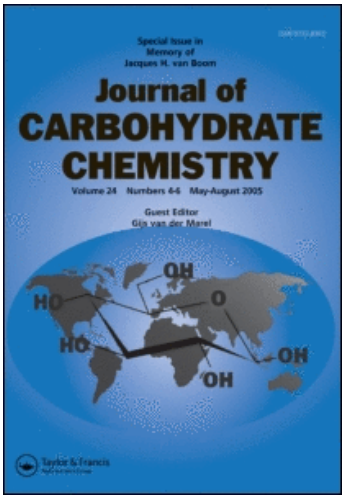

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Higher Sucrose Analogs: Homologation of a Glucose Unit of Sucrose by Two Carbon Atoms

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HIGHER SUCROSE ANALOGS: HOMOLOGATION OF A GLUCOSE UNIT OF SUCROSE BY TWO CARBON ATOMS

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ABSTRACT

The primary hydroxyl groups (at C-6 and C-6') in 2,3,4,3'4'-penta-*O*-benzyl-1'-*O*-methoxymethyl sucrose (**2**) can be reactively differentiated with *tert*-butyldiphenylsilyl chloride. Reaction of **2** with TBDPSCl afforded only one monosilylated product protected at C-6' (**6**). The regioisomeric monoprotected sucrose **8** was prepared by selective deprotection of the double silylated derivative **7**. Compound **6** was converted into 2,3,4,3',4'-penta-*O*-benzyl-6-carbomethoxymethylidene-1'-*O*-methoxymethylsucrose **10** in three steps. Osmylation of the double bond in **10** afforded stereoisomeric homologated sucroses: **11a** [6(*S*),7(*R*)] and **11b** [6(*R*),7(*S*)] in the ratio 3:2. A large downfield shift of the H-1 (up to 0.5 ppm) was observed for 6'-silylated derivatives.

INTRODUCTION

Selective protection of the free hydroxyl groups in sucrose is a big problem in transformation and utilization of this important disaccharide;[1] only the three primary

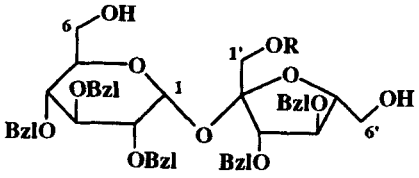


Fig. 1 **1** R = H; **2** R = MOM

hydroxyl groups of sucrose can be easily differentiated from secondary ones by bulky ether forming reagents.[2-4]

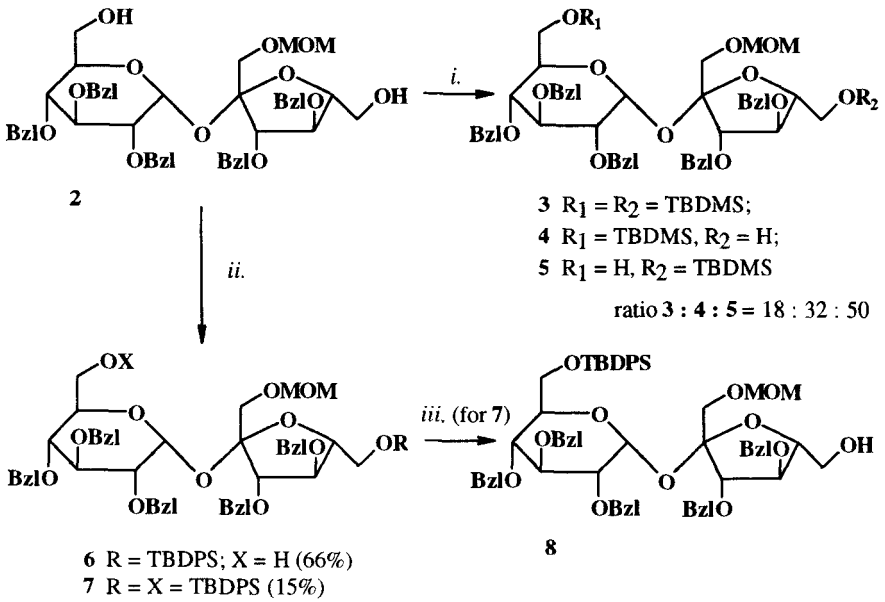
As a part of our program for conversion of sucrose into useful chiral synthons we elaborated a convenient synthesis of 2,3,4,3',4'-penta-*O*-benzylsucrose (**1**) (Fig. 1) in which all secondary hydroxyl groups are protected as the easily removable benzyl ethers (50% overall from sucrose).

This compound was converted further into 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose (**2**) *via* protection of the most reactive 6- and 6'-OH groups followed by reaction of the 1'-OH with methoxymethyl chloride (MOMCl) and deprotection at C-6 and C-6'.[5] For application of this compound as the starting material for the preparation of modified sucroses selective protection of either free hydroxyl group was needed.

RESULTS AND DISCUSSION

A literature survey on the selective protection of the primary hydroxyl groups in free sucrose indicates that bulky silyl chlorides (*tert*-butyldimethylsilyl[2] and *tert*-butyldiphenylsilyl[3]) react preferentially with the 6'-OH while trityl chloride does not differentiate between C-6 and C-6' hydroxyl groups.[4] We tried both silylating reagents for selective protection of the 6'-OH in **2**. Moderate selectivity was observed in the reaction of **2** with *tert*-butyldimethylsilyl chloride, while excellent selectivity occurred in the reaction with *tert*-butyldiphenylsilyl chloride.

Treatment of **2** with 1 equivalent of TBDMSCl afforded 6,6'-di-, 6-mono- and 6'-mono- (**3**, **4** and **5** respectively) silyl derivatives in the ratio 18:32:50. The same reaction performed with TBDPSCl gave only one monosilylated (at C-6') product (**6**) in



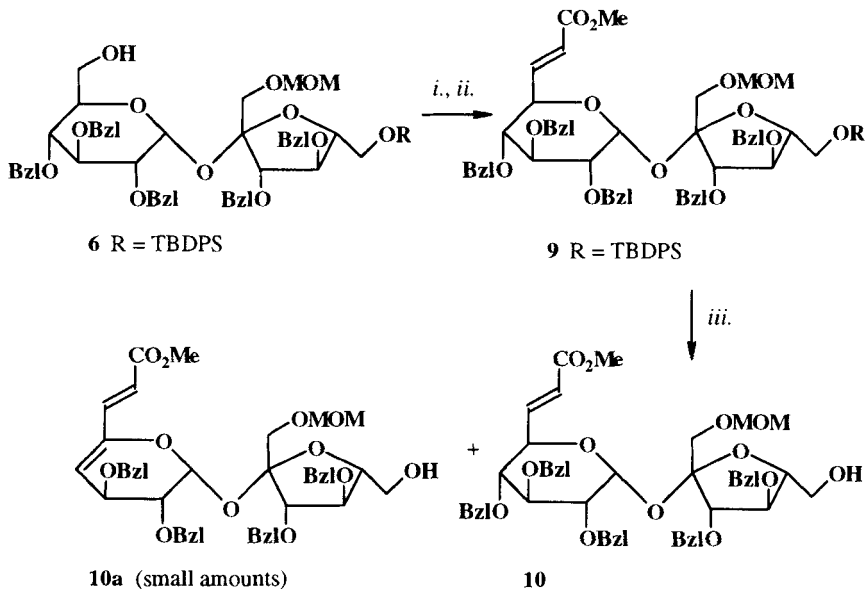
Scheme 1. *i.* Me_2-*tert*-BuSiCl (1.1 equiv), *i*-Pr_2NEt, CH_2Cl_2, rt, 3d.; *ii.* Ph_2-*tert*-BuSiCl (1.1 equiv), *i*-Pr_2NEt, cat. DMAP, CH_2Cl_2, rt, 3d.; *iii.* Bu_4NF (1 equiv), THF, rt, overnight

66% yield (together with 15% of double silylated 7). No monoprotection at C-6 was observed. The regioisomer of **6**, compound **8**, was also prepared in good yield by selective deprotection of 7 (at C-6') with 1 equivalent of B_4NF (Scheme 1).

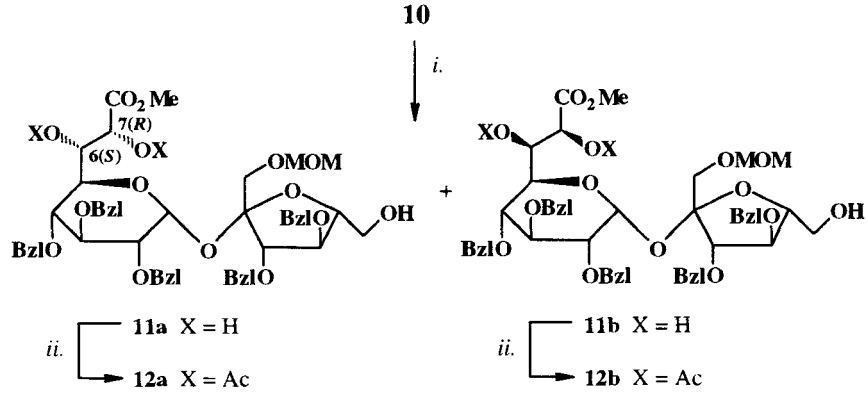
The position of substitution (C-6 vs C-6') was established by careful NMR experiments (COSY ^1H-^1H correlations). In the spectrum of monosubstituted compound **5**, signals at 3.63 and 3.51(both H-6) were coupled to OH (δ 1.9 ppm, J = 4.0 and 8.0 Hz) which proved that the C-6 position of the glucose part was unsubstituted. The analogous coupling in the spectrum of **6** was also observed [δ 3.36 and 3.43 (both H-6) with J = 4.0 and 8.0 Hz to OH at δ 1.68].

The synthetic potential of these selectively protected sucroses is illustrated in Schemes 2 and 3. Conversion of **6** into higher sucrose **11** utilizing Wittig homologation - osmylation methodology[6] serves as an example.

Alcohol **6** was oxidized to an aldehyde under the Swern conditions[7] and the crude aldehyde was treated with carbomethoxymethylenetriphenylphosphorane to give



Scheme 2. *i.* Swern oxidation; *ii.* $Ph_3P{=}CHCO_2Me$, benzene, rt; *iii.* Bu_4NF (excess), THF, rt, 3h.



Scheme 3. *i.* OsO_4, NMO, THF, H_2O; *ii.* Ac_2O, Et_3N, CH_2Cl_2

unsaturated ester **9** (Scheme 2). Treatment of this compound with excess of tetra-*n*-butyl ammonium fluoride for 3 hours removed the silyl group from the fructose 6'-OH and afforded alcohol **10**. When this reaction was performed for a longer time a small amount of side-product was detected in the post-reaction mixture. Treatment of **9** with Bu_4NF for

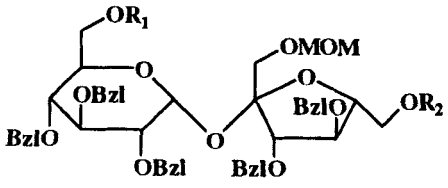
3 days afforded only this undesired side-product which was assigned the β-eliminated structure **10a** on the basis of NMR and mass spectroscopy. The ^{1}H NMR spectrum (COSY ^{1}H-^{1}H) of this material was remarkably different from the spectrum of **10**; a smaller coupling constant was observed for H-1 (δ 5.69, $J_{1,2}$ = 2.0 Hz), which suggested that the glucose ring was flattened. Moreover, coupling constants observed at H-3 signal ($J_{3,4}$= 3.6, $J_{2,3}$ = 5.6 Hz) of **10a** were very different from those expected (usually 9-10 Hz) and the H-4 signal was observed at very low field (δ 5.26, $J_{3,4}$ = 3.6 Hz) suggesting that elimination of the benzyl alcohol from the C-4 position had occurred. This was confirmed by the mass spectrum of **10a** in which no signal was seen at *m/z*: 913 [$C_{52}H_{58}O_{13}$ + Na^+]; this peak was observed for **10** but, in contrast to an *m/z* 805 [$C_{52}H_{58}O_{13}$ + Na^+ - BzlOH] for **10a**.

Compound **10** is a very useful synthon for the preparation of modified sucroses. The "glucose end" is homologated by two carbon atoms with a double bond, which allows for attachment by a suitable nucleophile (or radical) in inter- or intramolecular fashion. The double bond can also be oxidized to yield higher carbon sucrose analogs.

Compound **10** was transformed into a 'higher sucrose' **11** by catalytic osmylation of the double bond (Scheme 3); two stereoisomeric alcohols (**11a** and **11b**) were formed in the ratio 3:2 (^{1}H NMR estimation based on the integration of the ester methoxyl group signal in the crude post-reaction mixture). The 6(*S*),7(*R*) configuration was assigned to the main stereoisomer **11a** on the basis of Kishi's rule.[8] To the best of our knowledge, this is the first example of such 'higher sucrose'. Deprotection of **11** is, however, difficult due to the fact that removal of the MOM group under acidic conditions will probably also cause hydrolysis of the glycosidic bond. A protecting group that can be removed under neutral conditions (*e.g.* benzyloxymethyl) is recommended.

A very strong influence of the substitution at C-6' (fructose moiety) on the chemical shift of H-1 was noted (Fig. 2). Proton H-1 in the ^{1}H NMR spectrum of 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzylsucrose (**2**) resonates at δ 5.48 ppm.[5]

Protection at C-6 had a very small effect on this resonance; the δ value of H-1 in 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzyl-6-*O*-*tert*-butyldimethyl- and 6-*O*-*tert*-butyl-diphenylsilylsucrose (**4** and **8**) is observed at 5.47 ppm. However, substitution of the 6'-OH caused big changes in the chemical shift of H-1. When the 6'-OH group is protected as a silyl ether, signal H-1 is shifted downfield up to 0.5 ppm. For



3 $R_1 = R_2$ = TBDMS; δ = 5.88
4 R_1 = TBDMS; R_2 = H; δ = 5.47
5 R_1 = H; R_2 = TBDMS; δ = 5.96
6 R_1 = H; R_2 = TBDPS; δ = 5.83
7 $R_1 = R_2$ = TBDPS; δ = 5.85
8 R_1 = TBDPS; R_2 = H; δ = 5.47

Fig. 2 The chemical shiftsδ(H-1) ppm observed for different silylated derivatives 3 - 8

monosubstituted compounds **5** and **6** as well as for disubstituted **3** and **7** these resonances are observed at δ 5.96, 5.83, 5.88, and 5.85 respectively. We do not have the explanation of this phenomenon yet.

In conclusion, the 6'-OH group in 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzylsucrose (**2**) was selectively protected as its TBDPS ether **6** in 66% yield; the regioisomer **8** was also obtained in good yield by selective deprotection of the 6'-OH group in disilyl derivative **7**. Compound **6** was converted into homologated analog **11** (**a** and **b**) which can be used as a precursor for the synthesis of highly modified sucroses. Further work on synthesis of such sucroses is in progress.

EXPERIMENTAL

General methods. ^1H and ^{13}C NMR spectra were recorded with a Bruker AM 500 spectrometer for solutions in $CDCl_3$ (internal Me_4Si). Mass spectra (LSIMS; *m*-nitrobenzyl alcohol was used as a matrix to which sodium acetate was added) were recorded with a AMD-604 (AMD Intectra GmbH, Germany) spectrometer (isotopic pattern of all $[M + Na^+]$ ions agreed well with calculated ones). Column chromatography was performed on silica gel (Merck, 230-400 or 70-230 mesh). Organic solutions were dried over anhydrous magnesium sulfate. Specific rotations were measured in chloroform solution (*c* ~1) at room temperature.

Reaction of 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzylsucrose (2) with *tert*-butyldimethylsilyl chloride. To a solution of **2** (895 mg, 1.01 mmol) in methylene chloride (10 mL) TBDMSCl (180 mg, 1.1 mmol, 1.1 equiv) was added followed by diisopropylethylamine (0.5 mL). The mixture was stirred at room temperature for 3 days.

TLC (hexane - ethyl acetate, 3:1) showed three new products and unreacted starting material. Column chromatography (hexane - ethyl acetate, 9:1 to 4:1) of the mixture afforded:

a) 1'-*O*-methoxymethyl-6,6'-di-*O*-*t*-butyldimethylsilyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose **(3)**, (110 mg, 0.103 mmol, 10.2% or 14.3% calcd on consumed **2**). ^{1}H NMR δ: 5.88 (d, 1H, $J_{1,2}$ = 3.7 Hz, H-1), 4.91 - 4.52 (m, 12H, 5×OC$\underline{H_2}$Ph + OC$\underline{H_2}$O), 4.41 (d, 1H, $J_{3',4'}$ = 7.9 Hz, H-3'), 4.32 (t, 1H, $J_{4',5'}$ = 7.4 Hz, H-4'), 3.93 - 3.82 (m, 4H, H-5 + H-5' + both H-6'), 3.92 (dd, 1H, H-3), 3.75 and 3.61 (AB of both H-1' J_{AB} = 11.2 Hz), 3.67 (dd, 1H, $J_{3,4}$ = 9.4 Hz, $J_{4,5}$ = 9.7 Hz, H-4), 3.59 (dd, 1H, $J_{5,6b}$ = 2.6 Hz, H-6b), 3.48 (dd, 1H, $J_{5,6a}$ = 1.5 Hz, $J_{6a,6b}$ = 11.7Hz, H-6a;), 3.49 (dd, 1H, $J_{2,3}$ = 9.6Hz, H-2), 3.32 (s, 3H, OCH$_2$OC$\underline{H_3}$), 0.89 and 0.86 2×(s, 9H, *t*-Bu); *m/z*: 1087 [M($C_{61}H_{84}O_{12}Si_2$) + Na$^+$].

b) 1'-*O*-methoxymethyl-6-*O*-*t*-butyldimethylsilyl-2,3,4,3',4'-penta-*O*-benzylsucrose **(4)**, (160 mg, 0.177 mmol, 16.3 or 23.2%). ^{1}H NMR δ: 5.47 (d, 1H, $J_{1,2}$ = 3.4 Hz, H-1), 4.88 - 4.45 (m, 12H, 5×OC$\underline{H_2}$Ph + OC$\underline{H_2}$O), 4.44 (d, 1H, $J_{3',4'}$ = 7.9 Hz, H-3'), 4.36 (t, 1H, $J_{4',5'}$ = 7.9 Hz, H-4'), 4.00 (dd, 1H $J_{2,3}$ = 9.7, $J_{3,4}$ = 9.6 Hz, H-3), 3.98 - 3.95 (m, 2H, H-5 + H-5'), 3.90 (dd, 1H, $J_{5,6b}$ = 2.3 Hz, H-6b), 3.82 (dt, 1H, $J_{5',6'b}$ = 2.4 Hz, H-6'b), 3.77 (dd, 1H, $J_{6a,6b}$ = 12.0 Hz, $J_{5,6a}$ = 1.4 Hz, H-6a), 3.76 (t, 1H, $J_{3,4}$ = 9.5 Hz, H-4-), 3.62 and 3.56 (AB of both H-1' J_{AB} = 11.4 Hz), 3.75 (ddd, 1H, $J_{6'a,6'b}$ = 11.7 Hz, $J_{5',6a}$ = 2.6, H-6'a), 3.48 (dd, 1H, H-2), 3.28 (s, 3H, OCH$_2$OC$\underline{H_3}$), 3.15 (dd, 1H, $J_{6'a,OH}$ = 10.6 Hz, $J_{6'b,OH}$ = 2.4 Hz, O$\underline{H}$), 0.90 (s, 9H, *t*-Bu); *m/z*: 973 [M($C_{55}H_{70}O_{12}Si$) + Na$^+$].

c) 1'-*O*-methoxymethyl-6'-*O*-*t*-butyldimethylsilyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose **(5)**, (260 mg, 0.276 mmol, 27.3 or 37.9%). ^{1}H NMR δ: 5.96 (d, 1H, $J_{1,2}$ = 3.8 Hz, H-1), 4.94 - 4.51 (m, 12H, 5×OC$\underline{H_2}$Ph + OC$\underline{H_2}$O), 4.40 (d, 1H, $J_{3',4'}$ = 7.7 Hz, H-3'), 4.36 (dd, 1H, $J_{4',5'}$ = 7.3 Hz, H-4'), 4.03 (ddd, 1H, $J_{4,5}$ = 10.0, $J_{5,6a}$ = 2.3, $J_{5,6b}$ = 4.5 Hz, H-5), 3.94 (dd, 1H, $J_{2,3}$ = 9.6, $J_{3,4}$ = 9.1 Hz, H-3), 3.92 (dd, 1H, H-6'b), 3.88 (ddd, 1H, $J_{5',6'a}$ = 3.8 Hz, $J_{5',6'b}$ = 4.2 Hz, H-5'), 3.81 (dd, 1H, $J_{6'a,6'b}$ = 10.8 Hz, H-6'a), 3.72 and 3.63 (AB of both H-1' J_{AB} = 11.2 Hz), 3.50 (dd, 1H, H-2), 3.46 (dd, 1H, H-4), 3.63 (ddd (broad), 1H, H-6a), 3.51 (ddd (broad), 1H, $J_{6a,6b}$ ~ 12 Hz, H-6b), 3.32 (s, OCH$_2$OC$\underline{H_3}$), 1.94 (dd, 1H, $J_{6a,OH}$ = 4.0 Hz, $J_{6b,OH}$ = 7.9 Hz, O$\underline{H}$), 0.89 (s, 9H, *t*-Bu); *m/z*: 973 [M($C_{55}H_{70}O_{12}Si$) + Na$^+$].

d) unreacted **2** (240 mg, 0.287 mmol).

Reaction of 1'-*O*-methoxymethyl-2,3,4,3',4'-penta-*O*-benzylsucrose (2) with *tert*-butyldiphenylsilyl chloride. To a solution of **2** (1.5 g, 1.79 mmol) in methylene chloride (15 mL) TBDPSCl (540 mg, 1.97 mmol, 1.1 equiv) was added followed by diisopropylethylamine (0.5 mL). The mixture was stirred at room temperature for 1 day. TLC (hexane - ethyl acetate, 3:1) indicated no reaction at all. Catalytic amount of DMAP (*ca* 20 mg) was added and the mixture was stirred at room temperature for 3 more days. Two new products were formed which were isolated by column chromatography (hexane - ethyl acetate, 9:1 to 4:1):

a) 1'-*O*-methoxymethyl-6,6'-di-*O*-*t*-butyldiphenysilyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose (**7**), (0.35 g, 0.27 mmol, 15%). $[\alpha]_D$ 19.9 °. ^{1}H NMR δ: 5.85 (d, 1H, $J_{1,2}$ = 3.7 Hz, H-1), 4.85 - 4.26 (m, 12H, 5×OC$\underline{H_2}$Ph + OC$\underline{H_2}$O), 4.30 (d, 1H, $J_{3',4'}$ = 7.6 Hz, H-3'), 4.22 (t, 1H, $J_{4',5'}$ = 7.4 Hz, H-4'), 3.93 - 3.75 (m, 6H, H-3 + H-4 + H-5 + H-5' + both H-6'), 3.70 and 3.56 (AB of both H-1' J_{AB} = 11.2 Hz), 3.44 (dd, 1H, $J_{2,3}$ = 9.3 Hz, H-2), 3.24 (s, OCH$_2$OC$\underline{H_3}$), 0.97 and 0.93 (2×s, 2×*t*-Bu); *m/z*: 1335 [M($C_{81}H_{92}O_{12}Si_2$) + Na^+].

Anal. Calcd for $C_{81}H_{92}O_{12}Si_2$: C, 74.05; H, 7.06. Found: C, 73.8; H, 6.8.

b) 1'-*O*-methoxymethyl-6'-*O*-*t*-butyldiphenylsilyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose **(6)**, (1.27 g, 1.18 mmol, 66%). $[\alpha]_D$ = 26.7 °. ^{1}H NMR δ: 5.83 (d, 1H, $J_{1,2}$ = 3.8 Hz, H-1), 4.81 - 4.42 (m, 12H, 5×OC$\underline{H_2}$Ph + OC$\underline{H_2}$O), 4.35 - 4.31 (m, 2H, H-3' + H-4'), 3.93 - 3.86 (m, 2H, H-5 + H-5'), 3.90 (dd, 1H, $J_{5',6'b}$ = 3.6 Hz, H-6'b), 3.83 (dd, 1H, $J_{2,3}$ = 9.6, $J_{3,4}$ = 9.1 Hz, H-3), 3.74 (dd, 1H, $J_{6'a,6'b}$ = 11.0 Hz, $J_{5',6'a}$ = 4.1 Hz, H-6'a), 3.63 and 3.57 (AB of both H-1' J_{AB} = 11.2 Hz), 3.43 (ddd, 1H, $J_{6a,6b}$ = 11.8 Hz, $J_{5,6b}$ = 3.6 Hz, H-6b), 3.37 (dd, 1H, H-4), 3.36 (ddd (broad), 1H, H-6a), 3.36 (dd, 1H, H-2), 3.26 (s, 3H, OCH$_2$OC$\underline{H_3}$), 1.68 (dd, 1H, $J_{6b,OH}$ = 4.0 Hz, $J_{6a,OH}$ = 8.0 Hz, O$\underline{H}$), 0.98 (s, 9H, t-Bu); *m/z*: 1097 [M($C_{65}H_{74}O_{12}Si$) + Na^+].

Anal. Calcd for $C_{65}H_{74}O_{12}Si{\cdot}H_2O$: C, 71.40; H, 7.01. Found: C, 71.3; H, 6.5.

1'-*O*-Methoxymethyl-6-*O*-*tert*-butyldiphenylsilyl-2,3,4,3',4'-penta-*O*-benzyl-sucrose (8). Compound 7 (0.11 mmol in 2 mL of THF) was treated with TBAF (0.3 mL of a 0.38 M solution in THF) for 16 h. TLC (hexane - ethyl acetate, 3:1) showed 3 products which were isolated by column chromatography (hexane - ethyl acetate, 9:1 to 3:1):

a) unreacted **7** (0.015 mmol),

b) monosilylated (different from **6** by TLC) compound **8** (0.067 mmol, 55%), $[\alpha]_D$ 20.8 °. ^{1}H NMR *inter alia* δ: 5.47 (d, 1H, $J_{1,2}$ = 3.4 Hz, H-1), 4.35 (d, 1H, $J_{3',4'}$ = 7.9 Hz, H-3'), 4.22 (t, 1H, $J_{4',5'}$ = 7.9 Hz, H-4'), 3.96 (dd, 1H, $J_{2,3}$ = 9.7 Hz, $J_{3,4}$ = 9.5 Hz, H-3), 3.47 (dd, 1H, H-2), 3.20 (s, 3H, CH_2OMe), 2.70 (OH), 1.0 (s, 9H, *t*-Bu); *m/z*: 1097 [M($C_{65}H_{74}O_{12}Si$) + Na^+].

Anal. Calcd for $C_{65}H_{74}O_{12}Si{\cdot}H_2O$: C, 71.40; H, 7.01. Found: C, 71.9; H, 7.2

c) diol **2** (0.024 mmol).

2,3,4,3'4'-Penta-*O*-benzyl-6-carbethoxymethylidene-1'-methoxymethyl sucrose. a) To a solution of the Swern reagent[7] (prepared from 0.5 mL of oxalyl chloride and 3 mL DMSO) in methylene chloride (20 mL) at -78 °C was added a solution of **6** in CH_2Cl_2 (1.45g, 1.35 mmol in 5 mL). The mixture was stirred at -78 °C for 15 min, triethylamine (2 mL) was added and the mixture was allowed to reach room temperature (*ca* 1 h). Water (5 mL) was added, and the crude product was extracted with ether (40 mL). The organic phase was washed with water, dried, and concentrated.

b) The crude aldehyde was dissolved in dry benzene (10 mL) to which a Wittig reagent [Ph_3P=CH-CO_2Me (1.0 g, 3.0 mmol)] was added, the mixture was stirred at room temperature for 16 h and the product, ester **9** (1.11 g, 0.98 mmol, 72.6% for two steps), was isolated by column chromatography (hexane - ethyl acetate, 6:1 to 3:1) as an oil. ^{1}H NMR δ: 6.83 (dd, 1H, $J_{5,6}$ = 4.4, $J_{6,7}$ = 15.7 Hz, H-6), 5.94 (dd, 1H, $J_{5,7}$ = 1.9 Hz, H-7), 5.93 (d, 1H, $J_{1,2}$ = 3.7 Hz, H-1), 4.62 (ddd, 1H, $J_{4,5}$ = 10.2 Hz, H-5), 4.79 - 4.49 (m, 12H, 5×OCH_2Ph + OCH_2O), 4.42 - 4.36 (m, 2H, H-3' + H-4'), 3.93 (ddd, 1H, $J_{4',5'}$ = 7.9 Hz, H-5'), 3.97 (dd, 1H, $J_{5',6'b}$ = 3.9 Hz, H-6'b), 3.91 (dd, 1H, $J_{2,3}$ = 9.6, $J_{3,4}$ = 8.9 Hz, H-3), 3.82 (dd, 1H, $J_{6'a,6'b}$ = 11.1 Hz, $J_{5',6'a}$ = 4.3 Hz, H-6'a), 3.69 (s, 3H, CO_2CH_3), 3.70 and 3.61 (AB of both H-1' J_{AB} = 11.2 Hz), 3.44 (dd, 1H, H-2), 3.32 (s, 3H, OCH_2OCH_3), 3.15 (dd, 1H, H-4), 1.06 (s, 9H, *t*-Bu); *m/z*: 1151 [M($C_{68}H_{76}O_{13}Si$) + Na^+].

c) Silyl ether **9** (99 mg, 0.89 mmol) was dissolved in THF (2 mL), tetra-*n*-butylammonium fluoride trihydrate (*ca* 100 mg) was added, and the mixture was stirred at room temperature for 3 h. Purification of the crude product by column chromatography (hexane - ethyl acetate, 6:1 to 3:2) afforded alcohol **10** (65 mg, 0.73

mmol, 82%) as an oil. ^{1}H NMR δ: 6.98 (dd, 1H, $J_{5,6}$ = 5.2 Hz, $J_{6,7}$ = 15.8 Hz, H-6), 6.05 (dd, 1H, $J_{5,7}$ = 1.6 Hz, H-7), 5.55 (d, 1H, $J_{1,2}$ = 3.7 Hz, H-1), 4.65 (ddd, 1H, $J_{4,5}$ = 9.9 Hz, H-5), 4.89 - 4.51 (m, 12H, 5×OCH$_2$Ph + OCH$_2$O), 4.43 (d, 1H, $J_{3',4'}$ = 7.9 Hz, H-3'), 4.30 (dd, 1H, H-4'), 4.00 (dd, 1H, $J_{2,3}$ = 9.8 Hz, $J_{3,4}$ = 9.1 Hz, H-3), 3.97 (ddd, 1H, $J_{4',5'}$ = 8.0 Hz, $J_{5',6'a}$ = 2.6 Hz, $J_{5',6'b}$ = 3.2 Hz, H-5'), 3.81 - 3.72 (m, 2H, both H-6'), 3.73 (s, 3H, CO$_2$CH$_3$), 3.66 and 3.56 (AB of both H-1' J_{AB} = 11.3 Hz), 3.51 (dd, 1H, $J_{2,3}$ = 9.8 Hz, H-2), 3.30 (s, 3H, OCH$_2$OCH$_3$), 3.22 (dd, 1H, H-4), 1.91 (dd, 1H, $J_{6'a,OH}$ = 4.7 Hz, $J_{6'b,OH}$ = 6.9 Hz, OH); *m/z*: 913 [M(C$_{52}$H$_{58}$O$_{13}$) + Na$^+$].

Prolonged reaction of **9** with B$_4$NF caused partial elimination of benzyl alcohol from the C-4 position; after 3 days the 4,5-unsaturated ester **10a** was isolated as the only product. ^{1}H NMR δ: 6.93 (d, 1H, H-6), 6.23 (d, 1H, $J_{6,7}$ = 15.6 Hz, H-7), 5.69 (d, 1H, $J_{1,2}$ = 2.0 Hz, H-1), 5.26 (d, 1H, $J_{3,4}$ = 3.6 Hz, H-4), 4.79 - 4.53 (m, 12H, 5×OCH$_2$Ph + OCH$_2$O), 4.43 (dd, 1H, H-4'), 4.39 (d, 1H, $J_{3',4'}$ = 7.4 Hz, H-3'), 4.16 (dd, 1H, $J_{2,3}$ = 5.6 Hz, H-3), 4.03 (ddd, 1H, $J_{4',5'}$ = 7.0 Hz, $J_{5',6'a}$ = 2.6 Hz, $J_{5',6'b}$ = 3.9 Hz, H-5'), 3.80 (d (broad), 1H, H-6'a), 3.74 (s, 3H, CO$_2$CH$_3$), 3.73 (dd, 1H, H-2), 3.77 and 3.67 (AB of both H-1' J_{AB} = 11.1 Hz), 3.63 (dd (broad), 1H, $J_{6'a,6'b}$ = 12.4 Hz, H-6'b) 3.31 (s, 3H, OCH$_2$OCH$_3$), 2.53 (s (broad), 1H, OH); ^{13}C NMR d: 167.0 CO$_2$CH$_3$, 138.2 C-6, 138.0 C-5, 128.4 - 127.9 C-arom., 119.3 C-7, 108.9 C-4, 104.6 C-2', 96.7 OCH$_2$OCH$_3$, 92.6 C-1, 84.5 C-3', 81.7 C-5', 81.0 C-4', 75.3 C-2, 73.1, 73.0, 72.7 and 71.5 4×OCH$_2$Ph, 72.8 C-3, 68.0 C-1', 62.5 C-6', 55.6 OCH$_2$OCH$_3$, 51.7 CO$_2$CH$_3$; *m/z*: 805 [M(C$_{45}$H$_{50}$O$_{12}$) + Na$^+$].

***Cis*-hydroxylation of 2,3,4,3'4'-penta-*O*-benzyl-6-carbethoxymethylidene-1'-methoxymethyl sucrose (10).** The general procedure for catalytic osmylation[9] was followed; thus, compound **10** (505 mg, 0.57 mmol) in THF containing *tert*-BuOH and water was treated with OsO$_4$/NMO for 2 d to give **11a** and **11b** (375 mg, 0.41 mmol, 72%), as a 3:2 mixture [NMR estimation based on the integration of H-1 signals at δ 5.71 ($J_{1,2}$ = 3.7 Hz) for the major 6(*S*),7(*R*) isomer **11a** and δ 5.61 ($J_{1,2}$ = 3.5 Hz) for the minor 6(*R*),7(*S*) product **11b**); *m/z*: 947 [M(C$_{52}$H$_{60}$O$_{15}$) + Na$^+$]. These compounds were characterized as triacetates **12a** and **12b:**

12a [α]$_D$ 6.7 °. ^{1}H NMR δ: 5.66 (dd, 1H, H-6), 5.60 (d, 1H, H-1), 5.47 (d, 1H, $J_{6,7}$ = 3.1 Hz, H-7), 4.98 - 4.47 (m, 12H, 5×OCH$_2$Ph + OCH$_2$O), 4.42 - 4.33 (m, 3H, H-

3' + both H-6'), 4.27 (dd, 1H, $J_{5,6}$ = 2.3 Hz, H-5), 4.14 - 4.10 (m, 2H, H-4' + H-5'), 4.00 (dd, 1H, H-3), 3.67 (s, 3H, CO_2CH_3), 3.58 (dd, 1H, $J_{3,4}$ = 8.8 Hz, $J_{4,5}$ = 10.3 Hz, H-4), 3.72 and 3.57 (AB of both H-1' J_{AB} = 11.5 Hz), 3.46 (dd, 1H, $J_{1,2}$ = 3.5 Hz, $J_{2,3}$ = 9.8 Hz, H-2), 3.30 (s, 3H, OCH_2OCH_3), 2.08, 2.03 and 1.96 3×(s, 3H, OAc); ^{13}C NMR d: 170.6, 169.8, 169.7 and 168.7 4×C=O, 138.5 - 137.9 and 128.7 - 127.5 C-arom., 104.7 C-2', 96.6 OCH_2OCH_3, 90.5 C-1, 83.6 C-3', 83.0 C-5', 81.6 C-3, 79.5 C-2, 78.9 C-4', 78.3 C-4, 75.5, 74.9, 73.1, 72.9 and 72.6 5×OCH_2Ph, 71.8 C-5, 71.1 C-7, 68.6 C-6, 67.8 C-1', 65.9 C-6', 55.5 OCH_2OCH_3, 52.5 CO_2CH_3, 20.8, 20.51 and 20.45 3×OAc; *m/z*: 1073 [M($C_{58}H_{66}O_{18}$) + Na^+];

Anal. Calcd for $C_{58}H_{66}O_{18}$: C, 66.27; H, 6.33. Found: C, 65.9; H, 6.6.

12b $[\alpha]_D$ 13.5 °. ^{1}H NMR δ: 5.76 - 5.74 (m, 2H, H-6 + H-1), 5.34 (d, 1H, $J_{6,7}$ = 2.8 Hz, H-7), 4.95 - 4.43 (m, 10H, 5×OCH_2Ph), 4.61 (s, 2H, OCH_2OCH_3), 4.39 (dd, 1H, $J_{5,6}$ = 2.1 Hz, H-5), 4.30 - 4.26 (m, 3H, H-3' + both H-6'), 4.09 - 4.03 (m, 3H, H-3' + H-4' + H-5'), 3.71 (s, 3H, CO_2CH_3), 3.89 and 3.62 (AB of both H-1' J_{AB} = 11.3 Hz), 3.56 (dd, 1H, $J_{1,2}$ = 3.4 Hz, $J_{2,3}$ = 9.8 Hz, H-2), 3.42 (dd, 1H, $J_{3,4}$ = 8.9 Hz, $J_{4,5}$ = 10.0 Hz, H-4), 3.31 (s, 3H, OCH_2OCH_3), 2.15, 2.11 and 1.91 3×(s, 3H, OAc); ^{13}C NMR d: 170.8, 170.0, 169.8 and 168.4 4×C=O, 138.5 - 137.8 and 128.4 - 127.6 C-arom., 105.9 C-2', 96.7 OCH_2OCH_3, 91.3 C-1, 84.1 C-3', 83.0 C-5', 81.5 C-3, 79.5 C-2, 79.2 C-4', 77.5 C-4, 75.7, 75.2, 72.9, 72.4 and 72.3 5×OCH_2Ph, 71.7 C-5, 71.6 C-7, 68.7 C-6, 66.7 C-1', 64.7 C-6', 55.7 OCH_2OCH_3, 52.5 CO_2CH_3, 20.64, 20.58 and 20.55 3×OAc; *m/z*: 1073 [M($C_{58}H_{66}O_{18}$) + Na^+];

Anal. Calcd for $C_{58}H_{66}O_{18}$: C, 66.27; H, 6.33. Found: C, 66.3; H, 6.4.

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