Synthesis of Dihydrodiosgenin Glycosides as Mimetics of Bidesmosidic Steroidal Saponins

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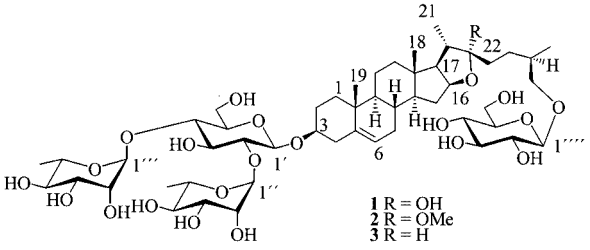
The focus of this work is the synthesis of bidesmosidic saponin mimetics. Therefore, dihydrodiosgenin derivatives, which differ from the natural compounds by reduction of the 22-(hemi) acetal were used as glycosyl acceptors. In preliminary studies, the dihydrodiosgenin glycosides **16**, **17** and **19**, as well as trisaccharide **22**, were synthesized. The acceptors **10** and **14** were subjected to DMTST-mediated glucosylation for the synthesis of the chacotriose-substituted compound **3**. For a selective 2,4-di-rhamnosylation of the dihydrodiosgenin glucopyranoside, differentiation of the glucose OH groups was achieved by selective benzoylation with 1-(benzoyloxy)benzotriazole. Reaction of the 3,6-di-*O*-benzoate **32** with the perbenzoylated ethyl thiorhamnopyranoside donor **15** gave the 2,4-di-rhamnosylated compound **33**, together with the mono-rhamnosylated derivative.

Introduction

The structurally diverse family of saponins, which are found in plants, is of increasing interest, due to their manifold biological activities. Many formulations of traditional medicine appear to contain such compounds as active components, and systematic screening of saponin-rich plant material offers access to saponin libraries. However, it is often the case that only small amounts of compound are available by isolation from natural sources. Thus, their synthesis from commercially or easily available starting materials is an interesting alternative.

The naturally occurring bidesmosidic saponins **1** (GI_{50} = 1.53−1.86 μg/mL, IC_{50} = 2.7 μM, K562 cell line)[1,2] and **2** (IC_{50} = 29 μM, HL-60 cell line)[3] were recently demonstrated to show promising cytostatic activity. These molecules have enhanced lability, due to their hemiacetal or acetal functionalities, respectively. In connection with various more general approaches to such complex glycoconjugate structures, we were interested in the synthesis of more stable cyclic ether mimetics, such as **3**, containing the easily-available dihydrodiosgenin moiety. In this compound, the furostenol aglycon is substituted at position 3β by 2,4-di-*O*-(α-L-rhamnopyranosyl)-β-D-glucopyranose (chacotriose) and at position 26 by β-D-glucopyranose. Preliminary work in this field,[4,5] and an effective synthesis of **3** have been reported previously.[6] The aim of this work was to apply an alternative, more general, synthetic pathway to target structure **3** and its derivatives, as well as other dihydrodiosgenin glycosides, in particular, by altering the glycosylation sequence, and through the use of benzoyl protecting groups. In contrast, the pathway to 22-methyl acetal furostan sapogenins[7] and saponins is very complex, and requires many more steps, as recently shown in the synthesis of a 3,26-diglucopyranosyl derivative[8] and in the total synthesis of **2**.[9]



Results and Discussion

The present approach towards the formation of **3** and other dihydrodiosgenin glycosides utilises thioglycosides as donors. These compounds allow a flexible synthesis and are stable to many protecting group manipulations.[10] Silyl and *p*-methoxybenzyl ethers were selected as orthogonal protecting groups, allowing selective cleavage in the presence of acyl protecting groups on the sugar and the double bond of the steroid moiety. Commercially available diosgenin **4**

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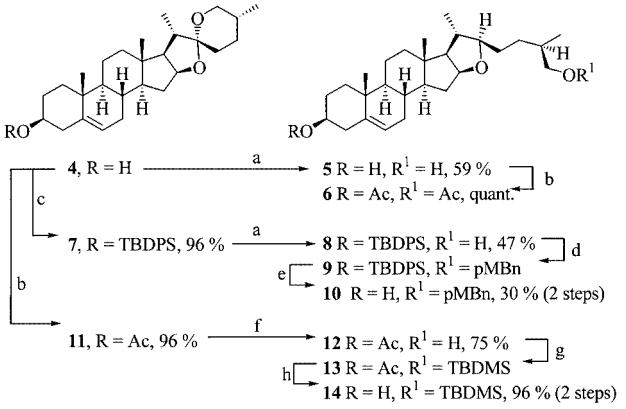
was used as the starting material for the steroid-acceptor synthesis. This compound leads to differentially protected dihydrodiosgenin derivatives via reductive spiroketal-opening. Crucial to the synthesis was the final introduction of the 26-*O*-β-D-glucopyranose, and therefore a 26-*O*-protected 3β-hydroxy steroid acceptor was necessary. This steroid acceptor in turn was glycosylated at the 3-position en route to the construction of the chacotriose moiety.

Synthesis of Steroid Acceptors

The ring-opening reaction of the protected and unprotected spiroketals **4**, **7** and **11** (Scheme 1) led to a 3β,26-dihydroxy furosten (dihydrodiosgenin, **5**)[11,12] and its 3β-protected derivatives. In order to differentiate between the two hydroxy groups in **5**, the 3β position of the diosgenin **4** was protected first, so that only the 26-OH group was free after the ring-opening reaction. Two different ring-opening reactions were applied to diosgenin **4**, and its derivatives **7**[13] and **11**. Whereas **4** and **7** were opened by the classic $LiAlH_4/AlCl_3$ procedure to give **5**[11,12] or **8**, respectively, optimal ring-opening of **11** to give **12** was achieved using sodium cyanoborohydride in acetic acid.[14]

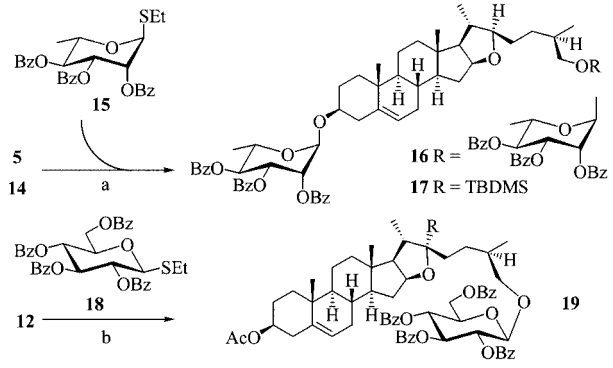


Scheme 1. a: $LiAlH_4/AlCl_3/Et_2O$; b: Ac_2O, pyridine; c: TBDPSCl, imidazole, DMF; d: pMBnCl, NaH, DMF; e: TBAF, THF; f: AcOH, $NaBH_3CN$; g: TBDMSCl, pyridine; h: NaOMe, MeOH

The 3β-hydroxy-26-protected compounds **10** and **14** were obtained via a protection/deprotection sequence from **8** and **12** respectively. The 3β-*O*-TBDPS derivative **8** was converted to the 26-*O*-*p*-methoxybenzyl derivative **10**, whereas **12** was converted into the *tert*-butyldimethylsilyl- (TBDMS) protected **14**. In summary, the best sequence resulted in an overall yield of 69% of **14** from diosgenin **4**.

Mono- and Diglycosylation of Steroid Acceptors

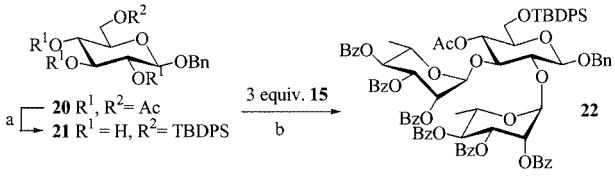
In preliminary studies, the acceptors **5**,[11,12] **12** and **14** were glycosylated (Scheme 2). Employing the benzoylated thiorhamnopyranoside **15**[15] and thioglucopyranoside **18**[16,17] as donors, the mono- or diglycosylated steroid derivatives **16**, **17** and **19** were obtained. Apparently, due to the solubility of the promoter dimethyl(methylthio)sulfoniumtriflate (DMTST) in dichloromethane, the reaction conditions were too vigorous, giving a poor yield in the glucosylation of **12**. Diethyl ether was selected as more appropriate solvent, and rhamnosylation of **5** and **12** was achieved, giving **16** and **17** in 66 and 36% yields, respectively. It may be possible to optimize this latter yield.



Scheme 2. a: DMTST, 4-Å mol. sieves, Et_2O argon, 6 h, room temp.; b: DMTST, 4-Å mol. sieves,CH_2Cl_2, argon, 4.5 h, room temp.

Regioselective 2,3-Dirhamnosylation of 1,6-Protected Glucopyranose

Attempts to achieve the 2,4-diglycosylation pattern by a regioselective rhamnosylation using the 6-protected model acceptor **21**[18] led to the 2,3-dirhamnosylated compound **22** in good yield. Apparently, the 4-OH position of the glucose acceptor showed considerably lower reactivity (Scheme 3).

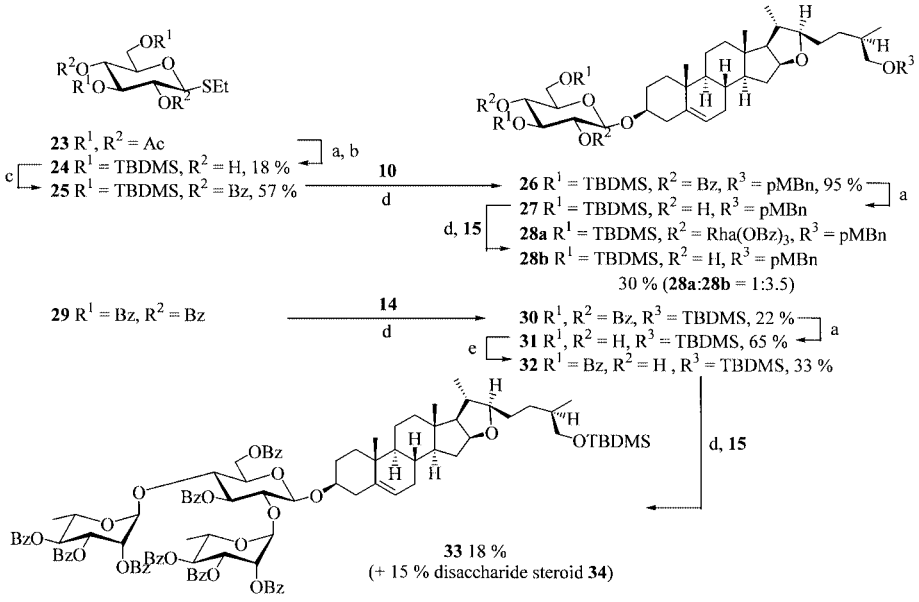


Scheme 3. a: 1) NaOMe, MeOH, 2) TPBPSCl, pyridine, DMAP, 47%; b: 1) DMTST, Et_2O, 4-Å mol. sieves, 2) Ac_2O, pyridine, 60%

Synthesis of Chacotriosyl Dihydrodiosgenin Derivatives

Two approaches to the synthesis of a chacotriose dihydrodiosgenin derivative, using different protecting groups and regioselectivity strategies, were followed (Scheme 4). As mentioned earlier, the main difficulty lies in the differentiation of the equatorial 2-, 3- and 4-positions of the glucose moiety.

One of the pathways investigated employed a predominantly 3,6-selective silylation[19] of β-D-thioglucopyranoside **23**, followed by separation of the regioisomers and 2,4-benzoylation to give **25**. This donor reacted with the *p*-methoxybenzyl-protected steroid acceptor **10** under DMTST-mediated activation to give the steroid glucopyranoside **26** in high yield. Due to steric hindrance of the bulky TBDMS groups, the subsequent debenzoylation under Zémplen conditions was rather difficult. Even more difficult was the 2,4-di-rhamnosylation using the thioglycoside donor **15**[15] with DMTST-mediated activation in diethyl ether under anhydrous conditions. An inseparable mixture of the chacotriose



Scheme 4. a: NaOMe/MeOH; b: TBDMSCl, NEt3, DMAP, DMF, 48 h, room temp.; c: benzoyl chloride, pyridine, DMAP, 0 °C → room temp., 5 d; d: DMTST, Et_2O, 4-Å mol. sieves, argon or N_2; e: 1-BBTZ, NEt_3, CH_2Cl_2

substituted steroid **28a** and the 2-rhamnopyranosylated steroid glucopyranoside **28b** was obtained.

In view of these difficulties, an alternative, improved pathway was followed. This time, the differentiation of the glucose positions was achieved at the level of the steroid glucopyranoside. Thus, the silylated steroid acceptor **14** was glucosylated employing the benzoylated thioglucopyranoside **29**[16,17] under DMTST-mediated conditions. The glucosteroid **30** thus obtained was debenzoylated under Zémplen conditions.

Pelyvás et al.[20] reported the 3,6-selective benzoylation of β-D-glucopyranosides by in situ generated 1-benzoyloxybenzotriazole (1-BBTZ).[21−23] In our system, it appeared to be better to prepare the pure 1-BBTZ first, and then apply it to the selective benzoylation of **31**. By this method, the formation of aromatic by-products was avoided, and better reaction control was obtained. By this procedure, compound **32** was obtained in 33% yield, along with small amounts of easily separable mono- and tri-benzoylated by-products.

Following rhamnosylation with **15**[15] under DMTST-mediated conditions, the chacotriosyl steroid **33** was obtained, again together with the 2-monorhamnoside **34**. This compound **33** represents a precursor en route to the 26-*O*-glucosylated target structure **3**. Further studies to complement this synthetic part will be reported in due course.

Conclusion

The syntheses of oligosaccharide mimetics of promising cytostatic bidesmosidic saponins was achieved. Selectively protected steroid derivatives were prepared for use as acceptors in the glycosylation reactions. DMTST-activated glycosylation of thioglycoside donors then gave the target structures.

Experimental Section

General Remarks: Thin-layer chromatography was carried out on pre-coated plates of silica gel 60 (F_{254}, Merck) with detection by UV absorption or spraying with 20% ethanolic sulfuric acid and subsequent heating. Column chromatography was performed by the flash technique on silica gel 60 (230−400 mesh, 40−63 μm) by Merck, Machery-Nagel or ICN using the given solvents as eluents (PE = petroleum ether, EA = ethyl acetat). NMR spectra were recorded with the Bruker spectrometers AMX-400 (400 MHz ^1H, 100.67 MHz ^{13}C) and DRX-500 (500 MHz ^1H, 125.77 MHz ^{13}C). As internal standard, tetramethylsilane (δ = 0.00 ppm) was added, or, especially for silylated compounds, the solvent residual peak was used.[24] Mass spectra were recorded with a Bruker Biflex™ III MALDI-TOF-Mass spectrometer (*positive reflector mode,* Matrix: DHB = dihydroxybenzoic acid).[25] Melting points were determined on a Olympus BH polarising microscope with a Mettler FP82 heating desk, or an Apotec melting point apparatus and are not corrected. Optical rotations were determined with a Perkin−Elmer 241 PE polarimeter (Na_D = 589 nm). Elemental analysis were performed in the microanalytical laboratory of the Institute of Organic Chemistry of the University of Hamburg. Solvents for reactions were distilled or dried before use. Dichloromethane (CaH_2) and diethyl ether (sodium wire/benzophenone) for glycosylation reactions were dried freshly under argon before use or stored over 4-Å mol. sieves. Methanol was dried by refluxing over magnesium and subsequent distillation and stored over 3-Å mol. sieves. Commercially available anhydrous acetonitrile, anhydrous pyridine and anhydrous DMF (Fluka) were used. Reagents were used with the available purity offered by the producer. DMTST was synthesized by a modified method according to the literature[26] and stored under argon with strict exclusion of moisture at ca. −15 °C. It was warmed to room temperature before use. Reac-

tions in inert gas atmosphere were performed under slight over pressure of argon or nitrogen by the Schlenk or balloon technique in glassware which was heated under vacuum before use.[27] Molecular sieves were activated under high vacuum at ca. 130−250 °C for several hours (usually overnight), cooled under slight over pressure of argon or nitrogen and used freshly activated.

General Procedure (GP). 1,2-*trans*-Selective Glycosylation with 2-*O*-Acylated Thioglycosides by DMTST Activation: A donor/acceptor ratio was chosen according to how valuable the compounds are deemed to be. Generally, an excess of donor (1.2−1.5 equiv.) is preferable. About 0.05 to 5 mmol donor and acceptor were placed in a 25 to 100 mL round-bottomed flask, and, especially for syrupy compounds, were co-distilled three times with dry toluene. The round-bottomed flask was flushed with argon and filled to about 3/4 with fresh anhydrous diethyl ether or diethyl ether/dichloromethane, 10:1. About 500 mg freshly activated molecular sieves per 0.1 mmol donor/acceptor were added, and the flask was closed with a rubber septum or a nitrogen tap and equipped with an argon-filled balloon. The mixture was stirred for 1 h at room temperature. Then 3 equiv. DMTST per 1 equiv. donor were added. The reaction was stirred for about 1 to 4 h at room temperature and monitored by TLC. For work-up, about 3 equiv. triethylamine per 1 equiv. DMTST were added, and the mixture was stirred for 10 min. Large-scale reaction mixtures were filtered through Celite, evaporated to dryness and the products isolated by chromatography. For small-scale reactions, a suitable amount of silica gel was added, the mixtures evaporated to dryness, and the so-obtained powders poured directly onto pre-packed columns of silica gel and purified by chromatography.

(22*R*,25*R*)-3β-*O*-*tert*-Butyldiphenylsilyloxy-26-hydroxy-5-furosten (8): Lithium aluminium hydride (877 mg, 23.0 mmol) was placed into a 500-mL three-neck round-bottomed flask, equipped with condenser, dropping funnel and N_2-tap, and dissolved in anhydrous diethyl ether (100 mL) under argon. $AlCl_3$ (12.32 g, 92 mmol) was dissolved in anhydrous diethyl ether (100 mL), added cautiously (*vigorous reaction!*) to the first solution dropwise and the mixture stirred for 30 min at room temperature. **7**[13] (1.509 g, 2.31 mmol) was dissolved in anhydrous diethyl ether (100 mL) and added through another dropping funnel. The reaction was monitored by TLC, and quenched by the addition of water (50 mL). 2 N hydrochloric acid (100 mL) was added and the ether phase was separated. The aqueous phase was extracted four times with diethyl ether (200 mL). The combined ether phases were washed three times with sodium hydrogen carbonate solution (200 mL) and dried over sodium sulfate. After flash chromatography, compound **8** (718 mg, 1.10 mmol, 47%) was obtained. Colourless solid, $C_{43}H_{62}O_3Si$ (mol. mass 655.036 g/mol), m.p. 63.5−64.1 °C, $[\alpha]_D^{20}$ = −46.5 (*c* = 1, $CHCl_3$), TLC (PE/EA, 3:1): R_f = 0.22, (PE/EA, 10:1): R_f = 0.07 (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.70−7.63 (m, 4 H, *o*-SiPh_2tBu), 7.45−7.32 (m, 6 H, *m*/*p*-SiPh_2tBu), 5.11 (br. d, 1 H, H-6, $^3J_{6,7a}$ = 4.8 Hz), 4.28 (m, 1 H, H-16), 3.57−3.40 (m, 3 H, H-3, H-26a, H-26b), 3.31 (m, 1H H-22), 2.33 (m, 2 H, H-4), 1.08 (s, 9 H, *t*BuPh_2Si), 1.00, 0.78 (je s, je 3 H, CH_3-18, CH_3-19), 0.98 (d, 3 H, CH_3-21, $^3J_{21,20}$ = 6.4 Hz), 0.92 (d, 3 H, CH_3-27, $^3J_{27,25}$ = 6.6 Hz), 2.02−1.04 (m, steroid H) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 141.29 (C-5), 135.77 (*o*-SiPh_2tBu), 134.82, 134.76 (*q*-SiPh_2tBu), 129.45, 129.41 (*p*-SiPh_2tBu), 127.46−127.43 (*m*-SiPh_2tBu), 120.88 (C-6), 90.34 (C-22), 83.23 (C-16), 73.19 (C-3), 68.05 (C-26), 37.90 (C-20), 40.67, 36.60 (C-10, C-13), 27.00 [(CH_3)CSi], 19.43 [(CH_3)*C*Si], 19.13, 18.90, 16.61, 16.42 (CH_3-18, -19, -21, -27), 32.20, 31.96, 31.85, 31.72, 30.63 30.41, 30.11, 20.63 (CH_2-1, -2, -4, -7, -11, -12, -15, -23, -24) 65.06, 56.98, 50.01, 35.71, 31.54 (CH-8, -9, -14, -17, -25) ppm.

(22*R*,25*R*)-3β-*O*-*tert*-Butyldiphenylsilyloxy-26-*p*-methoxybenzyloxy-5-furosten (9): Compound **8** (630 mg, 0.96 mmol) was dissolved under argon in anhydrous DMF (5 mL) in a 100-mL round-bottomed flask with condenser. The mixture was cooled in an ice-bath and sodium hydride (46 mg, 1.92 mmol) was added cautiously in small portions. The slightly yellow, foamy solution was stirred for 2.5 h. The mixture was again cooled in an ice-bath and *p*-methoxybenzyl chloride (0.16 mL, 181 mg, 1.15 mmol) was added. After stirring for 21 h under which time the temperature rose from 0 °C to room temperature, the reaction was quenched by the addition of methanol (0.5 mL). After a further 15 min stirring, the mixture was concentrated. After flash chromatography with PE/EA, 10:1, the product was directly converted into **10**. Colourless solid, $C_{51}H_{70}O_4Si$ (mol. mass 775.185 g/mol), m.p. 77.4 °C, $[\alpha]_D^{20}$ = −38.7 (*c* = 1, $CHCl_3$). TLC (PE/EA, 10:1): R_f = 0.30 (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.70−7.62 (m, 4 H, *o*-SiPh_2tBu), 7.44−7.31 (m, 6 H, *m*/*p*-SiPh_2tBu), 7.23, 6.88 (2 × m ≈ d, 2 × 2 H, $CH_3OC_6H_4CH_2O$, ^3J = 11.2 Hz), 5.12 (br. d, 1 H, H-6, $^3J_{6,7a}$ = 5.1 Hz), 4.42, 4.40 (2 × d, 2 × 1 H, $CH_3OC_6H_4CH_2O$, ^3J = 11.7 Hz), 4.27 (m, 1 H, H-16), 3.79 (s, 3 H, $CH_3OC_6H_4CH_2O$), 3.51 (m, 1 H, H-3),3.33−3.26 (m, 2 H, H-22, H-26a), 3.22 (dd, 1 H, H-26b, $^3J_{25,26b}$ = 6.6, 9.2 Hz), 2.33, 2.14 (2 × m, 2 × 2 H, H-4a, H-4b), 1.04 (s, 9 H, *t*BuPh_2Si), 0.99, 0.77 (je s, je 3 H, CH_3-18, -19), 0.96 (d, 3 H, CH_3-21, $^3J_{21,20}$ = 6.4 Hz), 0.91 (d, 3 H, CH_3-27, $^3J_{27,25}$ = 6.6 Hz), 2.00−0.72 (m, steroid H) ppm. ^{13}C NMR (125.77 MHz, $CDCl_3$): δ = 159.44, 131.30 ($CH_3OCC_4H_4CCH_2O$), 141.70 (C-5), 136.16 (*o*-SiPh_2tBu), 135.23 (*q*-SiPh_2tBu), 129.83, 129.52 (*p*-SiPh_2tBu), 129.80, 114.11 ($CH_3OCC_4H_4CCH_2O$), 127.85−127.82 (*m*-SiPh_2tBu), 121.29 (C-6), 90.73 (C-22), 83.54 (C-16), 76.05 (C-26), 73.60 (C-3), 73.05 ($CH_3OC_6H_4CH_2O$), 55.65 ($CH_3OC_6H_4CH_2O$), 42.85 (C-4), 41.06, 37.00 (C-10, C-13), 27.39 [(CH_3)CSi], 19.81, 16.79 (CH_3-18, -19), 19.53 (CH_3-21), 19.40 [(CH_3)*C*Si], 17.46 (CH_3-27), 39.85, 37.60, 32.37, 32.25, 31.96, 21.03 (CH_2-1, -2, -4, -7, -11, -12, -15, -23, -24) 64.44, 57.37, 50.43, 30.97, 38.26, 34.13 (CH-8, -9, -14, -17, -20, -25) ppm.

(22*R*,25*R*)-3β-Hydroxy-26-*p*-methoxybenzyloxy-5-furosten (10): Compound **9** (see above) was dissolved in wet THF (20 mL) in a 50 mL round-bottomed flask, and a 1 M solution of tetrabutylammonium fluoride in THF (400 μL) was added. After 3 days stirring at room temperature, an acceptable conversion was determined by TLC (PE/EA, 3:1). The reaction solvents were evaporated and the residue wastaken up in ethyl acetate and washed once with saturated sodium hydrogen carbonate solution and once with NaCl solution. After drying over $MgSO_4$, filtration, evaporation and flash chromatography with PE/EA, 5:1, compound **10** (132 mg, 0.25 mmol, 30% over two steps) was obtained. Colourless solid, $C_{35}H_{52}O_4$ (mol. mass 536.785 g/mol), m.p. 82.7−82.9 °C, $[\alpha]_D^{20}$ = −37.6 (*c* = 0.2, $CHCl_3$). TLC (PE/EA, 3:1): R_f = 0.14 (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.25, 6.86 (2 × m, 2 × 2 H, $CH_3OC_6H_4CH_2O$), 5.34 (br. d, 1 H, H-6, $^3J_{6,7a}$ = 5.5 Hz), 4.44, 4.40 (2 × d, 2 × 1 H, $CH_3OC_6H_4CH_2O$, ^3J = 11.7 Hz), 4.29 (ddd ≈ dt, 1 H, H-16, ^3J = 5.1, 7.7 Hz), 3.80 (s, 3 H, $CH_3OC_6H_4CH_2O$), 3.51 (m, 1 H, H-3), 3.33−3.26 (m, 2 H, H-22, H-26a), 3.22 (dd, 1 H, H-26b, $^3J_{25,26b}$ = 6.8, 9.0 Hz), 1.02, 0.80 (je s, je 3 H, CH_3-18, -19), 0.98 (d, 3 H, CH_3-21, $^3J_{21,20}$ = 6.6 Hz), 0.92 (d, 3 H, CH_3-27, $^3J_{27,25}$ = 6.4 Hz), 2.27−0.82 (m, steroid H) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 158.99, 130.92 ($CH_3OCC_4H_4CCH_2O$), 140.80 (C-5), 129.15, 113.77 ($CH_3OCC_4H_4CCH_2O$), 121.49 (C-6), 90.47 (C-22), 83.29 (C-16), 75.81 (C-26), 72.82 (C-3), 71.88 ($CH_3OC_6H_4CH_2O$), 55.46 ($CH_3OC_6H_4CH_2O$), 42.52 (C-4), 40.93,

36.87 (C-10, C-13) 19.71, 16.73 (CH_3-18, -19), 19.33 (CH_3-21), 17.38 (CH_3-27), 39.71, 38.14, 32.53, 32.27, 31.89, 31.26, 31.01, 21.00 (CH_2-1, -2, -7, -11, -12, -15, -23, -24) 65.40, 57.18, 50.33, 37.51, 31.87, 34.00 (CH-8, -9, -14, -17, -20, -25) ppm.

(22*R*,25*R*)-3β-*O*-Acetyldihydrodiosgenin, 3β-Acetoxy-26-hydroxy-5-furosten (12): 3β-*O*-Acetyldiosgenin (**11**, 3.24 g, 70.9 mmol) was suspended in glacial acetic acid (50 mL) in a 100 mL round-bottomed flask. $NaBH_3CN$ (579 mg, 92.2 mmol) was added cautiously (*gas production!*). The reaction was monitored by TLC with toluene/acetone, 10:1 [R_f (**11**) = 0.80]. After 24 h of stirring at room temperature, the reaction mixture was cautiously neutralized with saturated Na_2CO_3 solution and extracted three times with dichloromethane. The organic phase was dried over magnesium sulfate and the solvents evaporated. After flash chromatography with toluene/acetone, 10:1, compound **12** (2.43 g, 5.29 mmol, 75%) was obtained. Colourless solid, $C_{29}H_{46}O_4$ (mol. mass 458.673 g/mol), m.p. 108.3−108.6 °C, $[\alpha]_D^{20} = -57.3$ (c = 0.7, $CHCl_3$), ref.[12] (no data given). TLC (toluene/acetone, 10:1): R_f = 0.20 (H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.37 (br. d, 1 H, H-6, J = 4.1 Hz), 4.60 (m, 1 H, H-3), 4.31 (ddd ≈ q, 1 H, H-16, ^3J = 7.6, 5.4 Hz), 3.50 (dd, 1 H, H-26a, $J_{25,26a}$ = 6.3, $^3J_{26a,b}$ = 10.7 Hz), 3.45 (dd, 1 H, H-26b, $J_{25,26b}$ = 6.0, $^3J_{26a,b}$ = 10.7), 3.33 (ddd ≈ dt, 1H H-22, ^3J = 3.8, 8.2 Hz), 2.35−2.29 (m, 2 H, H-4a, H-4b), 2.03 (s, 3 H, CH_3COO), 1.03, 0.81 (je s, je 3 H, CH_3-18, -19), 1.00 (d, 3 H, CH_3-21, $^3J_{21,20}$ = 6.9 Hz), 0.92 (d, 3 H, CH_3-27, $^3J_{27,25}$ = 6.6 Hz), 2.02−0.90 (m, steroid H) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 170.68 (CH_3COO), 139.83 (C-5), 122.53 (C-6), 90.51 (C-22), 83.37 (C-16), 74.04 (C-3), 68.22 (C-26), 38.24 (C-4), 38.07 (C-20), 35.86 (C-25), 40.85, 36.85 (C-10, C-13), 21.56 (CH_3COO), 19.46, 16.58 (CH_3-18, -19), 19.04 (CH_3-21), 16.77 (CH_3-27), 39.55, 37.14, 32.36, 31.71, 30.58, 30.29, 27.89, 20.79 (CH_2-1, -2, -7, -11, -12, -15, -23, -24) 65.24, 57.04, 50.15, 32.12 (CH-8, -9, -14, -17) ppm.

(22*R*,25*R*)-3β-Acetoxy-26-*O*-*tert*-butyldimethylsilyloxy-5-furosten (13), (22*R*,25*R*)-26-*O*-*tert*-Butyldimethylsilyloxy-3β-hydroxy-5-furosten (14): Compound **12** (1.59 g, 3.46 mmol) was dissolved in anhydrous pyridine (30 mL) under argon in a 100 mL round-bottomed flask and cooled in an ice bath. *tert*-Butyldimethylchlorosilane (626 mg, 4.15 mmol) was added. The mixture was stirred for 24 h, and monitored by TLC with toluene/acetone, 10:1 [R_f (**12**) = 0.20). For work-up, methanol (0.5 mL) was added, whereupon the product crystallised. The so-obtained crude **13** was dissolved in dichloromethane (5 mL) and methanol (5 mL). The pH was raised to 9.5 by adding solid sodium methoxide, and the reaction mixture was stirred for 16 h at room temperature. Neutralisation was carried out by treatment with Amberlite IR 120 (H^+). After flash chromatography with toluene/acetone, 10:1, **14** (1.77 g, 3.33 mmol, 96%) was obtained.

13: Colourless solid. $C_{35}H_{60}O_4Si$ (572.934): calcd. C 73.37, H 10.56; found C 72.72, H 10.63. M.p. 68.1−68.7 °C, $[\alpha]_D^{20} = -53.7$ (c = 0.6, $CHCl_3$). TLC (toluene/acetone, 10:1): R_f = 0.86 (H_2SO_4). ^{1}H NMR (500 MHz, C_6D_6): δ = 5.29 (br. d, 1 H, H-6, J = 5.0 Hz), 4.84 (m, 1 H, H-3), 4.30 (m, 1 H, H-16), 3.48 (dd, 1 H, H-26a, $^3J_{25,26a}$ = 5.5, $^2J_{26a,26b}$ = 9.6 Hz), 3.45−3.37 (m, 2 H, H-26b, H-22), 2.49 (m, 1 H, H-4a), 2.37 (m, 1 H, H-4b), 1.97 (m, 1 H), 1.88 (m, 1 H), 1.84−0.86 (m, steroid H), 1.76 (s, 3 H, CH_3COO), 1.00 (s, 9 H, *tBu*Me_2Si), 0.99−0.96, 0.89−0.86 (2 × m, 2 × 6 H, CH_3-18, -19, -21, -27), 0.08 (s, 6 H, *t*BuMe_2Si) ppm. ^{13}C NMR (100.61 MHz, C_6D_6): δ = 169.64 (CH_3COO), 139.79 (C-5), 122.77 (C-6), 90.53 (C-22), 83.43 (C-16), 73.94 (C-3), 68.49 (C-26), 38.67 (C-4), 40.90, 36.92 (C-10, C-13), 26.23 [$(CH_3)_3CSi$], 21.04 (CH_3COO), 19.33, 19.22, 17.06, 16.65 (CH_3-18, -19, -21, -27), 18.59 [$(CH_3)_3CSi$], 65.82, 57.18, 50.36, 38.42, 36.28, 31.88 (CH-8, -9, -14, -17, -20, -25), 39.80, 37.29, 32.70, 32.32, 31.61, 30.77, 28.25, 21.02 (CH_2-1, -2, -7, -11, -12, -15, -23, -24), −5.17, −5.19 (*t*BuMe_2Si) ppm.

14: Colourless solid, $C_{33}H_{58}O_3Si$ (mol. mass 530.897 g/mol), m.p. 77.5 °C, $[\alpha]_D^{20} = -45.6$ (c = 0.5, $CHCl_3$). TLC (toluene/acetone, 10:1): R_f = 0.24 (H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 5.35 (br. d, 1 H, H-6, J = 4.7 Hz), 4.30 (m, 1 H, H-16), 3.55−3.42 (m, 2 H, H-3, H-26a), 3.37 (dd, 1 H, H-26b, $J_{25,26b}$ = 6.5, $^3J_{26a,b}$ = 9.6 Hz), 3.31 (m, 1 H, H-22), 2.33−2.19 (m, 2 H, H-4a, H-4b), 1.03, 0.81 (je s, je 3 H, CH_3-18, -19), 0.99 (d, 3 H, CH_3-21, $^3J_{21,20}$ = 6.5 Hz), 0.88 (m, 12 H, *tBu*Me_2Si, CH_3-27), 0.03 (s, 6 H, *t*BuMe_2Si), 2.04−0.86 (m, steroid-H) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 140.94 (C-5), 121.63 (C-6), 90.57 (C-22), 83.44 (C-16), 71.90 (C-3), 68.33 (C-26), 42.43 (C-4), 38.07 (C-20), 36.13 (C-25), 40.85, 36.78 (C-10, C-13), 26.11 [$(CH_3)_3CSi$], 19.56, 16.58 (CH_3-18, -19), 19.23 (CH_3-21), 18.51 [$(CH_3)_3CSi$], 16.88 (CH_3-27), 39.63, 37.42, 32.43, 32.17, 31.22, 30.58, 30.28, 20.86 (CH_2-1, -2, -7, -11, -12, -15, -23, -24) 65.46, 57.14, 50.28, 32.12 (CH-8, -9, -14, -17), −5.19, −5.21 (*t*BuMe_2Si) ppm.

(22*R*,25*R*)-3β-(2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyloxy)-26-(2,3,4-tri-*O*-benzoyl-α-L-rhamnopyranosyloxy)-5-furosten (16): Conversion following GP: **5**[11,12] (70 mg, 0.17 mmol), **15** (219 mg, 0.42 mmol), argon, fresh anhydrous diethyl ether (80 mL), freshly activated 4-Å mol. sieves, 80 min, room temperature, DMTST (325 mg, 1.26 mmol), 6 h. TLC with PE/EA, 3:1 [R_f (**15**) = 0.41] and PE/EA, 1:1 [R_f (**5**) = 0.04, R_f (**15**) = 0.81, R_f (monorhamnosylated) = 0.22, 0.28]. Triethylamine (1 mL), 10 min, filtration through Celite, evaporation to dryness, three times co-distillation with toluene. After flash chromatography with PE/EA, 8:1 → 5:1, **16** (149 mg, 0.11 mmol, 66%) was obtained. Colourless solid, $C_{81}H_{88}O_{17}$ (mol. mass 1333.555 g/mol). TLC (PE/EA, 1:1): R_f = 0.89, (PE/EA, 3:1): R_f = 0.23 (UV, H_2SO_4). ^{1}H NMR (500 MHz, C_6D_6): δ = 8.33−8.27, 8.09−7.98, 7.11−6.72 (m, 30 H, 6 × Bz), 6.45 (dd, 1 H, H-3′, $^3J_{2',3'}$ = 3.6, $^3J_{3',4'}$ = 10.2 Hz), 6.36 (dd, 1 H, H-3′′, $^3J_{2'',3''}$ = 3.5, $^3J_{3'',4''}$ = 10.3 Hz), 6.32−6.21 (m, 2 H, H-4′, H-4′′), 6.20 (dd, 1 H, H-2′, $^3J_{1',2'}$ = 1.8, $^3J_{2',3'}$ = 3.3 Hz), 6.17 (dd, 1 H, H-2′′, $^3J_{1'',2''}$ = 1.8, $^3J_{2'',3''}$ = 3.3 Hz), 5.31 (d, 1 H, H-1′, $^3J_{1',2'}$ = 1.3 Hz), 5.25 (br. d, 1 H, H-6, J = 5.3 Hz), 5.03 (d, 1 H, H-1′′, $^3J_{1'',2''}$ = 1.5 Hz), 4.55 (m, 1 H, H-5′), 4.43 (m, 1 H, H-5′′), 4.35 (ddd ≈ m, 1 H, H-16), 3.56 (m, 1 H, H-3), 3.52 (dd, 1 H, H-26a, $^3J_{25,26a}$ = 6.9, $^2J_{26a,26b}$ = 9.4 Hz), 3.43 (ddd, 1 H, H-22, ^3J = 2.6, 7.9, 8.1 Hz), 3.23 (dd, 1 H, H-26b, $^3J_{25,26b}$ = 5.9, $^2J_{26a,26b}$ = 9.4 Hz), 2.40 (m, 1 H), 2.31 (m, 1 H), 2.05−1.00 (m, steroid H), 1.45 (d, 3 H, H-6′′, $^3J_{5'',6''}$ = 6.4 Hz), 1.43 (d, 3 H, H-6′, $^3J_{5',6'}$ = 6.4 Hz), 0.99−0.89 (m, CH_3-18, -19, -21, -27) ppm. ^{13}C NMR (100.61 MHz, $CDCl_3$): δ = 166.61−166.11 (C_6H_5COO), 140.51 (C-5), 133.61, 133.43, 133.18, 130.54, 130.44, 130.36, 130.29, 130.25, 130.21, 129.07, 128.88, 128.66 (C_6H_5COO), 122.52 (C-6), 98.64 (C-1′′), 96.92 (C-1′), 90.51 (C-22), 83.75 (C-16), 78.70 (C-3), 74.24 (C-26), 72.99, 72.88 (C-4′, C-4′′), 72.44 (C-2′), 71.88 (C-2′′), 71.18 (C-3′, C-3′′), 67.72, 67.67 (C-5′, C-5′′), 66.06 (C-17), 57.53 (C-14), 50.83 (C-9), 38.57, 33.74 (C-8, C-20), 40.12, 39.02, 37.85, 32.95, 32.61, 32.10, 31.45, 31.15, 30.09, 21.38, 20.77 (C-10, C-13, CH_2-1, −2, -4, -7, -11, -12, -15, -23, -24, -25), 18.30, 18.19 (C-6′, C-6′′), 19.72, 19.43, 17.50, 16.95 (CH_3-18, -19, -21, -27) ppm.

(22*R*,25*R*)-3β-(2,3,4-Tri-*O*-benzoyl-α-L-rhamnopyranosyloxy)-26-*tert*-butyldimethylsilyloxy-5-furosten (17): Conversion following GP: **14** (200 mg, 0.38 mmol), **15** (255 mg, 0.49 mmol), argon, fresh anhydrous diethyl ether (80 mL), freshly activated 4-Å mol. sieves, 75 min, room temperature, DMTST (379 mg, 1.47 mmol), 5.5 h. TLC with PE/EA, 3:1 [R_f (**14**) = 0.29, R_f (**15**) = 0.41] and PE/EA, 1:1 [R_f (**14**) = 0.35, R_f (**15**) = 0.81]. Triethylamine (0.5 mL), 10 min,

filtration through Celite, evaporation to dryness, three times co-distillation with toluene. After flash chromatography with PE/EA, 6:1, **17** (137 mg, 0.14 mmol, 36%) and a mixture of **15** and **17** (90 mg) were obtained.

17: Colourless crystals. $C_{60}H_{80}O_{10}Si$ (989.357): calcd. C 72.84, H 8.15; found C 72.08, H 8.19. M.p. 82 °C, $[\alpha]_D^{20} = +33.9$ ($c = 0.5$, $CHCl_3$). TLC (PE/EA, 1:1): $R_f = 0.94$, (PE/EA, 3:1): $R_f = 0.36$ (UV, H_2SO_4). ^{1}H NMR (500 MHz, C_6D_6): δ = 8.32, 8.07, 8.04 (3 × d, 3 × 2 H, 3 × *o*-C_6H_5COO, ^3J = 7.3, 7.3, 7.6 Hz), 7.10−6.72 (m, 9 H, 3 × C_6H_5COO), 6.45 (dd, 1 H, H-3′, $^3J_{2',3'}$ = 3.2, $^3J_{3',4'}$ = 10.1 Hz), 6.29 (dd ≈ t, 1 H, H-4′, $^3J_{3',4'}$ = 10.1, $^3J_{4',5'}$ = 9.8 Hz), 6.20 (dd, 1 H, H-2′, $^3J_{1',2'}$ = 1.2, $^3J_{2',3'}$ = 3.2 Hz), 5.31 (d ≈ br. s, 1 H, H-1′), 5.26 (m, 1 H, H-6), 4.56 (m, 1 H, H-5′), 4.31 (m, 1 H, H-16), 3.56 (m, 1 H, H-3), 3.51−3.26 (m, 3 H, H-26a, H-22, H-26b), 2.40, 2.30 (2 × m, 2 × 1 H, H-4a, H-4b), 2.05−0.83 (m, steroid H), 1.43 (d, 3 H, H-6′, $^3J_{5',6'}$ = 6.3 Hz), 1.03−0.84 (m, CH_3-18, -19, -21, -27, *t*BuMe_2Si), 0.08, −0.01 (2 × s, 2 × 3 H, *t*BuMe_2Si) ppm.

(22*R*,25*R*)-26-(2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyloxy)-3β-acetoxy-5-furosten (19): Conversion following GP: **12** (100 mg, 0.21 mmol), **29** (153 mg, 0.24 mmol), argon, fresh anhydrous CH_2Cl_2 (80 mL), 1 spatula of freshly activated 4-Å mol. sieves, 1 h, room temperature, DMTST (204 mg, 0.79 mmol), 4.5 h. TLC was carried out using toluene/acetone, 20:1 [R_f (**12**) = 0.06, R_f (**29**) = 0.59]. Triethylamine (0.5 mL), 15 min. Evaporation was carried out in the presence of silica gel, and the so-obtained powdery mixture was poured onto a column of silica gel pre-packed with PE and directly chromatographed with PE/EA, 4:1. Compound **19** (40 mg, 0.04 mmol, 18%) was obtained. Slightly yellow solid. $C_{63}H_{72}O_{13}$ (1037.238): calcd. C 72.95, H 7.00; found C 72.81, H 7.43. M.p. 159.5−159.8 °C, $[\alpha]_D^{20} = -11.8$ ($c = 0.4$, $CHCl_3$). TLC (toluene/acetone, 20:1): $R_f = 0.37$, (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.19, 8.15, 8.05, 7.96 (4 × d, 4 × 2 H, 4 × *o*-C_6H_5COO, ^3J = 7.9, 7.6, 7.8, 7.6 Hz), (m, 12 H, 4 × *m*/*p*-C_6H_5COO), 6.19 (dd ≈ t, 1 H, H-3′, $^3J_{2',3'}$ = 9.5, $^3J_{3',4'}$ = 9.8 Hz), 5.96−5.86 (m, 2 H, H-2′, H-4′), 5.29 (br. d, 1 H, H-6, J = 4.7 Hz), 4.85 (m, 1 H, H-3), 4.64 (dd, 1 H, H-6′a, $^3J_{5',6'a}$ = 3.3, $^2J_{6'a,6'b}$ = 12.0 Hz), 4.58 (d, 1 H, H-1′, $^3J_{1',2'}$ = 7.9 Hz), 4.51 (dd, 1 H, H-6′b, $^3J_{5',6'b}$ = 5.0, $^2J_{6'a,6'b}$ = 12.0 Hz), 4.31 (m, 1 H, H-16), 3.79−3.73 (m, 2 H, H-26a, H-5′), 3.27 (dd, 1 H, H-26b, $J_{25,26b}$ = 7.0, $^3J_{26a,b}$ = 8.5 Hz), 3.18 (m, 1 H, H-22), 2.50 (m ≈ dd, 1 H, H-4β, $^3J_{3,4\beta}$ = 3.2, $^2J_{4\alpha,4\beta}$ = 12.9 Hz), 2.29 (ddd, 1 H, H-4α, $^3J_{3,4\alpha}$ = 11.0, $^2J_{4\alpha,4\beta}$ = 13.2, $^4J_{4\alpha,6}$ = 2.2 Hz), 1.96 (m, 1 H), 1.88 (m, 1 H), 1.81 (m, 1 H), 1.76 (s, 3 H, CH_3COO), 0.89 (d, 3 H, CH_3-21, $^3J_{20,21}$ = 9.2 Hz), 0.88 (s, 3 H, CH_3-19), 0.84 (s, 3 H, CH_3-18), 0.81 (d, 3 H, CH_3-27, $^3J_{25,27}$ = 6.9 Hz), 1.74−0.78 (m, steroid H) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 169.64 (CH_3*C*OO), 166.28, 166.05, 165.46, 165.23 (4 × C_6H_5*C*OO), 139.80 (C-5), 133.25, 133.12, 133.02, 132.96 (4 × *p*-C_6H_5COO), 130.54, 130.31, 129.73, 129.47 (4 × *q*-C_6H_5COO), 130.13−130.03 (4 × *o*-C_6H_5COO), 128.58−128.34 (4 × *m*-C_6H_5COO), 122.77 (C-6), 101.88 (C-1′), 90.39 (C-22), 83.35 (C-16), 75.17 (C-26), 73.94 (C-3), 73.72 (C-3′), 72.67 (C-5′), 72.51 (C-2′), 70.64 (C-4′), 65.78 (C-17), 63.50 (C-6′), 57.21 (C-14), 50.37 (C-9), 40.87, 36.91 (C-10, C-13), 38.68 (C-4), 38.38 (C-20), 33.77 (C-25), 31.86 (C-8), 21.04 (*C*H_3COO), 19.34, 19.15 (CH_3-19, -21), 16.90, 16.61 (CH_3-18, -27), 39.78, 37.27, 32.70, 32.33, 31.26, 30.85, 28.25, 21.01 (CH_2-1, -2, -7, -11, -12, -15, -23, -24) ppm.

Benzyl 4-*O*-Acetyl-6-*O*-*tert*-butyldiphenylsilyl-(2,3,4-tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-(2,3,4-tri-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→3)-β-D-glucopyranoside (22): Conversion following GP: Acceptor **21** (220 mg, 0.43 mmol), donor **15** (668 mg, 1.30 mmol), argon, anhydrous diethyl ether (40 mL), a spatula of freshly activated 4-Å mol. sieves, room temperature, 1 h, DMTST (1.01 g, 3.90 mmol), room temperature, TLC was carried out using toluene/EA, 6:1 [R_f (**21**) = 0, R_f (**15**) = 0.68] and PE/EA, 2:1 [R_f (**21**) = 0, R_f (**15**) = 0.62], 16 h, triethylamine (2 mL), room temperature, 15 min, filtration through Celite, evaporation, flash chromatography with PE/EA, 2:1. The so-obtained product was dissolved in pyridine (5 mL) and after cooling in an ice-bath, acetic acid anhydride (3 mL) was added. The reaction mixture was stirred at room temperature for 4 days. After evaporation and column chromatography with PE/toluene/EA, 4:1:1, compound **22** (379 mg, 0.26 mmol, 60%) was obtained. Needles. $C_{85}H_{82}O_{21}Si$ (1467.634): calcd. C 69.56, H 5.63; found C 69.96, H 5.62. M.p. 108.0−108.7 °C, $[\alpha]_D^{20} = +90.9$ ($c = 0.7$, $CHCl_3$). TLC (toluene/EA, 6:1): R_f = 0.62 (UV, H_2SO_4), (PE/EA, 2:1): $R_f = 0.39$ (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.16−8.11 (m, 2 H, Ar), 7.98−7.92 (m, 4 H, Ar), 7.88−7.82 (m, 2 H, Ar), 7.79−7.74 (m, 4 H, Ar), 7.72−7.68 (m, 2 H, Ar), 7.58−6.97 (m, 31 H, Ar), 5.94 (dd, 1 H, H-3′, $^3J_{2,3}$ = 3.3, $^3J_{3,4}$ = 10.3 Hz), 5.84 (dd, 1 H, H-2′, $^3J_{1,2}$ = 1.7, $^3J_{2,3}$ = 3.1 Hz), 5.78 (dd, 1 H, H-3′′, $^3J_{2,3}$ = 3.1, $^3J_{3,4}$ = 10.3 Hz), 5.74−5.61 (m, 4 H, H-1**, H-2′′, H-4′, H-4′′), 5.35 (d, 1 H, H-1* , $^3J_{1,2}$ = 1.8 Hz), 5.06 (d, 1 H, $C_6H_5CH_2$O-a, ^2J = 11.0 Hz), 5.00 (dd ≈ t, 1 H, H-4, $^3J_{3,4}$ = 8.8, $^3J_{4,5}$ = 9.5 Hz), 4.75 (d, 1 H, $C_6H_5CH_2$O-b, ^2J = 11.0 Hz), 4.72 (m, 1 H, H-5′), 4.68 (d, 1 H, H-1, $^3J_{1,2}$ = 7.3 Hz), 4.23−4.13 (m, 2 H, H-3, H-5′′), 4.09 (dd ≈ t, 1 H, H-2, $^3J_{1,2}$ = 8.1, $^3J_{2,3}$ = 8.4 Hz), 3.88 (dd, 1 H, H-6a, $^3J_{5,6a}$ = 7.0, $^2J_{6a,6b}$ = 11.4 Hz), 3.74 (dd, 1 H, H-6b, $^3J_{5,6a}$ = 2.2, $^2J_{6a,6b}$ = 11.7 Hz), 3.51 (ddd, 1 H, H-5, $^3J_{5,4}$ = 9.5, $^3J_{5,6a}$ = 7.0, $^3J_{5,6b}$ = 2.2 Hz), 1.95 (s, 3 H, CH_3COO), 1.28 (d, 3 H, H-6′′, $^3J_{5,6}$ = 6.2 Hz), 1.15 (s, 9 H, *t*BuPh_2Si), 1.11 (d, 3 H, H-6′, $^3J_{5,6}$ = 6.2 Hz) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 169.94 (CH_3*C*OO), 165.72, 165.68, 165.38, 165.23, 165.21, 164.85 (6 × C_6H_5*C*OO), 137.83, 136.54, 135.65, 135.61, 133.35−133.12, 132.76−132.39, 130.00−127.74, 125.31 (*C*$_6H_5CH_2$O, 6 × *C*$_6H_5$COO, *t*Bu*Ph*$_2$Si), 99.89 (C-1), 99.32 (C-1*), 98.05 (C-1**), 85.63 (C-5′′), 76.76 (C-2), 75.56 (C-5), 72.36, 72.08, 71.97 (C-2′′, C-4′, C-4′′), 71.18 (C-4), 70.98 (C-2′, $C_6H_5CH_2$O), 70.06 (C-3′), 69.08 (C-3′′), 68.04 (C-3), 67.31 (C-5′), 3.72 (C-6), 27.06 [(*C*H_3)$_3$CSi], 21.72 (*C*H_3COO), 19.55 [(CH_3)$_3$*C*Si], 17.45, 17.38 (C-6′, C-6′′) ppm.

Ethyl 2,4-Di-*O*-benzoyl-3,6-di-*O*-*tert*-butyldimethylsilyl-1-thio-β-D-glucopyranoside (25): Compound **23**[16,28] (1.65 g, 4.20 mmol) was dissolved in anhydrous methanol (30 mL) and the pH was raised to 9.5 by adding a 1 M solution of NaOMe in methanol. After stirring at room temperature for 2 h, the solution was neutralized with Dowex 50 WX8 (H^+) resin. The resin was filtered off, the mixture was evaporated to dryness and the crude product was co-distilled three times with toluene. The so-obtained crude product was dissolved in anhydrous DMF (4.2 mL), and triethylamine (1.4 mL, 10.08 mmol) and DMAP (42 mg, 0.4 mmol) were added. The solution was stirred while *tert*-butylchlorodimethylsilane (1.392 g, 9.24 mmol) in anhydrous DMF (4.2 mL) was added dropwise. After stirring at room temperature for 24 h, TLC: PE/EA, 4:1 [R_f (**23**) = 0, R_f (products) = 0.30, 0.59, 0.86], another portion of *tert*-butylchlorodimethylsilane (348 mg, 2.31 mmol) in anhydrous DMF (1 mL) was added dropwise. Stirring continued for 24 h at room temperature. The reaction solvents were evaporated under reduced pressure at 30 °C, and the resulting residue was dissolved in dichloromethane, washed with 10% NH_4Cl solution and with water and dried over sodium sulfate. A suitable amount of silica gel was added and concentration gave a powdery mixture, which was added to a PE pre-packed column of silica gel and chromatographed with PE/EA, 1:0 → 4:1. Three fractions were obtained. F1: 2,3,6-trisilylated (260 mg, 0.46 mmol, 11%, $R_f = 0.86$); F2: 3,6-

disilylated (341 mg, 0.75 mmol, 18%, R_f = 0.59); F3: 2,6- and 4,6-disilylated compounds (517 mg, 1.14 mmol, 27%, R_f = 0.30), as proven after benzoylation by ^{1}H NMR in the next step. The fraction F2 (341 mg, 0.75 mmol) was dissolved in anhydrous pyridine (5 mL), and after cooling in an ice bath, benzoyl chloride (0.19 mL, 1.65 mmol) and DMAP (3 mg) were added. The reaction was stirred at room temperature for 5 days with addition of benzoyl chloride (0.05 mL and 0.10 mL) after 3 and 4 days, respectively. The reaction mixture was dissolved in toluene (30 mL), washed three times with water and once with saturated NaCl solution, dried over $MgSO_4$, filtered and evaporated to dryness. After flash chromatography with PE/toluene/EA, 4:1:0 → 4:1:1, a mixture of the 2,4-dibenzoylated **25** and the 2-monobenzoylated compound (436 mg) was obtained (≈ 1.6:1 by ^{1}H NMR). In a second chromatographic approach **25** (56 mg, 0.08 mmol, 11%) was obtained along with 370 mg of the mixture. Syrup, $C_{34}H_{52}O_7SSi_2$ (mol. mass 661.010 g/mol). TLC (PE/EA, 9:1): R_f = 0.48 (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.20−8.12, 7.74- 7.41 (m, 10 H, 2 × C_6H_5COO), 5.34−5.23 (m, 2 H, H-2, H-4), 4.58 (d, 1 H, H-1, $^3J_{1,2}$ = 9.9 Hz), 4.17 (dd ≈ t, 1 H, H-3, $^3J_{2,3}$ = $^3J_{3,4}$ = 8.8 Hz), 3.76−3.58 (m, 3 H, H-5, H-6a, H-6b), 2.82−2.58 (m, 2 H, SCH_2CH_3), 1.46 (t, 3 H, SCH_2CH_3), 1.06, 0.86 [2 × s, 2 × 9 H, 2 × $(CH_3)_3CSiMe_2$], 0.12, 0.10, −0.02, −0.04 [4 × s, 4 × 3 H, 2 × *t*BuSi(CH_3)$_2$] ppm.

(22*R*,25*R*)-3β-(2,4-Di-*O*-benzoyl-3,6-di-*O*-*tert*-butyldimethylsilyl-β-D-glucopyranosyloxy)-26-*O*-*p*-methoxybenzyloxy-5-furosten (26): Conversion following GP: Donor **25** (56 mg, 0.08 mmol), acceptor **10** (45 mg, 0.08 mmol), argon, anhydrous diethyl ether (20 mL), room temperature, 1 h, DMTST (66 mg, 0.25 mmol), TLC PE/Et_2O, 1:1 [R_f (**25**) = 0.83, R_f (**10**) = 0.19], room temperature, 16 h, 0.05 mL triethylamine, 15 min. A suitable amount of silica gel was added to the reaction mixture, the solvent was evaporated and the powdery mixture was poured onto a pre-packed column of silica gel (PE) and chromatographed with PE/Et_2O, 1:0 → 10:1 → 5:1 → 2:1. Compound **26** (94 mg, 0.08 mmol, quant.) was obtained. Syrup, $C_{67}H_{98}O_{11}Si_2$ (mol. mass 1135.659 g/mol), $[\alpha]_D^{20}$ = −5.0 (*c* = 1, $CHCl_3$). TLC (PE/Et_2O, 1:1): R_f = 0.64 (UV, H_2SO_4). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.60−7.95, 7.58−7.38 (2 × m, 10 H, 2 × C_6H_5COO), 7.25, 6.84 (2 × m, 2 × 2 H, $CH_3OC_6H_4CH_2O$), 5.20−5.13 (m, 3 H, H-6, H-2′, H-4′), 4.64 (d, 1 H, H-1′, $^3J_{1',2'}$ = 8.0 Hz), 4.41, 4.37 (2 × d, 2 × 1 H, $CH_3OC_6H_4CH_2O$, ^3J = 11.7 Hz), 4.23 (ddd ≈ dt, 1 H, H-16, ^3J = 5.1, 7.7 Hz), 4.12 (dd ≈ t, 1 H, H-3′, $^3J_{2',3'}$ = $^3J_{3',4'}$ = 9.2 Hz), 3.76 (s, 3 H, $CH_3OC_6H_4CH_2O$), 3.73−3.58 (m, 3 H, H-5′, H-6a′, H-6b′), 3.45 (m, 1 H, H-3), 3.30−3.23 (m, 2 H, H-22, H-26a), 3.19 (dd, 1 H, H-26b, $^3J_{25,26b}$ = 6.8, 9.0 Hz), 2.18−0.82 [m, steroid H, 2 × $(CH_3)_3CMe_2Si$], −0.02, −0.06, −0.24, −0.26 [2 × $(CH_3)_3CMe_2Si$] ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 165.15, 165.06 (2 × C_6H_5COO), 158.96, 130.92 ($CH_3OCC_4H_4CCH_2O$), 140.56 (C-5), 135.18, 133.20−128.38 (2 × C_6H_5COO), 129.15, 113.77 ($CH_3OCC_4H_4CCH_2O$), 121.48 (C-6), 99.88 (C-1′), 90.48 (C-22), 83.26 (C-16), 79.53, 75.47, 74.97, 73.76, 72.91 (C-3, C-2′, C-3′, C-4′, C-5′), 75.78 (C-26), 72.81 ($CH_3OC_6H_4CH_2O$), 65.74 (C-6′), 55.44 ($CH_3OC_6H_4CH_2O$), 65.35, 63.64, 57.11, 50.32, 41.02−14.02 [steroid C, $(CH_3)_3CMe_2Si$)], −4.05, −4.22, −4.97, −5.08 [$(CH_3)_3CMe_2Si$)] ppm.

(22*R*,25*R*)-[3,6-Di-*O*-*tert*-butyldimethylsilyl-(2,3,4-tetra-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-(2,3,4-tetra-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→4)-β-D-glucopyranosyloxy]-(1-*O*→3β)-26-*O*-*p*-methoxybenzyloxy-5-furosten and (22*R*,25*R*)-[3,6-Di-*O*-*tert*-butyldimethylsilyl-(2,3,4-tetra-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-β-D-glucopyranosyloxy]-(1-*O*→3β)-26-*O*-*p*-methoxybenzyloxy-5-furosten (28): Compound **26** (94 mg, 0.08 mmol) was dissolved in a mixture of anhydrous methanol (4 mL) and anhydrous $CHCl_3$ (5 mL). Sodium methoxide was added until pH 8.5 was reached, whereupon no reaction occurred within 48 h. The pH was raised to 10−12, and the reaction mixture was stirred for a further 48 h. TLC: PE/EA, 4:1 [R_f (**26**) = 0.76, R_f (**27**) = 0.50]. The solvent was evaporated and after flash chromatography **27** (44 mg, 0.05 mmol, 59%) was obtained. Conversion following GP1: **27** (44 mg, 0.05 mmol), **15** (76 mg, 0.15 mmol), anhydrous CH_2Cl_2 (10 mL), 4-Å mol. sieves, argon, room temperature, 1 h, DMTST (77 mg, 0.30 mmol), 16 h. After flash chromatography with toluene/EA, 20:1, a mixture of trisaccharide and disaccharide (**28**, 20 mg, 1:3.5 by ^{1}H NMR) was obtained. TLC (toluene/EA, 20:1): R_f = 0.29 (UV, H_2SO_4). MALDI-TOF-MS (DHB, positive mode): 1866.24 $[M + Na]^+$ (calcd.: 1865.88), 1882.13 $[M + K]^+$ (calcd.: 1881.85) (trisaccharide). 1408.07 $[M + Na]^+$ (calcd.: 1407.74), 1424.00 $[M + K]^+$ (calcd.: 1423.71) (disaccharide). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.12−8.05, 8.02−7.94, 7.84−7.80, 7.63−7.35, 7.27−7.14 (m, C_6H_5COO), 6.90−6.85 (m, 2 × 2 H, $CH_3OC_6H_4CH_2O$), 6.09 (d, 1 H), 5.88−5.64 (m, H-3′′$_{trisaccharide}$, H-4′$_{trisaccharide}$), 5.79 (dd, 1 H, H-3′′$_{disaccharide}$, $^3J_{2'',3''}$ = 3.5, $^3J_{3'',4''}$ = 10.4 Hz), 5.70 (m), 5.61 (dd, 1 H, H-2′′$_{disaccharide}$, $^3J_{1'',2''}$ = 1.6, $^3J_{2'',3''}$ = 3.5 Hz), 5.55 (dd, 1 H, $H_{disaccharide}$, ^3J = 4.4, ^3J = 5.4 Hz), 5.37 (br. d, 1 H, H-6$_{disaccharide}$, ^3J = 5.1 Hz), 5.20 (br. s, 1 H, H-1′′$_{disaccharide}$), 5.02 4.92 (2 × d, 2 × 1 H, H-1′′$_{trisaccharide}$, H-1′′′$_{trisaccharide}$), 4.59−4.49 (m), 4.44, 4.40 (2 × d, 2 × 1 H, $CH_3OC_6H_4CH_2O_{disaccharide}$, ^3J = 11.7 Hz), 4.38 (d, 1 H, H-1′, $^3J_{1',2'}$ = 7.6 Hz), 4.31 (m, 1 H, H-16), 4.23−4.10, 3.95−3.79, 3.70−3.50 (3 × m), 3.80 (s, 3 H, $CH_3OC_6H_4CH_2O$), 3.39 (m, 1 H, H-5′$_{disaccharide}$), 3.37−3.28 (m, 3 H, H-3, H-22, H-26a), 3.23 (dd, 1 H, H-26b, $^3J_{25,26}$ = 6.6, $^2J_{26a,26b}$ = 8.8 Hz), 2.88 (d, 1 H, OH), 2.18−0.82 (m, steroid H, 2 × $(CH_3)_3CMe_2Si$), 0.20−0.02 [2 × $(CH_3)_3CMe_2Si$] ppm.

(22*R*,25*R*)-3β-(2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyloxy)-26-*tert*-butyldimethylsilyloxy-5-furosten (30): Conversion following GP: **14** (400 mg, 0.75 mmol), **18** (579 mg, 0.90 mmol), argon, fresh anhydrous diethyl ether (130 mL), 1 spatula of freshly activated 4-Å mol. sieves, 1 h, room temperature, DMTST (697 mg, 2.70 mmol), 4.5 h. TLC PE/EA, 2:1 [R_f (**14**) = 0.42, R_f (**18**) = 0.47] and toluene/acetone, 20:1 [R_f (**14**) = 0.18, R_f (**18**) = 0.18]. Triethylamine (2.0 mL), 15 min. A suitable amount of silica gel was added to the reaction mixture, the solvent was evaporated and the powdery mixture was poured on a pre-packed column of silica gel (PE) and chromatographed with PE/EA, 4:1. Compound **30** (183 mg, 0.16 mmol, 22%) was obtained. Colourless crystals, $C_{67}H_{84}O_{12}Si$ (1109.462): calcd. C 72.53, H 7.63; found C 71.59, H 7.65 (The deviation in the elementary analysis is caused by partial hydrolysis of the TBDMS group during storage.). M.p. 117 °C, $[\alpha]_D^{20}$ = −2.7 (*c* = 0.15, $CHCl_3$). TLC (PE/EA, 2:1): R_f = 0.60, (toluene/acetone 20:1): R_f = 0.74 (UV, H_2SO_4). MALDI-TOF-MS (DHB, positive mode): 1131.82 $[M + Na]^+$ (calcd.: 1131.56), 1147.72 $[M + K]^+$ (calcd.: 1147.54). ^{1}H NMR (500 MHz, C_6D_6): δ = 8.21, 8.17, 8.08, 7.99 (4 × m ≈ d, 4 × 2 H, 4 × *o*-C_6H_5COO, 4 × ^3J = 7.25 Hz), 7.13−6.76 (m, 12 H, 4 × *m*/*p*-C_6H_5COO), 6.22 (dd ≈ t, 1 H, H-3′, $^3J_{2',3'}$ = $^3J_{3',4'}$ = 9.8 Hz), 5.97 (dd, 1 H, H-2′, $^3J_{1',2'}$ = 8.8, $^3J_{2',3'}$ = 9.2 Hz), 5.89 (t, 2 H, H-4′, $^3J_{3',4'}$ = $^3J_{4',5'}$ = 9.5 Hz), 5.25 (br. d, 1 H, H-6, *J* = 5.0 Hz), 4.76 (d, 1 H, H-1′, $^3J_{1',2'}$ = 8.2 Hz), 4.63 (dd, 1 H, H-6′a, $^3J_{5',6'a}$ = 2.8, $^2J_{6'a,6'b}$ = 12.0 Hz), 4.53 (dd, 1 H, H-6′b, $^3J_{5',6'b}$ = 5.2, $^2J_{6'a,6'b}$ = 12.0 Hz), 4.29 (m, 1 H, H-16), 3.75 (ddd, 1 H, H-5′, $^3J_{4',5'}$ = 9.5, $^3J_{5',6'a}$ = 2.8, $^3J_{5',6'b}$ = 5.2 Hz), 3.65 (m, 1 H, H-3), 3.51−3.30 (m, 3 H, H-26a, H-26b, H-22), 2.42 (m, 1 H, H-4a), 2.31 (m, 1 H, H-4b), 2.05−1.92 (m, 2 H), 1.85−0.82 (m, steroid H), 1.02−0.82 (m, *t*BuMe$_2$Si, CH_3-18, -19, -

21, -27), 0.09, 0.07 (2 × s, 2 × 3 H, *t*Bu*Me*$_2$Si) ppm. ^{13}C NMR (100.67 MHz, C_6D_6): δ = 165.99−165.47 (4 × C_6H_5COO), 140.08 (C-5), 133.28−132.92, 130.15−130.00, 128.61−128.34 (4 × C_6H_5COO), 121.90 (C-6), 100.43 (C-1′), 90.52 (C-22), 83.41 (C-16), 80.08 (C-3), 73.80 (C-3′), 72.81 (C-2′), 72.44 (C-5′), 70.62 (C-4′), 68.01 (C-26), 63.38 (C-6′), 39.49 (C-4), 41.10, 36.50 (C-10, C-13), 26.20 [(CH_3)$_3$CSi], 19.25, 19.07, 17.05, 16.58 (CH_3-18, −19, −21, −27), 18.52 [(CH_3)$_3C$Si], 65.80, 57.22, 50.08, 38.35, 36.04, 31.85 (CH-8, 9, 14, 17, 20, 25), 39.61, 37.48, 32.72, 32.44, 31.51, 30.75, 30.05, 21.01 (CH_2-1, -2, -7, -11, -12, -15, -23, -24), −5.17, −5.19 (*t*Bu*Me*$_2$Si) ppm.

(22*R*,25*R*)-3β-(β-D-Glucopyranosyloxy)-26-*tert*-butyldimethylsilyloxy-5-furosten (31): Compound **30** (150 mg, 0.14 mmol) was dissolved in a mixture of anhydrous CH_2Cl_2 (10 mL) and anhydrous MeOH (10 mL), and the pH was raised to 8.5 by addition of solid sodium methoxide. The mixture was stirred for 4 h at room temperature until TLC PE/EA, 1:3 [R_f (**30**) = 0.91] and EA/EtOH, 10:1 [R_f (**30**) = 0.97] showed complete conversion. The pH was lowered to 6 by addition of AcOH/EtOH, 20:1. Flash chromatography with CH_2Cl_2/MeOH/NEt_3, 5:1:0.1 yielded **31** (65 mg, 0.09 mmol, 65%) and slightly impure product (40 mg). Colourless solid, $C_{39}H_{68}O_8Si$ (mol. mass 693.038 g/mol), decomposition: > 270 °C. TLC (PE/EA, 1:3): R_f = 0, (EA/EtOH, 10:1): R_f = 0.29 (UV, H_2SO_4). MALDI-TOF-MS (DHB, positive mode): 715.55 [M + Na]$^+$ (calcd.: 715.46), 731.43 [M + K]$^+$ (calcd.: 731.43).

(22*R*,25*R*)-3β-(3,6-Di-*O*-benzoyl-β-D-glucopyranosyloxy)-26-*O*-*tert*-butyldimethylsilyloxy-5-furosten (32): Compound **31** (65 mg, 0.09 mmol) and 1-(benzyloxy)benzotriazole[21,23] (61 mg, 0.2 mmol) were dissolved in anhydrous dichloromethane (2 mL), and triethylamine p. a. (30 μL) was added. The reaction mixture was stirred for 2.5 days at room temperature until TLC showed complete conversion of the starting material [PE/EA, 2:1 R_f (**31**) = 0, R_f (1-BBTZ) = 0.44, R_f (by-products) = 0.09, 0.22, 0.52, and toluene/acetone, 10:1 R_f (**31**) = 0, R_f (1-BBTZ) = 0.59, R_f (by-products) = 0.06, 0.17, 0.42]. After evaporation of the solvent and flash chromatography with toluene/acetone, 12:1 → 6:1, compound **32** (30 mg, 0.03 mol, 33%) was obtained. The small amount of by-products was not characterized. Amorphous substance, $C_{53}H_{76}O_{10}Si$ (mol. mass 901.250 g/mol), $[\alpha]_D^{20}$ = +25.3 (*c* = 1.2, $CHCl_3$). TLC (PE/EA, 2:1): R_f = 0.34, (toluene/acetone, 10:1): R_f = 0.25 (UV, H_2SO_4). MALDI-TOF-MS (DHB, positive mode): 924.26 [M + Na]$^+$ (calcd.: 923.51), 940.28 [M + K]$^+$ (calcd.: 939.49). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.07−8.00 (m, 4 H, 2 × *o*-C_6H_5COO), 7.57−7.51 (m, 2 H, 2 × *p*-C_6H_5COO), 7.44−7.38 (m, 4 H, 2 × *m*-C_6H_5COO), 5.30 (br. d, 1 H, H-6, *J* = 5.0 Hz), 5.18 (dd ≈ t, 1 H, H-3′, $^3J_{2',3'}$ = 8.8, $^3J_{3',4'}$ = 9.2 Hz), 4.64−4.60 (m, 2 H, H-6′), 4.51 (d, 1 H, H-1′, $^3J_{1',2'}$ = 7.6 Hz), 4.27 (m, 1 H, H-16), 3.73−3.69 (m, 2 H, H-4′, H-5′), 3.64 (dd, 1 H, H-2′, $^3J_{1',2'}$ = 8.5, $^3J_{2',3'}$ = 8.8 Hz), 3.54 (m, 1 H, H-3), 3.43 (dd, 1 H, H-26a, $^3J_{25,26a}$ = 5.7, $^2J_{26a,26b}$ = 9.8 Hz), 3.35 (dd, 1 H, H-26b, $^3J_{25,26b}$ = 6.6, $^2J_{26a,26b}$ = 9.8 Hz), 3.22 (br. s, 1 H, 4′-OH), 3.28 (dt, 1 H, H-22, ^3J = 4.1, 7.8 Hz), 2.50 (br. s, 1 H, 2′-OH), 2.34 (m, 1 H, H-4a), 2.25 (m, 2 H, H-4b), 2.00−1.88 (m, 3 H), 1.75−0.82 (m, steroid H), 0.97, 0.85 (d, CH_3-21, -27), 0.95, 0.77 (s, CH_3-18, -19), 0.86 (s, 9 H, *tBu*Me$_2$Si), −0.03 (2 × s, 2 × 3 H, *t*Bu*Me*$_2$Si) ppm. ^{13}C NMR (100.67 MHz, $CDCl_3$): δ = 167.95, 166.89 (2 × C_6H_5COO), 140.36 (C-5) 133.64, 133.29, 130.17, 130.08, 129.99, 129.55, 128.58, 128.52, 128.36 (2 × C_6H_5COO), 122.09 (C-6), 101.62 (C-1′), 90.56 (C-22), 83.25 (C-16), 79.97, 78.74, 74.46, 72.29, 70.00 (C-3, C-2′, C-3′, C-4′, C-5′), 68.30 (C-26), 64.03 (C-6′), 38.99 (C-4), 38.02 (C-20), 36.11 (C-25), 40.84, 36.92 (C-10, C-13), 26.13 [(CH_3)$_3$CSi], 19.47, 16.55 (CH_3-18, −19), 19.22 (CH_3-21), 18.49 [(CH_3)$_3C$Si], 16.87 (CH_3-27), 39.61, 37.27, 32.41, 32.18, 31.19, 30.26, 29.84, 20.81 (CH_2-1, -2, -7, -11, -12, -15, -23, -24), 65.45, 57.12, 50.26, 31.70 (CH-8, -9, -14, -17), −5.19, −5.21 (*t*Bu*Me*$_2$Si) ppm.

(22*R*,25*R*)-[3,6-Di-*O*-benzoyl-(2,3,4-tetra-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-(2,3,4-tetra-*O*-benzoyl-α-L-rhamnopyranosyl)-(1→4)-β-D-glucopyranosyloxy]-(1-*O*→3β)-26-*O*-*tert*-butyldimethylsilyloxy-5-furosten (33) and (22*R*,25*R*)-[3,6-Di-*O*-benzoyl-(2,3,4-tetra*O*-benzoyl-α-L-rhamnopyranosyl)-(1→2)-β-D-glucopyranosyloxy]-(1-*O*→3β)-26-*O*-*tert*-butyldimethylsilyloxy-5-furosten (34): Conversion following GP: **32** (30 mg, 0.03 mmol), **15** (52 mg, 0.09 mmol), argon, fresh anhydrous diethyl ether (20 mL), 1 spatula of freshly activated 4-Å mol. sieves, 1 h, room temperature, DMTST (52 mg, 0.20 mmol), 4.5 days. Observation of the reaction was carried out using TLC [PE/EA, 3:1, R_f (32) = 0.16, R_f (15) = 0.41 and toluene/acetone, 10:1, R_f (32) = 0.29, R_f (15) = 0.77] and with MALDI-TOF-MS (subjection of the reaction mixture on a DHB matrix). Triethylamine (0.1 mL), 10 min. A suitable amount of silica gel was added to the reaction mixture, the solvent was evaporated and the powdery mixture was poured onto a prepacked column of silica gel (toluene) and purified by flash chromatography with toluene/acetone, 16:1, whereby **34** (6 mg, 4.4 μmol, 15%). MALDI-TOF-MS (DHB, positive mode): 1382.92 [M + Na]$^+$ (calcd.: 1381.65), 1398.66 [M + K]$^+$ (calcd.: 1397.62)] and the 26,2′-di-α-L-rhamnopyranoside (5 mg, 2.9 μmol, 10%) were obtained. Flash chromatography of the first fraction with toluene/acetone, 16:1 yielded 33 (10 mg, 6 μmol, 18%).

33: Colourless crystals, $C_{107}H_{120}O_{24}Si$ (mol. mass 1818.17 g/mol), m.p. 109.4−110.1 °C. TLC (toluene/acetone, 10:1): R_f = 0.83 (UV, H_2SO_4). MALDI-TOF-MS (DHB, positive mode): 1839.85 [M + Na]$^+$ (calcd.: 1839.78), 1855.78 [M + K]$^+$ (calcd.: 1855.76). ^{1}H NMR (500 MHz, C_6D_6): δ = 8.25−7.91 (m, 16 H, 8 × *o*-C_6H_5COO), 7.14−6.69 (m, 24 H, 8 × *m*/*p*-C_6H_5COO), 6.41 (dd, 1 H, H-3′′, $^3J_{2'',3''}$ = 3.2, $^3J_{3'',4''}$ = 10.4 Hz), 6.35 (dd, 1 H, H-3′′′, $^3J_{2''',3'''}$ = 3.2, $^3J_{3''',4'''}$ = 10.4 Hz), 6.22−6.12 (m, 3 H, H-4′′, H-2′′′, H-4′′′), 6.06 (dd, 1 H, H-3′, ^3J = 9.5 Hz), 6.04 (dd, 1 H, H-2′′, $^3J_{1'',2''}$ = 1.6, $^3J_{2'',3''}$ = 3.2 Hz), 5.62 (br. d, 1 H, H-6, *J* = 5.0 Hz), 5.53 (d, 1 H, H-1′′, $^3J_{1'',2''}$ = 1.3 Hz), 5.50 (d, 1 H, H-1′′′, $^3J_{1''',2'''}$ = 1.3 Hz), 5.18 (dq, 1 H, H-5′′, $^3J_{4'',5''}$ = 10.1, $^3J_{5'',6''}$ = 6.3 Hz), 5.09 (dd, 1 H, H-6′a, $^3J_{5',6'a}$ = 1.9, $^2J_{6'a,6'b}$ = 12.3 Hz), 4.83 (dd, 1 H, H-6′b, $^3J_{5',6'b}$ = 4.7, $^2J_{6'a,6'b}$ = 12.3 Hz), 4.55 (dq, 1 H, H-5′′′, $^3J_{4''',5'''}$ = 9.7, $^3J_{5''',6''}$ = 6.3 Hz), 4.49 (d, 1 H, H-1′, $^3J_{1',2'}$ = 7.9 Hz), 4.35 (m, 1 H, H-16), 4.20−4.12 (m, 2 H, H-2′, H-4′), 3.78 (m, 1 H, H-3), 3.49 (dd, 1 H, H-26a, $^3J_{25,26a}$ = 5.4, $^2J_{26a,26b}$ = 9.5 Hz), 3.46−3.40 (m, 2 H, H-26b, H-22), 3.38 (ddd, 1 H, H-5′, $^3J_{4',5'}$ = 9.5, $^3J_{5',6'a}$ = 2.2, $^3J_{5',6'b}$ = 4.7 Hz), 2.88 (m, 1 H, H-4a), 2.69 (m, 1 H, H-4b), 2.12−2.03 (m, 2 H), 1.95 (m, 1 H), 1.83−0.85 (m, steroid H), 1.58 (d, 3 H, H-6′′, $^3J_{5'',6''}$ = 6.3 Hz), 1.02−1.00 (m, *tBu*Me$_2$Si, CH_3-21), 0.98 (d, 3 H, CH_3-27, $^3J_{25,27}$ = 6.9 Hz), 0.84−0.82 (m, CH_3-18, -19), 0.09 (s, 6 H, *t*Bu*Me*$_2$Si) ppm. ^{13}C NMR (125.76 MHz, C_6D_6): δ = 166.06−165.27 (8 × C_6H_5COO), 142.49 (C-5), 134.91, 133.29−132.74 (8 × *p*-C_6H_5COO), 130.47, 130.16−130.00 (8 × *o*-C_6H_5COO), 128.68−128.35 (*m*-C_6H_5COO), 122.30 (C-6), 100.37 (C-1′), 99.48 (C-1′′′), 98.54 (C-1′′), 90.56 (C-22), 83.48 (C-16), 79.78 (C-3), 78.11 (C-4′), 78.02 (C-2′), 77.73 (C-3′), 73.54 (C-5′), 72.73 (C-4′′), 72.01, 71.96 (C-2′′′, C-4′′′), 71.42 (C-2′′), 70.34 (C-3′′, C-3′′′), 68.58, 68.50 (C-5′′, C-5′′′, C-26), 65.92 (C-17), 63.04 (C-6′), 57.29 (C-14), 50.60 (C-9), 40.00−20.00 (steroid C), 26.57 [(CH_3)$_3$CSi], 17.60, 17.07, 15.59, 14.21 (CH_3-18, -19, -21, -27), − 9.95 (*t*Bu*Me*$_2$Si) ppm.

34: Syrup, $C_{80}H_{98}O_{17}Si$ (mol. mass 1359.71 g/mol). TLC (toluene/acetone 10:1): R_f = 0.31 (UV, H_2SO_4). MALDI-TOF-MS (DHB,

positive mode): 1382.92 $[M + Na]^+$ (calcd.: 1381.65), 1398.66 $[M + K]^+$ (calcd.: 1397.62). ^1H NMR (500 MHz, C_6D_6): δ = 8.20−7.80 (m, 10 H, 5 × *o*-C_6H_5COO), 7.15−6.60 (m, 15 H, 5 × *m*/*p*-C_6H_5COO), 6.43 (dd, 1 H, H-3′′, $^3J_{2'',3''} \approx 0$, $^3J_{3'',4''}$ = 10.7 Hz), 6.21 (dd, 1 H, H-4′′, $^3J_{3'',4''}$ = 10.7, $^3J_{4'',5''}$ = 9.2 Hz), 5.97 (dd ≈ br. s, 1 H, H-2′′), 6.63−5.53 (m, 3 H, H-1′′, H-3′, H-6), 5.12 (m, 1 H, H-5′′), 4.68−4.48 (m, 2 H, H-6′a, H-6′b), 4.33 (d, 1 H, H-1′, $^3J_{1',2'}$ = 9.2 Hz), 4.27 (m, 1 H, H-16), 4.12 (dd, 1 H, H-2′), 3.80−3.20 (m, 6 H, H-3, H-4′, H-26a, H-5′, H-26b, H-22), 2.80 (m, 1 H, H-4a), 2.68 (m, 1 H, H-4b), 2.15−0.70 (m, steroid H, CH_3-6′′, *tBu*Me_2Si), 0.09, − 0.03 (2 × s, 2 × 3 H, *t*Bu*Me*$_2$Si) ppm.^{13}C NMR (125.76 MHz, C_6D_6): δ = 167.0−163.0 (5 × C_6H_5*C*OO), 141.1 (C-5), 134.0−128.0 (5 × C_6H_5COO), 122.3 (C-6), 100.4 (C-1′), 98.2 (C-1′′), 90.8 (C-22), 83.7 (C-16), 80.0 (C-3, C-3′), 76.0 (C-2′), 74.8 (C-5′), 72.8 (C-4′′), 71.7 (C-2′′), 70.8 (C-3′′), 70.6 (C-4′), 68.3 (C-26), 67.9 (C-5′′), 65.9 (C-17), 64.0 (C-6′), 57.4 (C-14), 51.0 (C-9), 42.0−15.5 [steroid C, (*C*H_3)$_3$*C*Si] ppm.

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[1] T. Nakamura, C. Komori, Y.-y. Lee, F. Hashimoto, S. Yahara, T. Nohara, A. Ejima, *Biol. Pharm. Bull.* **1996**, *19*, 564−566.
[2] K. Hu, A. Dong, X. Yao, H. Kobayashi, S. Iwasaki, *Planta Med.* **1997**, *63*, 161−165.
[3] Y. Shao, O. Poobrasert, E. J. Kenelly, *Planta Med.* **1997**, *63*, 258−262.
[4] R. Suhr, *Thesis*, University of Hamburg, Hamburg **2001**. Abstract: http://www.sub.uni-hamburg.de/disse/848/zusammen.pdf; Full Text: http://www.sub.uni-hamburg.de/disse/848/dissertation.pdf.
[5] R. Suhr, M. Lahmann, S. Oscarson, J. Thiem, *20th International Carbohydrate Symposium*, Hamburg, **2000**; B-397.
[6] M. Lahmann, H. Gybäck, P. J. Garegg, S. Oscarson, R. Suhr, J. Thiem, *Carbohydr. Res.* **2002**, *337*, 2153−2159.
[7] P. Bovicelli, P. Lupattelli, D. Fracassi, *Tetrahedron Lett.* **1994**, *35*, 935−938.
[8] B. Yu, J. Liao, J. Zhang, Y. Hui, *Tetrahedron Lett.* **2001**, *42*, 77−79.
[9] M. S. Cheng, Q. L. Wang, Q. Tian, H. Y. Song, Y. X. Liu, Q. Li, X. Xu, H. D. Miao, X. S. Yao, Z. Yang, *J. Org. Chem.* **2003**, *68*, 3658−3662.
[10] P. J. Garegg, *Adv. Carbohydr. Chem. Biochem.* **1997**, *52*, 179−205.
[11] H. M. Doukas, T. D. Fontaine, *J. Am. Chem. Soc.* **1953**, *75*, 5355−5356.
[12] G. R. Pettit, W. J. Bowyer, *J. Org. Chem.* **1960**, *25*, 84−86.
[13] R. Tavares, T. Randoux, J.-C. Braekman, D. Daloze, *Tetrahedron* **1993**, *49*, 5079−5090.
[14] S. Bäsler, A. Brunck, R. Jautelat, E. Winterfeldt, *Helv. Chim. Acta* **2000**, *83*, 1854−1880.
[15] H. M. Zuurmond, G. H. Veeneman, G. A. van der Marel, J. H. van Boom, *Carbohydr. Res.* **1993**, *241*, 153−164.
[16] G. Schneider, R. Gille, K. Eisfeld, *Ber. Dtsch. Chem. Ges.* **1928**, *61*, 1244−1257.
[17] F. Weygand, H. Ziemann, *Justus Liebigs Ann. Chem.* **1962**, *657*, 179−188.
[18] D. B. Berkowitz, M. Bose, T. J. Pfannenstiel, T. Doukov, *J. Org. Chem.* **2000**, *65*, 4498−4508.
[19] T. Halmos, R. Montserret, J. Filippi, K. Antonakis, *Carbohydr. Res.* **1987**, *170*, 57−69.
[20] I. F. Pelyvás, T. K. Lindhorst, H. Streicher, J. Thiem, *Synthesis* **1991**, 1015−1018.
[21] O. L. Brady, C. V. Reynolds, *J. Chem. Soc.* **1928**, *130*, 193−202.
[22] M. Ueda, H. Oikawa, T. Teshirogi, *Synthesis* **1983**, 908−909.
[23] S. Kim, H. Chang, W. J. Kim, *J. Org. Chem.* **1985**, *50*, 1751−1752.
[24] H. E. Gottlieb, V. Kotlyar, A. Nudelman, *J. Org. Chem.* **1997**, *62*, 7512−7515.
[25] S. A. McLuckey, J. M. Wells, *Chem. Rev.* **2000**, *100*, 1−36.
[26] M. Ravenscroft, R. M. G. Roberts, J. G. Tillett, *J. Chem. Soc., Perkin Trans. 2* **1982**, 1569−1572.
[27] S. Komiya, *Synthesis of Organometallic Compounds − A Practical Guide*; John Wiley & Sons, Chichester, **1997**.
[28] J. J. Gridley, A. J. Hacking, H. M. I. Osborn, D. G. Spackman, *Tetrahedron* **1998**, *54*, 14925−14946.

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