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Alternative approaches towards glycosylated eight-membered ring compounds employing Claisen rearrangement of mono and disaccharide allyl vinyl ether precursors

Stefan Jürs and Joachim Thiem*

Institut für Organische Chemie der Universität, Martin-Luther-King-Platz 6, 20146 Hamburg, Germany

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Dedicated to the memory of Professor Christian Pedersen, Technical, University of Denmark, Lyngby-Copenhagen, the excellent Danish, carbohydrate chemist

Abstract—Highly functionalized eight-membered rings having a glycosidic residue were synthesized in two different ways involving either glycosylation of a sugar-derived cyclooctenone with high stereocontrol as well as a Claisen rearrangement of a disaccharide derivative.

1. Introduction

Glycosides of eight-membered carbocycles are exceptional structural motifs in nature and can be found in a number of novel taxane derivatives[1] as well as in further terpenoids based on the fusicoccane framework.[2] The biological functions of these structures are not fully understood at present, however, some of these compounds seem to have an impact on plant growth and development and stimulate seed germination.[3]

2. Results and discussion

An attractive approach to chiral oxygenated eight-membered rings consists of the ring enlargement of a pyranose-derived allyl vinyl ether to the corresponding 5-cyclooctenone derivative.[4,5] Thus, D-glucose **1** was transformed into the peracetylated α-bromide **2** (Scheme 1) and subsequently alkylated to afford the *C*-vinyl glucoside **3**[6] as an inseparable mixture of anomers (α:β = 0.2:1.0). The initially formed *C*-glucoside with unprotected hydroxyl groups had to be peracetylated in order to facilitate the removal of large amounts of magnesium salts. Deacetylation of **3** under Zemplén conditions and selective tosylation gave **5**. The introduction of benzyl groups simultaneously caused the substitution of the tosylate by a bromide, hence, this Finkelstein exchange was driven to completion by both heating and an extra addition of NaBr. The preparation of the enol ether **7** from **6**, accomplished by silver fluoride,[7] assisted the elimination of hydrogen bromide. Simple heating to 185 °C for 1 h in nitrobenzene furnished the desired 5-cyclooctenone **8** in over 80% yield.

Upon reduction using either $LiAlH_4$ or triisobutylaluminium, only one diastereomer of the 5-cyclooctenol **9** was formed. It is interesting to note that only minor changes of the coupling constant values could be observed after reduction of **8** to **9**. An additional large coupling constant ($J_{1,2}$ = 8.5 Hz) indicates a *trans*-arrangement and therefore (*S*)-configuration of the new stereogenic centre with an equatorial hydroxy group. Strong NOE interactions between H-2, H-4 and H-7 in compound **8** suggest a boat-chair like geometry, the most common conformation amongst eight-membered rings.[8] The same conformation is likely to apply to **9** in view of the lack of spectral changes. The secondary hydroxyl function could be glycosylated[9] using the benzylated β-trichloroacetimidate **10**[10] to give selectively the 1,2-*cis* configured α-glucoside **11**. The decrease of $J_{2,3}$ = 4.7 Hz in **9** to $J_{4,5}$ = 1.9 Hz in **11** is remarkable since all other coupling constants in both compounds again remain similar. Hence, **11** is assumed to feature

* Corresponding author. Tel.: +49 40 42838 4241; fax: +49 40 42838 4325; e-mail: joachim.thiem@chemie.uni-hamburg.de

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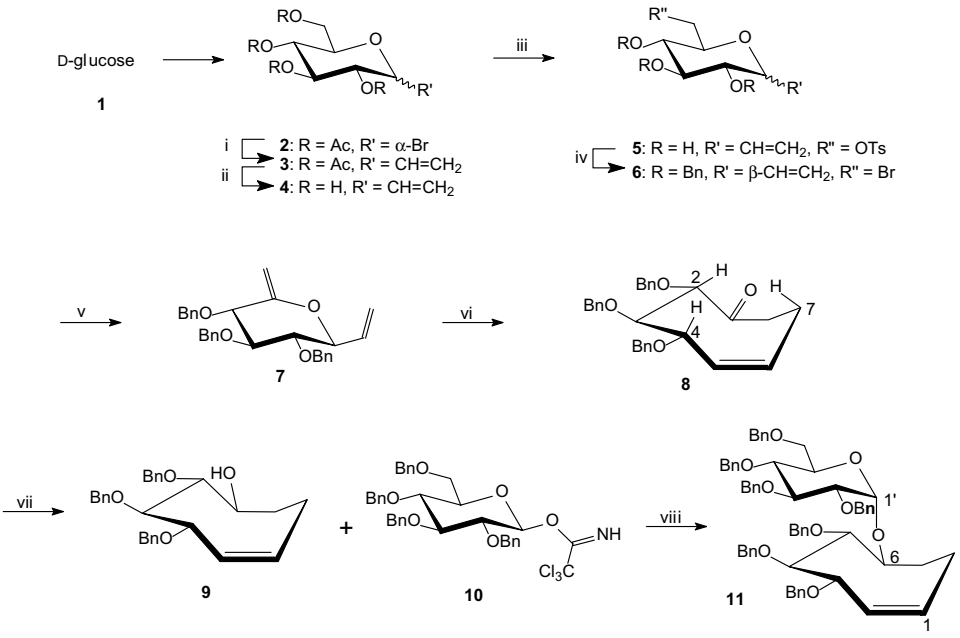


Scheme 1. Reagents and conditions: (i) CH_2=CHMgBr, THF, reflux, then Ac_2O, Py, 41%; (ii) NaOMe, MeOH, Amberlite IR 120 H^+, 100%; (iii) TsCl, Py, 93%; (iv) BnBr, NaH, DMF, then NaBr, 80 °C, 31%; (v) AgF, Py, 80%; (vi) $PhNO_2$, 185 °C, 81%; (vii) $LiAlH_4$, THF, 88%; (viii) **10**, TMSOTf, DCM, molecular sieves 4 Å, 51%.

a new interesting spatial arrangement of oxygenated functionalities, presumably boat-chair like in the cyclooctenyl residue, that could be of interest with respect to disaccharide mimetics. Moreover, the newly generated double bond offers opportunities for the introduction of further functionalities.

The selective introduction of a glycosidic residue to one of the benzyl protected hydroxyl groups in **8** was figured to be more complicated. To circumvent random glycosylation of deprotected **8**, the introduction of the glycoside should be carried out at an earlier stage in the synthesis of the 5-cyclooctenone with the aid of conventional protecting group manipulations. For this purpose, D-mannose **12** was converted into the acetylated α-bromide **13**, which in turn was used for the introduction of a *C*-vinyl group (Scheme 2). Subsequent deacetylation followed by selective silylation and isopropylidenation led to the mannose derivative **17** unprotected at the 4-position. The glycosylation of the latter using **10** (α:β = 1.0:0.8) under the same conditions as for the synthesis of **11** gave, selectively, the protected Glcα1-4Man disaccharide derivative **18** (53%). The following steps included desilylation (TBAF, THF, 61%), tosylation (TsCl, py, 92%) and substitution of the tosylate by a bromide (NaBr, DMF, 70 °C, quant.) to facilitate elimination using silver fluoride to give precursor **22** in quantitative yields after reaction (TLC), although in moderate yields after work-up.[11] In the subsequent experiment it was shown that the properly functionalized disaccharide with an allyl vinyl ether substructure **22** could be thermally converted into the corresponding glycosylated cyclooctenone **23** (70%) by a Claisen rearrangement. Precursor **22** was dissolved in a decane/toluene mixture (ratio 5:1) and heated to 180 °C for 15 min in a microwave device. The pronounced effectiveness of this solvent mixture can be attributed to the high heat capacity of decane, granting an improved energy transfer onto the substrate, and the absence of oxygen in both solvents, leading to significantly less decomposition. The use of triisobutylaluminium as a catalyst for the Claisen rearrangement, which was reported to be successful in several synthetic undertakings,[12,13] did not prove effective in this case, presumably due to the high density of oxygenated functionalities. The boat-chair conformation of **23** was also established by thorough analysis of NOE spectra and coupling constants. In this case, a relatively large coupling constant $J_{1,2}$ = 8.9 Hz was observed when compared to compound **8** ($J_{1,2}$ = 4.4 Hz). This can be attributed to the fused 1,3-dioxolane ring causing a somewhat more strained conformation.

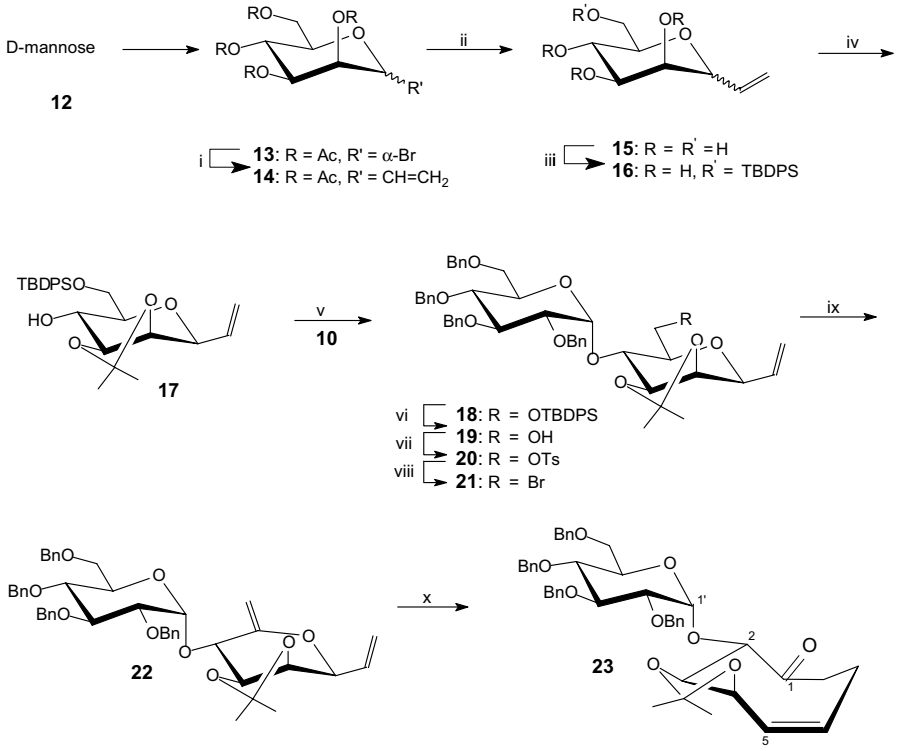
3. Conclusion

The novel enantiopure cyclooctenyl glycosides reported herein are of crucial interest with regards to disaccharide mimetics due to their unique conformational properties consisting of a boat-chair conformation in which the chair part is highly oxygenated and therefore bears exceptional resemblance to natural substrates. Further studies including complete deprotection as well as more functionalizations of the related compounds will be presented in due course.

4. Experimental

4.1. General

Solvents were purified and dried according to standard procedures. The microwave experiment was performed



Scheme 2. Reagents and conditions: (i) CH_2=CHMgBr, THF, reflux, then Ac_2O, Py, 45%; (ii) NaOMe, MeOH, Amberlite IR 120 H^+, 100%; (iii) TBDPSCl, imidazole, DMF, 80%; (iv) $CH_3C(OCH_3)_2CH_3$, acetone, *p*-TSA, 62%; (v) **10**, TMSOTf, DCM, molecular sieves 4 Å, 53%; (vi) TBAF, THF, 61%; (vii) TsCl, Py, cat. DMAP, 83%; (viii) NaBr, DMF, 70 °C, 100%; (ix) AgF, Py, 21%; (x) *n*-decane/toluene 5:1, 180 °C, 70%.

in a CEM microwave system (Discover, 300 W maximum power output). Petroleum ether used refers to bp 50–70 °C. TLC was performed on silica gel 60-coated aluminium sheets (Merck or Macherey-Nagel), with detection by UV at 254 nm and by heating with H_2SO_4 (5% in EtOH). Flash chromatography was carried out on silica gel 60 (0.04–0.063 mm; Merck, Macherey-Nagel or ICN). NMR spectra were recorded on a Bruker AMX-400 NMR spectrometer (^{1}H: 400 MHz; ^{13}C: 100 MHz) and analyzed with the respective solvent peaks as references. IR spectra were recorded on a Thermo Electron FT-IR spectrometer (Nicolet Avatar 370). Melting points were determined on a Leitz apparatus and are uncorrected. The optical rotations were measured on a Perkin–Elmer 243 or 341 polarimeter at 20 °C. With regards to nomenclature, in most cases the sugar nomenclature[14] was applied except for the more complex oligohydroxy cyclooctene derivatives.

4.2. 4,5,6,8-Tetra-*O*-acetyl-3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*gulo*-oct-1-enitol [β-anomer] and 4,5,6,8-tetra-*O*-acetyl-3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*ido*-oct-1-enitol [α-anomer] 3

Under an argon atmosphere, a solution of 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosylbromide **2**[15] (8.23 g, 20.00 mmol) in dry THF (60 mL) was added dropwise to a solution of vinyl magnesium bromide in THF (200 mL, 1 M, 200 mmol). At the end of the exothermic reaction, heating under reflux was continued for 5 h. The reaction mixture was poured onto ice/water and neutralized with acetic acid. The aqueous phase was evaporated and the residue dried for several hours in vacuo. After suspension of the residue in pyridine (200 mL) and addition of acetic anhydride (200 mL) at 0 °C, the reaction mixture was stirred for 2 days at room temperature. The mixture was then poured into iced water and extracted several times with dichloromethane. After evaporation of the solvent, the residue was purified by column chromatography (petroleum ether/ethyl acetate 3:1) to give 2.970 g of **3** (8.29 mmol, 41%, colourless crystals) as an inseparable anomeric mixture (α:β ≈ 0.2:1.0). $C_{16}H_{22}O_9$ (358.3); MALDI-TOF: $[M+Na]^+$: 381, $[M+K]^+$: 397; β-anomer: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.99, 2.00, 2.02, 2.08 (4 × s, 4 × 3H, Ac), 3.69 (ddd, 1H, H-7, $J_{6,7}$ = 9.7, $J_{7,8a}$ = 4.8, $J_{7,8b}$ = 2.2 Hz), 3.86 (dd, 1H, H-3, $J_{2,3}$ = 7.1, $J_{3,4}$ = 9.7 Hz), 4.12 (dd, 1H, H-8b, $J_{7,8b}$ = 2.2, $J_{8a,8b}$ = 12.4 Hz), 4.24 (dd, 1H, H-8a, $J_{7,8a}$ = 4.8, $J_{8a,8b}$ = 12.4 Hz), 4.93 (dd ~ t, 1H, H-4, $J_{3,4}$ = $J_{4,5}$ = 9.7 Hz), 5.08 (dd ~ t, 1H, H-6, $J_{5,6}$ = $J_{6,7}$ = 9.7 Hz), 5.22 (dd ~ t, 1H, H-5, $J_{4,5}$ = $J_{5,6}$ = 9.7 Hz), 5.26–5.37 (m, 2H, H-1a, H-1b, $J_{1a,2}$ = 17.4, $J_{1b,2}$ = 10.4 Hz), 5.75 (ddd, 1H, H-2, $J_{2,3}$ = 7.1 Hz) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.75, 20.79, 20.84, 20.90 (4C, 4 × acetyl–Me), 62.41 (1C, C-8), 68.66, 71.37, 74.09, 75.74, 79.59 (5C, C-3, C-4, C-5, C-6, C-7), 120.21 (1C, C-1), 133.35 (1C, C-2), 169.62, 169.63, 170.50, 170.87 (4C, 4 × acetyl–CO_2) ppm; Anal. Calcd for $C_{16}H_{22}O_9$ (358.3): C, 53.62; H, 6.20. Found C, 53.58; H, 6.24.

4.3. 3,7-Anhydro-1,2-dideoxy-D-*glycero*-D-*gulo*-oct-1-enitol [β-anomer] and 3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*ido*-oct-1-enitol [α-anomer] 4

To a solution of **3** (2.790 g, 8.288 mmol) in dry methanol (50 mL) was added sodium methoxide (NaOMe) until pH 9 was reached. The reaction mixture was stirred for several hours until TLC control (dichloromethane/methanol 10:1) confirmed complete reaction. After neutralization with Amberlite IR 120 H^+, the solution was filtered and the solvent evaporated to give 1.570 g of **4** (8.254 mmol, 100%) as an inseparable anomeric mixture (α:β ≈ 0.2:1.0); $C_8H_{14}O_5$ (190.2); MALDI-TOF: $[M+Na]^+$: 213, $[M+K]^+$: 229; β-anomer: ^1H NMR (400 MHz, MeOD): δ = 3.09 (dd ~ t, 1H, H-4), 3.25–3.38 (m, 6H, H-5, H-6, H-7, 3 × OH), 3.60–3.68 (m, 2H, H-3, H-8b, $J_{2,3}$ = 5.9 Hz), 3.86 (dd, 1H, H-8a), 5.21 (ddd, 1H, H-1b), 5.39 (ddd, 1H, H-1a), 5.93 (ddd, 1H, H-2) ppm; ^{13}C NMR (100 MHz, CD_3OD): δ = 63.10 (1C, C-8), 71.86, 75.40, 79.65, 81.57, 81.67 (5C, C-3, C-4, C-5, C-6, C-7), 117.68 (1C, C-1), 136.93 (1C, C-2) ppm; Anal. Calcd for $C_8H_{14}O_5$ (190.2): C, 50.51; H, 7.42; Found: C, 48.88; H, 7.71 (hygroscopic).

4.4. 3,7-Anhydro-1,2-dideoxy-8-*O*-(4-toluenesulfonyl)-D-*glycero*-D-*gulo*-oct-1-enitol [β-anomer] and 3,7-anhydro-1,2-dideoxy-8-*O*-(4-toluenesulfonyl)-D-*glycero*-D-*ido*-oct-1-enitol [α-anomer] 5

To a solution of **4** (1.432 g, 7.530 mmol) in dry pyridine (50 mL) was added *p*-toluenesulfonyl chloride (1.58 g, 8.29 mmol) at 0 °C. The solution was stirred at room temperature for 2 days. If necessary, further small portions of *p*-toluenesulfonyl chloride were added to effect the complete consumption of starting material. The reaction was terminated by the addition of water followed by evaporation of the solvents and co-distillation with toluene. Column chromatography of the residue (dichloromethane/methanol 10:1) gave 2.42 g **5** (7.03 mmol, 93%) as an inseparable mixture of anomers (α:β ≈ 0.2:1.0); $C_{15}H_{20}O_7S$ (344.4); MALDI-TOF: $[M+Na]^+$: 367, $[M+K]^+$: 383; β-anomer: ^1H NMR (400 MHz, $CDCl_3$): δ = 2.43 (s, 3H, Ts–Me), 3.20–3.79 (m, 7H, H-4, H-5, H-6, H-7, 3 × OH), 4.23–4.31 (m, 2H, H-8a/b), 5.23 (d, 1H, H-1b), 5.30 (d, 1H, H-1a), 5.85 (m, 1H, H-2), 7.32, 7.78 (2 × d, 4H, Ar) ppm; ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.79 (1C, Ts–Me), 69.52 (1C, C-8), 69.86, 73.62, 76.94, 78.11, 80.28 (5C, C-3, C-4, C-5, C-6, C-7), 118.57 (1C, C-1), 128.16, 130.03, 132.81 (5C, Ar), 134.75 (1C, C-2) ppm.

4.5. 3,7-Anhydro-4,5,6-tri-*O*-benzyl-8-bromo-1,2,8-trideoxy-D-*glycero*-D-*gulo*-oct-1-enitol 6

To a solution of **5** (1.692 g, 4.913 mmol) in dry DMF (45 mL) were added benzylbromide (4.67 mL, 39.3 mmol) and sodium hydride (1.179 g of a 60% suspension in paraffine, 29.48 mmol) one after another whilst stirring. After 3 h, sodium bromide was added (2.53 g, 24.56 mmol), the solution heated to 80 °C and stirring continued overnight. The reaction was terminated by the addition of ethyl acetate and water. The solution was extracted with dichloromethane and the combined organic extracts washed with saturated sodium chloride solution. After evaporation of the solvents, the residue was purified by column chromatography (petroleum ether/ethyl acetate 20:1) to give 0.921 g of **6** (1.759 mmol, 36%, yellowish solid) as pure β-anomer; mp (solid after chromatography): 65–67 °C; $[\alpha]_D^{20} = +19.4$ (*c* 0.5, $CHCl_3$); $C_{29}H_{31}O_4Br$, 523.5; MALDI-TOF: $[M+Na]^+$: 545, 547; $[M+K]^+$: 561; ^1H NMR (400 MHz, $CDCl_3$): δ = 3.35 (dd ~ t, 1H, H-4, $J_{3,4} = J_{4,5}$ = 9.4 Hz), 3.47–3.51 (m, 1H, H-7, $J_{6,7}$ = 9.4, $J_{7,8a}$ = 2.5, $J_{7,8b}$ = 4.3 Hz), 3.60–3.64 (m, 2H, H-6, H-8b, $J_{5,6} = J_{6,7}$ = 9.4, $J_{7,8b}$ = 4.3, $J_{8a,8b}$ = 10.9 Hz), 3.70 (dd, 1H, H-8a, $J_{7,8a}$ = 2.5, $J_{8a,8b}$ = 10.9 Hz), 3.75 (dd ~ t, 1H, H-5, $J_{4,5} = J_{5,6}$ = 9.4 Hz), 3.84 (dd, 1H, H-3, $J_{2,3}$ = 6.1, $J_{3,4}$ = 9.4 Hz), 4.67, 4.74, 4.76, 4.88, 4.94, 4.95 (6 × d, 6 × 1H, OCH_2), 5.30–5.33 (m, 1H, H-1b, $J_{1b,2}$ = 10.7, $J_{1a,1b}$ = 1.3 Hz), 5.49 (ddd ~ dt, 1H, H-1a, $J_{1a,2}$ = 17.3, $J_{1a,1b}$ = 1.3 Hz), 5.93–6.01 (m, 1H, H-2, $J_{1a,2}$ = 17.3, $J_{1b,2}$ = 10.7, $J_{2,3}$ = 6.1 Hz), 7.28–7.38 (m, 15H, Ar) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 33.57 (1C, C-8), 75.31, 75.48, 75.78 (3C, OCH_2), 77.21, 79.79, 79.99, 82.78, 86.57 (5C, C-3, C-4, C-5, C-6, C-7), 118.57 (1C, C-1), 127.85–128.75 (15C, Ar), 135.00 (1C, C-2), 138.05, 138.11, 138.58 (3C, Ar) ppm; Anal. Calcd for $C_{29}H_{31}O_4Br$, 523.5: C, 66.53; H, 5.98. Found: C, 65.71; H, 5.99.

4.6. 3,7-Anhydro-4,5,6-tri-*O*-benzyl-1,2,8-trideoxy-D-*gulo*-oct-1,7-dienitol 7

To a solution of **6** (1.147 g, 2.190 mmol) in dry pyridine (40 mL) was added silver fluoride (1.100 g, 8.67 mmol). The solution was stirred for 2 days at room temperature under light exclusion until TLC control confirmed the complete consumption of starting material. After dilution with dichloromethane followed by filtration, evaporation and co-distillation with toluene the residue was purified by column chromatography (petroleum ether/ethyl acetate 20:1) to give 0.780 g **7** (1.760 mmol, 80%) as colourless crystals (pure β-anomer). Mp (solid after chromatography): 55 °C; $[\alpha]_D^{20} = -75.1$ (*c* 0.2, $CHCl_3$); $C_{29}H_{30}O_4$, 442.6; MALDI-TOF: $[M+Na]^+$: 465, $[M+K]^+$: 481; ^1H NMR (400 MHz, $CDCl_3$): δ = 3.28 (dd, 1H, H-4, $J_{3,4}$ = 9.8, $J_{4,5}$ = 7.5 Hz), 3.57 (dd ~ t, 1H, H-5, $J_{4,5} = J_{5,6}$ = 7.5 Hz), 3.81 (d, 1H, H-6, $J_{5,6}$ = 7.5 Hz), 3.94–3.98 (m, 1H, H-3, $J_{2,3}$ = 6.4, $J_{3,4}$ = 9.8 Hz), 4.45–4.70 (m, 8H, H-8a/b, OCH_2), 5.16–5.19 (m, 1H, H-1b, $J_{1a,1b}$ = 1.3, $J_{1b,2}$ = 10.7 Hz), 5.31–5.36 (m, 1H, H-1a, $J_{1a,1b}$ = 1.3, $J_{1a,2}$ = 17.3 Hz), 5.76–5.34 (m, 1H, H-2, $J_{1a,2}$ = 17.3, $J_{1b,2}$ = 10.7, $J_{2,3}$ = 6.4 Hz), 7.10–7.24 (m, 15H, Ar) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 72.83, 74.54, 74.68 (3C, OCH_2), 78.99, 79.49, 82.12, 84.50 (4C, C-3, C-4, C-5, C-6), 94.94 (1C, C-8), 118.65 (1C, C-1), 127.84–128.60 (15C, Ar), 135.08 (1C, C-2), 138.02, 138.13, 138.46 (3C, Ar), 156.10 (1C, C-7) ppm.

4.7. *cis*-(2*S*,3*R*,4*S*)-2,3,4-Tribenzyloxycyclooct-5-enone 8

A solution of **7** (0.758 g, 1.710 mmol) in nitrobenzene (20 mL) was placed in a preheated oil bath and heated at 185 °C for 1 h. After evaporation of the solvent, the

residue was purified by column chromatography (petroleum ether/ethyl acetate 10:1) to give 0.612 g **8** (1.383 mmol, 81%) as an orange syrup. $C_{29}H_{30}O_4$, 442.6; MALDI-TOF: $[M+Na]^+$: 465, $[M+K]^+$: 481; $[\alpha]_D^{20} = +20.4$ (*c* 1, $CHCl_3$); *v* (film/cm^{-1}): 1719 (C=O); ^{1}H NMR (500 MHz, C_6D_6): δ = 1.77–1.83, 1.98–2.07, 2.59–2.65 (3 × m, 4H, H-7a/b, H-8a/b), 3.72 (dd, 1H, H-3, $J_{2,3}$ = 4.4, $J_{3,4}$ = 8.8 Hz), 4.07 (d, 1H, H-2, $J_{2,3}$ = 4.4 Hz), 4.15, 4.20 (2 × d, 2 × 1H, OCH_2), 4.24 (dd, 1H, H-4, $J_{3,4}$ = 8.8, $J_{4,5}$ = 6.6 Hz), 4.38, 4.51 (2 × d, 2 × 1H, OCH_2), 4.73 (s, 2H, OCH_2), 5.54–5.63 (m, 2H, H-5, H-6, $J_{4,5}$ = 6.6, $J_{5,6}$ = 11.4 Hz) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 23.68 (1C, C-7), 42.35 (1C, C-8), 71.87, 72.51, 74.65 (3C, OCH_2), 77.87, 80.31, 84.87 (3C, C-2, C-3, C-4), 127.62, 127.79, 127.91, 128.04, 128.44, 128.47, 128.60, 131.67, 131.71 (15C, Ar), (2C, C-5, C-6), 137.66, 138.47, 138.50 (3C, Ar), 212.58 (1C, C-1) ppm.

4.8. *cis*-(1*S*,2*R*,3*R*,4*S*)-2,3,4-Tribenzyloxycyclooct-5-en-1-ol 9

To a solution of **8** (92 mg, 208 μmol) in THF (4 mL) was added $LiAlH_4$ (14 mg, 369 μmol) at 0 °C and stirring continued overnight. Water was added to destroy excess $LiAlH_4$. The precipitate was diluted with a small amount of 2 M sulphuric acid. The solution was diluted with chloroform and the organic phase washed with water. After another extraction of the aqueous phase with chloroform the combined organic phases were evaporated. Column chromatography of the residue (petroleum ether/ethyl acetate 10:1) gave 81 mg of **9** (182 μmol, 88%) as a yellowish syrup; $C_{29}H_{32}O_4$, 444.6; MALDI-TOF: $[M+Na]^+$: 467, $[M+K]^+$: 483; $[\alpha]_D^{20} = -4.8$ (*c* 1, $CHCl_3$); ^{1}H NMR (500 MHz, C_6D_6): δ = 1.79–1.89, 1.96–2.03, 2.52–2.61 (3 × m, 4H, H-7a/b, H-8a/b), 3.29 (s, 1H, OH), 3.66 (dd, 1H, H-3, $J_{2,3}$ = 4.7, $J_{3,4}$ = 7.9 Hz), 3.77 (dd, 1H, H-2, $J_{1,2}$ = 8.5, $J_{2,3}$ = 4.7 Hz), 4.18–4.21 (m, 2H, H-1, OCH_2), 4.39, 4.46 (2 × d, 2 × 1H, OCH_2), 4.61 (d, 2H, OCH_2), 4.78 (d, 1H, OCH_2), 4.82 (dd ∼ t, 1H, H-4, $J_{3,4} = J_{4,5}$ = 7.9 Hz), 5.56–5.60 (m, 1H, H-5, $J_{4,5}$ = 7.9, $J_{5,6}$ = 10.9 Hz), 5.71–5.77 (m, 1H, H-6, $J_{5,6}$ = 10.9 Hz), 7.07–7.35 (m, 15H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 22.21 (1C, C-7), 32.42 (1C, C-8), 70.71, 78.97, 81.60, 85.20 (4C, C-1, C-2, C-3, C-4), 71.40, 73.61, 74.95 (3C, OCH_2), 127.70–128.62, 138.93, 139.09, 139.47 (18C, Ar), 129.76, 133.68 (2C, C-5, C-6) ppm.

4.9. [*cis*-(3*S*,4*R*,5*S*,6*S*)-3,4,5-Tribenzyloxycycloocten-6-yl]-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 11

To a solution of **9** (17 mg, 38 μmol) in dry dichloromethane (1.3 mL) with molecular sieves was added a solution of TMSOTf in dichloromethane (40 μL, concentration approx. 0.223 M, 9 μmol) at 0 °C under an argon atmosphere. Afterwards, a solution of **10** (41 mg, 60 μmol) in dichloromethane (1.1 mL) was added at 0 °C. The reaction mixture was stirred overnight and terminated by the addition of three drops of triethylamine. Evaporation of the solvent and chromatography of the residue (petroleum ether/ethyl acetate 12:1) gave 19 mg of **11** (20 μmol, 51%); $[\alpha]_D^{20} = +17.3$ (*c* 1, $CHCl_3$); $C_{63}H_{66}O_9$, 967.3; MALDI-TOF: $[M+Na]^+$ = 989, $[M+K]^+$ = 1005; ^{1}H NMR (500 MHz, C_6D_6): δ = 1.66–1.80 (m, 3H, H-8b, H-7a/b), 2.79–2.86 (m, 1H, H-8a), 3.57 (dd, 1H, H-2′, $J_{1',2'}$ = 3.2, $J_{2',3'}$ = 9.5 Hz), 3.70, 3.73 (2 × dd, 2 × 1H, H-6′a/b, $J_{5',6'a}$ = 4.1, $J_{5',6'b}$ = 2.0, $J_{6'a,6'b}$ = 10.5 Hz), 3.76 (dd ∼ t, 1H, H-4′, $J_{3',4'} = J_{4',5'}$ = 9.5 Hz), 3.88 (dd, 1H, H-4, $J_{3,4}$ = 8.5, $J_{4,5}$ = 1.9 Hz), 4.00 (dd, 1H, H-5, $J_{4,5}$ = 1.9, $J_{5,6}$ = 8.2 Hz), 4.05, 4.29 (2 × d, 2 × 1H, OCH_2), 4.40–4.43 (m, 1H, H-6, $J_{5,6}$ = 8.2 Hz), 4.67, 4.76, 4.88, 4.90 (4 × d, 4 × 1H, OCH_2), 4.92 (d, 1H, H-1′, $J_{1',2'}$ = 3.2), 4.98, 5.04 (2d, 2 × 1H, OCH_2), 5.26 (dd ∼ t, 1H, H-3, $J_{2,3} = J_{3,4}$ = 8.5 Hz), 5.68–5.74 (m, 1H, H-2, $J_{1,2}$ = 10.4, $J_{2,3}$ = 8.5 Hz), 5.77–5.82 (m, 1H, H-1, $J_{1,2}$ = 10.4 Hz), 7.02–7.44 (m, 35H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 20.89 (1C, C-8), 26.48 (1C, C-7), 69.45 (1C, C-6′), 71.24 (1C, C-5′), 71.69, 71.86, 72.96, 73.14 (4C, OCH_2), 73.26 (1C, C-6), 74.66, 74.71, 75.21 (3C, OCH_2), 78.59 (1C, C-4′), 78.87 (1C, C-3), 80.86, 80.94 (2C, C-5, C-2′), 82.00 (1C, C-3′), 85.31 (1C, C-4), 93.78 (1C, C-1′), 126.87–128.75 (42C, Ar), 130.60 (1C, C-2), 131.80 (1C, C-1) ppm.

4.10. 4,5,6,8-Tetra-*O*-acetyl-3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*galacto*-oct-1-enitol [β-anomer] and 4,5,6,8-tetra-*O*-acetyl-3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*talo*-oct-1-enitol [α-anomer] 14

Under an argon atmosphere, a solution of **13**[16] (8.19 g, 19.92 mmol) in dry THF (70 mL) was added dropwise to a solution of vinyl magnesium bromide in THF (200 mL, 1 M, 200 mmol). After the end of the exothermic reaction heating under reflux was continued for 5 h. The reaction mixture was poured into iced water and neutralized with acetic acid. The aqueous phase was evaporated and the residue dried for several hours in vacuo. After suspension of the residue in pyridine (150 mL) and addition of acetic anhydride (150 mL) at 0 °C, the reaction mixture was stirred for 2 days. The mixture was then poured into ice water and extracted with dichloromethane. After evaporation of the solvent the residue was purified by column chromatography (petroleum ether/ethyl acetate 3:1) to give 3.177 g of **14** (8.86 mmol, 45%, white solid) as an inseparable anomeric mixture (α:β ≈ 0.4:1.0). $C_{16}H_{22}O_9$, 358.4; MALDI-TOF: $[M+Na]^+$: 381, $[M+K]^+$: 397; β-anomer: ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.98, 2.04, 2.09, 2.13 (4 × s, 4 × 3H, Ac), 3.68 (ddd, 1H, H-7, $J_{6,7}$ = 9.9, $J_{7,8a}$ = 5.6, $J_{7,8b}$ = 2.5 Hz), 4.08–4.18 (m, 2H, H-3, H-8b, $J_{2,3}$ = 5.3, $J_{3,4}$ = 1.3, $J_{7,8b}$ = 2.5, $J_{8a,8b}$ = 12.2 Hz), 4.27 (dd, 1H, H-8a, $J_{7,8a}$ = 5.6, $J_{8a,8b}$ = 12.2 Hz), 5.08 (dd, 1H, H-5, $J_{4,5}$ = 3.4, $J_{5,6}$ = 9.9 Hz), 5.24 (ddd ∼ dt, 1H, H-1b, $J_{1a,1b}$ = 1.3, $J_{1b,2}$ = 10.8), 5.25 (dd ∼ t, 1H, H-6, $J_{5,6} = J_{6,7}$ = 9.9 Hz), 5.85 (ddd ∼ dt, 1H, H-1a, $J_{1a,1b}$ = 1.3, $J_{1a,2}$ = 17.5 Hz), 5.40 (dd, 1H, H-4, $J_{3,4}$ = 1.3, $J_{4,5}$ = 3.4 Hz), 5.72 (ddd, 1H, H-2, $J_{1a,2}$ = 17.5, $J_{1b,2}$ = 10.8, $J_{2,3}$ = 5.3 Hz) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.77, 20.83, 20.86, 20.95 (4C, Ac), 63.04 (1C, C-8), 66.23 (1C, C-6), 70.05 (1C, C-4), 72.41 (1C, C-5), 76.28 (1C, C-7), 77.57 (1C, C-3), 118.59 (1C, C-1), 132.43 (1C, C-2), 169.84, 170.35, 170.57, 170.91 (4C, acetyl–CO_2) ppm; Anal. Calcd for

$C_{16}H_{22}O_9$, 358.4: C, 53.62; H, 6.20. Found: C, 52.95; H, 6.20.

4.11. 3,7-Anhydro-1,2-dideoxy-D-*glycero*-D-*galacto*-oct-1-enitol [β-anomer] and 3,7-anhydro-1,2-dideoxy-D-*glycero*-D-*talo*-oct-1-enitol [α-anomer] 15

To a solution of **14** (3.102 g, 8.660 mmol) in dry methanol (50 mL) was added sodium methoxide (NaOMe) until pH 9 was reached. The reaction mixture was stirred for several hours until TLC control (dichloromethane/methanol 10:1) confirmed complete reaction. After neutralization with Amberlite IR 120 H^+, the solution was filtered and the solvent evaporated to give 1.645 g of **15** (8.649 mmol, 100%, colourless syrup) as an inseparable anomeric mixture (α:β ≈ 0.4:1.0). $C_8H_{14}O_5$, 190.2; MALDI-TOF: $[M+Na]^+$: 213, $[M+K]^+$: 229; β-anomer: ^1H NMR (500 MHz, $(CD_3)_2SO$): $\delta = 3.03$–3.06 (m, 1H, H-7), 3.28–3.47, 3.57–3.69 (2 × m, 10H, H-4, H-5, H-6, H-8a/b), 3.82 (dd, 1H, H-3), 4.29–4.75 (br m, 8H, OH), 5.09 (ddd ∼ dt, 1H, H-1b), 5.20–5.29 (m, 3H, H-1a, H-1b), 5.84–5.95 (m, 2H, H-2) ppm. ^{13}C NMR (100 MHz, $(CD_3)_2SO$): $\delta = 61.68$ (1C, C-8), 67.20, 71.79, 74.75, 78.92, 81.06 (5C, C-3, C-4, C-5, C-6, C-7), 115.73 (1C, C-1), 137.07 (1C, C-2) ppm.

4.12. 3,7-Anhydro-8-*O*-*tert*-butyldiphenylsilyl-1,2-dideoxy-D-*glycero*-D-*galacto*-oct-1-enitol [β-anomer] and 3,7-anhydro-8-*O*-*tert*-butyldiphenylsilyl-1,2-dideoxy-D-*glycero*-D-*talo*-oct-1-enitol [α-anomer] 16

To a solution of **15** (1.662 g, 8.738 mmol) in DMF (50 mL) was added imidazole (0.654 g, 9.606 mmol) and *tert*-butyldiphenylsilyl chloride (2.46 mL, 9.612 mmol). The reaction mixture was stirred for 3 days with two further additions of *tert*-butyldiphenylsilyl chloride (0.80 mL, 0.60 mL, respectively). After TLC control confirmed the disappearance of the starting material, the reaction was quenched with water. Acetone was then added in order to precipitate the imidazolium salts. After filtration and evaporation, the residue was purified by column chromatography (petroleum ether/ethyl acetate 1:2) to give 2.996 g of **16** (6.989 mmol, 80%, colourless syrup) as an inseparable anomeric mixture (α:β ≈ 0.4:1.0). $C_{24}H_{32}O_5Si$, 428.7; MALDI-TOF: $[M+Na]^+$: 452, $[M+K]^+$: 467; β-anomer: ^1H NMR (500 MHz, $CDCl_3$): $\delta = 1.06$ (s, 9H, *tert*-butyl), 2.87–3.05 (br s, 3H, 3 × OH), 3.37–3.41 (m, 1H, H-7, $J_{6,7} = 9.5$, $J_{7,8a} = 4.7$, $J_{7,8b} = 5.7$ Hz), 3.63 (dd, 1H, H-5, $J_{4,5} = 3.2$, $J_{5,6} = 9.1$ Hz), 3.87–3.90, 4.01–4.02 (2 × m, 3H, H-3, H-4, H-6, $J_{2,3} = 4.7$, $J_{4,5} = 3.2$, $J_{5,6} = 9.1$, $J_{6,7} = 9.5$ Hz), 3.93 (dd, 1H, H-8a, $J_{7,8a} = 4.7$, $J_{8a,8b} = 10.7$ Hz), 3.98 (dd, 1H, H-8b, $J_{7,8b} = 5.7$, $J_{8a,8b} = 10.7$ Hz), 5.29 (ddd ∼ dt, 1H, H-1a, $J_{1a,1b} = 1.5$, $J_{1a,2} = 17.3$ Hz), 5.39 (ddd ∼ dt, 1H, H-1b, $J_{1a,1b} = 1.5$, $J_{1b,2} = 10.7$ Hz), 5.87 (ddd, 1H, H-2, $J_{1a,2} = 17.3$, $J_{1b,2} = 10.7$, $J_{2,3} = 4.7$ Hz), 7.38–7.45, 7.66–7.70 (2 × m, 10H, Ar) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): $\delta = 26.79$ (4C, *tert*-butyl), 65.28 (1C, C-8), 70.54, 71.00, 75.31, 77.92, 78.23 (5C, C-3, C-4, C-5, C-6, C-7), 117.47 (1C, C-1), 127.80, 129.89, 132.75, 132.78, 134.06, 135.55 (12C, Ar), 134.06 (1C, C-2) ppm.

4.13. 3,7-Anhydro-8-*O*-*tert*-butyldiphenylsilyl-1,2-dideoxy-4,5-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-oct-1-enitol 17

To a stirred solution of **16** (0.259 g, 0.604 mmol) in acetone (6 mL) was added 2,2-dimethoxypropane (1.5 mL) and *p*-toluenesulfonic acid (0.003 g). After stirring overnight, two drops of triethylamine were added and the solvents evaporated. Chromatography of the residue (petroleum ether/ethyl acetate 4:1) gave 0.176 g of **17** (0.375 mmol, 62%, white solid) as pure β-anomer. Mp (solid after chromatography): 87–90 °C; $[\alpha]_{546}^{20} = -8.0$ (*c* 0.5, EtOAc); $C_{27}H_{36}O_5Si$, 468.7; MALDI-TOF: $[M+Na]^+$: 492, $[M+K]^+$: 508; ^1H NMR (400 MHz, C_6D_6): $\delta = 1.18$ (s, 9H, *tert*-butyl), 1.26, 1.50 (2 × s, 2 × 3H, 2 × Me), 2.21 (br s, 1H, 6-OH), 3.16 (m, 1H, H-7, $J_{6,7} = 9.2$, $J_{7,8a} = 3.8$, $J_{7,8b} = 4.6$ Hz), 3.72 (dd, 1H, H-4, $J_{4,5} = 2.3$ Hz), 3.75 (ddd ∼ dt, 1H, H-3, $J_{2,3} = 5.9$ Hz), 3.86–3.93 (m, 2H, H-5, H-6, $J_{4,5} = 2.3$, $J_{6,7} = 9.2$ Hz), 4.02–4.09 (m, 2H, H-8a/b, $J_{7,8a} = 3.8$, $J_{7,8b} = 4.6$, $J_{8a,8b} = 10.8$ Hz), 5.12 (ddd ∼ dt, 1H, H-1b, $J_{1a,1b} = 1.5$, $J_{1b,2} = 10.7$ Hz), 5.33 (ddd ∼ dt, 1H, H-1a, $J_{1a,1b} = 1.5$, $J_{1a,2} = 17.3$ Hz), 6.09 (ddd, 1H, H-2, $J_{1a,2} = 17.3$, $J_{1b,2} = 10.7$, $J_{2,3} = 5.9$ Hz), 7.19–7.26, 7.83–7.88 (2 × m, 10H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): $\delta = 26.64$ (1C, Me), 27.08 (3C, *tert*-butyl), 28.53 (1C, Me), 64.95 (1C, C-8), 70.97 (1C, C-6), 76.55 (1C, C-4), 77.38 (1C, C-3), 78.64 (1C, C-7), 80.63 (1C, C-5), 109.56 (1C, CMe_2), 116.54 (1C, C-1), 128.16–136.22 (13C, C-2, Ar) ppm; Anal. Calcd for $C_{27}H_{36}O_5Si$, 468.7: C, 69.18; H, 7.76. Found: C, 68.75; H, 7.75.

4.14. (3,7-Anhydro-8-*O*-*tert*-butyldiphenylsilyl-1,2,6-trideoxy-4,5-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-oct-1-enitol-6-yl)-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 18

To a solution of **17** (96 mg, 205 μmol) in dry dichloromethane (5 mL) with molecular sieves was added a solution of TMSOTf in dichloromethane (170 μL, concentration approx. 0.223 M, 38 μmol) at 0 °C under an argon atmosphere. Afterwards, a solution of **10** (168 mg, 248 μmol) in dichloromethane (4 mL) was added at 0 °C. The reaction mixture was stirred overnight and terminated by the addition of three drops of triethylamine. Evaporation of the solvent and chromatography of the residue (petroleum ether/ethyl acetate 12:1) gave 108 mg **18** (109 μmol, 53%) as a yellow syrup. $[\alpha]_{546}^{20} = +36.5$ (*c* 0.5, EtOAc); $C_{61}H_{70}O_{10}Si$, 991.4; MALDI-TOF: $[M+Na]^+$: 1014, $[M+K]^+$: 1030; ^1H NMR (500 MHz, C_6D_6): $\delta = 1.24$ (s, 9H, *tert*-butyl), 1.40, 1.53 (2 × s, 2 × 3H, 2Me), 3.32 (ddd, 1H, H-7, $J_{6,7} = 9.1$, $J_{7,8a} = 2.2$, $J_{7,8b} = 4.4$ Hz), 3.54 (d, 1H, H-6′b, $J_{6'a,6'b} = 10.4$ Hz), 3.61 (dd, 1H, H-2′, $J_{1',2'} = 3.5$, $J_{2',3'} = 9.8$ Hz), 3.69–3.74 (m, 3H, H-3, H-5, H-6′a, $J_{2,3} = 5.9$, $J_{6'a,6'b} = 10.4$ Hz), 3.98–4.03 (m, 2H, H-4′, H-5′), 4.14–4.30 (m, 6H, H-3′, H-8a/b, H-6, H-4, OCH_2, $J_{6,7} = 9.1$, $J_{7,8a} = 2.2$, $J_{7,8b} = 4.4$, $J_{2',3'} = 9.8$ Hz), 4.43, 4.58, 4.70, 4.71, 4.91, 5.00, 5.09 (7 × d, 7H, OCH_2), 5.15 (d, 1H, H-1b, $J_{1b,2} = 10.4$ Hz), 5.34 (d, 1H, H-1a, $J_{1a,2} = 17.0$ Hz), 5.90 (d, 1H, H-1′, $J_{1',2'} = 3.5$ Hz), 6.07–6.13 (m, 1H, H-2, $J_{1a,2} = 17.0$, $J_{1b,2} = 10.4$,

$J_{2,3}$ = 5.9 Hz), 7.08–7.42, 7.87–7.95 (2 × m, 30H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 26.62 (1C, Me), 27.29 (3C, *tert*-butyl), 28.26 (1C, Me), 64.48 (1C, C-8), 69.21 (1C, C-6′), 72.03 (1C, C-5′), 73.13 (1C, C-4), 73.27, 73.61, 75.40, 75.57 (4C, OCH_2), 76.71, 77.30 (2C, C-3, C-5), 78.34, 78.47 (2C, C-7, C-4′), 80.32 (1C, C-6), 81.07 (1C, C-2′), 82.24 (1C, C-3′), 95.84 (1C, C-1′), 109.72 (1C, CMe_2), 116.67 (1C, C-1), 127.52–128.57, 129.90, 129.99, 135.31, 136.08, 136.47 (37C, C-2, Ar) ppm.

4.15. (3,7-Anhydro-1,2,6-trideoxy-4,5-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-oct-1-enitol-6-yl)-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 19

To a solution of **18** (157 mg, 158 μmol) in THF (7 mL) was added a solution of tetrabutylammonium fluoride in THF (0.19 mL, 1 M, 190 μmol) at 0 °C. The solution was stirred at room temperature for 4 days. Evaporation of the solvent and chromatography of the residue (petroleum ether/ethyl acetate 4:1) gave 73 mg of **19** (97 μmol, 61%) as a yellowish syrup. $[\alpha]_{546}^{20}$ = +66.0 (*c* 0.5, EtOAc); $C_{45}H_{52}O_{10}$, 753.0; MALDI-TOF: $[M+Na]^+$: 776, $[M+K]^+$: 792; ^{1}H NMR (500 MHz, C_6D_6): δ = 1.22, 1.50 (2 × s, 2 × 3H, 2 × Me), 2.20 (br s, 1H, 8-OH), 3.12 (ddd, 1H, H-7, $J_{6,7}$ = 9.5, $J_{7,8a}$ = 2.5, $J_{7,8b}$ = 3.8 Hz), 3.62 (dd, 1H, H-2′, $J_{1',2'}$ = 3.8, $J_{2',3'}$ = 9.8 Hz), 3.68–3.70 (m, 2H, H-3, H-4, $J_{2,3}$ = 6.1 Hz), 3.75–3.79 (m, 3H, H-4′, H-6′a/b, $J_{3',4'}$ = $J_{4',5'}$ = 9.8, $J_{5',6'a}$ = $J_{5',6'b}$ = 3.2 Hz), 3.89 (br d, 1H, H-8b, $J_{7,8b}$ = 3.8 Hz), 3.95 (br d, 1H, H-8a, $J_{7,8a}$ = 2.5 Hz), 4.14 (ddd ∼ dt, 1H, H-5′, $J_{4',5'}$ = 9.8, $J_{5',6'a}$ = $J_{5',6'b}$ = 3.2 Hz), 4.18–4.22 (m, 2H, H-5, H-3′, $J_{5,6}$ = 6.9, $J_{2',3'}$ = $J_{3',4'}$ = 9.8 Hz), 4.26 (dd, 1H, H-6, $J_{5,6}$ = 6.9, $J_{6,7}$ = 9.5 Hz), 4.35, 4.43, 4.59, 4.63, 4.77, 4.87, 4.95 (7 × d, 7H, OCH_2), 5.07–5.10 (m, 2H, OCH_2, H-1b, $J_{1a,1b}$ = 1.3, $J_{1b,2}$ = 10.4 Hz), 5.23 (d, 1H, H-1a, $J_{1a,1b}$ = 1.3, $J_{1a,2}$ = 17.3 Hz), 5.88 (d, 1H, H-1′, $J_{1',2'}$ = 3.8 Hz), 6.04–6.11 (m, 1H, H-2, $J_{1a,2}$ = 17.3, $J_{1b,2}$ = 10.4, $J_{2,3}$ = 6.1 Hz), 7.06–7.45 (m, 20H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 26.58, 28.30 (2C, 2 × Me), 62.51 (1C, C-8), 69.52 (1C, C-6′), 71.98 (1C, C-5′), 73.08 (1C, OCH_2), 73.32 (1C, C-6), 73.55 (1C, OCH_2), 75.31, 75.63 (2C, OCH_2), 76.82, 77.70, 77.95, 78.53 (4C, C-3, C-4, C-7, C-4′), 80.42, 80.90, 82.38 (3C, C-5, C-2′, C-3′), 96.14 (1C, C-1′), 109.70 (1C, CMe_2), 117.00 (1C, C-1), 127.55–128.60, 139.27, 139.86 (24C, Ar), 135.05 (1C, C-2) ppm.

4.16. [3,7-Anhydro-8-*O*-(4-toluenesulfonyl)-1,2,6-trideoxy-4,5-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-oct-1-enitol-6-yl]-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 20

To a solution of **19** (63 mg, 84 μmol) in dry pyridine (4 mL) was added a catalytic amount of 4-dimethylaminopyridine (DMAP) and tosyl chloride (19 mg, 100 μmol). The solution was stirred at room temperature for 5 days with several extra additions of tosyl chloride until the largest part of starting material had reacted. Evaporation of the solvent and chromatography of the residue (petroleum ether/ethyl acetate 6:1) gave 63 mg of **20** (69 μmol, 83%) as a colourless syrup. $[\alpha]_{546}^{20}$ = +56.0 (*c* 0.25, EtOAc); $C_{52}H_{58}O_{12}S$, 907.2; MALDI-TOF: $[M+Na]^+$: 930, $[M+K]^+$: 946; ^{1}H NMR (400 MHz, C_6D_6): δ = 1.17, 1.39 (2 × s, 2 × 3H, 2 × Me), 1.78 (s, 3H, Ts–Me), 3.26 (ddd, 1H, H-7, $J_{6,7}$ = 9.4, $J_{7,8a}$ = 2.3, $J_{7,8b}$ = 5.4 Hz), 3.54–3.58 (m, 1H, H-3, $J_{2,3}$ = 5.9, $J_{3,4}$ = 2.4 Hz), 3.59–3.62 (m, 2H, H-4, H-2′, $J_{3,4}$ = 2.4, $J_{1',2'}$ = 3.8, $J_{2',3'}$ = 9.4 Hz), 3.94–4.04 (m, 4H, H-6, H-4′, H-6′a/b, $J_{5,6}$ = 6.4, $J_{6,7}$ = 9.4, $J_{3',4'}$ = $J_{4',5'}$ = 9.4 Hz), 4.11–4.17 (m, 2H, H-5, H-5′, $J_{5,6}$ = 6.4, $J_{4',5'}$ = 9.4 Hz), 4.22 (dd ∼ t, 1H, H-3′, $J_{2',3'}$ = $J_{3',4'}$ = 9.4 Hz), 4.34 (dd, 1H, H-8b, $J_{7,8b}$ = 5.4, $J_{8a,8b}$ = 10.5 Hz), 4.38 (1, H, OCH_2), 4.47–4.52 (m, 2H, H-8a, OCH_2, $J_{7,8a}$ = 2.3, $J_{8a,8b}$ = 10.5 Hz), 4.58, 4.67, 4.75, 4.95 (4 × d, 4H, OCH_2), 4.99–5.05 (m, 2H, H-1b, OCH_2, $J_{1a,1b}$ = 1.5, $J_{1b,2}$ = 10.5 Hz), 5.10 (d, 1H, OCH_2), 5.18 (ddd ∼ dt, 1H, H-1a, $J_{1a,1b}$ = 1.5, $J_{1a,2}$ = 17.0 Hz), 5.80 (d, 1H, H-1′, $J_{1',2'}$ = 3.8 Hz), 5.87–5.96 (m, 1H, H-2, $J_{2,3}$ = 5.9 Hz), 6.63 (d, 2H, Ar), 7.06–7.21 (m, 12H, Ar), 7.33, 7.41 (2 × d, 8H, Ar), 7.82 (d, 2H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 21.14 (1C, Ts–Me), 26.39, 28.10 (2C, 2 × Me), 69.45 (1C, C-6′), 69.82 (1C, C-8), 72.33 (1C, C-5′), 73.26 (1C, C-6), 73.41, 73.62 (2C, OCH_2), 75.37 (1C, OCH_2), 75.55 (1C, C-7), 75.66 (1C, OCH_2), 76.41, 80.85 (2C, C-4, C-2′), 77.25 (1C, C-3), 78.43 (1C, C-4′), 79.62 (1C, C-5), 82.20 (1C, C-3′), 96.22 (1C, C-1′), 116.94 (1C, C-1), 127.64–128.73, 129.88 (30C, Ar), 134.40 (1C, C-2) ppm.

4.17. (3,7-Anhydro-8-bromo-1,2,6,8-tetradeoxy-4,5-di-*O*-isopropylidene-D-*glycero*-D-*galacto*-oct-1-enitol-6-yl)-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 21

A solution of **20** (52 mg, 57 μmol) and NaBr (59 mg, 573 μmol) in DMF (4 mL) was heated to 70 °C and stirred overnight. After evaporation of the solvent, the residue was dissolved in dichloromethane and the solution filtrated. Evaporation of the solvent yielded 59 mg of the raw product **21** accompanied by sodium tosylate. The residue was directly used without further purification for the subsequent elimination.

4.18. (3,7-Anhydro-1,2,6,8-tetradeoxy-4,5-di-*O*-isopropylidene-D-*galacto*-octo-1,7-dienitol-6-yl)-2′,3′,4′,6′-tetra-*O*-benzyl-α-D-glucopyranoside 22

To a solution of raw product **21** dissolved in pyridine (3 mL), was added silver fluoride (47 mg, 370 μmol). The solution was stirred under light exclusion at room temperature. On the next day, a second portion of silver fluoride was added and stirring continued for 1 day until TLC showed complete conversion of bromide **21**. After filtration, co-distillation with toluene and evaporation of the solvents chromatography of the residue (petroleum ether/ethyl acetate 10:1) gave 9 mg of **22** (12.2 μmol, 21% via two steps) as a colourless syrup. $[\alpha]_D^{20}$ = +14.9 (*c* 0.5, $CHCl_3$); $C_{45}H_{50}O_9$, 735.0; MALDI-TOF: $[M+Na]^+$: 758, $[M+K]^+$: 774; ^{1}H NMR (400 MHz, C_6D_6): δ = 1.17, 1.50 (2 × s, 2 × 3H, 2 × Me), 3.51 (dd, 1H, H-2′, $J_{1',2'}$ = 3.7, $J_{2',3'}$ = 9.4 Hz), 3.67 (dd, 1H, H-6′b, $J_{5',6'b}$ = 1.8, $J_{6'a,6'b}$ = 10.7 Hz), 3.78 (dd, 1H, H-6′a, $J_{5',6'a}$ = 3.6, $J_{6'a,6'b}$ = 10.7 Hz), 3.90 (dd ∼ t, 1H, H-4′, $J_{3',4'}$ = $J_{4',5'}$ = 9.4 Hz), 4.09 (dd,

1H, H-4, $J_{3,4}$ = 1.5, $J_{4,5}$ = 7.4 Hz), 4.14–4.20 (m, 2H, H-3′, H-5′, $J_{2',3'} = J_{3',4'} = J_{4',5'}$ = 9.4, $J_{5',6'a}$ = 3.6, $J_{5',6'b}$ = 1.8 Hz), 4.27–4.37 (m, 5H, H-5, H-6, H-8b, OCH_2, $J_{4,5}$ = 7.4 Hz), 4.45, 4.53, 4.67 (3 × d, 3H, OCH_2), 4.76 (s, 1H, H-8a), 4.83 (d, 1H, OCH_2), 4.94–4.98 (m, 2H, H-1′, OCH_2, $J_{1',2'}$ = 3.7 Hz), 5.00 (dd, 1H, H-3, $J_{2,3}$ = 6.6, $J_{3,4}$ = 1.5 Hz), 5.10 (ddd ~ dt, 1H, H-1b, $J_{1a,1b}$ = 1.5, $J_{1b,2}$ = 10.4 Hz), 5.37 (ddd ~ dt, 1H, H-1a, $J_{1a,1b}$ = 1.5, $J_{1a,2}$ = 17.3 Hz), 6.10–6.19 (m, 1H, H-2, $J_{1a,2}$ = 17.3, $J_{1b,2}$ = 10.4, $J_{2,3}$ = 6.6 Hz), 7.03–7.35 (m, 20H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 24.72, 26.76 (2C, 2 × Me), 69.12 (1C, C-6′), 72.16 (1C, C-5′), 73.40, 74.43, 74.90 (3C, C-3, C-5, C-6), 73.46, 73.59 (2C, OCH_2), 75.24, 75.56 (2C, OCH_2), 75.72 (1C, C-4), 78.42 (1C, C-4′), 81.07 (1C, C-2′), 82.42 (1C, C-3′), 92.62 (1C, C-8), 96.78 (1C, C-1′), 117.58 (1C, C-1), 127.58–128.70 (24C, Ar), 135.13 (1C, C-2) ppm.

4.19. *cis*-(2*S*,3*R*,4*R*)-2-(2′,3′,4′,6′-Tetra-*O*-benzyl-α-D-glucopyranosyloxy)-3,4-isopropylidenedioxy-cyclooct-5-enone 23

A solution of **22** (9 mg, 12.2 μmol) in *n*-decane (5 mL) and toluene (1 mL) was heated under microwave irradiation to 180 °C for 15 min. Evaporation of the solvent and chromatography of the residue gave 1.0 mg of **23** (1.4 μmol, 70%) as a colourless syrup besides 7 mg recovered **22** (9.5 μmol). $C_{45}H_{50}O_9$, 735.0; MALDI-TOF: $[M+Na]^+$: 757; $[\alpha]^{20}_{546} = +53.0$ (*c* 0.1, $CHCl_3$); *v* (film/cm^{-1}): 1719 (C=O); ^{1}H NMR (500 MHz, C_6D_6): δ = 1.20, 1.46 (2 × s, 2 × 3H, Me), 1.56–1.70 (m, 2H, H-7a/b), 2.20 (ddd, 1H, H-8b, $J_{8a,8b}$ = 13.6 Hz), 2.41 (ddd, 1H, H-8a, $J_{8a,8b}$ = 13.6 Hz), 3.56–3.59 (m, 2H, H-2′, H-6′b, $J_{1',2'}$ = 3.8, $J_{2',3'}$ = 9.5, $J_{5',6'b}$ = 1.5, $J_{6'a,6'b}$ = 10.8 Hz), 3.67–3.73 (m, 2H, H-4′, H-6′a, $J_{3',4'} = J_{4',5'}$ = 9.5, $J_{5',6'a}$ = 4.7, $J_{6'a,6'b}$ = 10.8 Hz), 4.09–4.13 (ddd, 1H, H-5′, $J_{4',5'}$ = 9.5, $J_{5',6'a}$ = 4.7, $J_{5',6'b}$ = 1.5 Hz), 4.16 (d, 1H, H-2, $J_{2,3}$ = 8.9 Hz), 4.29 (dd ~ t, 1H, H-3′, $J_{2',3'} = J_{3',4'}$ = 9.5 Hz), 4.33 (d, 1H, OCH_2), 4.35–4.40 (m, 2H, H-3, OCH_2, $J_{2,3}$ = 8.9, $J_{3,4}$ = 5.2 Hz), 4.42–4.44 (m, 1H, H-4, $J_{3,4}$ = 5.2, $J_{4,5}$ = 6.3, $J_{4,6}$ = 1.8 Hz), 4.49, 4.60, 4.62, 4.68, 4.89, 4.95 (6 × d, 6H, OCH_2), 5.05 (d, 1H, H-1′, $J_{1',2'}$ = 3.8 Hz), 5.37–5.45 (m, 1H, H-6, $J_{4,6}$ = 1.8, $J_{5,6}$ = 11.2 Hz), 5.60 (ddd, 1H, H-5, $J_{4,5}$ = 6.3, $J_{5,6}$ = 11.2 Hz), 6.96–7.36, 7.48–7.51 (2 × m, 20H, Ar) ppm. ^{13}C NMR (100 MHz, C_6D_6): δ = 24.77 (1C, C-7), 26.35, 27.85 (2C, 2 × Me), 44.20 (1C, C-8), 69.70 (1C, C-6′), 71.72 (1C, C-5′), 71.96, 73.52 (2C, OCH_2), 73.87 (1C, C-4), 75.02, 75.60 (2C, OCH_2), 78.16 (2C, C-3, C-4′), 80.76 (1C, C-2′), 82.17 (1C, C-3′), 82.78 (1C, C-2), 99.20 (1C, C-1′), 127.21–128.88 (25C, C-6, Ar), 134.10 (1C, C-5) ppm.

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