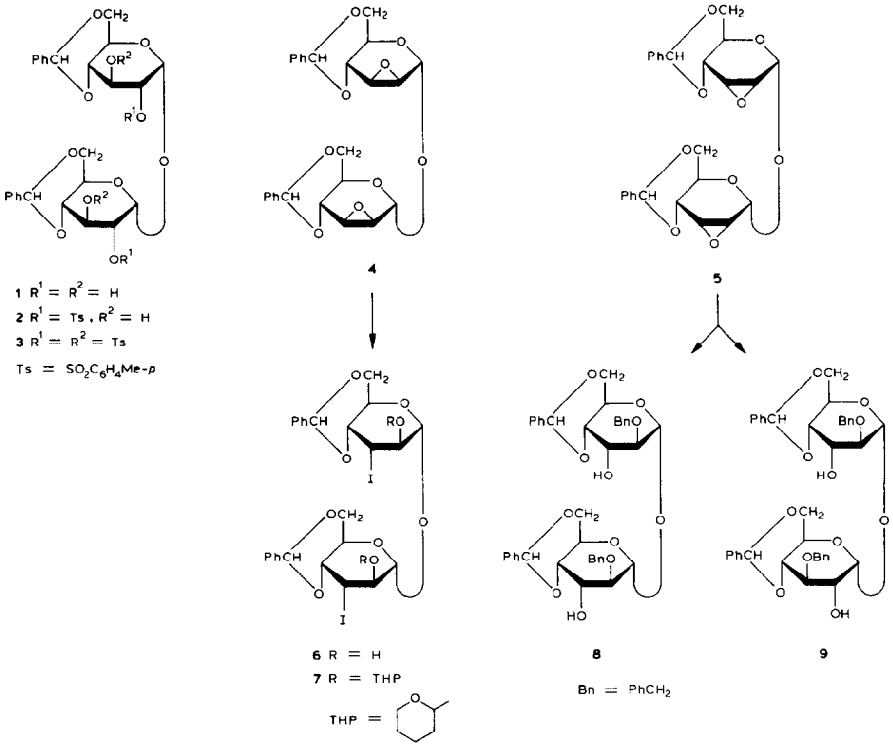
pursuits. They are, however, more directly obtainable as previously described[2]. A minor modification introduced in the preparation[2] of the tetratosylate **3** led to a 90% yield of this ester, on a 50-g scale. Finally, it proved possible to use **3**, instead of the corresponding tetramesylate, for the practical preparation of **5** (with slightly improved yield), although the reaction proceeded with some difficulty and required a considerably longer time, owing to the lower reactivity of tosylates.

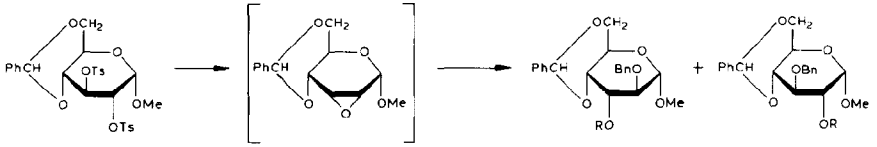
To arrive at an *altro,altro* disaccharide derivative meeting the aforementioned conditions, the diepoxide **4** was treated with sodium iodide in the presence of acetic acid and sodium acetate. The desired bis-iodohydrin **6** was readily obtained, and was subsequently protected as the 2,2′-bis(tetrahydropyran-2-yl) ether **7**. We found no evidence for the occurrence of any competing, 2,3-diequatorial, oxirane ring-opening, which conformed with the observed[5] iodohydrin formation from the analogous, monosaccharidic methyl glycoside.

For an alternative approach, the diepoxide **5** was treated with sodium benzoxide in a mixture of benzyl alcohol and oxolane. This reaction furnished a 6:1 mixture of 2-*O*-benzyl-4,6-*O*-benzylidene-α-D-altropyranosyl 2-*O*-benzyl-4,6-*O*-benzylidene-α-D-altropyranoside (**8**) and the unsymmetrical isomer, namely, 2-*O*-benzyl-4,6-*O*-benzylidene-α-D-altropyranosyl 3-*O*-benzyl-4,6-*O*-benzylidene-α-D-glucopyranoside (**9**), which, after chromatographic separation and recrystallization,



were obtained pure in 79 and 14% yield, respectively. Again, observance of the Fürst–Plattner rule of diaxial oxirane ring-opening was noted, although it applied less rigorously than in the preceding instance. The main product **8**, having in this way become available from commercial α,α-trehalose in four steps with an overall yield of 53%, proved to be a convenient stepping-stone for further synthetic work.

We also considered a possibility for simplifying the synthetic sequence just described, by treating the tetratosylate **3** with sodium benzoxide in benzyl alcohol, assuming that it might give **8** (and **9**) directly, *via* the epoxide **5** formed *in situ*. It is well known that methyl 4,6-*O*-benzylidene-2,3-di-*O*-*p*-tolylsulfonyl-α-D-glucopyranoside (**10**) readily produces the corresponding 2,3-anhydroallopyranoside **11** on treatment with alkoxide[6]; ring opening in **11** has been shown to occur with sodium benzoxide under more-forcing conditions[7]. Studying first this monosaccharide model, we did in fact obtain, from **10** directly, a 67% yield of a mixture of the 2-*O*-benzylaltroside **12** and the 3-*O*-benzylglucoside **15**, which were separated (with some loss) by chromatography. The former isomer preponderated, as was the case[7] in the ring opening of isolated **11**. For potential use in further, model reactions involving nucleophilic displacements, the alcohols **12** and **15** were derivatized by the introduction of leaving-groups. Thus, the D-glucoside **15** furnished a stable 2-triflate (**16**). From the altroside **12**, the 3-triflate **13** was obtained, and characterized by its ^{1}H-n.m.r. spectrum, but, in isolated form, it was rather unstable at ambient temperature and could not be submitted to elemental analysis. However,



10 **11** **12** R = H, **13** R = Tf, **14** R = SO_2–N, **15** R = H, **16** R = Tf

Tf = SO_2CF_3

a stable 1-imidazolylsulfonate (**14**) could be prepared. Unfortunately, translation of these model experiments into the disaccharide series did not meet with success, as treatment of **3** with sodium benzoxide in benzyl alcohol at elevated temperature led to extensive decomposition.

EXPERIMENTAL

Preparation of the starting disaccharide derivatives. — A. Benzylidenation[3] *of* α,α*-trehalose.* α,α-Trehalose dihydrate (50 g, 132 mmol) was dehydrated by boiling a suspension in absolute ethanol (300 mL) under reflux for 30 min, and evaporating the alcohol. The dry residue (45.64 g) was then suspended in dry *N,N*-dimethylformamide (300 mL), and α,α-dimethoxytoluene[3] (DMT; 20 mL, 133 mmol) was

added, together with *p*-toluenesulfonic acid (1 g). The mixure was heated, with occasional swirling, on a steam bath for 10 min. The flask was then attached to a rotary evaporator with water aspirator (bath temperature, 60°) for a period of 5 min, after which the heating procedures on the steam bath and on the evaporator were repeated twice, each time with the addition of fresh DMT (20 mL and 5 mL, respectively). At the end, only a negligible amount of solid material remained suspended in the reaction solution. Evaporation of most of the solvent, followed by dilution of the resulting syrup with benzene (150 mL), gave a first crop of crystalline diacetal **1**, which was collected and washed with benzene. Further crops were obtained from the combined mother-liquor and washings after partial evaporation, and from the last filtrate when it was poured into, and shaken with, aqueous sodium hydrogencarbonate solution. All crops were combined, washed by stirring it in the hydrogencarbonate solution, filtered, washed successively with water and hexane, and dried in the air. The product (69.8 g) was recrystallized by dissolution in boiling 99% ethanol (100 mL), addition of hot water (50 mL), and slow cooling. With processing of the mother liquor, a total of 65.6 g (94%) of **1** was obtained, in several crops melting within the range indicated in the literature for **1** · hemihydrate (m.p.[2] 198–199° and[8] 195°). The product was pure according to its n.m.r. spectrum and t.l.c. (R_F 0.4, 3:1 ethyl acetate–chloroform); $[\alpha]_D$ +81.3° (*c* 1, methanol), lit.[8] +80° (methanol).

B. Selective tosylation[4]. The diacetal hemihydrate **1** (32 g, 0.06 mol) and 1-tosylimidazole[4] (33.2 g, 0.15 mol) were suspended in chloroform (1 L), powdered sodium methoxide (10 g, 0.18 mol) was added, and the mixture was boiled under reflux for 4.5 h, with magnetic stirring. During the first 20 min, water droplets were seen to gather in the condenser, which was repeatedly exchanged for a dry one until the phenomenon abated. (Use of a Dean–Stark trap proved inefficient.) When all of **1** had been consumed (t.l.c.), the cooled reaction-mixture was washed three times with water, dried (Na_2SO_4), filtered through Celite, and evaporated. The resulting foam was dissolved in hot chloroform (60 mL) followed by hot ethanol (80 mL), and crystallization at 0° yielded 28 g of crude ditosylate **2**. Recrystallization from the same solvents gave pure **2** (25.5 g) as an ethanol solvate showing a double m.p., 143–150° (loss of ethanol) and 218–220°; lit.[2] 135–140 and 209–211°. An additional crop (1.7 g) was isolated from the mother liquors as described next, bringing the total yield of **2** to 27.2 g (50%). The specific rotation, $[\alpha]_D$ +63° in chloroform, and the ^{1}H-n.m.r. spectrum agreed with the data reported[2].

The mother liquors from the first crystallization, and from the recrystallization, showed several spots in t.l.c. (3:7 ethyl acetate–chloroform). After removal of the solvent, the material was processed by column chromatography on silica gel, with 1:1 chloroform-benzene as the initial eluant, followed by chloroform–ethyl acetate mixtures (20:1 to 7:3). Some mixed fractions were rechromatographed. The following compounds were isolated (in order of decreasing mobility): (*a*) the 2,3,2′-tritosylate of **1** as a syrup (3.9 g, 6.5%), identified by the ^{1}H-n.m.r. pattern of the *O*-tosyl resonances; (*b*) a mono-*O*-tosyl monoepoxide (1.1 g, 2.7%) of un-

certain configuration; (*c*) compound **2** (1.7 g); (*d*) crystalline 2,3-anhydro-4,6-*O*-benzylidene-α-D-mannopyranosyl 4,6-*O*-benzylidene-α-D-glucopyranoside (3.1 g, 10%), m.p. 150–155° (recrystallized from carbon tetrachloride) and $[\alpha]_D$ +90.2° (*c* 0.9, chloroform), lit.[2] m.p. 152–155° and $[\alpha]_D$ +88.5°; and (*e*) the 2-monotosylate of **1** (5.1 g, 12.3%), recrystallized from chloroform–carbon tetrachloride, m.p. 207° (dec.), $[\alpha]_D$ +70.4° (*c* 1.5, chloroform), lit.[2] m.p. 188–189° and $[\alpha]_D$ +75° for the dihydrate, and m.p. 215° for the anhydrous compound. Its n.m.r. data agreed with those reported[2].

C. Complete tosylation. For the preparation of **3** on a large scale, we found tosylation of **1** as previously described[2] (24 h at room temperature) to be unsatisfactory, with considerable proportions of intermediates remaining visible in t.l.c. We therefore treated **1** · hemihydrate (52.8 g, 0.1 mol) in pyridine (300 mL) with *p*-toluenesulfonyl chloride (114.7 g, 0.6 mol), in the presence of a catalytic amount (2 g) of 4-(dimethylamino)pyridine, for 1 day on a gently-operated steam-bath. Some partially tosylated material persisted even then, and heating was continued for 1 day after addition of fresh tosyl chloride (28.5 g, 0.15 mol). The dark-brown solution was concentrated to a small volume, and the resulting slurry was poured with efficient stirring into water (1 L). The precipitate was collected, and washed with water followed by absolute ethanol, to give crude **3** (116 g, air-dried). A solution of the product in chloroform (700 mL) was clarified by passage through Celite, and concentrated to half its volume, heated to reverse the incipient crystallization, mixed with hot 99% ethanol (200 mL), and allowed to cool. There was obtained pure **3** (101.52 g), and another 1.04 g was elaborated from the mother liquor, for a total yield of 90.3%; m.p. 255–259°, lit.[2] m.p. 250–254°; ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 7.91 and 7.19 (two d, *J* 8.5 Hz, TsO-2), 7.62 and 6.86 (two d, *J* 8.5 Hz, TsO-3), 7.40–7.25 (m, Ph), 5.66 (d, $J_{1,2}$ 3.9 Hz, H-1), 5.28 (s, *Ph*-CH), 5.09 (t, $J_{2,3} = J_{3,4} = 9.5$ Hz, H-3), 4.75 (dd, *J* 3.9 and 9.5 Hz, H-2), 4.53 (dd, H-6*e*), 4.20 (dt, $J_{5,6e}$ 5 Hz, H-5), 3.67 (t, $J_{5,6a} = J_{6a,6e} \sim 10$ Hz, H-6*a*), 3.60 (t, $J_{3,4} = J_{4,5} = 9.5$ Hz, H-4), 2.39 (s, TsO-2), and 2.20 (s, TsO-3). The completely resolved, first-order spectrum showed no evidence for the presence of any impurities. This is noted because of a discrepancy in $[\alpha]_D$ values: found, +2.15°; and +3.45° for a sample similarly prepared but from **2**; reported[2], +28° (all *c* 1, dichloromethane; reported for the corresponding tetrabrosylate, −21°).

D. 2,3-Anhydro-4,6-O-benzylidene-α-D-mannopyranosyl 2,3-anhydro-4,6-O-benzylidene-α-D-mannopyranoside (**4**). This compound was prepared[2] from **2** by action of ethanolic sodium ethoxide at the reflux temperature (1 h). It can also be prepared by stirring a solution of **2** (8.73 g) in *N,N*-dimethylformamide (100 mL) with sodium hydride (1.3 g, as a 62% oil dispersion) during 1 h at room temperature. Yields by either procedure are ~80%. The product was recrystallized from hot DMF; m.p. 295–297°, lit.[2] m.p. 291–293°.

E. 2,3-Anhydro-4,6-O-benzylidene-α-D-allopyranosyl 2,3-anhydro-4,6-O-benzylidene-α-D-allopyranoside (**5**). The tetratosylate **3** (104.75 g, 92.3 mmol) was dissolved in dry dichloromethane (1 L), and a solution of sodium (15 g) in

methanol (300 mL) was added in portions. The mixture was stirred for 3 days, after which the precipitate formed was collected, and washed with dry dichloromethane. The crude product was then successively washed with water, ethanol, and acetone, and dried, to give a major crop of **5** (29.9 g). The organic washing filtrates (that had been collected separately) were evaporated, and the resulting residue was combined with the original filtrate of the reaction mixture. Stirring of that solution was then continued for another 3 days, after which the mixture was shaken with added water, whereby a second crop of crude **5** (2.55 g) separated crystalline. The organic phase was washed with additional water, dried (Na_2SO_4), and evaporated, to give a mixture of materials (23 g) that contained unreacted **3**. It was subjected to a further treatment (2 days) with sodium methoxide (3 g of Na in 75 mL of methanol) in dichloromethane (250 mL), furnishing a third crop of **5** (3.05 g) after processing. The combined crops were recrystallized from boiling *N,N*-dimethylformamide (400 mL), yielding 33.7 g of pure **5** plus 1.45 g from the mother liquor (79%); m.p. 318-320° (dec.), lit.[2] m.p. 308–310° (dec.).

4,6-O-Benzylidene-3-deoxy-3-iodo-α-D-altropyranosyl 4,6-O-benzylidene-3-deoxy-3-iodo-α-D-altropyranoside (**6**). — A mixture of the diepoxide **4** (2.55 g), sodium iodide (7.50 g), anhydrous sodium acetate (0.41 g), acetic acid (12 mL), and acetone (50 mL) was stirred overnight at the reflux temperature. After cooling, the clear solution was processed by neutralization with excess sodium hydrogen carbonate in water, and extraction with ethyl acetate. The extract was successively washed with dilute, aqueous sodium thiosulfate solution and water, dried, and evaporated, to give a syrup (5.4 g) that showed **6** (R_F 0.35) and spots at R_F 0.63 and 0.0 in t.l.c. with 4:1 chloroform–ethyl acetate. Added acetone was evaporated from the syrup, which then crystallized from acetone (4 mL). The crystals (2.9 g) were successively washed with a little acetone and several times with chloroform, and recrystallized from acetone (10 mL), to give virtually pure **6** as an acetone solvate (2.29 g, 54%). Recrystallized once more, an analytical sample showed decomposition at 190–198°; $[\alpha]_D$ +120° (*c* 0.8, acetone); ^{1}H-n.m.r. (200 MHz in CD_3COCD_3): δ 7.5–7.4 (m, Ph), 5.88 (s, *Ph*-CH), 5.16 (d, $J_{1,2}$ 0.5 Hz, H-1), 4.52 (narrow m, H-2 and -3, unresolved), 4.27 (dd, $J_{5,6e}$ 4.8, $J_{6a,6e}$ 9.7 Hz, H-6*e*), 4.06 (td, $J_{4,5}$ 9.0, $J_{5,6a}$ 9.9, $J_{5,6e}$ 4.8 Hz, H-5), 3.89 (t, H-6*a*), 3.43 (dd, $J_{3,4}$ 3.7, $J_{4,5}$ 9.0 Hz, H-4), 2.87 (OH), and 2.09 (s, Me of acetone).

Anal. Calc. for $C_{26}H_{28}I_2O_9 \cdot C_3H_6O$ (796.4): C, 43.74; H, 4.30; I, 31.87. Found: C, 43.78; H, 4.35; I, 31.91.

4,6-O-Benzylidene-3-deoxy-3-iodo-2-O-(R,S-tetrahydropyran-2-yl)-α-D-altropyranosyl 4,6-O-benzylidene-3-deoxy-3-iodo-2-O-(R,S-tetrahydropyran-2-yl)-α-D-altropyranoside (**7**). — To a stirred suspension of the iodohydrin **6** (1.854 g) in anhydrous ether (50 mL) was added 3,4-dihydropyran (0.62 g) and *p*-toluenesulfonic acid (0.2 g). The solution rapidly became clear, but, after a few minutes, a precipitate appeared which redissolved within 2–3 h. Stirring was continued overnight, and the solution was then diluted with ether, washed successively with aqueous sodium hydrogencarbonate and water, dried (Na_2SO_4), and evapo-

rated. The crude product (2.27 g) crystallized from ethanol, giving 1.153 g (66.5%) of pure **7** which showed 3 spots in t.l.c. owing to the existence of diastereoisomers. A recrystallized (ethanol) sample had m.p. 178–180°; $[\alpha]_D$ +63.2° (*c* 0.65, chloroform). The complex, ^{1}H-n.m.r. spectrum (200 MHz in $CDCl_3$) showed the expected intensity ratio between aromatic protons (δ-7.5 region) and tetrahydropyranylic protons (δ-1.6 region), and 3 closely spaced, benzylidene-methine singlets (centered at δ 5.76).

Anal. Calc. for $C_{36}H_{44}I_2O_{11}$ (906.5): C, 47.69; H, 4.89; I, 28.00. Found: C, 47.81; H, 4.76; I, 27.78.

*2-O-Benzyl-4,6-O-benzylidene-α-*D*-altropyranosyl 2-O-benzyl-4,6-O-benzylidene-α-*D*-altropyranoside* (**8**) *and 2-O-benzyl-4,6-O-benzylidene-α-*D*-altropyranosyl 3-O-benzyl-4,6-O-benzylidene-α-*D*-glucopyranoside* (**9**). — Sodium (4.6 g) was dissolved in dry benzyl alcohol (60 mL) at 130–140° under a nitrogen atmosphere. To the cooled solution were added the diepoxide **5** (9.65 g, 0.02 mol) and dry oxolane (100 mL), and the mixture was then boiled under reflux (magnetic stirring) for 16 h. Upon cooling, water (200 mL) and ether (150 mL) were admixed, and after shaking and phase separation, the aqueous phase was extracted once with ether. The combined organic phases were washed once with water, dried (Na_2SO_4), and evaporated, to give a syrupy mixture of reaction products, benzyl alcohol, and dibenzyl ether. Benzyl alcohol was removed by distillation from a hot-water bath, under oil-pump vacuum. The remaining syrup gave crystalline **8** on prolonged trituration with hot methanol and by the aid of seed crystals that had formed in a pure sample during storage for several months. The mother liquor was processed by column chromatography on silica gel, with 3:17 ethyl acetate–hexane as the eluant, to give, successively, dibenzyl ether, compound **9** (R_F 0.28), and compound **8** (R_F 0.25; t.l.c. with 3:7 ethyl acetate–hexane).

The product **8** (11.08 g, 79.3%) had m.p. 194–197°, raised to 197–199° by recrystallization from methanol; $[\alpha]_D$ +94.7° (*c* 0.5, chloroform); ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 7.5–7.3 (m, aromatic), 5.61 (s, *Ph*-CH), 5.05 (s, H-1), 4.61 (AB-q, 2 benzylic protons), 4.2–3.7 (ill-resolved multiplets, H-2–6), and 3.2 (broad, exchangeable; OH).

Anal. Calc. for $C_{40}H_{42}O_{11}$ (698.7): C, 68.75; H, 6.06. Found: C, 68.90; H, 5.95.

Obtained crystalline from methanol, the fractions of **9** amounted to 1.913 g (13.7%); m.p. 184.5–186°, raised to 190.5–192.5° by recrystallization; $[\alpha]_D$ +93.2° (*c* 0.7, $CHCl_3$); ^{1}H-n.m.r. data (200 MHz in $CDCl_3$) for the *altro* moiety: δ 5.63 (s, *Ph*-CH), 5.05 (s, $J_{1,2}$ ~0 Hz, H-1), and 4.64 (AB-q, benzylic protons); for the *gluco* moiety: δ 5.55 (s, *Ph*-CH), 5.21 (d, $J_{1,2}$ 3.5 Hz, H-1), and 4.84 (AB-q, benzylic protons); for both moieties (unresolved), δ 7.4-region (m, aromatic) and 4.4–3.7 (m, H-2–6).

Anal. Calc. for $C_{40}H_{42}O_{11}$ (698.7): C, 68.75; H, 6.06. Found: C, 68.68; H, 5.97.

*Methyl 2-O-benzyl-4,6-O-benzylidene-α-*D*-altropyranoside* (**12**) *and methyl 3-*

O-benzyl-4,6-O-benzylidene-α-D-glucopyranoside (**15**) *from* **10**. — Sodium (1 g) was dissolved in dry benzyl alcohol (20 mL) at 130°, the ditosylate[9] **10** (5.9 g, 0.01 mol) was added in solid form, and the mixture was stirred under a nitrogen atmosphere for 15 min at 130°. After cooling, the dark-brown mixture was processed by addition of water and extraction with chloroform. The extract was washed twice with water, and evaporated, to give a syrup from which, after addition of sodium hydrogencarbonate (1 g), the major part of the benzyl alcohol present was removed by co-evaporation with water. The residue was mixed with chloroform, and the solution evaporated, and then passed through a column (2.5 × 9 cm) of dry silica gel by means of 1:1 chloroform–benzene (70 mL) followed by chloroform (400 mL). This served to remove brown impurities. The total eluate was evaporated, residual benzyl alcohol was removed by heating the syrup for some time under oil-pump vacuum, and the product was rechromatographed in a column (2.5 × 9 cm) of silica gel. Initial elution with 1:1 chloroform–benzene (50 mL) removed dibenzyl ether, and continued elution with ethyl acetate (100 mL) gave mixtures of **12** (the more-mobile, major product) and **15** (the less-mobile, minor product), totalling 2.5 g (67%). Separation was finally achieved by rechromatography (120 g of silica gel) using 1:4 ethyl acetate–hexane as the eluant. There were obtained crystalline **12** (1.23 g, 33%) and crystalline **15** (346 mg, 9.3%).

Recrystallized from 95% ethanol, **12** had m.p. 105–107°, $[\alpha]_D$ +60.7° (*c* 0.6, chloroform); lit.[7] m.p. 106–108°, $[\alpha]_D$ +61.5°; selected ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 5.64 (s, *Ph*-CH), 4.73 (broadened s, H-1), 4.64 (s, 2 H, *Ph*-CH_2), 3.74 (nm, $J_{1,2}$ ~1 Hz, H-2), 3.43 (s, 3 H, OMe), and 2.90 (d, *J* 7 Hz, OH).

Recrystallized from ether, **15** had m.p. 188.5–189.5°, $[\alpha]_D$ +85.2° (*c* 0.6, chloroform); lit.[7] m.p. 185–186°, $[\alpha]_D$ +80.0° and[10] m.p. 185°, $[\alpha]_D$ +84.0°; selected ^{1}H-n.m r. data (200 MHz, $CDCl_3$): δ 5.57 (s, *Ph*-CH), 4.87 (AB-q, 2 H, *Ph*-CH_2), 4.80 (d, $J_{1,2}$ 3.4 Hz, H-1), 3.44 (s, 3 H, OMe), and 2.34 (d, *J* 7 Hz, OH).

Methyl 2-O-benzyl-4,6-O-benzylidene-3-O-(trifluoromethylsulfonyl)-α-D-altropyranoside (**13**). — Trifluoromethanesulfonic anhydride (0.83 mL, 5 mmol) was added dropwise to a chilled (−18°) solution of **12** (1.65 g, 4.3 mmol) in dichloromethane (10 mL) and pyridine (10 mL). After 1 h, the reaction was judged to be complete (t.l.c. with 1:4 ethyl acetate–hexane). Processing with aqueous sodium hydrogencarbonate solution and chloroform in the usual way gave a brown, syrupy product from which several added portions of toluene were evaporated in order to remove pyridine. Chromatography on a column of silica gel with 1:1 benzene–hexane as the eluant gave **13**, which crystallized from 95% ethanol. The crude crystals (844 mg, 39.5%) began to turn brown at room temperature within 3 days. Recrystallized from 95% ethanol, **13** had m.p. 79–83° (dec.) and $[\alpha]_D$ +49.7° (*c* 0.9, chloroform); ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 7.4-region (10 H, arom.), 5.61 (s, *Ph*-CH), 5.13 (dd, $J_{2,3}$ 3, $J_{3,4}$ 2.6 Hz, H-3), 4.61 (broadened s, H-1), 4.66 (AB-q, 2 H, *Ph*-CH_2), 4.32 (dd, $J_{5,6e}$ 4.6, $J_{6a,6e}$ 9.6 Hz, H-6*e*), 4.22 (dt, $J_{4,5} = J_{5,6a}$ =9.5 Hz H-5), 4.12 (dd, $J_{3,4}$ 2.6, $J_{4,5}$ 9.5 Hz, H-4), 3.865 (dd, $J_{1,2}$ 0.7, $J_{2,3}$ 3 Hz, H-2), 3.80 (t, H-6*a*), and 3.37 (s, OMe).

Recrystallization of **13** was accompanied by losses, and it was not possible to obtain pure material from the mother liquors because of rapid onset of decomposition. The compound can be stored at −20°.

Methyl 2-O-benzyl-4,6-O-benzylidene-3-O-(1-imidazolylsulfonyl)-α-D-altropyranoside (**14**). — Compound **13** (1.05 g) in *N,N*-dimethylformamide (6 mL) was imidazylated[11] by treatment, first with sodium hydride (140 mg of a 60% suspension in mineral oil, prewashed with DMF) for 30 min at 0°, and then with 1,1′-sulfuryldiimidazole (1.15 g) for 5 min at −60° and continuing for 2 h at ambient temperature. After completion of the reaction, a small amount of ethanol was added to the mixture, which was then diluted with benzene, washed with water (5 ×), dried (Na_2SO_4), and evaporated. Crystallization of the residue from 95% ethanol gave 710 mg, and chromatography of the mother liquor gave an additional 215 mg, of slightly impure **14** (65%). Upon recrystallization from 95% ethanol, it had m.p. 125–126°, $[\alpha]_D$ +46.6° (*c* 1.4, chloroform); ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 7.78, 7.08, and 6.80 (imidazolyl protons), 7.4-region (m, phenyl protons), 5.50 (s, *Ph*-CH), 4.76 (~t, $J_{2,3}$ ~2.5, $J_{3,4}$ ~2.8 Hz, H-3), 4.64 (broadened s, H-1), 4.62 (AB-q, 2 H, *Ph*-CH_2), 4.30 (dd, $J_{5,6e}$ 5, $J_{6a,6e}$ 10.1 Hz, H-6*e*), 4.14 (dt, $J_{4,5}$ ~$J_{5,6a}$ ~9.9 Hz, H-5), 4.00 (dd, $J_{3,4}$ 2.85, $J_{4,5}$ 9.65 Hz, H-4), 3.75 (dd, $J_{1,2}$ 0.7, $J_{2,3}$ 2.5 Hz, H-2), 3.74 (t, H-6*a*), and 3.35 (s, OMe).

Anal. Calc. for $C_{24}H_{26}N_2O_8S$ (502.5): C, 57.36; H, 5.22; N, 5.57. Found: C, 56.98; H, 5.21; N, 5.48.

Methyl 3-O-benzyl-4,6-O-benzylidene-2-O-(trifluoromethylsulfonyl)-α-D-glucopyranoside (**16**). — Compound **15** was triflated as described for the preparation of **13**. The product crystallized on processing, without prior chromatography (crude yield, 74%). One recrystallization from a small volume of ethanol gave **16** (64%), still slightly impure, according to t.l.c. (1:4 ethyl acetate–hexane). The analytical sample was recrystallized twice more; m.p. 90–92°, $[\alpha]_D$ +42° (*c* 0.6, chloroform); ^{1}H-n.m.r. data (200 MHz, $CDCl_3$): δ 7.4-region (m, arom.), 5.57 (s, *Ph*-CH), 4.97 (d, $J_{1,2}$ 3.7 Hz, H-1), 4.82 (AB-q, 2 H, *Ph*-CH_2), 4.74 (dd, $J_{2,3}$ 9.4 Hz, H-2), 4.32 (dd, $J_{5,6e}$ 4.4, $J_{6a,6e}$ 9.8 Hz, H-6*e*), 4.14 (t, $J_{3,4} = J_{4,5}$ = 9.3 Hz, H-4), 3.90 (dt, H-5), 3.76 (t, $J_{5,6a}$ 9.7 Hz, H-6*a*), 3.70 (t, *J* 9.4 Hz, H-3), and 3.47 (s, OMe).

Anal. Calc. for $C_{22}H_{23}F_3O_8S$ (504.5): C, 52.38; H, 4.60. Found: C, 52.23; H, 4.66.

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