Note

Crystalline 2,3,4,3′,4′-penta-*O*-acetyl-6,1′,6′-tri-*O*-tosylsucrose and its reactions

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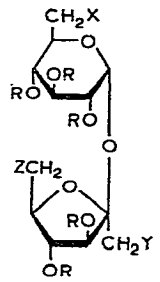
Lemieux and Barrette[1] described crystalline 6,6′-di-*O*-tosylsucrose, which was prepared by chromatographic fractionation of a mixture of *O*-tosylsucroses[2]. It has been demonstrated that the two tosyloxy groups on C-6 and C-6′ of this di-*O*-tosylsucrose are readily replaced by iodine atoms by treatment with sodium iodide in acetone[1]. On the other hand, several authors[1,3–6] have noted that a tosyloxy group on C-1′ of sucrose is highly resistant toward a replacement by an iodine atom. This has been deduced from the reaction of amorphous 6,1′,6′-tri-*O*-tosylsucrose with sodium iodide; tri-*O*-tosylsucrose and its derivatives have resisted attempts at crystallization. Recently, Isaacs *et al.*[7] have briefly described the crystalline pentaacetate.

In connection with a previous paper on sucrose chemistry[8], the present authors have independently prepared crystalline 2,3,4,3′,4′-penta-*O*-acetyl-6,1′,6′-tri-*O*-tosylsucrose (**2**), starting from 2,3,4,3′,4′-penta-*O*-acetylsucrose[9]. In the present article we report the preparation of **2** and its reaction with sodium iodide.

RESULTS AND DISCUSSION

2,3,4,3′,4′-Penta-*O*-acetylsucrose (**1**) was prepared by the method of Bredereck *et al.*[9] from 2,3,4,3′,4′-penta-*O*-acetyl-6,1′,6′-tri-*O*-tritylsucrose[10]. Treatment of **1** with tosyl chloride in pyridine afforded 2,3,4,3′,4′-penta-*O*-acetyl-6,1′,6′-tri-*O*-tosylsucrose (**2**), having m.p. 135.5–136.5°, in 74% yield. *O*-De-acetylation of **2** in methanolic ammonia gave amorphous 6,1′,6′-tri-*O*-tosylsucrose (**3**), which gave a correct elemental analysis.

When compound **2** was heated in acetone with sodium iodide, 2,3,4,3′,4′-penta-*O*-acetyl-6,6′-dideoxy-6,6′-diiodo-1′-*O*-tosylsucrose (**4**) was obtained in 88% yield. Catalytic hydrogenolysis of **4** with Raney nickel[11] T-4 was conducted in the presence of Amberlite IR-4B (OH^-). Dehalogenation[12] and partial desulfonylation[13] occurred, to give a mixture of 2,3,4,3′,4′-penta-*O*-acetyl-6,6′-dideoxy-1′-*O*-tosylsucrose (**5**) and 2,3,4,3′,4′-penta-*O*-acetyl-6,6′-dideoxysucrose (**6**) having m.p. 163–165.5°. Tosylation of **6** afforded **5**, which was detected by thin-layer chromatography (t.l.c.).



	R	X	Y	Z
1	Ac	OH	OH	OH
2	Ac	OTs	OTs	OTs
3	H	OTs	OTs	OTs
4	Ac	I	OTs	I
5	Ac	H	OTs	H
6	Ac	H	OH	H
7	Ac	OH	OAc	OAc
8	Ac	OTs	OAc	OAc
9	Ac	I	OAc	OAc
10	Ac	H	OAc	OAc

The structure of **5** and **6** were established by proton magnetic resonance (p.m.r.) spectroscopy. The p.m.r. spectrum of **5** revealed two doublets at δ 1.19 (J 6.3 Hz) and 1.32 (J 6.5 Hz) for two methyl groups, and that of **6** showed two comparable doublets at δ 1.20 (J 6.1 Hz) and 1.40 (J 6.2 Hz). If there had been a methyl group at C-2', a three-proton singlet would have been observed. The fact that doublets were observed for the two methyl groups proved that these groups were located at C-5 and C-5'. An analogous result was observed with the spectrum of methyl 2,3,2',3',4'-penta-*O*-acetyl-6,6'-dideoxy-β-maltoside[14].

To identify the signal arising from the methyl group at C-5 in the D-glucosyl moiety, 2,3,4,1',3',4',6'-hepta-*O*-acetyl-6-deoxysucrose (**10**) was prepared. The spectrum of **10** showed a doublet at δ 1.20 (J 6.0 Hz) for the methyl group at C-5. Therefore, the doublets at δ 1.19 and 1.20 were attributed to the methyl groups at C-5 in **5** and **6**, respectively, and the doublets at δ 1.32 and 1.40 were assigned to the methyl groups at C-5' in **5** and **6**, respectively. These assignments are consistent with data given by Sinclair and Sleeter[14,15].

EXPERIMENTAL

General. — Melting points were determined on a Mitamura micro hot-stage and are uncorrected. Optical rotations were determined with a Carl Zeiss photoelectric polarimeter. P.m.r. spectra were determined with a Varian A-60D instrument at 60 MHz in chloroform-*d*, with tetramethylsilane as an internal standard, and the peak positions are given as δ-values. I.r. spectra were recorded with a Japan Spectroscopic IR-E spectrophotometer. T.l.c. was performed on silica gel (Wakogel B-10) plates.

*2,3,4,3',4'-Penta-*O*-acetylsucrose* (**1**). — Compound **1** was prepared by the method of Bredereck *et al.*[9] with a slight modification. The product was chromatographed on column of silica gel (Wakogel C-200, 30 g, 1.5×25 cm) by using 1:4:1 benzene–ethyl acetate–butanone as developing solvent, to give **1** (0.74 g, 34%), m.p. 133–134°, $[\alpha]_D^{21.5}$ +52.5° (*c* 0.40, chloroform) [Lit.[9] m.p. 122°, $[\alpha]_D^{20}$ +31.2° (chloroform)]; (*Anal.* Found: C, 47.97; H, 5.99).

*2,3,4,3',4'-Penta-*O*-acetyl-6,1',6'-tri-*O*-tosylsucrose* (**2**). — To a solution of **1** (1.00 g, 1.8 mmole) in pyridine (25 ml), tosyl chloride (2.45 g, 12.9 mmole) was added at 0°. The mixture was kept for 72 h at room temperature and then poured into ice–

water (200 ml). The resultant precipitate was filtered off to give 1.52 g (84%) of the crude product. Recrystallization from ethanol (50 ml) afforded 1.34 g (74%) of **2**, m.p. 135.5–136.5°, $[\alpha]_D^{22}$ +68.0° (*c* 0.44, chloroform) (Lit.[7] m.p. 134–135°, $[\alpha]_D$ +61.5°); R_F 0.43 (single spot on t.l.c. with 9:4 benzene–ethyl acetate); λ_{max}^{KBr} 1760 (acetate), 1370, 1176 cm^{-1} (sulfonate); p.m.r. δ 1.94 (s, OAc, 3 H), 1.98 (s, OAc, 6H), 2.04 (s, OAc 3H), 2.07 (s, OAc, 3H) and 2.45 (s, aryl CH_3, 9H).

Anal. Calc. for $C_{43}H_{50}O_{22}S_3$: C, 50.88; H, 4.97; S, 9.48. Found: C, 51.13; H, 4.99; S, 9.46.

6,1',6'-Tri-O-tosylsucrose (**3**). — Compound **2** (0.19 g, 0.19 mmole) was dissolved in methanol (80 ml) previously saturated with ammonia at 0°, and the solution was refrigerated overnight. The solution was evaporated under diminished pressure and the residue was dissolved in acetone (1 ml). The acetone solution was poured into ice-cold water (50 ml) to give a gummy precipitate, which was dissolved in chloroform. The chloroform solution was washed with water, dried (sodium sulfate), and evaporated, to give a crude product (0.16 g) the product was chromatographed on a column of silica gel (Wakogel C-200, 9.0 g, 0.8 × 30 cm) with 7:1 chloroform–ethanol as the developing solvent, to give **3** (0.13 g, 86%) as an amorphous solid, $[\alpha]_D^{24}$ +39.4° (c 1.27, chloroform); λ_{max}^{KBr} 3500 (OH), 1360, 1180 cm^{-1} (sulfonate). (Found: C, 49.26; H, 5.12; S, 11.78).

2,3,4,3'4'-Penta-O-acetyl-6,6'-dideoxy-6,6'-diiodo-1'-O-tosylsucrose (**4**). — Compound **2** (1.01 g, 1.00 mmole), sodium iodide (4.96 g, 33 mmole), and acetone (30 ml) were heated for 3 days at reflux. The insoluble sodium *p*-toluenesulfonate (0.40 g, 2.1 mmole) was filtered off, the filtrate was evaporated, and the residue was extracted repeatedly with chloroform. The combined chloroform extracts were washed with 10% sodium thiosulfate solution, water, and dried. The solvent was evaporated off under diminished pressure and the residue was dissolved in warm ethanol. The solution was kept overnight at room temperature to give **4** (0.81 g, 88%) as an amorphous powder, m.p. 69–71°, $[\alpha]_D^{29}$ +32.0° (*c* 0.72, chloroform); Beilstein halogen test, positive; λ_{max}^{KBr} 1750, 1220 (acetate), 1370, 1180 cm^{-1} (sulfonate); p.m.r. δ 2.01 (s, OAc, 3H), 2.04 (s, OAc, 6H), 2.08 (s, OAc, 3H), 2.11 (s, OAc, 3H) and 2.46 (s, aryl CH_3, 3H).

Anal. Calc. for $C_{29}H_{36}I_2O_{16}S$: C, 37.60; H, 3.92. Found: C, 37.86; H, 3.92.

2,3,4,3'4'-Penta-O-acetyl-6,6'-dideoxy-1'-O-tosylsucrose (**5**) *and 2,3,4,3'4'-penta-O-acetyl-6,6'-dideoxysucrose* (**6**). — Compound **4** (0.503 g, 0.54 mmole) was added to a mixture of 90% aqueous acetone (8 ml), ethanol (8 ml), Amberlite IR-4B (OH^-), and Raney nickel T-4 catalyst[11]. The mixture was shaken in a hydrogen atmosphere (3.4 $kg.cm^{-2}$) for 21 h with a Parr-shaker type of hydrogenation apparatus. The ion-exchange resin and the catalyst were filtered off and the filtrate was evaporated *in vacuo* to give a syrup. The residue was chromatographed on a silica-gel column (Wakogel C-200, 20 g, 1.5 × 19 cm) with 9:4 benzene–ethyl acetate as a developing solvent. Each fraction (1.5 ml) was monitored by t.l.c. with the same solvent mixture. The fractions from No. 16 to 32 (R_F 0.57) were combined and evaporated to give **5** (0.194 g, 53%) as an amorphous solid, $[\alpha]_D^{23}$ +60.3° (*c* 0.32, chloroform); λ_{max}^{KBr} 1750

(acetate), 1370, 1170 cm^{-1} (sulfonate); p.m.r. δ 1.19 (d, 5-CH_3, 3H J 6.3 Hz), 1.32 (d, 5'-CH_3, 3H J 6.5 Hz), 1.98 (s, OAc, 6H), 2.03 (s, OAc, 3H), 2.06 (s, OAc, 3H), 2.09 (s, OAc, 3H) and 2.29 (s, aryl CH_3, 3H).

Anal. Calc. for $C_{29}H_{38}O_{16}S$: C, 51.63; H, 5.68; S, 4.75. Found: C, 51.74; H, 5.62; S, 4.46.

The fractions from No. 75 to 77 (R_F 0.32) were combined and evaporated to give a crystalline residue (0.062 g, 22%) m.p. 159–161°. Recrystallization from ethanol gave **6**, m.p. 163–165.5° $[\alpha]_D^{21}$ +33.2° (*c* 0.24, chloroform); λ_{max}^{KBr} 3470 (OH), 1750 cm^{-1} (acetate); p.m.r. δ 1.20 (d, 5-CH_3, 3H, J 6.1 Hz), 1.40 (d, 5'-CH_3, J 6.2 Hz), 2.00 (s, OAc, 3H), 2.03 (s, OAc, 6H), 2.06 (s, OAc, 3H), 2.17 (s, OAc, 3H) and 2.35 (s, 1'-OH, H, disappeared by addition of D_2O).

Anal. Calc. for $C_{22}H_{32}O_{14}$: C, 50.77; H, 6.20. Found: C, 50.85; H, 6.25.

Tosylation of **6** in pyridine afforded an amorphous product, which showed a single spot at R_F 0.57 by t.l.c. with the solvent mixture already noted.

*2,3,4,1'3',4',6'-Hepta-*O*-acetylsucrose* (**7**). — 2,3,4,1',3,'4',6'-Hepta-*O*-acetyl-6-*O*-tritylsucrose[16], m.p. 120–121.5°, $[\alpha]^{21}$ +87.8° (c 0.47, chloroform), (Found: C, 61.68; H, 5.91), was detritylated by the method of Bredereck *et al.*[9] to give[16] compound **7**, $[\alpha]_D^{19}$ +61.3° (*c* 0.55, chloroform); (Found: C, 49.50; H, 5.95); p.m.r. δ 2.02 (s, OAc, 3H), 2.06 (s, OAc, 3H), 2.08 (s, OAc, 3H), 2.10 (s, OAc, 9H), 2.19 (s, OAc, 3H) and 2.52 (6-OH, H, disappeared on addition of D_2O).

*2,3,4,1',3',4',6'-Hepta-*O*-acetyl-6-*O*-tosylsucrose* (**8**). — Tosyl chloride (1.07 g, 5.61 mmole) was added to a solution of **7** (1.19 g, 1.87 mmole) in pyridine (15 ml) at 0°. The mixture was kept for 3 days at room temperature and then evaporated under diminished pressure. The residue was dissolved in ethyl acetate and the solution was washed with water and concentrated to a glassy residue (1.29 g). The crude product was chromatographed on a silica gel column (Wakogel C-200, 50 g, 2.8 × 18 cm) 1:2 with benzene–ethyl acetate as developing solvent, to give **8** (1.19 g, 81%) as a glass, $[\alpha]_D^{22}$ +23.2° (c 0.40, chloroform); λ_{max}^{KBr} 1750, 1240 (acetate), 1380, 1180 cm^{-1} (sulfonate); p.m.r. δ 1.96 (s, OAc, 3H), 1.97 (s, OAc, 3H), 2.04 (s, OAc, 3H), 2.07 (s, OAc, 9H), 2.13 (s, OAc, 3H), and 2.43 (s, aryl CH_3, 3H).

Anal. Calc. for $C_{33}H_{42}O_{20}S$: C, 50.13; H, 5.35; S, 4.06. Found: C, 50.34; H, 5.63; S, 4.24.

*2,3,4,1',3',4',6'-Hepta-*O*-acetyl-6-deoxy-6-iodosucrose* (**9**). — A mixture of **8** (1.00 g, 1.26 mmole) and sodium iodide (2.82 g, 1.9 mmole) in acetone (20 ml) was heated for 3 days under reflux. The mixture was processed as described for the preparation of **4**, to give **9** (0.96 g) as a glass, which was used without further purification for the following reaction, $[\alpha]_D^{23}$ +58.8° (*c* 0.37, chloroform), λ_{max}^{KBr} 1750, 1240 cm^{-1} (acetate); p.m.r. δ 2.00 (s, OAc, 3H), 2.05 (s, OAc, 3H), 2.07 (s, OAc, 3H), 2.10 (s, OAc, 6H), 2.12 (s, OAc, 3H), and 2.16 (s, OAc, 3H).

*2.3.4,1',3',4',6'-Hepta-*O*-acetyl-6-deoxysucrose* (**10**). — Compound **9** (0.73 g, 0.99 mmole) was hydrogenated over Raney nickel T-4 catalyst[11] in 95% ethanol (30 ml) in the presence of Amberlite IR-4B (OH^-) for 6 h, as described for the preparation of **5** and **6**, to give **10** (0.44 g, 72%) as a glass, m.p. 47–51°, $[\alpha]_D^{16}$ +90.0°

(*c* 0.88, chloroform); (Beilstein halogen test negative; λ_{max}^{KBr} 1750, 1230 cm^{-1} (acetate); P.m.r. δ 1.20 (d, 5-CH_3, *J* 6.0 Hz), 1.99 (s, OAc, 3H), 2.03 (s, OAc, 3H), 2.05 (s, OAc, 3H), 2.08 (s, OAc, 9H) and 2.15 (s, OAc, 3H).

Anal. Calc. for $C_{26}H_{36}O_{17}$: C, 50.32; H, 5.85. Found: C, 50.28; H, 5.89.

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