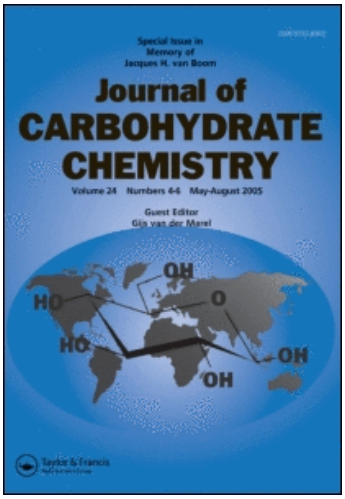

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SYNTHESIS OF SELECTIVELY PERMODIFIED γ-CYCLODEXTRINS. A NEW SET OF CHIRAL STATIONARY PHASES IN CAPILLARY GC.

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ABSTRACT

Two pairs of new chiral selectors, derived from *octakis*(6-*O*-*t*-butyldimethylsilyl)- and *octakis*(6-*O*-*t*-hexyldimethylsilyl)-γ-cyclodextrin, were synthesized with inverse substitution patterns at the secondary positions. 2-*O*-methyl-3-*O*-acetyl- and 2-*O*-acetyl-3-*O*-methyl derivatives are suggested as useful models to further investigate the effect of substituents at C-2 and C-3 on the efficiency of enantioseparation using gas chromatography.

INTRODUCTION

The literature of the past two decades has witnessed a vastly growing interest in the synthesis of modified cyclodextrins (CDs),[1] a class of compounds that is susceptible to numberless applications in biological,[2] pharmaceutical[3] and synthetic fields.[4] Because of their marked ability to form complexes with a great variety of organic compounds

both in solution and in the solid state, in 1979 they were first employed by Casu *et al.* [5] as the stationary phase in gas chromatography (GC).[6]

In this report we describe a few approaches to the regioselective persubstitution of γ-cyclodextrin, whose native form is a cyclic octamer of α-D-glucose. The oligosaccharide ring forms a tapered torus with the primary hydroxyl groups lying on the narrow side whereas the secondary hydroxyl groups are located on the wider side.

As gathered from the literature,[1,7] it is not trivial to selectively modify the three kinds of hydroxyl group in CDs, especially because reaction outcomes are often driven by the complexation of the reagent within the hydrophobic cavity. Some degree of regioselectivity, however, is to be expected because the primary hydroxyl in 6 is the most reactive, is easily accessible and also the most basic (which usually means the most nucleophilic); the secondary hydroxyl in 2 is the most acidic,[8] while the secondary hydroxyl in 3 is the least accessible. The hardest problems in selective modification are met on the more crowded side,[9,10] that is also less flexible owing to hydrogen bonding between the secondary hydroxyl groups.[11] Substituents on the primary side seem to have a more marked influence on polarity, melting point and solubility; enantioselectivity especially depends on their chemical nature. Abundant research on these aspects[12] has shown that the enantioselectivity of CDs carrying the same alkyl substituent at C-2 and C-3 is wholly dependent on the nature of the substituent group at C-6: it is favored by a methyl group, and suppressed by an acetate group. Contrary to a former hypothesis,[13] it is not reduced even by a rigid and bulky group like *t*-butyldimethylsilyl (TBDMS).[14] In order to maximize it, a compromise must be struck in choosing the substituent: the CD should be made more hydrophobic to favor analyte inclusion, yet unfavorable steric hindrance must be avoided. The formation of an inclusion complex in the CD cavity seems indeed to be the dominant process in enantiomeric resolution. In a previous paper[15] we compared the enantioselectivities of 6-O-*t*-butyldimethylsilyl- and 6-O-*t*-hexyldimethylsilyl (TXDMS) derivatives of β– and γ-CD on a series of racemates whose volatilities were widely different.

In order to investigate the effect of substitution on the two secondary hydroxyls, we have now effected the alternate insertion of a methyl ether, a small and flexible group, and an acetate group, a rigid and bulkier one (Figure 1).

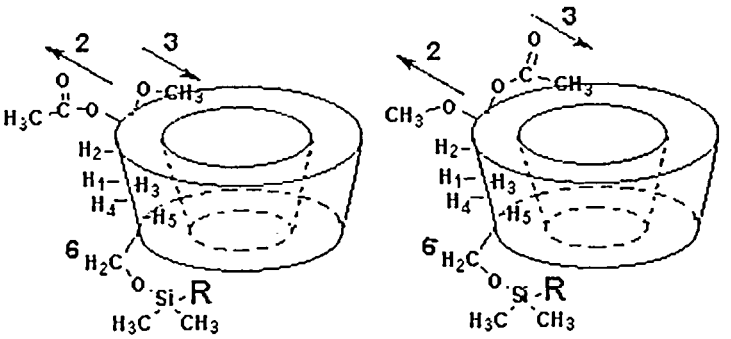
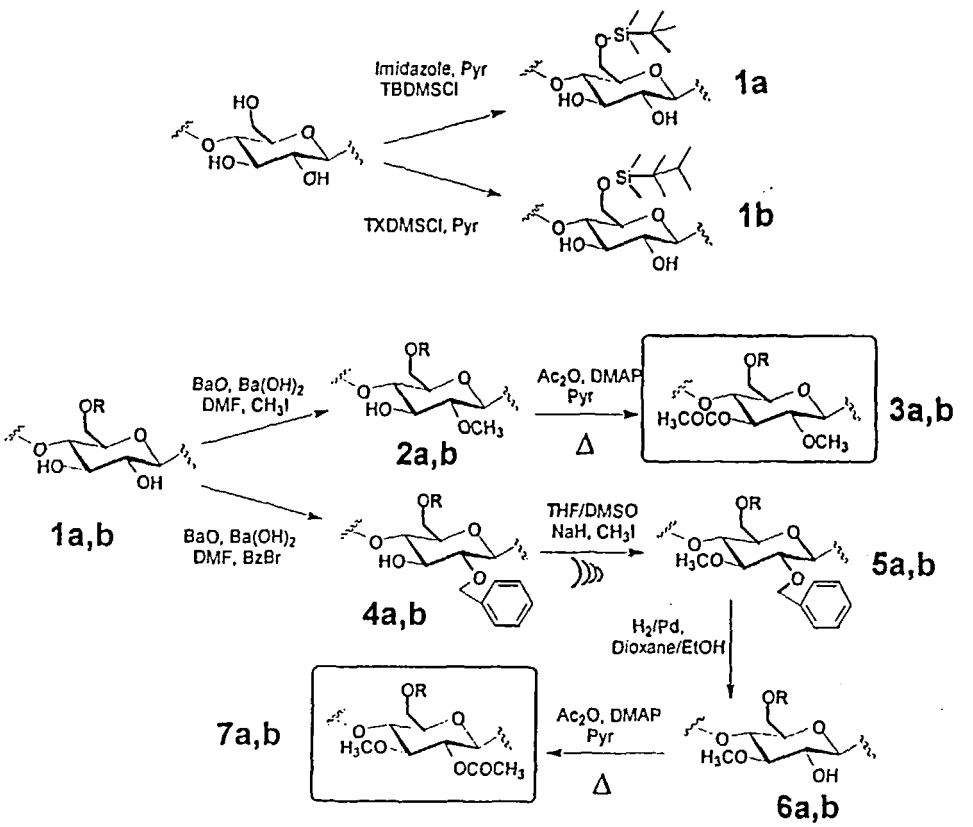


Figure 1. Substituents orientation on the CD torus (R= *t*-Butyl, *t*-Hexyl)

RESULTS AND DISCUSSION

As shown in Scheme 1, after selective silylation of the primary hydroxyl group we took advantage of the greater acidity of the 2-hydroxyl group. In either synthetic pathway the latter was deprotonated with a mixture of BaO and $Ba(OH)_2 \cdot H_2O$ in dimethylformamide (DMF),[9] then selectively alkylated either with methyl iodide or benzyl bromide. The 2-*O*-methyl derivatives were acetylated with acetic anhydride in pyridine in the presence of dimethylaminopyridine (DMAP).[16] Esterification yields were dramatically sensitive to temperature as well as to traces of water: at 60 °C, under stirring and nitrogen pressure, the reaction was completed in 4 hours. We obtained the alternatively substituted compound by selective deprotonation of the 2-*O*-benzyl derivative with sodium hydride and subsequent alkylation with methyl iodide. As expected, permethylation in position 3 was particularly difficult,[1,7] and even under stringent conditions, such as a rigorously water-free mixed solvent (THF/DMSO), heating at 50 °C, a well-timed addition of reagents and a lengthy reaction time (up to 96 hours), uniformly met with failure. The difficulty was overcome when the reaction was carried out in a Carius-type pyrex tube that was stoppered with a pressure-proof screw cap and placed in a sonication apparatus.[17] Accordingly after 6 hours both 2-*O*-benzyl derivatives, *i.e.*, *6-O-t*-butyldimethylsilyl-γ-CD (**4a**) and *6-O-t*-hexyldimethylsilyl-γ-CD (**4b**), were fully methylated at C-3 in excellent yields. The protecting group was easily removed from the 2-position by catalytic hydrogenation in the presence of 10% Pd/C. The synthesis of the second pair of compounds was completed by acetylation with Ac_2O



Scheme 1

in pyridine and DMAP; special care had likewise to be paid to water removal and heating conditions (50 °C for 7 hours, or 2 hours under sonication).

In the case of compound **2a,b** and **3a,b** the presence of strong hydrogen bonds is inferred from our finding that the R_f values of acetates are markedly lesser than those of the corresponding alcohols. The inverse situation is observed between **6a,b** and **7a,b** where the acetates have larger R_f's, thereby implying that strong hydrogen bonds can only be formed by the free hydroxyl group in position 3. This is in accordance with NMR studies[18] where the OH in 3 has been found to be the dominant hydrogen-bond donor. At each reaction step the purity of products was checked from their ^{1}H NMR and ESI-MS spectra.

Preliminary tests carried out on these new chiral selectors for capillary GC generally gave promise of a high degree of enantio-selection. Significant differences were observed between **3a,b** and **7a,b**: with some exceptions, the first substitution pattern at the secondary hydroxyl groups gave the best results. Both the **3a,b** compounds, in comparison with the more commonly used[15] *6-O*-silylated-γ-CDs (2,3-di-*O*-methyl, 2,3-di-*O*-ethyl and 2,3-di-*O*-acetyl), showed a higher efficiency in enantio-separation. Studies are underway to evaluate the steric and electronic effects which control this instance of enantioselection and how it may be improved by chemical modification at the secondary OH groups.

CONCLUSION

In this paper we have described an improved entry to selectively permodified γ–cyclodextrins. Our strategy introduced at the secondary positions an ester and an ether group in the two alternative substitution patterns. The resulting compounds showed significantly different powers of enantio-separation in capillary GC. Further investigations are under way to understand how substituents at the secondary positions influence enantioselectivity.

EXPERIMENTAL

General methods. Melting points were obtained on a Büchi SMP-20 apparatus and are uncorrected. ^{1}H NMR spectra were recorded on a Bruker AC-400 spectrometer at 400 MHz, and chemical shifts are expressed in parts per million downfield from TMS. ESI-MS spectra were recorded on a TSQ-700 Finnigan-Mat spectrometer (positive mode, CH_3CN) and IR spectra with a Shimadzu FT-IR 8001 spectrometer. All solvents and chemicals were reagent grade and anhydrous conditions were achieved (when indicated) by flame-drying flasks and other critical equipment. Solvents were dried by distillation: CH_2Cl_2 from P_4O_{10}, THF from benzophenone-ketyl Na, DMF and DMSO from CaH_2 and pyridine from BaO. Reactions were monitored by TLC on Alugram Sil-Macherey Nagel (F_{254}, 0.25 mm) plates, spots were detected by staining with 5% H_2SO_4 in EtOH and heating. Column chromatography was performed using silica gel 60 (Merck). Sonication

was performed in a Sonic Vibra Cell 600W apparatus. Before each subsequent reaction step, intermediates were dried for 2-3 h at 100 °C in a vacuum oven.

***Octakis*-6-*O*-*t*-butyldimethylsilyl-(TBDMS) γ-CD (1a) and *Octakis*-6-*O*-*t*-hexyldimethylsilyl-(TXDMS) γ-CD (1b)** were prepared according to a reported procedure,[15] and spectral data were found to be in accordance with the literature.

***Octakis*-2-*O*-methyl-6-*O*-TBDMS-γ-CD (2a) and *Octakis*-2-*O*-methyl-6-*O*-TXDMS-γ-CD (2b).** Either 6-silyl-γ-CD derivative **1a** or **1b** (1.00 g, 0.45 and 0.41 mmol respectively), placed in a 50-mL two-necked round-bottomed flask equipped with a magnetic stirrer and a nitrogen inlet, was dissolved in anhydrous DMF (10 mL). An excess of BaO (1.4 g) and $Ba(OH)_2$ monohydrate (0.7 g) was then added, and the mixture was stirred for 3 h at room temperature. The suspension was cooled in an ice-water bath, methyl iodide (20 eq) was slowly added, and stirring was continued overnight at 40 °C. After TLC analysis (hexane/EtOAc 1:9 for the TBDMS-derivative and $CHCl_3$/MeOH 9:1 for the TXDMS-derivative) the reaction mixture was diluted with a 10% ammonia solution (15 mL) filtered through a pad of silica gel - florisil® and washed with water. The product was eluted with EtOAc, washed with brine and dried over $MgSO_4$. After removal of the solvent, the oily residue was purified by column chromatography using an eluent gradient to eliminate less polar impurities. **2a** was eluted with hexane/EtOAc 3:7 in 46.2% yield (486 mg, 0.208 mmol), whereas **2b** was isolated with $CHCl_3$/MeOH 95:5 in 72.2% yield (754 mg, 0.296 mmol).

Data for **2a**: mp 284 °C; IR (KBr) 3435, 1474, 1254, 1094, 1047, 835, 777 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.00 (s, 1H, OH), 4.99 (d, 1H, $J_{1,2}$ = 2.6 Hz, H-1), 3.93 (t, 1H, $J_{3,4}$ = 5.7 Hz, H-4), 3.89 (dd, 1H, $J_{5,6a}$ = 6.4 Hz, $J_{6a,6b}$ = 1.6 Hz, H-6a), 3.60 (s, 3H, OCH_3), 3.64-3.53 (m, 2H, H-5, H-6b), 3.43 (t, 1H, $J_{3,4}$ = 5.7 Hz, H-3), 3.14 (d, 1H, J_{2-3} = 6.0 Hz, $J_{1,2}$ = 2.4 Hz, H-2), 0.81 (s, 9H, *t*-Bu), -0.01 (s, 6H, $(CH_3)_2Si$). R_f(hexane/EtOAc 1:9) = 0.29. ESI-MS (Calcd for $C_{104}H_{208}O_{40}Si_8$ 2323.3) 2321.6 $[M+H]^+$, 2343.6 $[M+Na]^+$.

Data for **2b**: mp 189 °C; IR (KBr) 3432, 1466, 1252, 1159, 1092, 1047, 1018, 827, 779 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.00 (br s, 1H, OH), 4.90 (br s, 1H, H-1), 3.88 (dd, 1H, $J_{3,4}$ = 5.2 Hz, H-4), 3.58 (s, 3H, OCH_3), 3.81-3.14 (m, 4H, H-6a, H-5, H-6b, H-3), 3.09 (d, 1H, $J_{2,3}$ = 5.8 Hz, H-2), 0.82 (d, 6H, $(CH_3)_2CH$-), 0.78 (s, 6H, $(CH_3)_2C<$), 0.03 (s, 6H, $(CH_3)_2Si$). R_f($CHCl_3$/MeOH 9:1) = 0.63. ESI-MS (Calcd for $C_{120}H_{240}O_{40}Si_8$ 2547.8) 2545.9 $[M+H]^+$, 2567.9 $[M+Na]^+$.

***Octakis*-2-*O*-methyl-3-*O*-acetyl-6-*O*-TBDMS-γ-CD (3a) and *Octakis*-2-*O*-methyl-3-*O*-acetyl-6-*O*-TXDMS-γ-CD (3b).** Either **2a** or **2b** (500 mg, 0.22 and 1.96 mmol respectively) was placed in a 50-mL two-necked round-bottomed flask equipped with a magnetic stirrer and a nitrogen inlet, and then dissolved in anhydrous pyridine (9 mL). Acetic anhydride (3 mL) was slowly added, and the mixture was stirred for 4 h at room temperature in the presence of a catalytic amount of 4-dimethylaminopyridine (DMAP). Reactions were monitored by TLC, using $CHCl_3$/MeOH 8:2 in the case of **3a** and $CHCl_3$/MeOH 9:1 in the case of **3b**. The reaction mixture was diluted with water (50 mL) and extracted with $CHCl_3$ (15 mL x 3); the combined organic layers were washed three times with HCl 3N (15 mL), then with saturated aqueous $NaHCO_3$ (20 mL) and brine. After drying over $MgSO_4$ and removal of the solvent, the oily residue was purified by column chromatography. Elution of **3a** with $CHCl_3$/MeOH 9:1 afforded 436 mg (0.164 mmol) of product (76.7% yield); elution of **3b** with $CHCl_3$/MeOH 95:5 afforded 480 mg (0.166 mmol) of peracetylated derivative (84.5% yield).

Data for **3a**: mp 160 °C; IR (KBr) 1759, 1234, 1095, 1040, 835, 777 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.17 (t, 1H, $J_{3,4}$ = 5.7 Hz, H-3), 5.12 (d, 1H, $J_{1,2}$ = 1.9 Hz, H-1), 4.13 (d, 1H, $J_{5,6a}$ = 6.80 Hz, H-6a), 3.80 (t, 1H, $J_{3,4}$ = 5.7 Hz, H-4), 3.71 (d, 1H, $J_{5,6ab}$ = 6.6 Hz, H-5), 3.66 (d, 1H, $J_{5,6b}$ = 7.0 Hz, H-6b), 3.33 (s, 3H, OCH_3), 3.14 (dd, 1H, $J_{2,3}$ = 6.1 Hz, $J_{1,2}$ = 1.8 Hz, H-2), 2.05 (s, 3H, Ac), 0.87 (s, 9H, *t*-Bu), 0.02 (s, 6H, $(CH_3)_2Si$). R_f ($CHCl_3$/MeOH 8:1) = 0.61. ESI-MS 2657.9 $[M+H]^+$, 2679.9 $[M+Na]^+$.

Anal. Calcd for $C_{120}H_{224}O_{48}Si_8$ (2659.7): C, 54.19; H, 8.49. Found: C, 54.21; H, 8.30.

Data for **3b**: mp 120 °C; IR (KBr) 1757, 1232, 1094, 1032, 825, 779 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.20-4.90 (m, 2H, H-1, H-3), 4.15-4.05 (m, 1H, H-6a), 3.75-3.6 (m, 3H, H-4, H-5, H-6b), 3.34 (s, 3H, OCH_3), 3.08 (br d,1H, H-2), 2.04 (s, 3H, Ac), 0.86 (d, 6H, J = 2.1, $(CH_3)_2CH$-), 0.81 (s, 6H, $(CH_3)_2C<$), 0.06 (s, 6H, $(CH_3)_2Si$). R_f($CHCl_3$/MeOH 8:2) = 0.69. ESI-MS 2882.7 $[M+H]^+$, 2904.7 $[M+Na]^+$.

Anal. Calcd for $C_{136}H_{256}O_{48}Si_8$ (2884.2): C, 56.64; H, 8.95. Found C, 56.47; H, 8.72.

***Octakis*-2-*O*-benzyl-6-*O*-TBDMS-γ-CD (4a) and *Octakis*-2-*O*-benzyl-6-*O*-TXDMS-γ-CD (4b).** We used the same procedure described for the preparation of **2a** and **2b**. Starting from **1a** or **1b** (1.00 g, 0.45 and 0.41 mmol respectively) and an excess

of benzyl bromide (0.6 mL), after purification by column chromatography we obtained both **4a** (934 mg, 70.5% yield) and **4b** (956 mg, 73.9% yield). **4a** was eluted with hexane/ EtOAc 9:1, **4b** with $CHCl_3$/MeOH 98:2.

Data for **4a**: mp 219 °C; IR (KBr) 3432, 1464, 1254, 1088, 1047, 835, 777, 698 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.40-7.36 (m, 5H, H_{Ar}), 4.99 (d, 1H, J = 7.3 Hz, CH_2Ph), 4.95 (s, 1H, OH), 4.88 (d, 1H, $J_{1,2}$ = 2.3 Hz, H-1), 4.72 (d, 1H, J = 7.3 Hz, CH_2Ph), 4.06 (t, 1H, $J_{3,4}$ = 5.81 Hz, H-4), 3.89 (dd, 1H, $J_{5,6a}$ = 7.10 Hz, J = 1.70 Hz, H-6a), 3.64 (d, 1H, $J_{5,6ab}$ = 6.95 Hz, H-5), 3.59 (d, 1H, $J_{5,6ab}$ = 6.72 Hz, H-6b), 3.44 (t, 1H, $J_{3,4}$ = 5.81 Hz, H-3), 3.36 (dd, 1H, $J_{2,3}$ = 5.9 Hz, $J_{1,2}$ = 2.3 Hz, H-2), 0.86 (s, 9H, *t*-Bu), 0.00 (s, 6H, $(CH_3)_2Si$). R_f (hexane/EtOAc 8:2) = 0.36. ESI-MS (Calcd for $C_{152}H_{240}O_{48}Si_8$ 2932.2) 2930.2 $[M+H]^+$, 2952.2 $[M+Na]^+$.

Data for **4b**: mp 72 °C; IR (KBr) 3435, 1456, 1252, 1086, 1047, 826 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.38 (m, 5H, H_{Ar}), 5.02 (d, 1H, J = 7.34 Hz, CH_2Ph), 4.97 (s, 1H, OH), 4.86 (d, 1H, $J_{1,2}$ = 2.32 Hz, H-1), 4.72 (d, 1H, J = 7.33 Hz, CH_2Ph), 4.06 (t, 1H, $J_{3,4}$ = 5.83 Hz, H-4), 3.89 (dd, 1H, $J_{5,6ab}$ = 7.00 Hz, J = 1.71 Hz, H-6a), 3.64 (d, 1H, $J_{5,6ab}$ = 6.95 Hz, H-5), 3.57 (d, 1H, J = 5.72 Hz, H-6b), 3.41 (t, 1H, $J_{3,4}$ = 5.83 Hz, H-3), 3.36 (dd, 1H, $J_{2,3}$ = 5.9 Hz, $J_{1,2}$ = 2.32 Hz, H-2), 0.87 (s, 6H, $(CH_3)_2CH$-), 0.83 (6H, $(CH_3)_2C<$), 0.04 (s, 6H, $(CH_3)_2Si$). R_f ($CHCl_3$/MeOH 95:5) = 0.63. ESI-MS (Calcd for $C_{168}H_{272}O_{48}Si_8$ 3156.7) 3155.0 $[M+H]^+$, 3177.0 $[M+Na]^+$.

***Octakis*-2-*O*-benzyl-3-*O*-methyl-6-*O*-TBDMS-γ-CD (5a) and *Octakis*-2-*O*-benzyl-3-*O*-methyl-6-*O*-TXDMS-γ-CD (5b).** Both reactions were carried out on 250 mg of starting material (**4a** and **4b**, 0.085 and 0.079 mmol respectively), in a Carius-type pyrex tube (100 mL) stoppered with a pressure-resistant screw cap. An excess of NaH (60%, 100 mg) was added to a THF (8 mL) / DMSO (1 mL) solution that was left in an ultrasonic bath for 1 h, then cooled down to 0-5 °C. An excess of MeI (0.2 mL) was added and after 6 hours in the sonication apparatus the reaction was complete as shown by TLC analysis. Formation of **5a** was monitored by TLC with hexane/EtOAc 8:2, *idem* for **5b** with $CHCl_3$/MeOH 98:2. Reaction mixtures were quenched by adding iced water (20 mL) and then extracted with $CHCl_3$ (15 mL x 2). The organic layer was washed with brine, dried on $MgSO_4$, concentrated, and purified by column chromatography. **5a** (180 mg, 0.059 mmol, 69.2% yield) was obtained by elution with hexane/EtOAc 9:1; **5b** (194 mg, 0.059 mmol, 75.1% yield) by elution with $CHCl_3$.

Data for **5a**: mp 81 °C; IR (KBr) 1464, 1161, 1090, 1047, 835, 777, 698 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.34 (m, 5H, H_{Ar}), 4.99 (d, 1H, CH_2Ph), 4.88 (d, 1H, H-1), 4.82-4.60 (m, 3H, CH_2Ph, H-6a, H-5), 3.68-3.44 (m, 3H, H-4, H-3, H-6b), 3.35 (dd, 1H, H-2), 3.34 (s, 3H, OCH_3), 0.84 (s, 9H, *t*-Bu), -0.02 (s, 6H, $(CH_3)_2Si$). R_f (hexane/ EtOAc 8:2) = 0.49. ESI-MS (Calcd for $C_{160}H_{256}O_{48}Si_8$ 3044.4) 3042.5 $[M+H]^+$, 3064.5 $[M+Na]^+$.

Data for **5b**: oily compound; IR (KBr) 1460, 1252, 1159, 1090, 1047, 826, 779 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.38 (m, 5H, H_{Ar}), 4.98 (m, 1H, CH_2Ph), 4.87 (s, 1H, H-1), 4.84-4.62 (m, 3H, CH_2Ph, H-6a, H-5), 3.68-3.40 (m, 3H, H-4, H-3, H-6b) 3.32 (d, 1H, H-2), 0.87 (s, 6H, $(CH_3)_2CH$-), 0.83 (s, 6H, $(CH_3)_2C<$), 0.04 (6H, s, $(CH_3)_2Si$). R_f ($CHCl_3$/MeOH 98:2) = 0.82. ESI-MS (Calcd for $C_{176}H_{224}O_{48}Si_8$ 3268.8) 3267.1 $[M+H]^+$, 3289.1 $[M+Na]^+$.

Debenzylation of **5a** and **5b** to **6a** and **6b**. To a solution of **5a** or **5b** (250 mg) in 10 mL of dioxane/EtOH 1:1, 50 mg of 10% palladium on carbon was added; the flask was evacuated and purged with hydrogen, then vigorously stirred overnight under a hydrogen atmosphere. The reaction mixture was filtered through a pad of celite and the residue washed with EtOAc; the filtrate and washings were concentrated. **6a** and **6b** were quantitatively recovered (98-100% yield) and used directly for the last synthetic step.

***Octakis*-2-*O*-acetyl-3-*O*-methyl-6-*O*-TBDMS-γ-CD (7a) and *Octakis*-2-*O*-acetyl-3-*O*-methyl-6-*O*-TXDMS-γ-CD (7b)**. Using the same acetylation procedure described for the preparation of **3a** and **5b** and starting from 200 mg of **6a** or **6b**, (0.086 and 0.078 mmol respectively), we obtained 147 mg (0.055 mmol; 64.0% yield) of **7a** after purification by column chromatography ($CHCl_3$) and 148 mg (0.051 mmol; 65.4% yield) of **7b** after a similar purification ($CHCl_3$/MeOH 98:2).

Data for **7a**: mp 145 °C; IR (KBr) 1750, 1375, 1240, 1046, 825, 779 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.50 (br s, 1H, H-1), 5.20-5.17 (m, 1H, H-6a), 3.75-3.60 (m, 3H, H-4, H-5, H-6b), 3.34 (s, 3H, OCH_3), 2.11 (s, 3H, Ac), 0.85 (s, 9H, *t*-Bu), 0.00 (s, 6H, $(CH_3)_2Si$). R_f ($CHCl_3$/MeOH 8:1) = 0.36. ESI-MS 2658.0 $[M+H]^+$, 2680.0 $[M+Na]^+$.

Anal. Calcd for $C_{120}H_{224}O_{48}Si_8$ (2659.7): C, 54.19; H, 8.49. Found C, 54.20; H, 8.34

Data for **7b**: mp 105 °C; IR (KBr) 1752, 1375, 1246, 1044, 825, 779 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.55 (br s, 1H, H-1), 5.10-3.57 (m, 5H, H-3, H-6a, H-4, H-5, H-6b),

3.34 (s, 3H, OCH_3), 2.11 (s, 3H, Ac), 0.85 (s, 6H, $(CH_3)_2CH$-), 0.81 (s, 6H, $(CH_3)_2C<$), 0.06 (s, 6H, $(CH_3)_2Si$). R_f ($CHCl_3$/MeOH 8:2) = 0.43. ESI-MS 2882.4 $[M+H]^+$, 2904.4 $[M+Na]^+$.

Anal. Calcd for $C_{136}H_{256}O_{48}Si_8$ (2884.2): C, 56.64; H, 8.95. Found C, 56.50; H, 8.79.

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