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Organofluorine compounds and fluorinating agents[☆] Part 31. Mixed alkyl-perfluoroalkyl substituted monosaccharide derivatives

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Abstract

Starting with 1,2,4,6-tetra-*O*-acetyl-3-*O*-dodecyl-β-D-glucose (**1**), mixed alkyl-perfluoroalkyl substituted sugar derivatives with an anomeric perfluoroalkylthio group and an *O*-alkyl group in the 3 position were synthesized via 2,4,6-tri-*O*-acetyl-3-*O*-dodecyl-1-thio-β-D-glucose (**4**). The latter was *S*-perfluorohexylated with 1-iodoperfluorohexane in a dithionite initiated reaction yielding perfluorohexyl 2,4,6-tri-*O*-acetyl-3-*O*-dodecyl-1-thio-β-D-glucopyranoside (**5**). Experiments with the aim compound **5** completely to deacetylate ended in surprising results. Thus, methanolic methanolate solution produced the orthoester **7** as the result of α-fluoride replacement by methoxy groups as well as the methyl glucoside **8** as the result of a transglycosylation reaction. Alumina supported cesium fluoride cleaved regioselectively the two acetyl groups in the 4- and 6-position yielding perfluorohexyl 2-*O*-acetyl-3-*O*-dodecyl-1-thio-β-D-glucopyranoside (**10**). A complete deacetylation of **5** to amphiphile **11** succeeded only with methanolic *tert*-butanolate. However, the products **8** and **10** were likewise formed.

Keywords: *S*-Perfluoroalkylation; Carbohydrates; Thioglycosides; Deacetylation; Orthoester derivative

1. Introduction

Recently, we observed for the first time that a mixed substituted amphiphile [(3-perfluorooctylpropyl) 6-*O*-dodecanoyl-β-D-glucopyranoside], containing a long perfluoroalkyl chain as well as an unbranched lipophilic acyl chain, shows an interesting liquid crystalline behavior, that is polymorphism of two *discotic* mesophases [2]. This observation drew attention to mixed substituted amphiphilic monosaccharides with a regio-variable arrangement of the fluorophilic and the lipophilic chain. In this paper, we report about the synthesis of 1,3-mixed substituted glucose derivatives, i.e. compounds with angled arranged chains. In the end, the amphiphilic target compound did not show liquid crystalline behavior, however, unexpected experimental results were obtained in deprotection procedures.

2. Results and discussion

Perfluorohexyl 3-*O*-dodecyl-1-thio-β-D-glucopyranoside (**11**) was selected as 1,3-mixed alkylated/perfluoroalkylated amphiphile with angled arranged chains. The compound was synthesized in five steps starting with 3-*O*-dodecyl-1,2,4,6-tetra-*O*-acetyl-β-D-glucopyranose (**1**) [3]. Initially, glycosyl bromide **2** was generated by treatment of **1** with hydrobromic acid in glacial acetic acid followed by transformation of the crude product into the isothiouronium bromide **3**. The latter was, likewise without further purification, hydrolyzed under weak basic conditions yielding 2,4,6-tri-*O*-acetyl-3-*O*-dodecyl-1-thio-β-D-glucose (**4**), Scheme 1. The methods of these four steps correspond to procedures reported by Cerny et al. [4]. Subsequently, thiol **4** was perfluoroalkylated with 1-iodoperfluorohexane in a sodium dithionite mediated reaction. This method has been described in a previous paper [5]. To prevent the oxidation of the hydrogen iodide formed, the procedure was carried out under an argon atmosphere. The major product **5** was isolated in 51% yield. In addition, disulfide **6** (8%) was formed, an analogous dimeric by-product has been observed by Bhar and Chandrasekaran [6], Scheme 1.

[☆] For Part 30, see [1].

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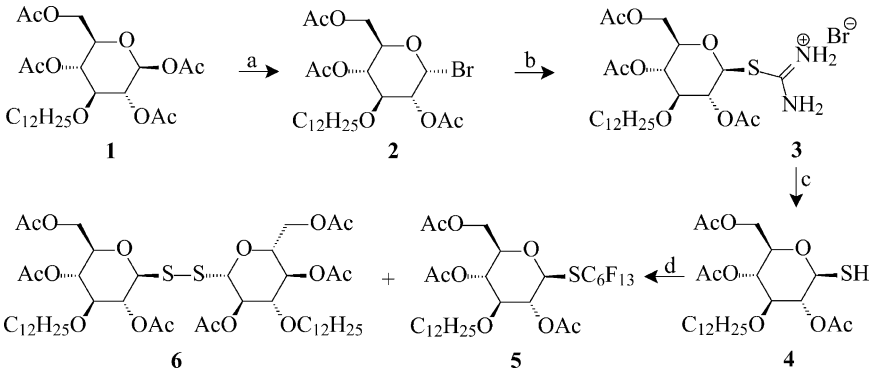


Scheme 1. (a) HBr, acetic acid; (b) thiourea, acetone, 45 min, reflux; (c) $Na_2S_2O_5$, CCl_4, H_2O, 10 min, 85 °C; (d) $C_6F_{13}I$, $Na_2S_2O_4$, satd. $NaHCO_3$-soln., DMF, argon atmosphere, 0 °C RT, 3 h.

Methanolic sodium methoxide solution (Zemplén reagent [7]) is the conventional deacetylation reagent in carbohydrate chemistry. Surprisingly, on treatment of compound **5** with this reagent for 2 h at RT, the desired amphiphilic thioglucoside **11** was not obtained. The deacetylations were accompanied by substitution reactions, i.e. orthoester **7** (17%) and methyl glucoside **8** (58%) were formed (Scheme 2).

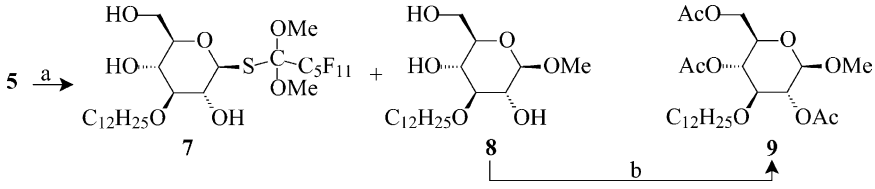
In the case of compound **7**, the two α-fluorine atoms of the perfluoroalkyl chain were replaced by methoxy groups generating an orthoester function. Comparable replacement reactions are known for a number of perfluoroalkylated heterocyclic compounds and anilines [8–10]. Even substitution of β-fluorine atoms can occur provided the starting material allows a sequence α,β-elimination/Michael addition as found for α-perfluoroalkylated acetic acid derivatives or ketones [11,12]. By contrast neither phenyl-perfluorohexyl- nor benzyl-perfluorohexyl-thioether yielded orthoesters on treatment with methanolic methanolate solution.

The structure elucidation of compound **7** was accomplished via a comparison of its NMR spectra with those of starting material **5**. In the ^{19}F NMR-spectrum of compound **5**, two multiplets at −85 and −88 ppm were found. These signals were assigned to the α-fluorine atoms in the chain. In the corresponding spectrum of orthoester derivative **7**, signals with similar chemical shifts are missing. A further difference is that the initially β-positioned CF_2-group at −112 ppm shows now the typical splitting pattern for an α-CF_2-group. The two methoxy groups of compound **7** give characteristic singlets with chemical shifts of $\delta_H = 3.58$ ppm and $\delta_C = 54.3/53.8$ ppm, respectively.

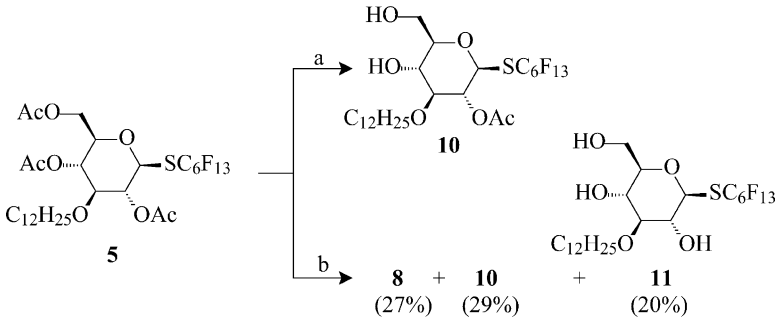
The ^{19}F NMR spectrum of glucoside **8** did not contain any resonances, confirming the loss of the perfluoroalkylthio group. Because the ^{1}H and the ^{13}C spectra of compound **8** were hard to interpret, the compound was acetylated to derivative **9** (Scheme 2) and this one was investigated more detailed. The ^{13}C signal at 56.7 ppm, characteristic of methyl glucosides, confirms the replacement of the perfluoroalkylthio group by a methoxy group. The α-configuration of the anomeric center is supported by the large coupling constant of 10 Hz between the anomeric proton and H-2.

In order to get the target compound **11** from **5**, the reagent used for the deacetylation was varied. Aluminia supported cesium fluoride, first introduced by Hanafusa et al. [13] as catalyst in alkylation procedures of alcohols and phenols, has been also shown to be a mild catalyst for the complete deacetylation of peracetylated perfluoroalkyl thioglycosides [5]. On treatment of compound **5** with a methanolic suspension of this catalyst ($c = 1.533$ mmol CsF/g support, 1/15 mol eq. fluoride per acetyl group) for 2 h at RT, the monoacetyl product **10** (87%) was exclusively obtained, Scheme 3. Prolongation of the reaction time did not influence the result.

In a further experiment, potassium *tert*-butanolate (1/9 mol eq. per acetyl group) was used as the deacetylation reagent. The butanolate was added to the methanolic suspension of compound **5** at RT and the mixture was stirred (after a short-time heating onto 35–40 °C) for 45 min. The product mixture contained the desired amphiphile **11** in 20% yield besides monoacetyl derivative **10** (29%) and methyl glucoside **8** (27%), Scheme 3.



Scheme 2. (a) Methanolic NaOMe-soln., RT, 2 h; (b) acetic anhydride, pyridine, RT, 18 h.



Scheme 3. (a) CsF on Al_2O_3, MeOH, RT, 2 h; (b) $KOBu^t$, MeOH, 40 °C RT, 45 min.

3. Conclusions

Deacetylations of mixed alkyl-perfluoroalkyl substituted sugar derivatives like compound **5** with an anomeric perfluoroalkylthio group show a different course in depending on the reagent.

(1) The formation of methylglucoside **8** from **4** shows that a perfluoroalkylthio group is a good leaving group usable for transglycosylations without prior oxidation to activate the glycosidic C−S bond; for the reactivity of perfluoroalkylated *O*-glycosides see ref. [14]. Moreover, methoxide ions are able to replace the α-fluorine atoms of a glycosidic perfluoroalkylthio chain.
(2) A methanolic suspension of alumina supported cesium fluoride allows a very selective partial deacetylation of peracetylated 1,3-alkyl-perfluoroalkyl substituted sugar derivatives as shown for compound **5**. The increased selectivity of this catalyst compared to methanolic sodium methoxide and potassium *tert*-butoxide reagents is probably due to a high activity on the sterically hindered surface of the supported material on the one hand but a very low concentration of active base in the methanolic solution on the other hand.

In contrast to (3-perfluorooctylpropyl) 6-*O*-dodecanoyl-β-D-glucopyranoside [2], the mixed 1,3-alkyl-perfluoroalkyl substituted amphiphile **11** was not liquid crystalline.

4. Experimental

The reactions were followed by thin layer chromatography using precoated aluminia sheets (Merck 60, F254), detection was effected by spraying with 10% methanolic sulfuric acid solution and subsequent thermal treatment. Silica Gel 60 (0.062–0.2 mm, Merck) and Silica Gel 60 (40–63 μm, Merck), respectively, was used for column chromatographic separations. All solvents were purified and dried using standard procedures [15]. Melting points were determined with a Leitz Laborlux 12 Pol microscope equipped with a Mettler FP 90 hot stage. Optical rotations were measured on a polarimeter Polar LμP (IBZ Meßtechnik) and the NMR spectra were recorded on a Bruker AC-250 and an AVANCE 500 using TMS and CCl_3F as internal standards, respectively.

Commercial chemicals used: 1-Iodoperfluorohexane (Fluka), sodium dithionite (Fluka), Amberlite IR-120 (Fluka), hydrobromide in acetic acid (Fluka), thiourea (Fluka), sodium pyrosulphite (Fluka), potassium *tert*-butanolate (Fluka).

*4.1. 2,4,6-tri-O-Acetyl-3-O-dodecyl-1-thio-β-D-glucose pyranose (**4**)*

A solution of 1,2,4,6-tetra-*O*-acetyl-3-*O*-dodecyl-β-D-glucose (**1**) (4.5 g, 8.71 mmol) [3] in 33% HBr/glacial acetic acid (60 ml) was stirred at 0 °C for 90 min. After completion of the reaction (TLC-control), the mixture was poured onto ice/water (300 ml) and the aqueous phase was extracted with EtOAc; ice was added to keep this solution cool. The organic phase was neutralized by washing with saturated $NaHCO_3$ solution followed by washing with water. After drying (Na_2SO_4), the solution was concentrated under reduced pressure at about 30 °C. The resulting glucosyl bromide **2** was converted into the thiol **4** *via* isourea derivative **3** without further purification.

A solution of **2** and thiourea (1.2 g, 15.76 mmol) in dry acetone (9 ml) was refluxed for 45 min under exclusion of moisture and then concentrated under reduced pressure. The residue (isourea derivative **3**) was dissolved in CCl_4 (25 ml) followed by adding of a solution of $Na_2S_2O_5$ (2.0 g) in water (10 ml). After refluxing of the two phase system for 10 min, the reaction forming **4** was complete (TLC-control, $R_f = 0.41$, heptane/EtOAc 1:1 v/v). The phases were separated, the aqueous phase was washed with $CHCl_3$ (25 ml), the combined organic phases were dried (Na_2SO_4) and concentrated under reduced pressure. Crude product **4** was purified by column chromatography (500 ml heptane/EtOAc 9:1 v/v, 2 L heptane/EtOAc 5:1 v/v) giving 3.17 g (74%) of **4** as colorless oil: $[\alpha]_D^{24}$ −37.3° (MeOH, $c = 1.12$).

^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 5.04$ (dd, $^3J_{3/4} = 9.5$ Hz, $^3J_{4/5} = 10.0$ Hz, 1H, H-4), 4.92 (t, 1H, $^3J_{1/2} = {}^3J_{2/3} = 10.0$ Hz, H-2), 4.42 (t, $^3J_{1/SH} = {}^3J_{1/2} = 10.0$ Hz,

1H, H-1), 4.19 (dd, $^3J_{5/6a} = 5.1$ Hz, $^3J_{6a/6b} = 12.4$ Hz, 1H, H-6a), 4.09 (dd, $^3J_{5/6a} = 2.5$ Hz, 1H, H-6b), 3.58 (ddd, 1H, H-5), 3.52–3.43 (m, 3H, H-3, OCH_2), 2.28 (d, 1H, SH), 2.11, 2.07, 2.06 (3m, 3 × 3H, CH_3), 1.44–1.23 (m, 20 H, 10 CH_2), 0.86 (t, 3H, CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 170.8$, 169.5, 169.2 (3 s, C=O), 81.5 (s, C-3), 79.0 (s, C-1), 76.6 (s, C-5), 75.0 (s, C-2), 72.6 (s, OCH_2), 69.3 (s, C-4), 62.3 (s, C-6), 31.9, 30.2, 29.6, 29.4, 29.3, 25.9, 22.6 (7s, CH_2), 21.0, 20.8, 20.7 (3s, 3 acetyl-CH_3), 14.1 (s, alkyl-CH_3); EIMS (70 eV), *m/z*: 457 $[M - SH]^+$; FAB-MS (pos. NBA), *m/z*: 513 $[M + Na]^+$, 491 $[M]^+$, 457 $[M - SH]^+$. $C_{24}H_{42}O_8S$ (490.7): Calc. C 58.75, H 8.6, S 5.5; Found C 59.0, H 8.6, S 6.3.

4.2. Perfluorohexyl 2,4,6-tri-O-acetyl-3-O-dodecyl-1-thio-β-D-glucopyranoside (5) and bis-(2,4,6-tri-O-acetyl-3-O-dodecyl-β-D-glucopyranosyl)disulfide (6)

To a suspension of thiol **4** (2.85 g, 5.81 mmol) in a mixture of DMF (30 ml) and saturated aqueous $NaHCO_3$ solution (30 ml), 1-iodoperfluorohexane (2.55 ml, 11.72 mmol) and sodium dithionite (1.01 g, 5.81 mmol) were added at 0 °C with stirring (argon atmosphere). The mixture was allowed to warm up to RT and stirring was continued for 3 h. Subsequently, diethyl ether (100 ml) was added, the suspension was washed with water (four times 50 ml), the organic phase was separated and dried (Na_2SO_4), then concentrated under reduced pressure. The residue was purified by column chromatography (heptane/EtOAc 1:1 v/v) yielding 3.17 g (51%) of **5** ($R_f = 0.19$) as colorless crystals: mp 72–73 °C (MeOH); $[\alpha]_D^{21}$ −4.1° ($CHCl_3$, $c = 1.30$) and 475 mg (8%) of the crystalline disulfide **6** ($R_f = 0.29$); mp 125–126 °C (MeOH/H_2O).

5: ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 5.01$ (dd, $^3J_{3/4} = 9.5$ Hz, $^3J_{4/5} = 10.0$ Hz, 1H, H-4), 4.99 (dd, $^3J_{1/2} = 10.2$ Hz, $^3J_{2/3} = 8.6$ Hz, 1H, H-2), 4.88 (d, 1H, H-1), 4.20 (dd, $^3J_{5/6a} = 5.9$ Hz, $^3J_{6a/6b} = 12.5$ Hz, 1H, H-6a), 4.07 (dd, $^3J_{5/6a} = 2.5$ Hz, 1H, H-6b), 3.65 (ddd, 1H, H-5), 3.57–3.48 (m, 3H, H-3, OCH_2), 2.10, 2.07, 2.05 (3 s, 3 × 3H, acetyl-CH_3), 1.43–1.23 (m, 20H, 10 CH_2), 0.86 (t, 3H, CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 170.7$, 169.2, 169.1 (3 s, C=O), 81.5 (s, C-3), 81.0 (m, C-1), 76.6 (s, C-5), 72.9 (s, OCH_2), 70.5, 69.2 (2 s, C-2, C-4), 62.1 (s, C-6), 31.9, 30.2, 29.6, 29.6, 29.6, 29.4, 29.3, 25.9, 22.7 (9 s, CH_2), 20.7, 20.6, 20.5 (3 s, 3 acetyl-CH_3), 14.1(s, alkyl-CH_3); ^{19}F NMR (235 MHz, $CDCl_3$): $\delta = -80.5$ (t, $^3J_{F/F} = 11$ Hz, CF_3), −85.0 to −86.00 (m, $^2J_{F\alpha1/F\alpha2} = 240$ Hz, $^3J_{F/F} = 14$ Hz, SCF_{2a}), −88.2 to −89.2 (m, $^3J_{F/F} = 14$ Hz, SCF_{2b}), −118.0 to −119.6 (m, CF_2), −121.1 (s, CF_2), −122.5 (s, CF_2), −125.8 (s, CF_2). $C_{30}H_{41}F_{13}O_8S$ (808.7): Calc. C 44.6, H 5.1; Found C 44.6, H 5.2.

6: ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 5.07$ (dd, $^3J_{3/4} = 9.5$ Hz, $^3J_{4/5} = 10.0$ Hz, 1H, H-4); 5.00 (t, $^3J_{1/2} = {}^3J_{2/3} = 10.0$ Hz, 1H, H-2); 4.54 (d, $^3J_{1/2} = 10.0$ Hz, 1H, H-1); 4.28 (dd, $^3J_{5/6a} = 5.1$ Hz, $^3J_{6a/6b} = 12.4$ Hz, 1H, H-6a); 4.10 (dd, $^3J_{5/6a} = 2.4$ Hz, 1H, H-6b); 3.63 (ddd, 1H, H-5); 3.54–3.43 (m, 3H, H-3, OCH_2); 2.12, 2.09, 2.06 (3 m, 3 × 3H, acetyl-CH_3); 1.44–1.23 (m, 20H, 10 CH_2); 0.86 (t, 3H, CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 170.7$, 169.5, 169.0 (3 s, C=O); 88.2 (s, C-1); 81.5 (s, C-3); 76.4 (s, C-5); 72.4 (s, OCH_2); 71.05 (s, C-2); 69.4 (s, C-4); 62.1 (s, C-6); 31.9, 30.2, 29.6, 29.5, 29.3, 26.0, 22.7 (7 s, CH_2); 20.8, 20.8, 20.7 (3 s, 3 acetyl-CH_3); 14.1(s, alkyl-CH_3).

MS-eI (70 eV) $m/z = 457$ [(monomer, *M*) − SH]$^+$; MS-FAB (pos. NBA) $m/z = 1001$ $[M + Na]^+$, 457 [(monomer, *M*) − SH]$^+$ $C_{48}H_{82}O_{16}S_2$ (979.3): Calc. C 58.9, H 8.4, S 6.55; Found C 58.7, H 8.4, S 6.4.

4.3. (1,1-Dimethoxy-2,2,3,3,4,4,5,5,6,6,6-undecafluorohexyl) 3-O-dodecyl-1-thio-β-D-glucopyranoside (7) and methyl 3-O-dodecyl-β-D-glucopyranoside (8)

A solution of **5** (800 mg, 0.99 mmol) in 15 ml of a methanolic solution of sodium methanolate (1%) was stirred at RT with exclusion of moisture. After about 1 h (no starting material was detectable by TLC), the solution was neutralized with an acidic ion exchanger (Amberlite IR 120). After filtration and concentration of the solution under reduced pressure, the products were separated by column chromatography with gradient eluation (heptane/EtOAc 1:1 v/v 500 ml; 1:2 v/v 300 ml; 1:3 v/v 300 ml; 1:5 v/v). Thus, 120 mg (17%) of compound **7** ($R_f = 0.49$, heptane/EtOAc 1:1 v/v), colorless crystals, mp 106 °C (MeOH/H_2O); $[\alpha]_D^{22}$ +1.3° (MeOH, $c = 1.08$) and 209 mg (58%) of compound **8** ($R_f = 0.50$, heptane/EtOAc 1:1 v/v) were isolated. The latter was peracetylated to methyl 2,4,6-tri-*O*-acetyl-3-*O*-dodecyl-β-D-glucopyranoside (**9**) without further purification.

7: ^{1}H NMR (250 MHz, CD_3OD): $\delta = 4.58$ (d, $^3J_{1/2} = 10.0$ Hz, 1H, H-1), 3.89–3.75 (m, 3H, OCH_2, H-6a), 3.64 (dd, $^3J_{5/6b} = 5.0$ Hz, $^3J_{6a/6b} = 12.0$ Hz, 1H, H-6b), 3.58 (s, 6H, OCH_3), 3.38 (dd, $^3J_{2/3} = 8.8$ Hz, 1H, H-2), 3.30–3.12 (m, 3H, H-3, H-4, H-5), 1.63–1.28 (m, 20 H, 10 CH_2), 0.88 (t, 3H, CH_3); ^{13}C NMR (63 MHz, CD_3OD): $\delta = 88.1$ (s, C-3 or C-5), 86.1 (m, C-1), 82.0 (s, C-3 or C-5), 74.6 (s, OCH_2), 74.8 (s, C-4), 71.0 (s, C-2), 62.7 (s, C-6), 54.3 (s, OCH_3), 53.8 (s, OCH_3), 33.1, 31.5 30.9, 30.8, 30.8, 30.5, 27.2, 23.8 (8 s, CH_2), 14.5 (s, alkyl-CH_3); ^{19}F NMR (235 MHz, $CDCl_3$): $\delta = -79.0$ (t, $^3J_{F/F} = 10$ Hz, CF_3), −110.0 to −111.4 (m, $2J_{F\beta1/F\beta2} = 285$ Hz, $^3J_{F/F} = 16$ Hz, β-CF_{2a}), −112.0 to −113.4 (m, $^3J_{F/F} = 16$ Hz, β-CF_{2b}), −117.6 (s, CF_2), −120.3 (s, CF_2), −123.7 (s, CF_2); CIMS, *m/z*: 343 $[(MeO)_2C(CF_2)_4CF_3]^+$. $C_{26}H_{41}F_{11}O_7S$ (706.7): Calc. C 44.2, H 5.85; Found C 44.4, H 5.5.

4.4. Methyl 2,4,6-tri-O-acetyl-3-O-dodecyl-β-D-glucopyranoside (9)

To a solution of **8** (209 mg, 0.58 mmol) in dry pyridine (10 ml) acetic anhydride (10 ml) was added at 0 °C. The resulting mixture was stirred at RT overnight and then poured onto ice water (50 ml) followed by stirring for about

20 min. After extraction with ethyl acetate (twice 20 ml), the combined organic phases were washed with water (20 ml), saturated aqueous $NaHSO_4$ solution (10 ml) and water (20 ml). After drying (Na_2SO_4) the solvent was evaporated under reduced pressure and the solid crude product of **9** was recrystallized from MeOH/H_2O yielding 220 mg (46%) colorless crystals, mp 56–57 °C (MeOH/H_2O); $[\alpha]_D^{22}$ −23.3° (MeOH, $c = 1.08$).

^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 5.04$ (dd, $^3J_{3/4} = {}^3J_{4/5} = 9.8$ Hz, 1H, H-4), 4.95 (dd, $^3J_{1/2} = 7.9$ Hz, $^3J_{2/3} = 9.5$ Hz, 1H, H-2), 4.31 (d, 1H, H-1), 4.21 (dd, $^3J_{5/6a} = 4.9$ Hz, $^2J_{6a/6b} = 12.3$ Hz, 1H, H-6a), 4.11 (dd, $^3J_{5/6b} = 2.6$ Hz, 1H, H-6b), 3.57 (ddd, 1H, H-5), 3.53–3.46 (m, 6H, H-3, OCH_3, OCH_2), 2.08, 2.07, 2.06 (3s, 3 × 3H, acetyl-CH_3), 1.43–1.23 (m, 20H, 10 CH_2), 0.86 (t, 3H, CH_3); ^{13}C NMR (63 MHz, $CDCl_3$): $\delta = 170.8$, 169.2, 169.2 (3 s, 3 C=O), 101.8 (s, C-1), 80.3, 72.3, 72.1, 69.5 (4 s, C-2, C-3, C-4, C-5), 72.1 (s, OCH_2), 62.3 (s, C-6), 56.7 (s, OCH_3), 31.9, 30.2, 29.6, 29.6, 29.6, 29.5, 29.3, 26.0, 22.7 (9 s, alkyl-CH_2), 20.9, 20.8, 20.8 (3 s, acetyl-CH_3), 14.1 (s, alkyl-CH_3); CIMS, *m/z*: 457 $[M - OCH_3]^+$; FAB-MS, *m/z*: 489 $[M]^+$, 457 $[M - OCH_3]^+$. $C_{25}H_{44}O_9$ (488.6): Calc. C 61.45, H 9.1; Found C 61.15, H 9.3.

4.5. Perfluorohexyl 2-O-acetyl-3-O-dodecyl-1-thio-β-D-glucopyranoside (*10*)

To a solution of compound **5** (350 mg, 0.43 mmol) in dry methanol (10 ml) 56 mg of CsF/Al_2O_3 ($c(F^-)$ = 1.533 mmol/g) were added and the mixture was stirred for 2 h at RT under exclusion of moisture. After completion of the reaction, the suspension was filtered and aluminia was washed with a small volume of methanol. The combined filtrates were concentrated under reduce pressure and the solid residue was recrystallized from MeOH/H_2O yielding 272 mg (87%) of **10**, colorless crystals, mp 108 °C (MeOH/H_2O), $[\alpha]_D^{21}$ +0.2° (MeOH, $c = 1.11$).

^{1}H NMR (500 MHz, CD_3OD): $\delta = 5.13$ (d, $^3J_{1/2} = 10.4$ Hz, 1H, H-1), 4.81 (dd, $^3J_{2/3} = 9.1$ Hz, 1H, H-2), 3.84–3.80 (m, 2H, H-6a, OCH_{2a}), 3.70 (dd, 1H, $^3J_{5/6a} = 5.0$ Hz, $^2J_{6a/6b} = 12.3$ Hz, 1H, H-6b), 3.60 (m, 1H, OCH_{2b}), 3.54 (m, 1H, H-4), 3.47 (m, 1H, H-3), 3.40 (ddd, $^3J_{4/5} = 9.5$ Hz, $^3J_{5/6a} = 2.2$ Hz, $^3J_{5/6b} = 4.7$ Hz, 1H, H-5), 2.08 (s, 3H, acetyl-CH_3), 1.55–1.28 (m, 20H, 10 CH_2), 0.89 (t, 3H, CH_3); ^{13}C NMR (63 MHz, CD_3OD): $\delta = 171.2$ (s, C=O), 85.2 (s, C-3), 82.6 (s, C-5), 82.2 (m, C-1), 74.4 (s, OCH_2), 72.4 (s, C-2), 70.7 (s, C-4), 62.1 (s, C-6), 31.4, 30.8, 30.8, 30.8, 30.7, 30.5, 27.2, 23.7 (8s, CH_2), 20.9 (s, acetyl-CH_3), 14.5 (s, alkyl-CH_3); ^{19}F NMR (235 MHz, $CDCl_3$): $\delta = -79.0$ (t, $^3J_{F/F} = 10$ Hz, CF_3), −82.4 to −83.5 (m, $^2J_{F\alpha1/F\alpha2} = 240$ Hz, $^3J_{F/F} = 13$ Hz, SCF_{2a}), −85.3 to −86.4 (m, $^3J_{F/F} = 14$ Hz, SCF_{2b}), −117.5 (m, CF_2), −118.9 (s, CF_2), −120.4 (s, CF_2), −123.9 (s, CF_2); FAB-MS, *m/z*: 747 $[M + Na]^+$, 373 $[M - SC_6F_{13}]^+$. $C_{26}H_{37}F_{13}O_6S$ (724.6): Calc. C 43.1, H 5.15; Found C 43.1, H 5.2.

4.5.1. Preparation of aluminia supported cesium fluoride analogously to [13]

To a solution of 10 g (65.8 mmol) of cesium fluoride in 100 ml water 32.9 g of aluminia (ICN Aluminia N – Super I) were added. After shaking the mixture for a short time the solvent was removed under reduced pressure and the residue was dried for 2 h at 60–75 °C/1 mbar.

4.6. Perfluorohexyl 3-O-dodecyl-1-thio-β-D-glucopyranoside (*11*)

To stirred suspension of **5** (500 mg, 0.617 mmol) in dry methanol (15 ml), potassium *tert*-butanolate (23 mg, 0.206 mmol) was added and the mixture was short-time heated to 35–40 °C and stirring was continued for 45 min at RT. Then, the solution was neutralized by a H^+ resin, filtered and concentrated under reduced pressure. After column chromatographic purification (toluene/EtOAc 3:1 v/v) 84 mg (20%) of **11** ($R_f = 0.22$) were isolated as colorless crystals: mp 86–88 °C (MeOH/H_2O); $[\alpha]_D^{23}$ −20.1° (MeOH, $c = 0.33$).

^{1}H NMR (250 MHz, CD_3OD): $\delta = 4.92$ (d, $^3J_{1/2} = 9.9$ Hz, 1H, H-1), 4.81 (dd, $^3J_{2/3} = 9.1$ Hz, 1H, H-2), 3.86–3.76 (m, 3H, H-6a, OCH_2), 3.68 (dd, $^3J_{5/6b} = 4.6$ Hz, $^3J_{6a/6b} = 12.0$ Hz, 1H, H-6b), 3.44 (m, 1H, H-3), ≈3.35 (ddd, H-5),[1] 1.67–1.28 (m, 20H, 10 CH_2), 0.89 (t, 3H, CH_3); ^{13}C NMR (63 MHz, CD_3OD): $\delta = 87.8$ (s, C-3), 85.0 (m, C-1), 82.4 (s, C-4 or C-5), 74.8 (s, OCH_2), 73.6, 70.5 (2 s, C-2, C-4 or C-5), 62.3 (s, C-6), 31.4, 30.9, 30.8, 30.8, 30.5, 27.2, 23.8 (7 s, CH_2), 14.5 (s, CH_3); ^{19}F NMR (235 MHz, CD_3OD): $\delta = -79.0$ (t, $^3J_{F/F} = 10$ Hz, CF_3) −81.1 to −82.3 (m, $^2J_{F\alpha1/F\alpha2} = 240$ Hz, $^3J_{F/F} = 14$ Hz, SCF_{2a}), −85.2 to −86.3 (m, $^3J_{F/F} = 15$ Hz, SCF_{2b}), −117.4 (m, CF_2), −118.9 (s, CF_2), −120.4 (s, CF_2), −123.9 (s, CF_2). $C_{24}H_{35}F_{13}O_5S$ (682.6): Calc. C 42.2, H 5.2; Found C 42.3, H 4.9.

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