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General access to asymmetric γ-cyclodextrins for gas chromatographic applications by insertion of a selectively modified sugar unit

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Abstract

Gas chromatography (GC) using chiral stationary phases (CSPs) based on modified cyclodextrins is the most commonly used technique to quantify enantiomeric purity of synthesized volatile racemic drugs. The fully methylated cyclodextrin derivatives are the most used because of their easy synthesis, their thermal stability and their ability to recognize a wide range of compounds. To complete the background on molecular recognition, we describe a route to access fully characterized new asymmetric cyclodextrins derived from fully methylated ones, thereby directly useful in chiral gas chromatography. The synthesis of these compounds involves a three-step procedure: ring opening of fully methylated cyclodextrins, elongation of the chain with correctly modified monosaccharide derivatives and, finally, macrocyclization to obtain the desired compounds. This strategy is applied to achieve the synthesis of a series of asymmetric γ-cyclodextrins, by insertion of glucopyranosic derivatives. Appropriate selection of the glycosylating reagents during chain elongation and macrocyclization steps allows satisfactory anomeric selectivities to be reached.

1. Introduction

The resolution and determination of the enantiomeric purity of chiral drugs are absolutely necessary nowadays and can be achieved conveniently by various chromatographic methods: gas chromatography (GC), high performance liquid chromatography (HPLC) and supercritical fluid chromatography (SFC). When new drugs cannot be derivatized to form diastereoisomeric pairs, the separation may be carried out by the direct method, which consists of direct enantiomer separation using chiral stationary phases (CSPs). Nevertheless, in spite of all the separations

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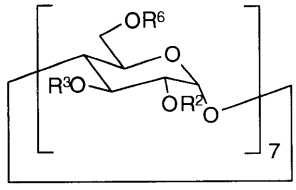
listed and described in the literature, there is no rule that clearly indicates the CSP to use for a given racemate.

In GC, most of the separations are done on CSPs based on cyclodextrin derivatives, which are widely used as chiral selectors because of their structure and binding properties.[1] Various fully modified derivatives[2] have been synthesized and evaluated for the separation of a wide range of compounds; a non exhaustive list of these derivatives is presented in Table 1. Most of them are diluted in an achiral polysiloxane to obtain separations at temperatures below their melting points.[4] The use of 'heavy derivatives', such as fully pentylated[5] cyclodextrins, is also possible and their use for the separation of low volatile racemates[6] has been described.

Table 1
Non exhaustive list of cyclodextrin derivatives useful in chiral GC[a]



R^2	R^3	R^6	References
Pe	Pe	Ac	1
Pe	Ac	Pe	3a
Me	TFAc	Me	3b
Pe	Pe	TBDMS	3c
Me	Pe	Me	3d
Pe	TFAc	Pe	3e
Ci	Me	Ci	3f

[a] Ac = acetyl, Ci = cinnamyl, Me = methyl, Pe = pentyl, TBDMS = *tert*-butyldimethylsilyl, TFAc = trifluoroacetyl.

All these derivatives are symmetrical or disymmetrical (they possess at least one axis or pseudo-axis of symmetry C_n with $n \neq 1$), because every 2-*O*, 3-*O* and 6-*O* position of the cyclodextrin derivatives is identical.[3f] The influence of the modification of the substituents (polarity, size) on chiral recognition phenomena is well known[7a,b] and CSPs made with these compounds are often evaluated to increase the number of chiral separations or to improve existing ones. Nevertheless, past papers do not contribute to the establishment and/or the understanding of the molecular recognition phenomena.

Another kind of cyclodextrin derivatives used as CSPs are the asymmetric ones, which are chemically bound to a polysiloxane backbone; only a few have been described and fully characterized. Schurig et al.[8] have presented the use of a mixture of cyclodextrins containing from 1 to 7 alkenyl group(s) on the rim of the cyclodextrin and bonded to a polyhydromethylsiloxane (PHMS). Despite the fact that they use a mixture instead of a pure monoalkenyl-substituted compound, they were the first to deal with asymmetric cyclodextrins useful[9] for chiral GC. Later, Bradshaw and Lee[10] were successful in the synthesis of a monofunctionalized derivative at the 6-*O* position of the cyclodextrin and its full characterization. The bonding onto a PHMS results in a CSP that exhibits excellent chiral selectivities.

In these last two cases, the authors highlight the gain in thermal stability as a great advantage over chiral selectors diluted in a polysiloxane. In addition they never point out the influence of

the position of the arm, its 'role' and its influence on the chiral recognition process. However, to the best of our knowledge, no systematic study over a range of asymmetric cyclodextrins used in chiral GC has been done to complete the background on molecular recognition.

Therefore, through one series, we describe herein a general way to access asymmetric cyclodextrins derived from fully methylated cyclodextrins, thereby useful in chiral GC; details of chromatographic results concerning this series will be published elsewhere.

2. Results and discussion

Asymmetric cyclodextrins can be obtained mainly from two routes: 'direct' and 'indirect' methods.

The 'direct' method consists of reacting the native cyclodextrin with the chosen reagent under suitable conditions in terms of base, solvent and temperature. D'Souza[11,12a] reviews the influence of these parameters to modify selectively one of the 2-*O*, the 3-*O* or one of the 6-*O* positions and, in our laboratory, Cousin et al. have established a strategy to obtain the three isomers of the mono hydroxyl-eicosa-*O*-methyl-β-cyclodextrin.[12b] In fact, this method deals with regio- and/or chemoselectivity. Nevertheless, with every cyclodextrin monoderivative synthesized by this method, the assignment of the modified position of the product is a rather complicated task.[12a,13]

In the 'indirect method', all modifications are possible since this involves the total synthesis of the ring. This strategy has been extensively used to obtain various macrocycles[14] composed of several types of monosaccharide residues, linked with α or β-(1→3), (1→4) or (1→6) glycosidic linkages: the possibilities of combination are potentially numerous. In fact, the only limitation is the capacity to control regio- and stereochemistry, especially in the final cyclization steps.

An alternative route is presented in Fig. 1, which involves the ring opening of a cyclic oligosaccharide followed by chain elongation and, finally, cycloglycosylation. In this method, each position of the monosaccharide must be modified in the most suitable ways. The 4-*O* position has to be deprotected to carry out the elongation of the oligosaccharide chain and the 1-*O* position has to be protected with a group, itself either removable or ready to achieve the cycloglycosylation. The 2-*O*, 3-*O* and 6-*O* positions have also to be differentiated. The oligosaccharide chain is obtained by careful cleavage of one interglycosidic bond of the cyclodextrin and by correct protection/activation of the strategic positions. Recently, Sakairi et al.[15] used this approach to achieve the synthesis of mono (2-amino-2-deoxy)-β-cyclodextrin from fully acetylated α-cyclodextrin. Therefore, we decided to use this 'homologation methodology' to obtain the desired asymmetric compounds. The ability to control the regiochemistry and the relative facility of fully characterizing the modifications during the synthesis of the derivatives are the main advantages of this method.

In a first approach, only glucopyranosic derivatives, correctly modified with groups compatible with GC, that is to say methyl and pentyl groups, are employed, and only fully methylated β-cyclodextrin is used as the precursor.

The synthesis of monosaccharide units **10a**–**f** is presented in Scheme 1. The first step is the transformation of the fully acetylated α-D-glucopyranose into the corresponding thioglycoside, in order to protect the anomeric position and to activate it as the glycosyl donor in the final cyclization step. Phenyl 2,3,4,6-tetra-*O*-acetyl-1-thio-β-D-glucopyranose is submitted to the deprotection of all acetyl groups, and the resulting compound reacts[16] with benzaldehyde in

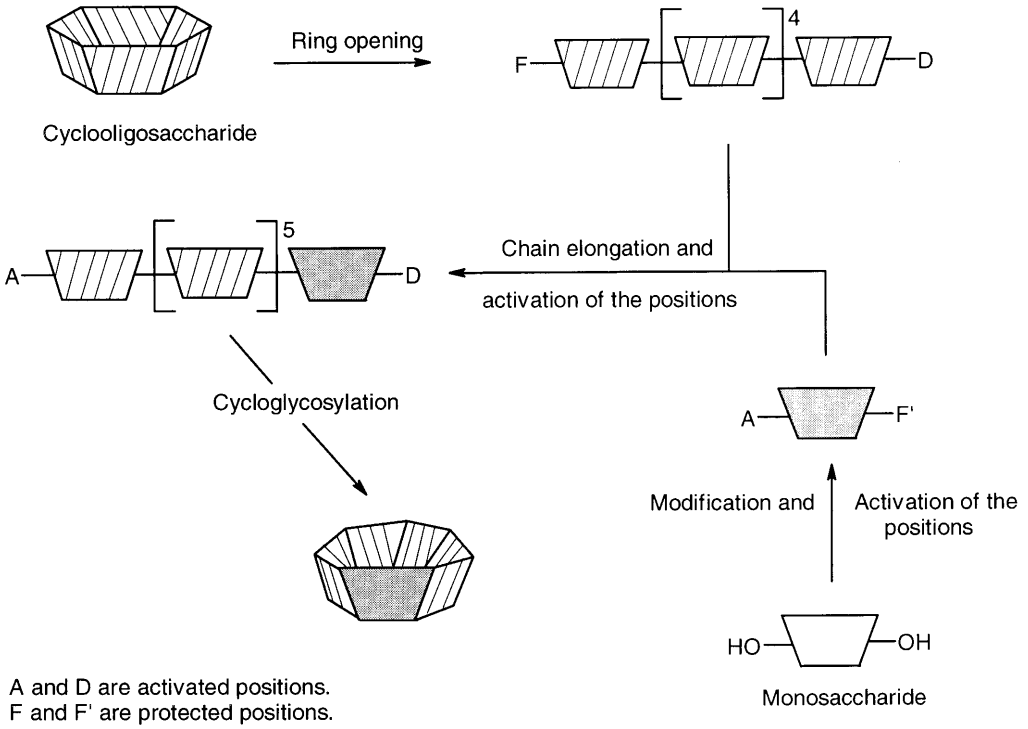
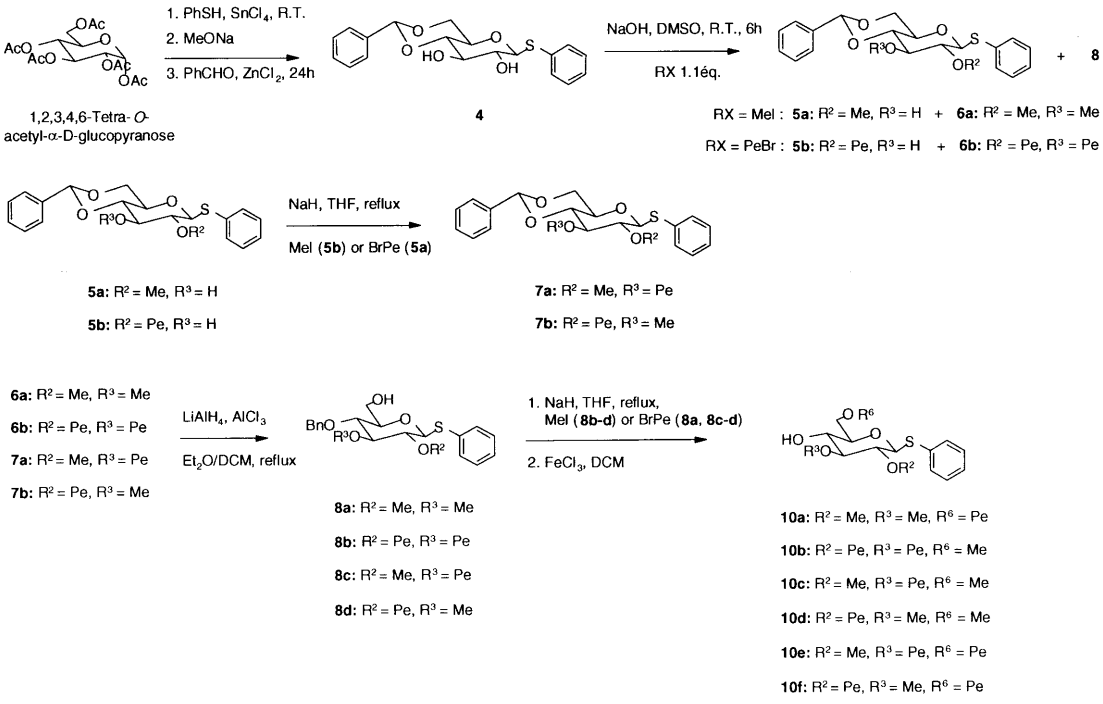


Figure 1. Synthesis strategy to obtain asymmetric cyclooligosaccharides

the presence of the $ZnCl_2$ to protect the 4-*O* and the 6-*O* positions: the 2-*O* and 3-*O* positions are then differentiated from the 6-*O* position.

Next, a TBDMS group is used to protect the 3-*O* position. Unfortunately, the significant rate of 3-*O*→2-*O* migration of the TBDMS group under our basic conditions, known and applied in cyclodextrin chemistry,[17] does not permit this method to be used. Therefore, compound **4** is directly reacted, in the presence of a base, with methyl iodide or pentyl bromide. In each case, the resultant mixture, analyzed by HPLC-MS, is composed of the starting material ($\approx$12%), the mono 2-*O*-alkyl derivative ($\approx$50%), the mono 3-*O*-alkyl derivative (3%) and the 2,3-di-*O*-alkyl derivative ($\approx$35%). Purification by column chromatography on silica gel affords the mono 2-*O*-alkyl (35 and 44%, respectively) and the 2,3-di-*O*-alkyl (50 and 30%) derivatives with very satisfactory purity; the mono 3-*O*-alkyl derivatives are not isolated. NMR experiments allow us to assign unambiguously the modified position. Thus, the 2-*O* alkylation is accomplished with a high selectivity. Compounds **5a** and **5b** are allowed to react with the 'complementary' alkyl halides, to obtain **7a** and **7b** in good yields.

The final step involves the alkylation of the 6-*O* position and the deprotection of the 4-*O* position. After removal of the benzyl acetal of compounds **6a**, **6b**, **7a** and **7b** under acidic conditions, treatment of the 6-*O*, 4-*O* free hydroxyl group derivatives under thermodynamic or kinetic control conditions do not permit access to the desired 6-*O*-alkylated products. Therefore, we turned our attention to a three-step process. Firstly, the selective reduction[16] of the benzyl acetal in the presence of $AlCl_3$ and $LiAlH_4$ leads to compounds **8a–d** with satisfactory yields and good regioselectivity. Secondly, the alkylation of the 6-*O* position with methyl iodide or pentyl bromide is achieved under basic conditions to afford compounds **9a–f**. Finally, cleavage of the



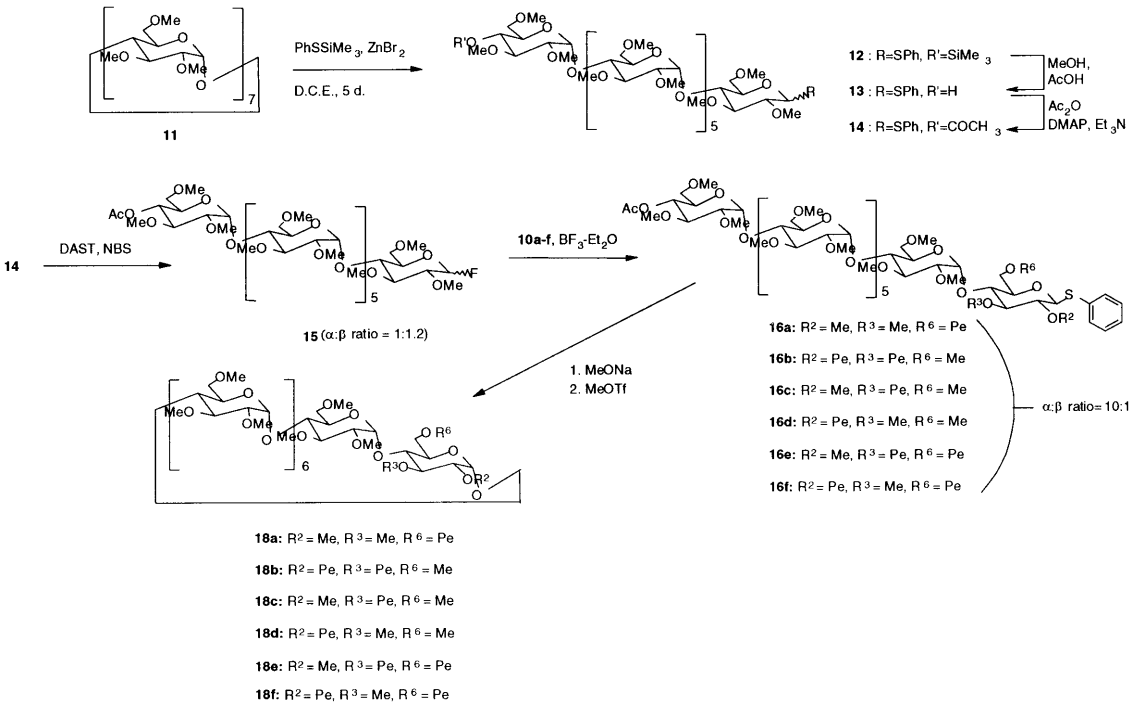
Scheme 1. Synthesis of compounds **10a–f**

benzyl ether in the presence of $FeCl_3$[17] gives the desired products with overall yields ranging from 13 to 22%, which are fully characterized using NMR spectra, HPLC-MS and elemental analysis.

Selective cleavage of one glucosidic bond of the fully methylated β-cyclodextrin is realized following the method of Sakairi et al.[18] (Scheme 2): starting compound **11** is treated with phenylthiotrimethylsilane[19] and $ZnBr_2$ at room temperature. The reaction is monitored by TLC and stopped after 5 days. TLC shows two spots: one corresponding to the starting material, with no UV absorption, and the other to compound **12**, which moves faster and has a UV absorption. The mixture is then treated with acetic acid in methanol under reflux, to remove the TMS group. Compound **13**, first isolated and characterized, is not isolated in the next experiments, and we perform the protection of the free hydroxyl, by treatment with acetic anhydride, in the presence of triethylamine and DMAP. Purification by chromatography on silica gel affords compound **14** as an anomeric mixture having an α:β ratio of 1:1 (determined by ^1H NMR and HPLC-MS).

Two distinct procedures[20] have to be used for the two glycosidation reactions involved during the elongation of the chain on the one hand and during the macrocyclization on the other. Therefore, to avoid the activation of the thioglycoside moiety of the monosaccharide unit and then its oligomerization, the elongation of the chain is achieved with the Koenig–Knorr 'modified' method: a glycosyl fluoride[21] donor versus an unprotected acceptor. The cyclization step uses a thioglycoside donor versus an unprotected glycosyl acceptor.

First of all, the thioether group of compound **14** is converted into fluoride derivative **15** with DAST in the presence of NBS, in good yield but with poor anomeric selectivity: the ^{19}F NMR spectrum shows that the ratio of the α and β anomers is 1:1.2. The elongation of the oligosaccharide chain can occur by reacting derivatives **10a–f** and compound **15** in the presence



Scheme 2. Synthesis of compounds **18a–f**

of BF_3–Et_2O and molecular sieves to afford the homologated **16a–f** products. This step is achieved with a satisfactory selectivity (α:β ratio = 10:1, determined by HPLC–ELSD and ^1H NMR). After cleavage of the residual acetyl group in basic conditions, cycloglycosylation is performed in the presence of methyl trifluoromethanesulfonate (MeOTf) via high dilution techniques (concentration of the oligosaccharide $\approx$5 mmol/l) to afford the final cyclic products **18a–f** as anomeric mixtures. ^1H NMR spectra reveal that the coupling constant of the doublet assignable to the anomeric proton of the incorporated unit is 3.0–3.2 Hz and, consequently, that the pyranoside residue is linked with α-glycosidic bond; moreover, HPLC–ELSD analysis shows that these mixtures are in the majority in favor of these α anomers (α:β ratio = 15:1).

3. Conclusion

In conclusion, owing to the development of efficient glycosylation methodologies, we performed a route to access fully characterized asymmetric γ-cyclodextrins, directly useful in chiral GC. The overall yields are quite poor but do not restrict the use for GC because it requires only small quantities. This process can be adapted to give other series of derivatives, with other types of ether groups or with other sugar units included. For example, modification with an alkenyl group will allow the bonding onto PHMS and comparison with the existing CSP. Moreover, the range of applications of these derivatives may be enlarged: other functional groups may be employed to obtain various compounds suitable for other applications. Finally, the utilization of fully modified α-cyclodextrins as precursors to obtain asymmetric β-cyclodextrins is currently one of our major concerns.

4. Experimental

4.1. General conditions and equipment

All commercial solvents were distilled before use (DMSO, tetrahydrofuran (THF), dichloroethane (DCE), dichloromethane (DCM), methanol (MeOH), diethyl ether (Et_2O). All reactions were monitored by thin-layer chromatography (TLC), which was run on 0.2 mm Merck aluminum backed precoated silica gel plates (60 F_{254}) with UV light and sulfuric acid: ethanol solution (10:90, v/v) and heat as developing agents. The following solvent systems were used: DCM (100) A, DCM:ethyl acetate (50:50, V/V) B, ethyl acetate (100) C, toluene:acetone (60:40, V/V) D, toluene:acetone (50:50, V/V) E. Purifications were carried out using flash column chromatography with Merck silica gel (70–230 mesh) or preparative TLC using 2 mm Merck glass backed precoated silica gel plates (60 F_{254}).

^1H NMR, ^{13}C NMR and ^{19}F NMR were recorded on a Bruker DPX-300 spectrometer at 300.13, 75.47 and 282.40 MHz, respectively. Chemical shifts are relative to the spectrometer reference for the solvent. Coupling constants are quoted in hertz (Hz).

HPLC analysis was performed on a C18 HYPERSIL 5 μm column using MeOH/H_2O as solvent and a Spectra-Physics Analytical system, composed of a P4000 quaternary pump, a UV2000 detector and a mass spectrometer detector (Navigator, Finnigan) or an Evaporative Light Scattering Detector (ELSD) (DDL31, Eurosep).

Infrared (IR) spectra were recorded on a Perkin–Elmer 1600 Series FTIR spectrophotometer using bromide potassium or compounds as neat products.

Melting points were determined on a LEICA VMHB and are uncorrected; elementary analyses were carried out on an EA 1110 (CE instruments).

Heptakis (2,3,6-tri-*O*-methyl)-β-cyclodextrin[22] **11** and phenyl 4,6-*O*-benzylidene-1-thio-β-D-glucopyranose[23] **4** were prepared according to the literature and dried at 110°C under vacuum for 12 hours prior to use.

4.2. Synthesis

4.2.1. *Phenyl 4,6-*O*-benzylidene-2-*O*-methyl-1-thio-β-D-glucopyranose*, ***5a*** *and phenyl 4,6-*O*-benzylidene-2,3-di-*O*-methyl-1-thio-β-D-glucopyranose*, ***6a***

Under dry argon atmosphere, in 10 ml of DMSO were dissolved **4** (1.5 g, 4.16 mmol) and sodium hydroxide (0.25 g, 6.25 mmol). The agitation was maintained for 24 h at room temperature. Then, methyl iodide (0.624 g, 4.55 mmol) was added and stirring was continued for six hours. The reaction mixture was diluted with 50 ml of DCM and washed with 3 M aqueous HCl (2×15 ml) and with saturated aqueous $NaHCO_3$ (2×15 ml). The organic layer was dried over Na_2SO_4 and concentrated. TLC in solvent A showed four spots with R_f values: 0, 0.15, 0.22 and 0.51. The mixture was purified by flash chromatography in solvent A to afford *phenyl 4,6-*O*-benzylidene-2,3-di-*O*-methyl-1-thio-β-D-glucopyranose* as a white solid (0.778 g, 2.08 mmol, 50%). Mp 88–90°C; *m*/*z* (APCI$^+$), M+Na$^+$, found: 411.23; $C_{21}H_{24}O_5SNa$ requires: 411.12. Anal. $C_{21}H_{24}O_5S$ requires: C, 66.54, H, 6.38, S, 8.46; found: C, 66.72, H, 6.25, S, 8.68; δ_H ($CDCl_3$) 3.05 (t, 1H, *J* 9.30), 3.45 (m, 3H), 3.57 (s, 3H), 3.58 (s, 3H), 3.69 (t, 1H, *J* 10.00), 4.28 (dd, 1H, *J* 10.00, *J* 4.00), 4.57 (d, 1H, *J* 9.30), 5.45 (s, 1H), 7.25 (m, 6H), 7.42 (m, 4H); δ_C ($CDCl_3$) 61.4, 61.6, 69.0, 70.5, 81.5, 82.5, 85.1, 88.3, 101.5, 126.4, 128.2, 128.6, 129.3, 129.5, 133.9, 134.6, 139.4; ν_{max} (KBr)/cm^{-1} 3060, 2863; and *phenyl 4,6-*O*-benzylidene-2-*O*-methyl-1-*

thio-β-D-glucopyranose as a white solid (0.560 g, 0.374 mmol, 35%). Mp 137°C; *m*/*z* (APCI$^+$), M+Na$^+$, found: 397.21; $C_{20}H_{22}O_5SNa$ requires: 397.10. Anal. $C_{20}H_{22}O_5S$ requires: C, 64.21, H, 6.34, S, 8.57; found: C, 64.32, H, 6.39, S, 8.62; δ_H (DMSO-d_6) 3.02 (t, 1H, *J* 9.30), 3.45 (m, 3H), 3.49 (s, 4H), 3.85 (t, 1H, *J* 10.00), 4.12 (dd, 1H, *J* 10.00, *J* 4.00), 4.70 (d, 1H, *J* 9.30), 5.46 (s, 1H), 7.30 (m, 6H), 7.45 (m, 4H); δ_C (DMSO-d_6) 60.7, 68.0, 69.6, 79.6, 80.5, 83.3, 87.6, 100.5, 126.4, 127.2, 128.4, 129.4, 129.4, 130.7, 133.1, 137.1; ν_{max} (KBr)/cm^{-1} 3200, 3054, 2875. Further elution with solvent C offered unchanged compound **4**.

4.2.2. *Phenyl 4,6-O-benzylidene-2-O-pentyl-1-thio-β-D-glucopyranose*, ***5b***, *and phenyl 4,6-O-benzylidene-2,3-di-O-pentyl-1-thio-β-D-glucopyranose*, ***6b***

The same method was applied, except adding pentyl bromide, with the same molecular ratio. TLC in solvent A showed three spots with R_f values: 0, 0.12, and 0.45. The mixture was then purified by flash chromatography in solvent A to afford phenyl 4,6-*O*-benzylidene-2,3-di-*O*-pentyl-1-thio-β-D-glucopyranose as a white solid (0.915 g, 1.83 mmol, 44%); mp 74°C; *m*/*z* (APCI$^+$), M+Na$^+$, found; 523.28; $C_{29}H_{40}O_5SNa$ requires: 523.24. Anal. $C_{29}H_{40}O_5S$: C, 69.62, H, 8.06, S, 6.41; found: C, 70.12, H, 8.15, S, 6.54; δ_H ($CDCl_3$) 1.02 (m, 6H), 1.45 (m, 8H), 1.72 (m, 4H), 3.15 (m, 1H), 3.60–3.72 (m, 4H), 3.85 (dd, 2H, *J* 7.05, *J* 4.01), 4.00 (m, 2H), 4.15 (dd, 1H, *J* 10.00, *J* 4.00), 4.74 (d, 1H, *J* 9.30), 5.33 (s, 1H), 7.25 (m, 6H), 7.42 (m, 4H); δ_C ($CDCl_3$) 14.6, 14.7, 23.3, 23.3, 29.1, 29.1, 30.9, 31.0, 69.1, 70.7, 73.9, 74.5, 81.9, 82.0, 84.2, 89.1, 101.7, 127.0, 128.7, 129.0, 129.4, 132.7, 135.2, 138.8; ν_{max} (KBr)/cm^{-1} 3065, 2867; and *phenyl 4,6-O-benzylidene-2-O-pentyl-1-thio-β-D-glucopyranose* as a white solid (0.537 g, 1.248 mmol, 30%); mp 83°C; *m*/*z* (APCI$^+$), M+Na$^+$, found: 453.22; $C_{24}H_{30}O_5SNa$ requires: 453.17. Anal. $C_{24}H_{30}O_5S$ requires: C, 67.01, H, 7.03, S, 7.45; found: C, 67.15, H, 7.11, S, 7.58; δ_H (DMSO-d_6) 0.64 (m, 3H), 1.12 (m, 4H), 1.31 (m, 2H), 2.95 (t, 1H, *J* 9.30), 3.15 (s, 2H), 3.40 (m, 4H), 3.55 (t, 1H, *J* 10.00), 4.01 (dd, 1H, *J* 10.00, *J* 4.00), 4.75 (d, 1H, *J* 9.30), 5.55 (s, 1H), 7.20 (m, 6H), 7.35 (m, 4H); δ_C (DMSO-d_6) 14.5, 23.0, 29.7, 32.2, 69.0, 70.4, 74.3, 75.8, 80.6, 81.5, 88.5, 102.2, 126.6, 128.1, 129.4, 129.6, 132.3, 133.5, 137.3; ν_{max} (KBr)/cm^{-1} 3211, 3060, 2874. Further elution with solvent C offered unchanged compound **4**.

4.2.3. *Procedure for* ***7a–b***

4.2.3.1. Phenyl 4,6-O-benzylidene-2-O-methyl-3-O-pentyl-1-thio-β-D-glucopyranose, ***7a***. 2 g (4.65 mmol) of **5a** was dissolved in 25 ml of THF and 372 mg (9.30 mmol) of sodium hydride and 1.614 g (10.69 mmol) of pentyl bromide were added and heated under reflux for 5 hours. Then, the mixture was diluted with 20 ml of DCM and washed with 3 M aqueous HCl (2×15 ml) and with saturated aqueous $NaHCO_3$ (2×15 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by flash chromatography in solvent A to afford a white powder (1.962 g, 4.417 mmol, 95%); TLC in solvent A: R_f 0.50; mp 50°C; *m*/*z* (APCI$^+$), M+Na$^+$, found: 467.23; $C_{25}H_{32}O_5SNa$ requires: 467.18. Anal. $C_{25}H_{32}O_5S$: C, 67.60, H, 7.26, S, 7.22; found: C, 67.48, H, 7.17, S, 7.38; δ_H ($CDCl_3$) 0.78 (m, 3H), 1.25 (m, 4H), 1.52 (m, 2H), 3.15 (m, 1H), 3.31 (m, 2H), 3.41 (m, 1H), 3.51 (s, 3H), 3.62 (m, 3H), 4.21 (dd, 1H *J* 10.00, *J* 4.00), 4.56 (d, 1H, *J* 9.70), 5.41 (s, 1H), 7.25 (m, 6H), 7.34 (m, 4H); δ_C ($CDCl_3$) 14.0, 22.4, 28.7, 30.6, 60.8, 69.0, 70.6, 74.0, 81.4, 81.5, 83.2, 88.9, 101.6, 126.5, 128.4, 128.6, 129.3, 129.4, 131.6, 134.9, 135.4 C; ν_{max} (KBr)/cm^{-1} 3084, 2880.

*4.2.3.2. Phenyl 4,6-*O*-benzylidene-3-*O*-methyl-2-*O*-pentyl-1-thio-β-D-glucopyranose*, ***7b***. The same method was applied, except adding methyl iodide, to yield a white powder, 95%; TLC in solvent A: R_f 0.48; mp 51°C; *m/z* (APCI$^+$), M+Na$^+$, found: 467.22; $C_{25}H_{32}O_5SNa$ requires: 467.18. Anal. $C_{25}H_{32}O_5S$ requires: C, 67.60, H, 7.26, S, 7.22; found: C, 67.72, H, 7.31, S, 7.41; δ_H ($CDCl_3$) 0.74 (m, 3H), 1.25 (m, 4H), 1.51 (m, 2H), 3.16 (t, 1H, *J* 9.70), 3.31 (m, 2H), 3.46 (m, 1H), 3.55 (s, 3H), 3.70 (m, 3H), 4.25 (dd, 1H, *J* 10.00, *J* 4.00), 4.62 (d, 1H, *J* 9.70), 5.45 (s, 1H), 7.25 (m, 6H), 7.31 (m, 4H); δ_C ($CDCl_3$) 13.0, 21.4, 27.2, 28.9, 61.5, 69.0, 70.5, 74.3, 81.2, 81.6, 85.2, 88.8, 101.5, 126.4, 128.2, 128.6, 129.3, 129.3, 132.5, 132.5, 136.3; ν_{max} (KBr)/cm^{-1} 3076, 2870.

4.2.4. Procedure for ***8a–d***

*4.2.4.1. Phenyl 4-*O*-benzyl-2,3-di-*O*-methyl-1-thio-β-D-glucopyranose*, ***8a***. Under a dry argon atmosphere, 1.70 g (4.38 mmol) of **6a** was dissolved in 34 ml of a solvent mixture Et_2O:DCM (50:50, v:v) and 0.598 g (15.77 mmol) of lithium aluminum hydride was added in three portions. The mixture was heated at reflux temperature and a solution of aluminum chloride (1.75 g, 13.14 mmol) in 17 ml of Et_2O was added carefully. Reflux was maintained for 1.5 h, then the mixture was diluted with Et_2O and washed with water (2×10 ml) and with saturated aqueous $NaHCO_3$ (2×10 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by flash chromatography in solvent B to afford a white powder (1.538 g, 3.942 mmol, 90%); TLC in solvent C: R_f 0.64; mp 52°C; *m/z* (APCI$^+$), M+Na$^+$, found: 413.16; $C_{21}H_{26}O_5SNa$ requires: 413.14. Anal. $C_{21}H_{26}O_5S$ requires: C, 64.65, H, 6.72, S, 8.22; found: C, 64.72, H, 6.85, S, 8.38; δ_H ($CDCl_3$) 2.95 (t, 1H *J* 9.30), 3.15 (m, 2H), 3.25 (m, 1H), 3.53 (s, 4H), 3.55 (s, 3H), 3.65 (m, 2H), 4.38 (m, 2H), 5.45 (d, 1H, *J* 11.01), 7.15 (m, 6H), 7.34 (m, 4H); δ_C ($CDCl_3$) 61.3, 61.5, 62.3, 75.3, 77.7, 79.7, 83.2, 87.5, 88.9, 128.3, 128.4, 128.8, 128.9, 129.4, 131.8, 134.3, 138.6; ν_{max} (KBr)/cm^{-1} 3220, 3055, 2870.

*4.2.4.2. Phenyl 4-*O*-benzyl-2,3-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***8b***. Flash chromatography in solvent B yielded a white powder, 91%; TLC in solvent C: R_f 0.58; mp 48°C; *m/z* (APCI$^+$), M+Na$^+$, found: 525.31; $C_{29}H_{42}O_5SNa$ requires: 525.26. Anal. $C_{29}H_{42}O_5S$ requires: C, 69.35, H, 8.43, S, 6.38; found: C, 69.57, H, 8.56, S, 6.46; δ_H ($CDCl_3$) 0.92 (m, 6H), 1.25 (m, 8H), 1.61 (m, 4H), 3.12 (m, 1H), 3.21 (m, 2H), 3.40 (m, 1H), 3.61 (m, 3H), 3.83 (m, 2H), 3.98 (m, 2H), 4.54 (m, 2H), 5.30 (d, 1H, *J* 11.01), 7.15 (m, 6H), 7.36 (m, 4H); δ_C ($CDCl_3$) 14.5, 14.6, 23.2, 23.3, 28.9, 29.0, 30.8, 30.9, 62.2, 73.8, 74.4, 75.3, 77.5, 79.8, 84.1, 89.0, 89.1, 128.4, 128.5, 128.6, 129.1, 129.5, 131.8, 135.9, 138.6; ν_{max} (KBr)/cm^{-1} 3205, 3060, 2865.

*4.2.4.3. Phenyl 4-*O*-benzyl-2-*O*-methyl-3-*O*-pentyl-1-thio-β-D-glucopyranose*, ***8c***. Flash chromatography in solvent B yielded a white powder, 93%; TLC in solvent C: R_f 0.61; mp 46°C; *m/z* (APCI$^+$), M+Na$^+$, found: 469.22; $C_{25}H_{34}O_5SNa$ requires: 469.20. Anal. $C_{25}H_{34}O_5S$ requires: C, 67.29, H, 7.68, S, 7.19; found: C, 67.35, H, 7.73, S, 7.26; δ_H ($CDCl_3$) 0.92 (m, 3H), 1.34 (m, 4H), 1.63 (m, 2H), 3.08 (t, 1H, *J* 9.70), 3.22 (m, 2H), 3.34 (m, 1H), 3.48 (s, 3H), 3.54 (m, 5H), 4.44 (m, 2H), 5.32 (d, 1H, *J* 11.01), 7.18 (m, 6H), 7.30 (m, 4H); δ_C ($CDCl_3$) 15.0, 22.9, 29.3, 31.1, 61.1, 62.1, 74.3, 75.4, 77.3, 80.0, 83.0, 88.6, 88.8, 128.6, 128.7, 128.8, 129.3, 129.5, 131.7, 135.5, 138.6; ν_{max} (KBr)/cm^{-1} 3210, 3070, 2872.

4.2.4.4. Phenyl 4-O-benzyl-3-O-methyl-2-O-pentyl-1-thio-β-D-glucopyranose, ***8d***. Flash chromatography in solvent B yielded a white powder, 93%; TLC in solvent C: R_f 0.60; mp 47°C; m/z (APCI$^+$), M+Na$^+$, found: 469.21; $C_{25}H_{34}O_5SNa$ requires: 469.20. Anal. $C_{25}H_{34}O_5S$ requires: C, 67.29, H, 7.68, S, 7.19; found: C, 67.31, H, 7.76, S, 7.29; δ_H ($CDCl_3$) 0.82 (m, 3H), 1.34 (m, 4H), 1.57 (m, 2H), 3.07 (t, 1H, *J* 9.70), 3.20 (m, 2H), 3.38 (m, 1H), 3.57 (s, 4H), 3.66 (m, 4H), 4.54 (m, 2H), 5.42 (d, 1H, *J* 11.00), 7.22 (m, 6H), 7.32 (m, 4H); δ_C ($CDCl_3$) 13.1, 21.5, 27.2, 29.0, 61.6, 62.1, 74.3, 75.3, 76.8, 80.2, 82.3, 87.7, 88.7, 128.2, 128.5, 128.8, 129.4, 129.4, 131.8, 135.5, 137.7; ν_{max} (KBr)/cm^{-1} 3200, 3055, 2880.

4.2.5. Procedure for ***9a–f***

4.2.5.1. Phenyl 4-O-benzyl-2,3-di-O-methyl-6-O-pentyl-1-thio-β-D-glucopyranose, ***9a***. 600 mg (1.54 mmol) of **8a** was dissolved in 5 ml of THF and 123 mg (3.08 mmol) of sodium hydride and 433 mg (3.08 mmol) of pentyl bromide were added and heated under reflux for 4 h. Then, the mixture was diluted with 10 ml of DCM and washed with 3 M aqueous HCl (2×5 ml) and with saturated aqueous $NaHCO_3$ (2×5 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by flash chromatography in solvent A to afford a colorless oil (617 mg, 1.340 mmol, 87%); TLC in solvent A: R_f 0.54; m/z (APCI$^+$), M+Na$^+$, found: 483.23; $C_{26}H_{36}O_5SNa$ requires: 483.22. Anal. $C_{26}H_{36}O_5S$ requires: C, 69.98, H, 8.13, S, 7.19; found: C, 70.19, H, 8.19, S, 7.2; δ_H ($CDCl_3$) 0.75 (m, 3H), 1.24 (m, 4H), 1.48 (m, 2H), 2.97 (t, 1H, *J* 9.70), 3.16 (t, 1H *J* 9.70), 3.32 (m, 2H), 3.54 (s, 3H), 3.55 (m, 4H), 3.56 (s, 3H), 4.38 (d, 1H, *J* 9.70), 4.57 (d, 1H, *J* 10.90), 4.72 (d, 1H, *J* 10.90), 7.15 (m, 6H), 7.35 (m, 4H); δ_C ($CDCl_3$) 14.5, 22.9, 28.8, 29.9, 61.1, 61.5, 70.0, 72.1, 75.3, 78.0, 79.4, 83.1, 87.5, 89.2, 128.3, 128.4, 128.9, 128.9, 129.5, 131.8, 134.2, 138.7; ν_{max} (neat)/cm^{-1} 3075, 2860.

4.2.5.2. Phenyl 4-O-benzyl-6-O-methyl-2,3-di-O-pentyl-1-thio-β-D-glucopyranose, ***9b***. The same method as for compound **9a** was applied, except adding methyl iodide, to yield a colorless oil, 86%; TLC in solvent A: R_f 0.55; m/z (APCI$^+$), M+Na$^+$, found: 539.29; $C_{30}H_{44}O_5SNa$ requires: 539.28. Anal. $C_{30}H_{44}O_5S$ requires: C, 69.80, H, 8.59, S, 6.21; found: C, 69.94, H, 8.67, S, 6.41; δ_H ($CDCl_3$) 0.90 (m, 6H), 1.36 (m, 8H), 1.64 (m, 4H), 3.21 (t, 1H, *J* 9.70), 3.35 (s, 3H), 3.40–3.80 (m, 9H), 4.60 (d, 1H, *J* 9.70), 4.63 (d, 1H, *J* 10.90), 4.82 (d, 1H, *J* 10.90), 7.30 (m, 6H), 7.51 (m, 4H); δ_C ($CDCl_3$) 14.5, 23.0, 28.7, 28.8, 30.4, 30.7, 59.7, 71.7, 74.0, 74.3, 75.4, 77.9, 79.3, 81.6, 87.2, 88.4, 126.5, 128.5, 128.7, 129.3, 129.4, 131.6, 134.3, 135.4; ν_{max} (neat)/cm^{-1} 3085, 2870.

4.2.5.3. Phenyl 4-O-benzyl-2,6-O-methyl-3-O-pentyl-1-thio-β-D-glucopyranose, ***9c***. The same method was applied, except adding methyl iodide, to yield a colorless oil, 88%; TLC in solvent A: R_f 0.52; m/z (APCI$^+$), M+Na$^+$, found: 483.22; $C_{26}H_{36}O_5SNa$ requires: 483.22. Anal. $C_{26}H_{36}O_5S$ requires: C, 69.98, H, 8.13, S, 7.19; found: C, 70.18, H, 8.25, S, 7.38; δ_H ($CDCl_3$) 0.75 (m, 3H), 1.18 (m, 4H), 1.51 (m, 2H), 3.00 (t, 1H, *J* 9.70), 3.15 (t, 1H, *J* 9.70), 3.30 (s, 3H), 3.41 (s, 3H), 3.50–3.70 (m), 4.41 (d, 1H, *J* 9.70), 4.52 (d, 1H, *J* 10.90), 4.75 (d, 1H, *J* 10.90), 7.20 (m, 6H), 7.50 (m, 4H); δ_C ($CDCl_3$) 14.5, 23.0, 28.7, 30.5, 59.7, 61.5, 71.7, 74.2, 75.4, 77.9, 79.3, 81.7, 87.9, 89.2, 128.4, 128.5, 128.9, 128.9, 129.5, 131.9, 134.3, 138.7; ν_{max} (neat)/cm^{-1} 3080, 2865.

4.2.5.4. Phenyl 4-O-benzyl-3,6-O-methyl-2-O-pentyl-1-thio-β-D-glucopyranose, ***9d***. The same method was applied, except adding methyl iodide, to yield a colorless oil, 88%; TLC in solvent

A: R_f 0.53; *m/z* (APCI$^+$), M+Na$^+$, found: 483.23; $C_{26}H_{36}O_5Sna$: 483.22. Anal. $C_{26}H_{36}O_5S$ requires: C, 69.98, H, 8.13, S, 7.19; found: C, 70.12, H, 8.20, S, 7.35; δ_H ($CDCl_3$) 0.77 (m, 3H), 1.22 (m, 4H), 1.47 (m, 2H), 2.98 (t, 1H, *J* 9.70), 3.15 (m), 3.25 (s, 3H), 3.30 (s, 3H), 3.32–3.65 (m), 4.38 (d, 1H, *J* 9.70), 4.50 (d, 1H, *J* 10.90), 4.75 (d, 1H, *J* 10.90), 7.15 (m, 6H), 7.40 (m, 4H); δ_C ($CDCl_3$) 14.5, 23.0, 28.8, 30.7, 59.7, 61.4, 71.7, 74.2, 75.4, 77.9, 79.3, 81.7, 87.9, 89.2, 128.4, 128.5, 128.9, 128.9, 129.5, 131.9, 134.3, 138.7; ν_{max} (neat)/cm^{-1} 3080, 2875.

*4.2.5.5. Phenyl 4-*O*-benzyl-2-*O*-methyl-3,6-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***9e***. The same method was applied to yield a colorless oil, 86%; TLC in solvent A: R_f 0.55; *m/z* (APCI$^+$), M+Na$^+$, found: 539.29; $C_{30}H_{44}O_5SNa$ requires: 539.28. Anal. $C_{30}H_{44}O_5S$: C, 69.80, H, 8.59, S, 6.21; found: C, 69.98, H, 8.69, S, 6.43; δ_H ($CDCl_3$) 0.65 (m, 6H), 1.24 (m, 8H), 1.48 (m, 4H), 3.02 (t, 1H, *J* 9.70), 3.32 (m), 3.52 (s, 3H), 3.60–3.65 (m), 4.41 (d, 1H, *J* 9.70), 4.52 (d, 1H, *J* 10.90), 4.77 (d, 1H, *J* 10.90), 7.21 (m, 6H), 7.42 (m, 4H); δ_C ($CDCl_3$) 14.5, 23.0, 28.8, 29.9, 30.7, 61.3, 70.0, 72.0, 74.2, 75.3, 78.0, 79.4, 83.0, 87.6, 87.9, 126.5, 128.4, 128.6, 129.3, 129.4, 131.6, 134.3, 135.4; ν_{max} (neat)/cm^{-1} 3075, 2876.

*4.2.5.6. Phenyl 4-*O*-benzyl-3-*O*-methyl-2,6-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***9f***. The same method was applied to yield a colorless oil, 85%; TLC in solvent A: R_f 0.54; *m/z* (APCI$^+$), M+Na$^+$, found: 539.29; $C_{30}H_{44}O_5SNa$ requires: 539.28. Anal. $C_{30}H_{44}O_5S$ requires: C, 69.80, H, 8.59, S, 6.21; found: C, 69.91, H, 8.63, S, 6.32; δ_H ($CDCl_3$) 0.67 (m, 6H), 1.27 (m, 8H), 1.45 (m, 4H), 3.01 (t, 1H, *J* 9.70), 3.20–3.34 (m), 3.45 (s, 3H), 3.48–3.60 (m), 4.39 (d, 1H, *J* 9.70), 4.48 (d, 1H, *J* 10.90), 4.72 (d, 1H, *J* 10.90), 7.21 (m, 6H), 7.44 (m, 4H); δ_C ($CDCl_3$) 14.4, 14.5, 22.9, 23.0, 28.8, 28.8, 30.0, 30.7, 61.3, 70.0, 72.1, 74.2, 75.3, 78.0, 79.4, 81.5, 87.6, 89.2, 126.5, 128.4, 128.7, 129.3, 129.4, 131.6, 134.3, 135.4; ν_{max} (neat)/cm^{-1} 3072, 2871.

4.2.6. Procedure for ***10a–f***

*4.2.6.1. Phenyl 2,3-di-*O*-methyl-6-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10a***. Under a dry argon atmosphere, 60 mg (0.116 mmol) of **9a** was dissolved in 3 ml of DCM. Anhydrous iron (III) chloride (37 mg, 0.232 mmol) was added in one portion and, immediately, the color turned to green and brown. After 15 min of stirring, mixture was diluted with 5 ml of DCM and washed with saturated aqueous $NaHCO_3$ (2×3 ml) and saturated brine (2×3 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by flash chromatography in solvent A, to afford a colorless oil (32 mg, 0.087 mmol, 75%); TLC in solvent A: R_f 0.35; *m/z* (APCI$^+$), M+Na$^+$, found: 393.18; $C_{19}H_{30}O_5SNa$ requires: 393.17. Anal. $C_{19}H_{30}O_5S$ requires: C, 61.60, H, 8.17, S, 8.66; found: C, 61.72, H, 8.28, S, 8.77; δ_H ($CDCl_3$) 0.85 (m, 3H), 1.33 (m, 4H), 1.46 (m, 2H), 3.00 (t, 1H, *J* 9.70), 3.14 (t, 1H, *J* 9.70), 3.30 (m, 1H), 3.55 (s, 3H), 3.57 (m, 3H), 3.58 (s, 3H), 3.59 (m, 2H), 4.39 (d, 1H, *J* 9.70), 7.15 (m, 3H), 7.35 (m, 2H); δ_C ($CDCl_3$) 14.5, 22.9, 28.8, 29.9, 61.1, 61.5, 70.1, 71.2, 72.1, 79.7, 83.1, 87.6, 89.2, 128.8, 129.2, 132.1, 134.2; ν_{max} (neat)/cm^{-1} 3071, 2855.

*4.2.6.2. Phenyl 6-*O*-methyl-2,3-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10b***. The same method as for compound **10a** was applied to yield a colorless oil, 72%; TLC in solvent A: R_f 0.38; *m/z* (APCI$^+$), M+Na$^+$, found: 449.24; $C_{23}H_{38}O_5SNa$ requires: 449.23. Anal. $C_{23}H_{38}O_5S$ requires: C, 64.81, H, 8.98, S, 7.52; found: C, 64.95, H, 9.12, S, 7.64; δ_H ($CDCl_3$) 0.85 (m, 6H), 1.23 (m, 8H), 1.68 (m, 4H), 3.11 (t, 1H, *J* 9.70), 3.34 (s, 3H), 3.36–3.80 (m), 4.54 (d, 1H, *J* 9.70), 7.32 (m, 3H),

7.53 (m, 2H); δ_C ($CDCl_3$) 14.4, 23.0, 28.7, 30.5, 59.7, 70.2, 71.7, 74.1, 74.3, 79.4, 81.7, 87.2, 88.4, 128.5, 129.3, 132.4, 133.7; ν_{max} (neat)/cm^{-1} 3221, 3065, 2850.

*4.2.6.3. Phenyl 2,6-di-*O*-methyl-3-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10c***. The same method was applied to yield a colorless oil, 75%; TLC in solvent A: R_f 0.40; m/z ($APCI^+$), $M+Na^+$, found: 393.18; $C_{19}H_{30}O_5SNa$ requires: 393.17. Anal. $C_{19}H_{30}O_5S$ requires: C, 61.60, H, 8.17, S, 8.66; found: C, 61.78, H, 8.22, S, 8.72; δ_H ($CDCl_3$) 0.84 (m, 3H), 1.26 (m, 4H), 1.64 (m, 2H), 3.02 (t, 1H, *J* 9.70), 3.16 (t, 1H, *J* 9.70), 3.32 (s, 3H), 3.36 (m, 2H), 3.38 (s, 3H), 3.45–3.70 (m, 4H), 4.41 (d, 1H, *J* 9.70), 7.22 (m, 3H), 7.46 (m, 2H); δ_C ($CDCl_3$) 14.1, 22.8, 27.8, 30.3, 59.5, 61.3, 70.4, 71.8, 74.2, 79.6, 82.2, 88.3, 89.3, 128.5, 129.7, 132.3, 134.3; ν_{max} (neat)/cm^{-1} 3226, 3060, 2853.

*4.2.6.4. Phenyl 3,6-di-*O*-methyl-2-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10d***. The same method was applied to yield a colorless oil, 75%; TLC in solvent A: R_f 0.40; m/z ($APCI^+$), $M+Na^+$, found: 393.18; $C_{19}H_{30}O_5SNa$ requires: 393.17. Anal. $C_{19}H_{30}O_5S$ requires: C, 61.60, H, 8.17, S, 8.66; found: C, 61.75, H, 8.28, S, 8.78; δ_H ($CDCl_3$) 0.83 (m, 3H), 1.29 (m, 4H), 1.56 (m, 2H), 3.00 (t, 1H, *J* 9.70), 3.15 (t, 1H, *J* 9.70), 3.25 (s, 3H), 3.27 (m, 2H), 3.29 (s, 3H), 3.30–3.65 (m, 4H), 4.45 (d, 1H, *J* 9.70), 7.21 (m, 3H), 7.45 (m, 2H); δ_C ($CDCl_3$) 14.1, 22.9, 28.5, 30.2, 59.4, 61.2, 70.2, 70.3, 74.1, 79.6, 82.3, 87.9, 89.2, 128.9, 129.3, 132.0, 134.30; ν_{max} (neat)/cm^{-1} 3215, 3060, 2853.

*4.2.6.5. Phenyl 2-*O*-methyl-3,6-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10e***. The same method was applied to yield a colorless oil, 74%; TLC in solvent A: R_f 0.37; m/z ($APCI^+$), $M+Na^+$, found: 449.24; $C_{23}H_{38}O_5SNa$ requires: 449.23. Anal. $C_{23}H_{38}O_5S$ requires: C, 64.81, H, 8.98, S, 7.52; found: C, 64.92, H, 9.15, S, 7.60; δ_H ($CDCl_3$) 0.73 (m, 6H), 1.36 (m, 8H), 1.54 (m, 4H), 3.00 (t, 1H, *J* 9.70), 3.15–3.45 (m, 6H), 3.55 (s, 3H), 3.60 (m, 1H), 3.65 (m, 2H), 4.41 (d, 1H, *J* 9.70), 7.23 (m, 3H), 7.44 (m, 2H); δ_C ($CDCl_3$) 14.5, 23.1, 28.9, 29.9, 30.8, 61.3, 70.1, 71.6, 72.1, 74.2, 79.7, 83.0, 87.6, 88.0, 128.4, 129.3, 131.8, 134.3; ν_{max} (neat)/cm^{-1} 3218, 3063, 2858.

*4.2.6.6. Phenyl 3-*O*-methyl-2,6-di-*O*-pentyl-1-thio-β-D-glucopyranose*, ***10f***. The same method was applied to yield a colorless oil, 73%; TLC in solvent A: R_f 0.38; m/z ($APCI^+$), $M+Na^+$, found: 449.23; $C_{23}H_{38}O_5SNa$ requires: 449.23. Anal. $C_{23}H_{38}O_5S$ requires: C, 64.81, H, 8.98, S, 7.52; found: C, 64.89, H, 9.17, S, 7.62; δ_H ($CDCl_3$) 0.72 (m, 6H), 1.38 (m, 8H), 1.56 (m, 4H), 3.00 (t, 1H, *J* 9.70), 3.16–3.48 (m, 6H), 3.56 (s, 3H), 3.58 (m, 1H), 3.60 (m, 2H), 4.39 (d, 1H, *J* 9.70), 7.24 (m, 3H,), 7.47 (m, 2H); δ_C ($CDCl_3$) 14.5, 14.5, 22.9, 23.0, 28.8, 28.8, 30.0, 30.7, 61.1, 70.1, 70.5, 72.1, 74.2, 79.2, 82.5, 87.8, 89.2, 128.8, 129.3, 131.6, 134.3; ν_{max} (neat)/cm^{-1} 3224, 3068, 2852.

4.2.7. Phenyl O-*(2,3,6-tri-*O*-methyl-4-*O*-trimethylsilyl-α-D-glucopyranosyl)-(1→4)-pentakis [*O*-(2,3,6-tri-*O*-methyl-α-D-glucopyranosyl)-(1→4)]-2,3,6-tri-*O*-methyl-1-thio-D-glucopyranose*, ***12***

Under a dry argon atmosphere, in 15 ml of DCE were dissolved **11** (1.0 g, 0.70 mmol), zinc bromide (0.63 g, 2.80 mmol) and phenylthiotrimethylsilane (0.51 g, 2.80 mmol). The agitation was maintained for 5 days at room temperature. Reaction mixture was diluted with 100 ml of water and ice, and extracted with DCM (2×20 ml). Resultant organic phase was washed with saturated aqueous $NaHCO_3$ (2×10 ml) and brine (2×10 ml). The organic layer was dried over

Na_2SO_4 and concentrated. TLC in solvent D showed two spots with R_f values: 0.47 (no absorption UV light) and 0.51 (absorption of UV light). The mixture was purified by flash chromatography in solvent D to afford **12** as a colorless oil (0.428 g, 0.27 mmol, 38%); *m/z* (APCI$^+$), M+Na$^+$, found: 1633.76; $C_{72}H_{126}O_{35}SSiNa$ requires: 1633.74. Anal. $C_{72}H_{126}O_{35}SSi$ requires: C, 53.69, H, 7.88, S, 1.99; found: C, 53.75, H, 7.96, S, 2.18; δ_H ($CDCl_3$) 0.11 (s, 9H), 3.15–3.68 (m), 4.12 (d, 0.5H, *J* 9.80), 4.45 (d, 0.5H, *J* 3.70), 5.35–5.42 (m, 7H), 5.55 (m, 1H), 7.15 (m, 3H), 7.39 (m, 2H); δ_C ($CDCl_3$) 0.0, 58.4, 58.4, 58.5, 58.6, 58.7, 58.8, 58.9, 59.1, 59.3, 59.6, 59.7, 59.8, 60.1, 60.2, 60.7, 69.8, 69.9, 70.0, 70.3, 70.8, 71.1, 71.3, 72.7, 72.8, 73.0, 73.5, 81.6, 81.8, 81.9, 82.1, 82.4, 82.5, 82.7, 82.8, 82.9, 83.4, 85.9, 86.9, 87.9, 95.9, 96.2, 96.3, 96.6, 126.7, 128.5, 130.9, 133.61; ν_{max} (neat)/cm^{-1} 3052, 2860.

4.2.8. Phenyl O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-pentakis[*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-2,3,6-tri*-O-*methyl-1-thio-D-glucopyranose*, ***13***

2 g (1.24 mmol) of **12** was dissolved in 10 ml of MeOH and 1 ml (1.049 g, 17.13 mmol) of acetic acid was added and the mixture was allowed to gently reflux for 3 hours. All the solvents were then evaporated and purification on column chromatography of silica gel afforded compound **13** as a colorless oil (1.86 g, 1.21 mmol, 98%); TLC in solvent E: R_f 0.26; *m/z* (APCI$^+$), M+Na$^+$, found: 1538.74; $C_{69}H_{118}O_{35}SNa$ requires: 1538.72. Anal. $C_{69}H_{118}O_{35}S$ requires: C, 53.86, H, 7.73, S, 2.08; found: C, 53.90, H, 7.78, S, 2.21; δ_H ($CDCl_3$) 3.12–3.70 (m), 4.15 (d, 0.5H, *J* 9.80), 4.70 (d, 0.5H, *J* 3.70), 5.28–5.454 (m), 7.14 (m, 3H), 7.37 (m, 2H); δ_C ($CDCl_3$) 58.4, 58.5, 58.6, 58.7, 58.7, 58.8, 58.9, 59.2, 59.3, 59.6, 59.8, 59.8, 60.2, 60.2, 60.7, 69.8, 69.9, 70.0, 70.4, 70.9, 71.1, 71.3, 72.7, 72.8, 73.0, 73.6, 81.6, 81.7, 81.9, 82.1, 82.4, 82.5, 82.7, 82.8, 82.9, 83.4, 85.9, 86.9, 87.9, 95.8, 96.2, 96.3, 96.5, 126.7, 128.5, 130.9, 133.6; ν_{max} (neat)/cm^{-1} 3210, 3085, 2869.

4.2.9. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-pentakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-2,3,6-tri*-O-*methyl-1-thio-D-glucopyranose*, ***14***

Compound **13** (1.5 g, 0.97 mmol) was dissolved in 10 ml of DCM. Acetic anhydride (1 ml, 1.082 g, 10 mmol), and catalytic amounts of triethylamine (10 μl/g of **13**) and DMAP (5 mg/g of **13**) were added. The mixture was allowed to stir at room temperature for 5 hours. Then, the mixture was diluted with 10 ml of DCE and washed with 3 M aqueous HCl (2×5 ml) and with saturated aqueous $NaHCO_3$ (2×5 ml). The organic layer was dried over Na_2SO_4 and concentrated. Purification on column chromatography of silica gel afforded **14** as a colorless oil (1.49 g, 0.95 mmol, 98%); TLC in solvent E: R_f 0.52; *m/z* (APCI$^+$), M+Na$^+$, found: 1595.70; $C_{71}H_{120}O_{36}SNa$ requires: 1595.65. Anal. $C_{71}H_{120}O_{36}S$ requires: C, 54.22, H, 7.69, S, 2.04; found: C, 54.38, H, 7.75, S, 2.17; δ_H ($CDCl_3$) 2.11 (s, 3H), 3.00–3.72 (m), 4.20 (d, 0.5H, *J* 9.80), 4.87 (d, 0.5H, *J* 3.70), 5.37–5.45 (m), 5.55 (m, 1H), 7.15 (m, 3H), 7.39 (m, 2H); δ_C ($CDCl_3$) 21.8, 59.2, 59.3, 59.3, 59.4, 59.5, 59.6, 59.7, 59.8, 60.1, 60.2, 60.5, 60.7, 60.9, 69.5, 70.6, 71.2, 71.6, 72.5, 73.1, 73.8, 73.9, 74.0, 80.6, 81.7, 82.5, 83.2, 83.5, 96.6, 97.1, 127.3, 128.6, 129.9, 134.4, 170.0; ν_{max} (neat)/cm^{-1} 3065, 2867, 1727.

*4.2.10. [*O-*(4*-O-*Acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-pentakis[*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-1-deoxy-1-fluoro-2,3,6-tri*-O-*methyl-D-glucopyranose*, ***15***

Under a dry argon atmosphere, 900 mg (0.57 mmol) of compound **14** was dissolved in 6 ml of DCE and the solution was cooled at −15°C to add 91 μl (119 mg, 0.74 mmol) of (diethylamino)sulfur trifluoride. After 2 min, 132 mg (0.74 mmol) of *N*-bromosuccinimide was

added and the mixture was stirred for 25 min at −15°C. The mixture was then allowed to warm slowly to room temperature. Work-up as described for **14** gave compound **15** as a colorless oil (0.75 g, 0.50 mmol, 88%); TLC in solvent E: R_f 0.36; m/z (APCI$^+$), M+Na$^+$, found: 1513.71; $C_{65}H_{115}O_{36}FNa$ requires: 1513.70. Anal. $C_{65}H_{115}O_{36}F$ requires: C, 52.37, H, 7.77; found: C, 52.44, H, 7.82; δ_H ($CDCl_3$) 2.04 (s, 3H), 2.90–3.85 (m), 4.85 (t, 1H, *J* 9.70), 5.05 (dd, 0.55H, *J* 6.30, *J* 53.10), 5.34 (dd, 0.45H, *J* 3.01, *J* 53.00), 5.37–5.53 (m, 6H), 5.64 (m, 1H); δ_C ($CDCl_3$) 21.9, 59.2, 59.3, 59.3, 59.3, 59.4, 59.6, 59.7, 59.7, 59.8, 60.1, 60.2, 60.3, 60.5, 60.8, 60.9, 69.6, 70.6, 71.2, 71.6, 72.4, 73.1, 73.9, 73.9, 74.1, 80.6, 81.7, 82.6, 83.2, 83.5, 96.6, 97.1, 170.0; δ_F ($CDCl_3$) −136.80 (dd, 0.55F, *J* 11.80, *J* 53.00), −149.90 (dd, 0.45F, *J* 25.78, *J* 53.00); ν_{max} (neat)/cm^{-1} 2870, 1715.

4.2.11. General procedure for ***16a–f***

4.2.11.1. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis[*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-2,3-di*-O-*methyl-6*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16a***. Compound **15** (40 mg, 0.027 mmol) and alcohol **10a** (11.99 mg, 0.032 mmol) were azeotropically dried with benzene and then dried under high vacuum for 1 h. The dried mixture was diluted with 0.5 ml of DCM, 4 Å MS were added and the mixture was stirred at ambient temperature for 20 min. Then, reaction mixture was cooled to −35°C and BF_3–Et_2O (0.34 μl, 0.003 mmol) was added. After stirring for 1.5 h, reaction mixture was diluted with EtOAc (50 ml) and washed with saturated aqueous $NaHCO_3$ (2×10 ml) and saturated brine (2×10 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by flash chromatography in solvent A, to yield compound **16a** as a colorless oil (17 mg, 0.009 mmol, 35%); TLC in solvent A: R_f 0.14. Anal. $C_{84}H_{144}O_{41}S$ requires: C, 54.81, H, 7.88, S, 1.75; found: C, 54.92, H, 7.96, S, 1.54; δ_H ($CDCl_3$) 0.83 (m, 3H), 1.34 (m, 4H), 1.48 (m, 2H), 2.04 (s, 3H), 2.86 (t, 1H, *J* 9.70), 2.90–3.95 (m), 4.41 (d, 1H, *J* 9.70), 5.37–5.53 (m, 7×1H), 7.13 (m, 3H), 7.35 (m, 2H); δ_C ($CDCl_3$) 14.5, 21.8, 22.9, 28.8, 29.9, 59.2, 59.3, 59.3, 59.3, 59.4, 59.6, 59.7, 59.7, 59.8, 60.1, 60.2, 60.4, 60.5, 60.8, 60.9, 61.1, 61.5, 69.6, 70.1, 70.6, 71.2, 71.3, 71.6, 72.1, 72.4, 73.1, 73.9, 73.9, 74.1, 79.7, 80.6, 81.6, 82.6, 83.1, 83.2, 83.5, 96.6, 97.1, 128.8, 129.2, 132.1, 134.1, 170.0; ν_{max} (neat)/cm^{-1} 3055, 2905, 1730.

4.2.11.2. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-6*-O-*methyl-2,3-di*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16b***. The same method as for compound **16a** was applied to yield a colorless oil, 34%; TLC in solvent A: R_f 0.16. Anal. $C_{88}H_{152}O_{41}S$ requires: C, 56.49, H, 8.18, S, 1.71; found: C, 56.55, H, 8.12; S, 1.80; δ_H ($CDCl_3$) 0.85 (m, 6H), 1.34 (m, 8H), 1.54 (m, 4H), 2.03 (s, 3H), 2.84 (t, 1H, *J* 9.70), 2.91–4.00 (m), 4.45 (d, 1H, *J* 9.70), 5.38–5.45 (m, 7×1H), 7.15 (m, 3H), 7.36 (m, 2H); δ_C ($CDCl_3$) 14.5, 22.2, 23.3, 28.8, 30.2, 59.2, 59.3, 59.3, 59.4, 59.6, 59.7, 59.7, 59.8, 60.1, 60.2, 60.3, 60.6, 60.8, 60.9, 61.1, 61.5, 69.6, 70.1, 70.3, 70.7, 71.2, 71.2, 71.6, 71.7, 72.1, 72.5, 73.1, 73.9, 73.9, 74.0, 74.1, 79.5, 79.7, 80.6, 81.7, 81.7, 81.8, 82.6, 83.1, 83.2, 83.5, 87.3, 88.5, 96.6, 97.1, 128.9, 129.2, 132.1, 134.1, 170.0; ν_{max} (neat)/cm^{-1} 3064, 2885, 1725.

4.2.11.3. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-2,6-di*-O-*methyl-3*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16c***. The same method was applied to yield a colorless oil, 30%; TLC in solvent A: R_f 0.14. Anal. $C_{84}H_{144}O_{41}S$ requires: C, 54.81, H, 7.88, S, 1.75; found: C, 54.88, H, 8.00, S, 1.66; δ_H ($CDCl_3$)

0.84 (m, 3H), 1.30 (m, 4H), 1.52 (m, 3H), 2.01 (s, 3H), 2.83 (t, 1H, *J* 9.70), 2.94–3.98 (m), 4.46 (d, 1H, *J* 9.70), 5.39–5.57 (m, 7×1H), 7.22 (m, 3H), 7.43 (m, 2H); δ_C ($CDCl_3$) 14.1, 21.8, 23.0, 28.8, 30.1, 59.3, 59.3, 59.3, 59.4, 59.6, 59.7, 59.7, 59.8, 60.1, 60.2, 60.3, 60.6, 60.8, 60.9, 61.1, 61.5, 69.6, 70.1, 70.3, 70.3, 70.6, 71.2, 71.2, 71.6, 71.7, 72.1, 72.4, 73.1, 73.9, 73.9, 74.1, 74.1, 79.5, 79.7, 80.6, 81.7, 81.7, 81.8, 82.6, 83.1, 83.2, 83.5, 87.1, 88.5, 96.6, 97.1, 128.8, 129.2, 132.2, 134.1, 170.0; ν_{max} (neat)/cm^{-1} 3065, 2910, 1729.

4.2.11.4. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-3,6-di*-O-*methyl-2*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16d***. The same method was applied to yield a colorless oil, 28%; TLC in solvent A: R_f 0.14. Anal. $C_{84}H_{144}O_{41}S$ requires: C, 54.81, H, 7.88, S, 1.75; found: C, 54.75, H, 7.85, S, 1.71; δ_H ($CDCl_3$) 0.82 (m, 3H), 1.33 (m, 4H), 1.55 (m, 3H), 2.04 (s, 3H), 2.80 (t, 1H, *J* 9.70), 2.89–3.92 (m), 4.39 (d, 1H, *J* 9.70), 5.28–5.45 (m, 7×1H), 7.20 (m, 3H), 7.31 (m, 2H); δ_C ($CDCl_3$) 14.1, 22.1, 23.1, 28.7, 30.1, 59.4, 59.4, 59.5, 59.5, 59.6, 59.7, 59.7, 59.8, 60.0, 60.2, 60.4, 60.6, 60.7, 60.9, 61.1, 61.4, 69.6, 70.2, 70.3, 70.4, 70.6, 71.2, 71.3, 71.6, 71.7, 72.1, 72.5, 73.2, 73.7, 73.9, 74.1, 74.2, 79.5, 79.8, 80.6, 81.7, 81.8, 81.8, 82.6, 83.1, 83.2, 83.4, 87.1, 88.6, 96.6, 97.1, 128.6, 129.2, 132.5, 134.1, 170.0; ν_{max} (neat)/cm^{-1} 3065, 2910, 1734.

4.2.11.5. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-2*-O-*methyl-3,6-di*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16e***. The same method as for compound **16a** was applied to yield a colorless oil, 32%; TLC in solvent A: R_f 0.17. Anal. $C_{88}H_{152}O_{41}S$ requires: C, 56.49, H, 8.18, S, 1.71; found: C, 56.52, H, 8.15; S, 1.78; δ_H ($CDCl_3$) 0.83 (m, 6H), 1.33 (m, 8H), 1.54 (m, 4H), 2.04 (s, 3H), 2.85 (t, 1H, *J* 9.70), 2.90–4.05 (m), 4.48 (d, 1H, *J* 9.70), 5.36–5.48 (m, 7×1H), 7.12 (m, 3H), 7.34 (m, 2H); δ_C ($CDCl_3$) 14.5, 22.3, 23.2, 28.8, 30.2, 59.3, 59.3, 59.4, 59.5, 59.6, 59.7, 59.8, 59.8, 60.1, 60.1, 60.2, 60.4, 60.5, 60.9, 61.1, 61.3, 69.6, 70.1, 70.3, 70.8, 71.2, 71.2, 71.5, 71.7, 72.3, 72.5, 73.0, 73.8, 73.9, 74.0, 74.1, 79.6, 79.7, 80.6, 81.6, 81.8, 82.5, 83.2, 83.3, 83.5, 87.2, 88.6, 96.7, 97.3, 128.9, 129.1, 132.1, 134.0, 170.0; ν_{max} (neat)/cm^{-1} 3058, 2875, 1728.

4.2.11.6. Phenyl O-*(4*-O-*acetyl-2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)-hexakis [*O-*(2,3,6-tri*-O-*methyl-α-D-glucopyranosyl)-(1→4)]-3*-O-*methyl-2,6-di*-O-*pentyl-1-thio-β-D-glucopyranose*, ***16f***. The same method as for compound **16a** was applied to yield a colorless oil, 30%; TLC in solvent A: R_f 0.17. Anal. $C_{88}H_{152}O_{41}S$ requires: C, 56.49, H, 8.18, S, 1.71; found: C, 56.45, H, 8.12; S, 1.70; δ_H ($CDCl_3$) 0.82 (m, 6H), 1.34 (m, 8H), 1.56 (m, 4H), 2.06 (s, 3H), 2.87 (t, 1H, *J* 9.70), 2.85–4.08 (m), 4.49 (d, 1H, *J* 9.70), 5.35–5.50 (m, 7×1H), 7.12 (m, 3H), 7.35 (m, 2H); δ_C ($CDCl_3$) 14.4, 22.4, 23.3, 28.8, 30.3, 59.3, 59.4, 59.6, 59.7, 59.8, 59.9, 60.1, 60.2, 60.3, 60.3, 60.5, 60.7, 61.1, 61.3, 69.5, 70.1, 70.2, 70.6, 71.2, 71.3, 71.5, 71.8, 72.3, 72.4, 73.0, 73.8, 73.9, 74.1, 74.1, 79.6, 79.7, 80.5, 81.7, 81.9, 82.5, 83.1, 83.3, 83.4, 87.2, 88.7, 96.7, 97.4, 128.8, 129.1, 132.2, 134.1, 170.0; ν_{max} (neat)/cm^{-1} 3044, 2873, 1710.

4.2.12. General procedure for ***17a–f***

Note: Due to the very poor differences that appear for compounds **17a–f** in comparison with compounds **16a–f**, characterizations of de-acetylated products **17a–f** are not presented.

4.2.13. General procedure for **18a–f**

4.2.13.1. $2^{I-VIII},3^{I-VIII},6^{I-VII}$-Tricosa-O-*methyl*-$6^{VIII}$-O-*pentyl*-γ-*cyclodextrin*, **18a**. Thioglycoside **17a** (17 mg, 9.44 μmol) was dissolved in Et_2O (2 ml) and flame dried 4 Å molecular sieves (500 mg) were added. Methyl trifluoromethanesulfonate (40 mg, 28 μl, 245 μmol) was added at 0°C and then the reaction mixture was allowed to stir at room temperature for 2 days. The reaction was quenched with MeOH, diluted with chloroform and washed successively with 3 M aqueous HCl (2×2 ml), saturated aqueous $NaHCO_3$ (2×2 ml) and saturated brine (2×2 ml). The organic layer was dried over Na_2SO_4, concentrated and purified by preparative TLC in solvent D to afford compound **18a** as a colorless oil (5.60 mg, 3.30 μmol, 35%); TLC in solvent D: R_f 0.55. Anal. $C_{76}H_{136}O_{40}$ requires: C, 54.02, H, 8.11; found: C, 54.12, H, 8.18; δ_H ($CDCl_3$) 0.80 (m, 3H), 1.32 (m, 4H), 1.54 (m, 2H), 3.14 (m, 8H), 3.30 (s, 27H), 3.38–3.80 (m), 4.95–5.15 (m, 8×1H); δ_C ($CDCl_3$) 14.5, 22.8, 28.6, 29.9, 59.2, 59.7, 61.1, 61.1, 69.6, 70.1, 70.6, 71.2, 71.6, 81.6, 82.6, 82.7, 82.7, 83.1, 83.2, 83.4, 96.6, 97.2, 97.3.

4.2.13.2. $2^{I-VII},3^{I-VII},6^{I-VIII}$-Docosa-O-*methyl*-$2^{VIII},3^{VIII}$-*di*-O-*pentyl*-γ-*cyclodextrin*, **18b**. The same method as for compound **18a** was applied to yield a colorless oil, 33%; TLC in solvent D: R_f 0.57. Anal. $C_{80}H_{144}O_{40}$ requires: C, 55.03, H, 8.31; found: C, 55.15, H, 8.34; δ_H ($CDCl_3$) 0.86 (m, 6H), 1.35 (m, 8H), 1.56 (m, 4H), 2.80–3.15 (m), 3.29 (s, 27H), 3.40–3.85 (m), 4.92–5.14 (m, 8×1H); δ_C ($CDCl_3$) 14.6, 22.2, 28.8, 30.2, 59.2, 59.4, 59.6, 60.2, 61.6, 70.1, 70.3, 70.7, 71.2, 71.6, 72.1, 73.1, 73.8, 79.5, 79.7, 80.6, 81.7, 82.6, 83.2, 83.6, 88.5, 96.6.

4.2.13.3. $2^{I-VIII},3^{I-VII},6^{I-VIII}$-Tricosa-O-*methyl*-$3^{VIII}$-O-*pentyl*-γ-*cyclodextrin*, **18c**. The same method as for compound **18a** was applied to yield a colorless oil, 31%; TLC in solvent D: R_f 0.55. Anal. $C_{76}H_{136}O_{40}$ requires: C, 54.02, H, 8.11; found: C, 54.22, H, 8.00; δ_H ($CDCl_3$) 0.81 (m, 3H), 1.34 (m, 4H), 1.55 (m, 2H), 3.16 (m, 8H), 3.29 (s, 27H), 3.37–3.83 (m), 4.98–5.17 (m, 8×1H); δ_C ($CDCl_3$) 14.6, 22.8, 28.5, 29.8, 59.2, 59.7, 61.1, 61.3, 69.7, 69.8, 70.1, 70.6, 71.3, 71.4, 81.6, 81.7, 82.6, 82.7, 82.8, 83.2, 83.3, 83.4, 96.7, 97.1, 97.2.

4.2.13.4. $2^{I-VII},3^{I-VIII},6^{I-VIII}$-Tricosa-O-*methyl*-$2^{VIII}$-O-*pentyl*-γ-*cyclodextrin*, **18d**. The same method as for compound **18a** was applied to yield a colorless oil, 28%; TLC in solvent D: R_f 0.55. Anal. $C_{76}H_{136}O_{40}$ requires: C, 54.02, H, 8.11; found: C, 54.15, H, 7.95; δ_H ($CDCl_3$) 0.82 (m, 3H), 1.33 (m, 4H), 1.55 (m, 2H), 3.14 (m, 8H), 3.30 (s, 27H), 3.39–3.87 (m), 4.99–5.12 (m, 8×1H); δ_C ($CDCl_3$) 14.6, 22.9, 28.6, 29.8, 59.2, 59.5, 59.7, 61.3, 69.8, 69.9, 70.1, 70.3, 71.2, 71.3, 71.5, 81.7, 81.9, 82.5, 82.7, 82.9, 83.3, 83.3, 83.5, 96.8, 97.1.

4.2.13.5. $2^{I-VIII},3^{I-VII},6^{I-VII}$-Docosa-O-*methyl*-$3^{VIII},6^{VIII}$-*di*-O-*pentyl*-γ-*cyclodextrin*, **18e**. The same method as for compound **18a** was applied to yield a colorless oil, 31%; TLC in solvent D: R_f 0.57. Anal. $C_{80}H_{144}O_{40}$ requires: C, 55.03, H, 8.31; found: C, 54.85, H, 8.22; δ_H ($CDCl_3$) 0.83 (m, 6H), 1.32 (m, 8H), 1.58 (m, 4H), 2.85–3.20 (m), 3.28 (s, 27H), 3.42–3.90 (m), 4.93–5.16 (m, 8×1H); δ_C ($CDCl_3$) 14.5, 22.3, 28.8, 30.3, 59.2, 59.4, 60.3, 61.6, 61.7, 70.2, 70.3, 70.5, 71.2, 71.5, 72.1, 73.3, 73.7, 79.5, 79.6, 80.6, 81.7, 81.8, 82.7, 83.2, 83.5, 88.5, 96.7.

4.2.13.6. $2^{I-VII},3^{I-VIII},6^{I-VII}$-Docosa-O-*methyl*-$2^{VIII},6^{VIII}$-*di*-O-*pentyl*-γ-*cyclodextrin*, **18f**. The same method as for compound **18a** was applied to yield a colorless oil, 27%; TLC in solvent D: R_f 0.56. Anal. $C_{80}H_{144}O_{40}$ requires: C, 55.03, H, 8.31; found: C, 55.10, H, 8.39; δ_H ($CDCl_3$) 0.86

(m, 6H), 1.36 (m, 8H), 1.57 (m, 4H), 2.82–3.14 (m), 3.27 (s, 27H), 3.42–3.88 (m), 4.93–5.16 (m, 8×1H); δ_C ($CDCl_3$) 14.5, 22.3, 28.8, 30.3, 59.2, 59.8, 59.9, 60.1, 61.7, 70.2, 70.3, 70.6, 71.2, 71.5, 72.2, 73.3, 73.8, 79.5, 79.7, 80.7, 81.8, 82.6, 83.2, 83.6, 88.6, 96.6, 96.7.

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