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Chemical Modification of Maltose. III.[1] Selective *p*-Toluenesulfonylation of 1,6-Anhydro-4′,6′-O-benzylidene-β-maltose[2]

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Selective tosylation of 1,6-anhydro-4′,6′-O-benzylidene-β-maltose (**1**) with 4.2 molar equivalents of tosyl chloride (TsCl) in pyridine at 0° yielded 5 tosylates, which were designated **2** to **6** in order of decreasing *Rf* value on thin-layer chromatography. After column chromatography on silica gel, compounds **2**—**6** were separated and identified as the 2,2′,3,3′-tetratosylate (**2**, 2%), 2,2′,3-tritosylate (**3**, 15%), 2,2′,3′-tritosylate (**4**, 10%), 2,2′-ditosylate (**5**, 67.7%), and 2′-monotosylate (**6**, 1.7%), respectively.

Selective tosylation of **5** with 8 molar equivalents of TsCl in pyridine at 0° afforded **2** (9.3%), **3** (17.3%), and **4** (24.7%), together with **5** (39.3%). Compound **5**, the major product of the selective tosylation of **1**, is a valuable intermediate in the chemical modification of maltose.

Keywords——selective tosylation; maltosan; benzylidene maltosan; 2,2′,3,3′-tetratosylmaltosan; 2,2′,3-tritosylmaltosan; 2,2′,3′-tritosylmaltosan; 2,2′-ditosylmaltosan; 2′-monotosylmaltosan; partially methylated maltitol; partially methylated glucitol

Partially *p*-toluenesulfonylated sugar derivatives are very useful intermediates for displacement reactions with or without inversion at definite hydroxyl groups those carrying the *p*-toluenesulfonyl (tosyl) groups.[3] The versatility of partially tosylated cellobiosyl, maltosyl, and lactosyl derivatives has been shown by a series of experiments in this laboratory.[4] In Part II of this series, the order of reactivity of hydroxyl groups in **1** was suggested to be 2′>2,3′>3 on the basis of selective benzoylation of 1,6-anhydro-4′,6′-O-benzylidene-β-maltose (**1**). According to our program of synthetic studies on oligosaccharides, selective *p*-toluenesulfonylation (tosylation) of **1** was investigated in order to obtain useful intermediates. The results are now reported in detail.

Tosylation of **1** with 4.2 molar equivalents of *p*-toluenesulfonyl chloride (TsCl) in pyridine at 0° gave 5 products.[5] The reaction was monitored by thin-layer chromatography (TLC), and these products were designated **2** to **6** in order of decreasing *Rf* value; **5** was the major product. Products **2**—**6** were isolated by column chromatography on silica gel.

Compound **2** was isolated as white prisms in 2% yield. The proton nuclear magnetic resonance (^{1}H-NMR) spectrum and elemental analytical data of **2** were in accordance with those of the tetratosylate of **1**, 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3,3′-tetra-O-tosyl-β-maltose (**2**).

Compound **3**, isolated as an amorphous powder in 15% yield, gave a monoacetate (**7**) and a monomethyl ether (**8**), as indicated by ^{1}H-NMR and elemental analytical data. Thus, **3** was assigned as a tritosylate of **1**. In order to determine the position of the tosyl groups, detosylation of **8** with sodium amalgam or lithium aluminum hydride was investigated under various conditions. However, **8** always gave a complex mixture containing decomposition products. Therefore, we could not assign the structures of **3**, **7**, and **8** by this approach. The structural assignment of these compounds will be described in the latter part of this paper in detail.

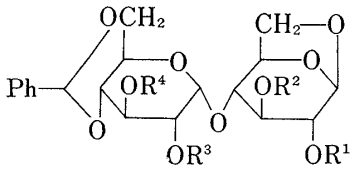
Compound **4**, isolated as an amorphous powder in 10% yield, gave a monoacetate (**9**) and a monomethyl ether (**10**), as indicated by ^{1}H-NMR and elemental analytical data. On detosyl-

ation followed by acetylation of the detosylated product, **10** gave a triacetyl-monomethyl ether (**11**). Compound **11** was indistinguishable from 2,2′,3′-tri-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-3-O-methyl-β-maltose prepared from authentic 1,6-anhydro-2,2′,3′-tri-O-benzoyl-4′,6′-O-benzylidene-3-O-methyl-β-maltose[1] through debenzoylation followed by acetylation. Thus, **4**, **9**, and **10** were assigned as 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3′-tri-O-tosyl-β-maltose (**4**), 3-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,2′,3′-tri-O-tosyl-β-maltose (**9**), and 1,6-anhydro-4′,6′-O-benzylidene-3-O-methyl-2,2′,3′-tri-O-tosyl-β-maltose (**10**), respectively.

Compound **5**, the major product (67.7%) in this reaction, yielded a crystalline diacetate (**12**) and an amorphous dimethyl ether (**13**). In order to determine the positions of the tosyl groups, **13** was converted to a dimethylmaltiool by the following series of reactions; detosylation, acetylation, acetolysis of the 1,6-anhydro-β-ring with concomitant debenzylidenation and acetylation, deacetylation, and sodium borohydride reduction. Acid hydrolysis of the resulting dimethylmaltiool produced 3-O-methylglucose[6] and 3-O-methylglucitol,[7] which were identified by paper partition chromatography (PPC). Therefore, the tosyl groups in **5** must be located at HO-2 and HO-2′, and the structures of **5**, **12**, and **13** were assigned as 1,6-anhydro-4′,6′-O-benzylidene-2,2′-di-O-tosyl-β-maltose(**5**), 3,3′-di-O-acetyl-1,6-anhydro-4′,-6′-O-benzylidene-2,2′-di-O-tosyl-β-maltose (**12**), and 1,6-anhydro-4′,6′-O-benzylidene-3,3′-di-O-methyl-2,2′-di-O-tosyl-β-maltose (**13**), respectively.

Compound **6**, isolated in 1.7% yield, gave an amorphous triacetate (**15**) and a crystalline trimethyl ether (**16**). On detosylation followed by acetylation of the detosylated product, **16** yielded a monoacetyl-trimethyl ether (**17**). Compound **17** was indistinguishable from 2′-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-β-maltose prepared from authentic 1,6-anhydro-2′-O-benzoyl-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-β-maltose[1] through debenzoylation followed by acetylation. Therefore, the tosyl group in **6** must be located at HO-2′ and the structures of **6**, **15**, and **16** were assigned as 1,6-anhydro-4′,6′-O-benzylidene-2′-O-tosyl-β-maltose (**6**), 2,3,3′-tri-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2′-O-tosyl-β-maltose (**15**), and 1,6-anhydro-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-2′-O-tosyl-β-maltose (**16**), respectively.

The yields of **2**—**6** suggest that HO-2 and HO-2′ are more reactive than HO-3 and HO-3′. The result is consistent with that obtained by selective benzoylation of **1**.[1] In order to determine the order of reactivity of HO-3 and HO-3′, selective tosylation of **5** was next investigated.



1: $R^1=R^2=R^3=R^4=H$
2: $R^1=R^2=R^3=R^4=Ts$
3: $R^1=R^2=R^3=Ts$, $R^4=H$
4: $R^1=R^3=R^4=Ts$, $R^2=H$
5: $R^1=R^3=Ts$, $R^2=R^4=H$
6: $R^1=R^2=R^4=H$, $R^3=Ts$
7: $R^1=R^2=R^3=Ts$, $R^4=Ac$
8: $R^1=R^2=R^3=Ts$, $R^4=Me$
9: $R^1=R^3=R^4=Ts$, $R^2=Ac$
10: $R^1=R^3=R^4=Ts$, $R^2=Me$
11: $R^1=R^3=R^4=Ac$, $R^2=Me$
12: $R^1=R^3=Ts$, $R^2=R^4=Ac$
13: $R^1=R^3=Ts$, $R^2=R^4=Me$
14: $R^1=R^3=Ac$, $R^2=R^4=Me$
15: $R^1=R^2=R^4=Ac$, $R^3=Ts$
16: $R^1=R^2=R^4=Me$, $R^3=Ts$
17: $R^1=R^2=R^4=Me$, $R^3=Ac$

Ac=acetyl
Me=methyl
Ph=phenyl
Ts=tosyl

Chart 1

When the reaction was carried out with 2.1 or 4.1 molar equivalents of TsCl at room temperature for 4 days, tosylation hardly proceeded, and unchanged **5** was recovered. Thus, **5** was tosylated with 8 molar equivalents of TsCl. Column chromatography of the tosylation mixture yielded a tetratosylate (**2**) and two isomeric tritosylate (**3** and **4**) in 9.3, 17.3, and 24.7% yields, respectively, together with unchanged **5** (39%). Therefore, no marked difference in reactivity of HO-3 and HO-3′ was observed by this method, but valuable information for the structural elucidation of **3** was obtained. Namely, starting from the 2,2′-ditosylate (**5**), the tritosylate (**3**) was isolated with **4** as mentioned above. Because the structure of **4** has been assigned as the 2,2′,3′-tritosylate, the isomeric **3** must be the 2,2′,3-tritosylate. Therefore, the structures of **3**, **7**, and **8** were finally assigned as 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3-tri-O-tosyl-β-maltose (**3**), 3′-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,2′,3-tri-O-tosyl-β-maltose (**7**), and 1,6-anhydro-4′,6′-O-benzylidene-3′-O-methyl-2,2′,3-tri-O-tosyl-β-maltose (**8**), respectively.

In conclusion, the order of reactivity of hydroxyl groups in **1** upon tosylation is suggested to be HO-2′>HO-2>HO-3, HO-3′. Compound **5**, the major product isolated in comparatively good yield, is a versatile intermediate for chemical modifications of maltose. Syntheses of aminodisaccharides from **5** will be reported in a subsequent paper.[8]

Experimental

Melting points were determined with a Yanagimoto micro melting point apparatus, and are uncorrected. Solutions were concentrated in a rotary evaporator below 40° under a vacuum unless otherwise indicated. Optical rotations were measured with a Union Giken PM-201 automatic digital polarimeter in a 0.5 dm tube. Infrared (IR) spectra were measured with a Jasco IRA-2 spectrometer. ^{1}H-NMR spectra were recorded at 100 MHz on a JEOL JNM-MH-100 spectrometer with tetramethylsilane (TMS) as an internal standard in $CDCl_3$. Chemical shifts are given in ppm from TMS. Thin-layer chromatography (TLC) on pre-coated silica gel plates 0.25 mm thick (Kiesel Gel 60 F_{254}, Merck) was performed with the following solvent combinations (v/v): (A), CH_2Cl_2–acetone (9: 1); (B), benzene–ether (3: 1). Detection was effected with H_2SO_4 or by ultraviolet spectrum (UV) irradiation (short wavelength). Column chromatography on silica gel was performed with Wakogel C-200 (Wako Pure Chemical Industries, Ltd., Osaka). Solvent combinations are given as v/v. Paper partition chromatography (PPC) was performed on Toyo filter paper No. 50 (Toyo Roshi Kaisha, Ltd., Tokyo) by the ascending method[9] with BuOH–pyridine–H_2O (6: 4: 3, v/v), and detection was effected with (a) the alkaline silver nitrate reagent,[10] (b) aniline hydrogen phthalate,[11] and (c) the permanganate-periodate reagent.[12]

Selective Tosylation of 1,6-Anhydro-4′,6′-O-benzylidene-β-maltose (1)——TsCl (0.80 g, 4.2 mmol) in dry pyridine (5 ml) was added dropwise to a chilled solution of **1** (0.41 g, 1 mmol) in dry pyridine (10 ml), with stirring at 0°, and stirring was continued, with exclusion of moisture, for a further 30 min. After standing at room temperature for 4 days, the mixture was poured into ice-H_2O (50 ml), and the whole was extracted with CH_2Cl_2 (20 ml×3). The combined extracts were washed with ice-cold 10% H_2SO_4 (30 ml×2), satd. $NaHCO_3$ (30 ml×2), and H_2O (30 ml), dried (Na_2SO_4), and concentrated to a syrup (0.80 g). The syrup contained 5 components having *Rf* 0.65, 0.58, 0.40, 0.36, and 0.10 (TLC, solvent A). By column chromatography with CH_2Cl_2 (100 ml) and CH_2Cl_2–acetone [60: 1 (200 ml), 30: 1 (200 ml), and 20: 1 (500 ml)], the following products (**2**—**6**) were isolated from the syrup.

The component having *Rf* 0.65 crystallized from MeOH. Recrystallization from AcOEt gave white prisms (20 mg, 2%), mp 131—133°, $[\alpha]_D^{23}$ +12.9° (c=1.24, $CHCl_3$); this compound was assigned as 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3,3′-tetra-O-tosyl-β-maltose (**2**). *Anal.* Calcd for $C_{47}H_{48}O_{18}S_4$: C, 54.85; H, 4.70. Found: C, 54.87; H, 4.87. ^{1}H-NMR ($CDCl_3$): 2.23, 2.33 (6H, each s, $CH_3C_6H_4SO_2$×2), 2.46 (6H, s, $CH_3C_6H_4SO_2$×2). TLC: *Rf* 0.65 (solvent A), 0.47 (B).

The component having *Rf* 0.58 was 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3-tri-O-tosyl-β-maltose (**3**), an amorphous powder (130 mg, 15%), $[\alpha]_D^{22}$ +24° (c=1.1, $CHCl_3$). *Anal.* Calcd for $C_{40}H_{42}O_{16}S_3$: C, 54.91; H, 4.84. Found: C, 54.72; H, 4.79. IR ν_{max}^{Nujol} cm^{-1}: 3500 (OH). ^{1}H-NMR ($CDCl_3$): 2.36, 2.46, 2.49 (9H, all s, $CH_3C_6H_4SO_2$×3). TLC: *Rf* 0.58 (solvent A), 0.49 (B).

The component having *Rf* 0.40 was 1,6-anhydro-4′,6′-O-benzylidene-2,2′,3′-tri-O-tosyl-β-maltose (**4**), an amorphous powder (90 mg, 10%), $[\alpha]_D^{23}$ 0° (c=1.05, $CHCl_3$). *Anal.* Calcd for $C_{40}H_{42}O_{16}S_3$: C, 54.91; H, 4.84. Found: C, 54.71; H, 4.79. IR ν_{max}^{Nujol} cm^{-1}: 3500 (OH). ^{1}H-NMR ($CDCl_3$): 2.20, 2.35, 2.43 (9H, all s, $CH_3C_6H_4SO_2$×3). TLC: *Rf* 0.40 (solvent A), 0.34 (B).

The component having *Rf* 0.36 was 1,6-anhydro-4′,6′-O-benzylidene-2,2′-di-O-tosyl-β-maltose (**5**) (485 mg, 67.7%). The product crystallized from EtOH as white needles, mp 180—181°, $[\alpha]_D^{25}$ +75° (c=1.0, $CHCl_3$).

Anal. Calcd for $C_{33}H_{36}O_{14}S_2$: C, 54.99; H, 5.03. Found: C, 54.84; H, 5.29. IR ν_{max}^{Nujol} cm^{-1}: 3430, 3510 (OH). ^{1}H-NMR ($CDCl_3$): 2.36, 2.43 (6H, each s, C$\underline{H}_3C_6H_4SO_2\times2$). TLC: *Rf* 0.36 (solvent A), 0.40 (B).

The component having *Rf* 0.10 was 1,6-anhydro-4′,6′-O-benzylidene-2′-O-tosyl-β-maltose (**6**), an amorphous powder (10 mg, 1.7%), $[\alpha]_D^{23}$ +32.7° (c=1.14, acetone). *Anal.* Calcd for $C_{26}H_{30}O_{12}S$: C, 55.12; H, 5.34. Found: C, 54.93; H, 5.38. IR ν_{max}^{Nujol} cm^{-1}: 3380—3500 (OH). ^{1}H-NMR (acetone-d_6): 2.43 (3H, s, C$\underline{H}_3C_6H_4SO_2$). TLC: *Rf* 0.10 (solvent A), 0.13 (B).

3′-O-Acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,2′,3-tri-O-tosyl-β-maltose (**7**)——Compound **3** (100 mg) was acetylated with Ac_2O (2 ml) in pyridine (2 ml) at room temperature overnight. The mixture was evaporated to dryness by repeated co-distillation with EtOH and toluene. On column chromatography with CH_2Cl_2–acetone (40: 1), **7** was isolated as an amorphous powder (95 mg, 91%), $[\alpha]_D^{22}$ +37.3° (c=0.96, $CHCl_3$). *Anal.* Calcd for $C_{42}H_{44}O_{17}S_3$: C, 55.01; H, 4.84. Found: C, 55.05; H, 4.79. ^{1}H-NMR ($CDCl_3$): 1.89 (3H, s, OAc), 2.30 (3H, s, C$\underline{H}_3C_6H_4SO_2$), 2.45 (6H, s, C$\underline{H}_3C_6H_4SO_2\times2$). TLC: *Rf* 0.65 (solvent A), 0.45 (B).

1,6-Anhydro-4′,6′-O-benzylidene-3′-O-methyl-2,2′,3-tri-O-tosyl-β-maltose (**8**)——A mixture of **3** (195 mg), Ag_2O (250 mg), and CH_3I (20 ml) was refluxed for 10 hr under stirring, filtered, and the residue was washed with hot acetone (10 ml×2). The combined filtrate and washings were evaporated to dryness. On column chromatography with CH_2Cl_2–acetone (50: 1), **8** was isolated as an amorphous powder (182 mg, 92%), $[\alpha]_D^{20}$ +19.1° (c=1.04, $CHCl_3$). *Anal.* Calcd for $C_{41}H_{44}O_{16}S_3$: C, 55.40; H, 4.99. Found: C, 55.29; H, 4.90. ^{1}H-NMR ($CDCl_3$): 2.35, 2.45, 2.48 (9H, all s, C$\underline{H}_3C_6H_4SO_2\times3$), 3.25 (3H, s, OMe). TLC: *Rf* 0.68 (solvent A), 0.43 (B).

3-O-Acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,2′,3′-tri-O-tosyl-β-maltose (**9**)——Acetylation of **4** (55 mg) as described above for the acetylation of **3** gave **9** (52 mg, 90%) as an amorphous powder, $[\alpha]_D^{24}$ −5.1° (c=0.91, $CHCl_3$). *Anal.* Calcd for $C_{42}H_{44}O_{17}S_3$: C, 55.01; H, 4.84. Found: C, 54.93; H, 4.86. ^{1}H-NMR ($CDCl_3$): 2.01 (3H, s, OAc), 2.22, 2.34, 2.44 (9H, all s, C$\underline{H}_3C_6H_4SO_2\times3$). TLC: *Rf* 0.60 (solvent A), 0.29 (B).

1,6-Anhydro-4′,6′-O-benzylidene-3-O-methyl-2,2′,3′-tri-O-tosyl-β-maltose (**10**)——Methylation of **4** (214 mg) as described above for the methylation of **3** gave **10** (185 mg, 85.1%) which crystallized from MeOH–AcOEt as white prisms, mp 188—189°, $[\alpha]_D^{20}$ +0.1° (c=1.23, $CHCl_3$). *Anal.* Calcd for $C_{41}H_{44}O_{16}S_3$: C, 55.40; H, 4.99. Found: C, 55.21; H, 4.90. ^{1}H-NMR ($CDCl_3$): 2.22, 2.36, 2.47 (9H, all s, C$\underline{H}_3C_6H_4SO_2\times3$), 3.24 (3H, s, OMe). TLC: *Rf* 0.65 (solvent A), 0.50 (B).

2,2′,3′-Tri-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-3-O-methyl-β-maltose (**11**)——1) From Compound **10**: A suspension of **10** (120 mg) in MeOH (20 ml) was treated with 2% sodium amalgam (2 g). The mixture was stirred at room temperature for 30 hr, filtered, and the residue was washed with hot MeOH. The combined filtrate and washings were neutralized with AcOH in MeOH, then evaporated to dryness, and the residue was acetylated with Ac_2O (3 ml) and pyridine (3 ml) at 5° for 20 hr. The mixture was treated as described above for the preparation of **7** to give a syrup. On column chromatography with CH_2Cl_2–acetone (30: 1), **11** was isolated as an amorphous powder (60 mg, 81%) which crystallized from EtOH. Recrystallization from EtOH gave white needles, mp 185—188°, $[\alpha]_D^{17}$ +25.8° (c=0.72, $CHCl_3$). *Anal.* Calcd for $C_{26}H_{32}O_{13}$: C, 56.52; H, 5.84. Found: C, 56.53; H, 5.66. ^{1}H-NMR ($CDCl_3$): 2.05, 2.07, 2.17 (9H, all s, OAc×3), 3.45 3H, s, OMe).

2) From 1,6-Anhydro-2,2′,3′-tri-O-benzoyl-4′,6′-O-benzylidene-3-O-methyl-β-maltose: A chilled solution of 1,6-anhydro-2,2′,3′-tri-O-benzoyl-4′,6′-O-benzylidene-3-O-methyl-β-maltose[1] (80 mg) in dry MeOH (2 ml) was treated with methanolic NaOMe (0.5 N, 0.05 ml), and the mixture was stirred at room temperature overnight. The mixture was neutralized with dry Amberlite IR-120 (H^+) resin, filtered, and evaporated to dryness. The residue was acetylated with Ac_2O (1 ml) in pyridine (1 ml). On column chromatography with CH_2Cl_2–acetone (20: 1), **11** (49 mg, 81%) was isolated. It crystallized from EtOH as white needles, mp 188—189°, $[\alpha]_D^{24}$ +25.8° (c=1.0, $CHCl_3$).

3,3′-Di-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,2′-di-O-tosyl-β-maltose (**12**)——Acetylation of **5** (100 mg) as described above for the acetylation of **3** gave **12** (90 mg, 80.6%), which crystallized from EtOH as a white crystalline powder, mp 109—112°, $[\alpha]_D^{23}$ +6.8° (c=0.71, $CHCl_3$). *Anal.* Calcd for $C_{37}H_{40}O_{16}S_2$: C, 55.22; H, 5.01. Found: C, 54.93; H, 5.02. ^{1}H-NMR ($CDCl_3$): 1.86, 2.00 (6H, each s, OAc×2), 2.33, 2.42 (6H, each s, C$\underline{H}_3C_6H_4SO_2\times2$). TLC: *Rf* 0.59 (solvent A), 0.35 (B).

1,6-Anhydro-4′,6′-O-benzylidene-3,3′-di-O-methyl-2,2′-di-O-tosyl-β-maltose (**13**)——Methylation of **5** (260 mg) as described above for the methylation of **3** gave **13** (236 mg, 87.4%) as an amorphous powder, $[\alpha]_D^{25}$ +19.2° (c=1.2, $CHCl_3$). *Anal.* Calcd for $C_{35}H_{40}O_{14}S_2$: C, 56.14; H, 5.38. Found: C, 56.39; H, 5.27. ^{1}H-NMR ($CDCl_3$): 2.30, 2.43 (6H, each s, C$\underline{H}_3C_6H_4SO_2\times2$), 3.27, 3.29 (6H, each s, OMe×2). TLC: *Rf* 0.66 (solvent A), 0.54 (B).

Identification of the Component Monosaccharides in 13——Detosylation of **13** (200 mg) followed by acetylation of the detosylated product as described above for the preparation of **11** afforded 2,2′-di-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-3,3′-di-O-methyl-β-maltose (**14**) as an amorphous powder (80 mg, 58.4%), $[\alpha]_D^{25}$ +52.9° (c=0.7, $CHCl_3$). ^{1}H-NMR ($CDCl_3$): 2.13, 2.15 (6H, each s, OAc×2), 3.47, 3.61 (6H, each s, OMe ×2).

Compound **14** (60 mg) was dissolved in acetolysis mixture (3 ml, 1: 70: 30, v/v, H_2SO_4–Ac_2O–AcOH) at 0° and the mixture was allowed to stand at room temperature for 1 hr. The solution was poured into ice-H_2O (10 ml) and extracted with CH_2Cl_2 (10 ml×3), then the combined extracts were washed with ice-H_2O,

satd. $NaHCO_3$, and ice-H_2O, dried (Na_2SO_4), and evaporated to a syrup. The residue was chromatographed on a silica gel column with CH_2Cl_2–acetone (20: 1) to give an amorphous powder, which was deacetylated by the Zemplén method[13] to yield syrupy 3,3′-di-O-methylmaltose.

A solution of this syrup in H_2O (1 ml) was treated with $NaBH_4$ (20 mg). After being stirred at room temperature for 5 hr, the mixture was neutralized with Amberlite IR-120 (H^+) resin, filtered, and the filtrate was concentrated to dryness. The contaminating boric acid was then removed by repeated co-distillation with MeOH. The residue was hydrolyzed with 0.5 M H_2SO_4 (5 ml) at 95° for 4 hr. The hydrolysate was neutralized with $BaCO_3$, filtered, and concentrated to a syrup, in which 3-O-methylglucose[6] (*Rf* 0.58) and 3-O-methylglucitol[7] (*Rf* 0.50) were identified by PPC.

2,3,3′-Tri-O-acetyl-1,6-anhydro-4′,6′-O-benzylidene-2′-O-tosyl-β-maltose (**15**)——Acetylation of **6** (60 mg) as described above for the acetylation of **3** gave **15** as an amorphous powder (61 mg, 83.5%), $[\alpha]_D^{18}$ +11.6° (c=1.19, $CHCl_3$). *Anal.* Calcd for $C_{32}H_{36}O_{15}S$: C, 55.49; H, 5.24. Found: C, 55.60; H, 5.25. ^{1}H-NMR ($CDCl_3$): 1.85, 2.12, 2.16 (9H, all s, OAc×3), 2.45 (3H, s, $CH_3C_6H_4SO_2$). TLC: *Rf* 0.54 (solvent A), 0.30 (B).

1,6-Anhydro-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-2′-O-tosyl-β-maltose (**16**)——Compound **6** (120 mg) was methylated as described above for the methylation of **3** to give **16** (100 mg, 77.6%), which crystallized from EtOH as white needles, mp 150—151°, $[\alpha]_D^{18}$ +23.7° (c=1.3, $CHCl_3$). *Anal.* Calcd for $C_{29}H_{36}O_{12}S$: C, 57.23; H, 5.96. Found: C, 57.16; H, 6.16. ^{1}H-NMR ($CDCl_3$): 2.43 (3H, s, $CH_3C_6H_4SO_2$), 3.29, 3.50, 3.52 (9H, all s, OMe×3). TLC: *Rf* 0.60 (solvent A), 0.51 (B).

2′-O-Acetyl-1,6-anhydro-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-β-maltose (**17**)——1) From compound **16**: Detosylation of **16** (100 mg) followed by acetylation of the detosylated product as described above for the preparation of **11** afforded **17** (53 mg, 64%), which crystallized from EtOH. Recrystallization from EtOH gave white needles, mp 140—141°, $[\alpha]_D^{17}$ +86.8° (c=0.61, $CHCl_3$). *Anal.* Calcd for $C_{24}H_{32}O_{11}$: C, 58.06; H, 6.50. Found: C, 58.01; H, 6.61. ^{1}H-NMR ($CDCl_3$): 2.15 (3H, s, OAc), 3.43, 3.48, 3.63 (9H, all s, OMe×3).

2) From 1,6-Anhydro-2′-O-benzoyl-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-β-maltose: 1,6-Anhydro-2′-O-benzoyl-4′,6′-O-benzylidene-2,3,3′-tri-O-methyl-β-maltose[1] (150 mg) in dry MeOH (3 ml) was treated as described above for the preparation of **11** (method 2). On recrystallization from EtOH, **17** (88 mg, 76.7%) was obtained as white needles, mp 139—141°, $[\alpha]_D^{15}$ +78° (c=0.82, $CHCl_3$).

Identification of the Component Monosaccharides in 17——Treatment of **17** (200 mg) as described above for **14** gave 3-O-methylglucose (*Rf* 0.59) and 2,3-di-O-methylglucitol[14] (*Rf* 0.65), which were identified by PPC.

Selective Tosylation of 1,6-Anhydro-4′,6′-O-benzylidene-2,2′-di-O-tosyl-β-maltose (**5**)——TsCl (455 mg, 2.4 mmol) in dry pyridine (5 ml) was added dropwise to a chilled solution of **5** (216 mg, 0.3 mmol) in dry pyridine (10 ml) under stirring at 0°, and stirring was continued, with exclusion of moisture, for a further 30 min. The mixture was stored at room temperature for 4 days and then treated as described above for the selective tosylation of **1** to provide **2** (28 mg, 9.3%), **3** (45 mg, 17.3%), and **4** (64 mg, 24.7%), together with unreacted **5** (85 mg, 39.3%). However, when the reaction was carried out with 2.1 or 4.1 molar equivalents of TaCl at room temperature for 4 days, the bulk of the starting material (**5**) was recovered unchanged.

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