Solid-Phase Synthesis of a Branched Hexasaccharide Using a Highly Efficient Synthetic Strategy

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The solid-phase synthesis of branched lacto-*N*-neohexaose derivative **1** occurring in human milk is described. The new building block of lactose **3** bearing the orthogonal temporary hydroxy protecting groups 9-fluorenylmethyloxycarbonyl (Fmoc) and levulinoyl (Lev) has been prepared. Its use, together with that of lactosamine donor **4**, glucosamine donor **5**, and *O*-galactosyl trichloroacetimidate **6**, has enabled the preparation of hexasaccharide **22** following two different approaches in excellent overall yield (43%, 90% per step over eight steps). An additional key feature of this work is the successful use of newly prepared ester-type linker **2**, having a benzylic spacer connected to the anomeric oxygen. This linker presents the advantage of producing a benzylic anomeric moiety after cleavage from the polymer support, which could be easily removed to obtain the unprotected oligosaccharide **1**.

Introduction

Oligosaccharides are known to be important in a multitude of biological processes; therefore, they have attracted a lot of interest in recent years.[1] However, contrary to oligopeptides[2] and oligonucleotides[3] which are routinely constructed on automated synthesizers employing polymer-supported synthesis, no general synthetic strategy has yet emerged for solid-phase oligosaccharide synthesis.[4] The construction of complex oligosaccharides in solution is quite laborious. Though their synthesis on a solid phase remains a challenging task, this method would present several advantages over solution-phase techniques. Notably, an excess of reagents can be used to drive reactions to completion, and syntheses can be accomplished faster with simpler purification procedures. One important key issue for the construction of oligosaccharides on a solid phase is the use of a high-yielding and stereoselective glycosylation strategy. Several methodologies available for the solution-phase construction of oligosaccharides were applied to the solid-phase synthesis of these oligomers. Besides the successful application of *O*-glycosyl trichloroacetimidates[5] widely developed in our group,[6] thioglycosides,[7] glycosyl sulfoxides,[8] glycosyl fluorides,[9] 1,2-anhydrosugars,[10] glycosyl phosphates,[11] and *n*-pentenyl glycosides[12] have also been explored for solid-phase oligosaccharide synthesis.

Another fundamental key issue for the construction of oligosaccharides on a solid phase is the protecting group strategy. Recently, we have reported the first preparation of *O*-glycosyl trichloroacetimidate possessing Fmoc-protected (Fmoc = 9-fluorenylmethyloxycarbonyl) hydroxy groups[13] and their high efficiency for the solid-phase construction of oligosaccharides.[6a,14] The mild basic conditions required for the Fmoc removal have proven to be compatible with the use of Fmoc-containing building blocks in conjunction with a novel ester-type linker.[13] The usefulness of this new solid-phase system was demonstrated by the successful synthesis of a set of tri- and tetrasaccharides.[6a]

In an endeavor to develop this promising methodology, we report here on a highly efficient strategy for the solid-phase synthesis of human milk branched lacto-*N*-neohexaose derivative **1** (Scheme 1).[15] An important requirement for the synthesis of the desired compound was the design of a galactose moiety (b) possessing orthogonal protecting groups in the 3b- and 6b-*O*-positions. For this purpose, a novel key building block of lactose **3** bearing levulinoyl (Lev) and Fmoc groups[16] in the 6b- and 3b-*O*-positions, respectively, was prepared allowing for selec-

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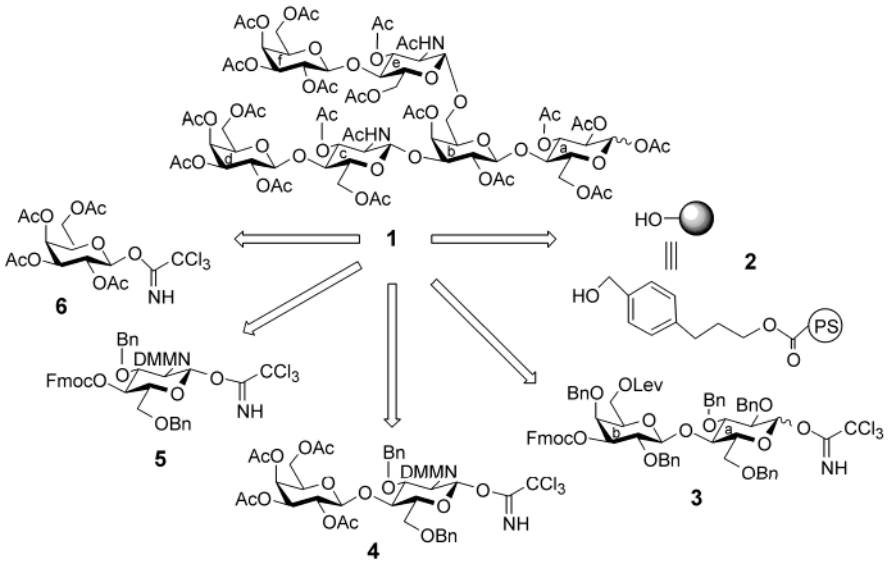
Scheme 1. Building Blocks for the Solid-Phase Synthesis of Branched Lacto-*N*-neohexaose Derivative 1



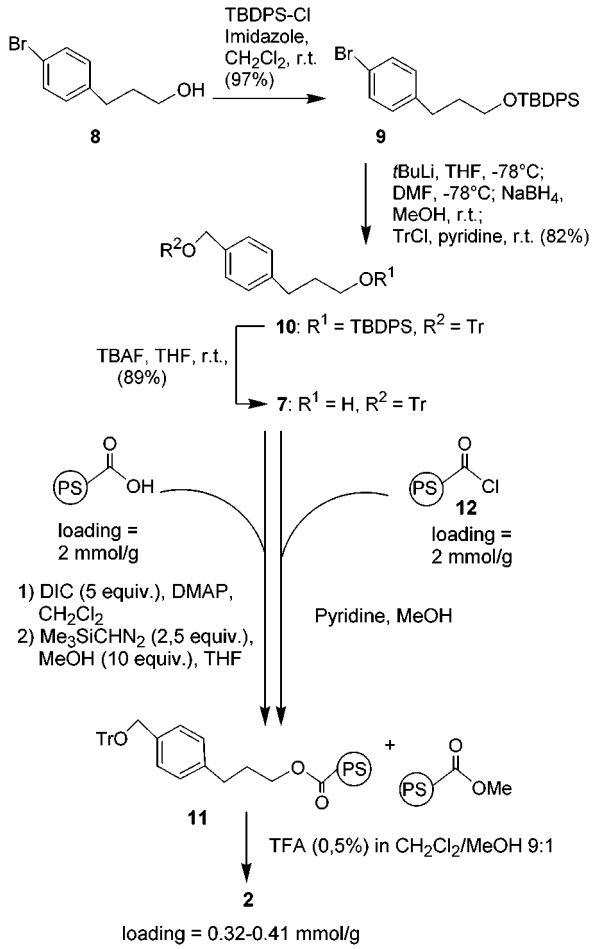
tive elongation at both positions. In addition to lactosyl donor **3**, three other building blocks, namely, lactosamine **4**,[6a,c] glucosamine **5**,[17] and galactose **6**,[18] were used. The recently introduced dimethylmaleoyl (DMM) group[19] was selected as an amino-protecting group of both glucosamine moieties of **4** and **5**.

The previous ester-type linker that we have developed has proven to be stable to all reaction conditions all along the synthesis and allowed the release of the oligosaccharide from the polymeric support in high yield.[6a,13] However, the oligosaccharides obtained after cleavage from the solid support possessed an anomeric hydroxyoctyl aglycon moiety which could not be removed. To circumvent this problem, a novel ester-type linker (**2**) having a benzylic spacer connected to the anomeric oxygen was designed and successfully used, allowing the deprotection of the anomeric position in the solution phase and therefore target compound **1** to be obtained.

Results and Discussion

Preparation of Novel Ester-Type Linker 2. The tritylated alcohol **7** was obtained from readily available 3-(4-bromophenyl)propan-1-ol[20] (**8**) (Scheme 2). The alcohol **8** was protected as *tert*-butyldiphenylsilyl (TBDPS) ether in practically quantitative yield under conventional conditions. The silylated compound **9** thus obtained was then subjected to hydroxymethylation using *tert*-butyllithium (*t*-BuLi) as base and DMF as electrophile, followed by a one-pot reduction with sodium borohydride ($NaBH_4$). The resultant crude alcohol was tritylated under standard conditions to furnish **10** in 82% yield. Subsequent desilylation was performed by treatment with tetrabutylammonium fluoride (TBAF) in tetrahydrofuran, affording the corresponding alcohol **7** in 89% yield.

Scheme 2. Preparation of Linker 2



The attachment of tritylated alcohol **7** onto a polystyrene support was carried out under two different conditions. In the first route, carboxypolystyrene resin commercially available from Advanced ChemTech (100−200 mesh, 1% cross-linked, 2 mmol/g) was esterified by reaction with 0.19 equiv of **7** using *N*,*N*-diisopropylcarbodiimide (DIC) and a catalytic amount of Steglich's reagent (4-(dimethylamino)pyridine, DMAP) as activators. The unreacted carboxyl sites were then capped by

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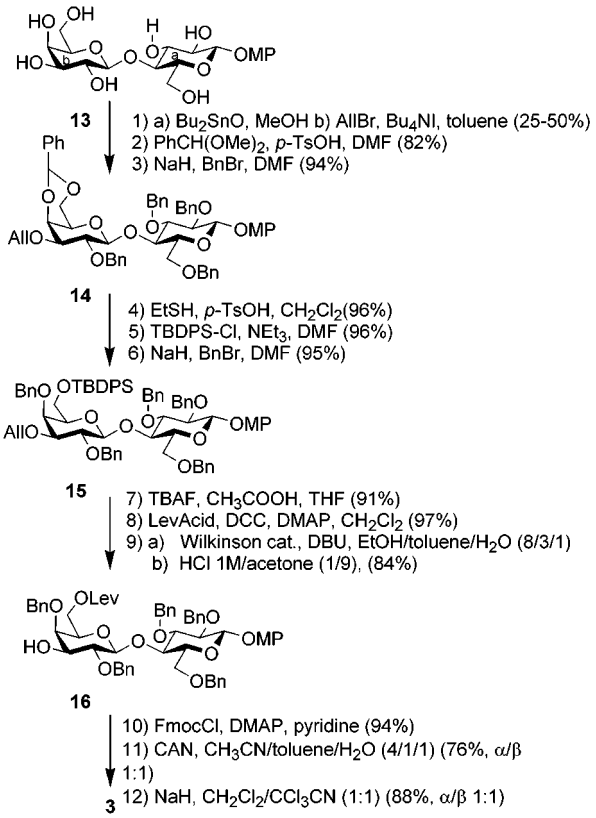
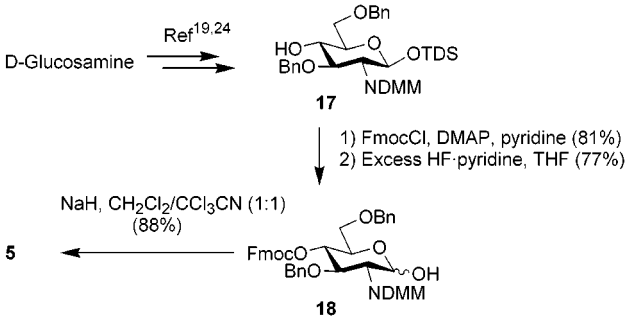
Scheme 3. Synthesis of Lactosyl Donor 3



reaction with trimethylsilyldiazomethane (Me_3SiCHN_2) and MeOH to furnish **11**. Trityl groups were cleaved by treatment with trifluoroacetic acid (TFA), allowing the calculation of the loading by colorimetric assay (0.32 mmol/g), thus affording linker-loaded resin **2**. According to a second route, acid chloride support **12**, derived from a commercial carboxypolystyrene resin, was reacted with alcohol **7** (0.24 equiv) in pyridine followed by capping with anhydrous methanol. After detritylation, the resin-bound linker **2** was obtained (loading 0.41 mmol/g).

Synthesis of the Building Blocks of Lactose and Glucosamine. 4-Methoxyphenyl β-lactoside (**13**)[21] served as starting material for the synthesis of lactosyl donor **3** (Scheme 3). According to the conditions developed by Veyrières et al.,[22] an assisted regioselective allylation of the 3b-*O*-position was carried out. Given the poor solubility of **13** in methanol, a low yield was obtained for this reaction. However, a second run enabled us to improve the yield up to 50%. Under standard conditions a benzylidene acetal function was regioselectively introduced into the 4b,6b-*O*-positions followed by a perbenzylation, furnishing **14**. Subsequent removal of the benzylidene group was accomplished using *p*-TsOH and ethanethiol as the nucleophile,[23] and the released primary hydroxyl group was regioselectively silylated in excellent yield. Next, a benzylation of the axial hydroxyl group was performed under conventional conditions to yield **15**. Selective removal of the TBDPS group by treatment with TBAF was followed by reaction with levulinic acid (LevOH) and DCC in the presence of catalytic amounts of DMAP to yield the corresponding ester in practically

Scheme 4. Synthesis of Glucosamine Donor 4



quantitative yield. The *C*-3b allyl ether was removed using a two-step, one-pot sequence. An isomerization step was first accomplished by treatment with Wilkinson catalyst and 1,8-diaza[5.4.0]bicycloundec-7-ene (DBU), and then hydrolysis of the enol ether was performed using a mixture of HCl and acetone to provide **16** in good yield. The Fmoc group was subsequently introduced by reaction with FmocCl and catalytic amounts of DMAP, giving the corresponding fully protected derivative in excellent yield. The anomeric *p*-methoxyphenyl group was oxidatively cleaved by treatment with ceric ammonium nitrate (CAN), and then, the trichloroacetimidate function was introduced under the previously described conditions[6a] using trichloroacetonitrile and sodium hydride to furnish **3** in good yield.

The glucosamine donor **5** was prepared starting from glucosamine (Scheme 4). The Fmoc group was installed under standard conditions in the 4-*O*-position of **17**, which was obtained in five steps starting from D-glucosamine,[19,24] to give the corresponding fully protected glucosamine derivative. The anomeric thexyldimethylsilyl (TDS) was then removed by treatment with an excess of HF·pyridine complex. The resulting hemiacetal **18** was converted into trichloroacetimidate **5** under the conditions described above.

Solid-Phase Synthesis of Lacto-*N*-neohexaose Derivative 1. With the required building blocks at our disposal, the multistep synthesis of branched hexasaccharide **1** was initiated. Linker-loaded polystyrene resin **2** was glycosylated with 3 equiv of new *O*-lactosyl trichloroacetimidate **3** under trimethylsilyl triflate (TMSOTf) activation (0.24 equiv) to furnish the corresponding support-bound disaccharide **19** (Scheme 5). The glycosylation here and in the next steps was carried out twice at −40 °C to ensure a complete reaction. The batch of resin **19** was then split into two pools to prepare the target hexasaccharide via two different routes, thus emphasizing the orthogonality between the Fmoc and Lev protecting groups.

Concerning the first protocol (Scheme 5), the Fmoc group was selectively removed in the presence of the Lev group by treatment of **19** with triethylamine in CH_2Cl_2. No loss of the Lev group was observed during this reaction. Next, an elongation of the immobilized disaccharide was performed by reaction with 4 equiv of lactosamine donor **4** upon activation with TMSOTf (0.28 equiv), leading to resin-bound tetrasaccharide **20**. The Lev group was subsequently removed by reaction with 2 equiv of hydrazinium acetate (N_2H_4·HOAc), releasing the *C*-6b primary hydroxyl group. To exhibit further the

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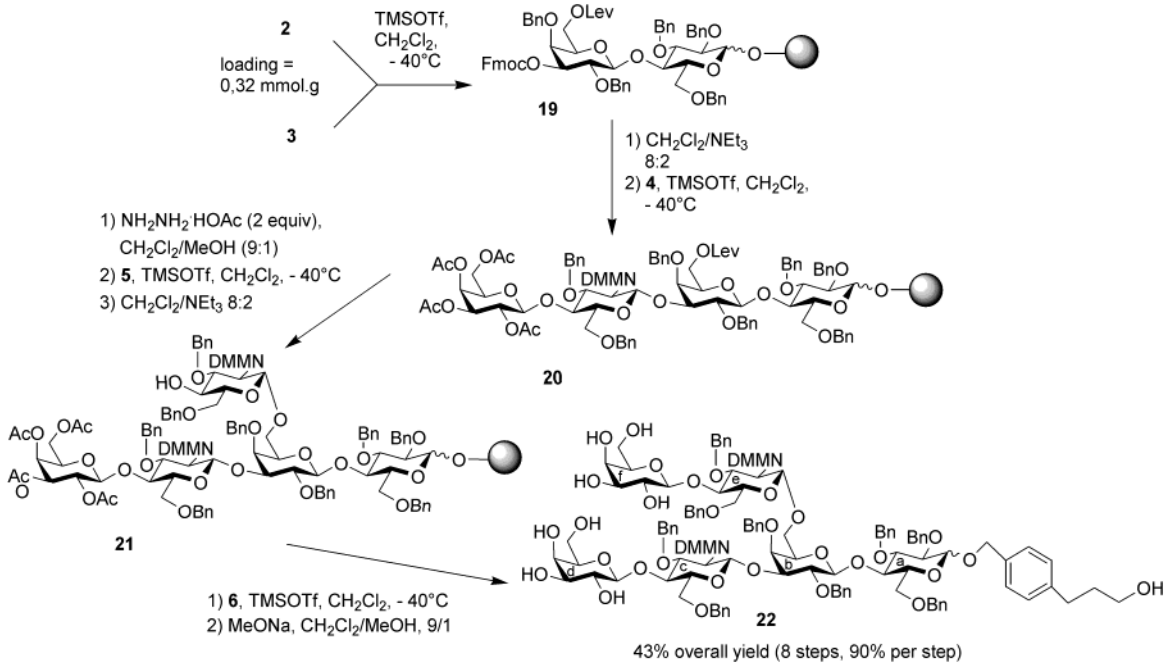
Scheme 5. First Route of the Solid-Phase Synthesis of Branched Hexasaccharide 22

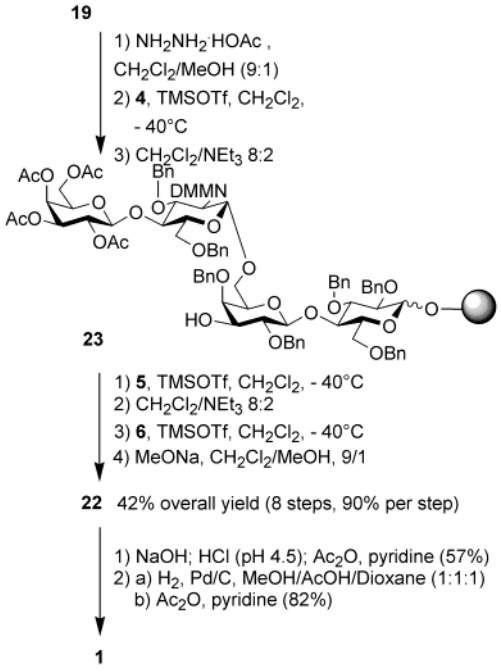


efficiency of Fmoc-containing *O*-glycosyl trichloroacetimidates for solid-phase oligosaccharide synthesis, the second lactosamine moiety (e, f) was introduced by using instead of lactosamine donor **4** at first glucosamine donor **5** and then galactosyl donor **6**. Thus, it will be demonstrated that our future aim to prepare a small library of branched oligosaccharides starting from resin-bound lactose **19** is feasible. Glycosylation with **5** (4 equiv) and TMSOTf (0.28 equiv) as catalyst and then removal of the Fmoc group furnished resin-bound pentasaccharide **21** as acceptor. New elongation with *O*-galactosyl trichloroacetimidate **6**[18] (3 equiv) as donor under TMSOTf activation (0.45 equiv) furnished the corresponding resin-bound hexasaccharide. Cleavage from the polymer support under alkaline conditions (MeONa) was executed twice to give an anomeric mixture (β/α, 1:1) of hexasaccharide **22** in 43% overall yield from **2** (90% per step, eight steps).

A second route to the synthesis of **22** was performed in which the Lev group of **19** was first selectively removed in the presence of the Fmoc group using the conditions described above (Scheme 6). This time, the elongation with **4** started at the 6b-*O*-position, thus allowing also the isolation of the corresponding immobilized tetrasaccharide. After removal of the Fmoc group, furnishing **23**, the branching of the oligosaccharide was continued at the 3b-*O*-position of **23**, applying exactly the sequence used during the first route. Thus, the desired compound **22** was obtained in almost the same overall yield (42%) as described above. Thus, the usefulness of lactose building block **3** and the efficiency of the selected protective group pattern were demonstrated in the synthesis of **22** with two different approaches.

With derivative **22** in hand, the removal of protecting groups was then undertaken. At first, the two DMM groups were removed following the conditions previously described,[19] and the released amino groups were converted into *N*-acetamido functions by treatment with acetic anhydride. Finally, the benzylic groups were smoothly cleaved by catalytic hydrogenation over palladium to produce, after acetylation, the linker-free

Scheme 6. Second Route of the Solid-Phase Synthesis of Branched Hexasaccharide 22 and Removal of the Protecting Groups



peracetylated lacto-*N*-neohexaose **1**. The spectroscopic data of **1** were in agreement with the values reported in the literature.[25]

Conclusions

We have described a highly efficient synthesis of branched peracetylated lacto-*N*-neohexaose **1** on a solid phase. For this purpose, the efficient combination of Fmoc and Lev as temporary orthogonal hydroxy protecting

(25) Takamura, T.; Chiba, T.; Tejima, S. *Chem. Pharm. Bull.* **1981**, *29*, 2270.

groups through the use of newly prepared *O*-lactosyl trichloroacetimidate **3** was demonstrated. The efficiency of this temporary protecting group system was shown by the preparation of the desired human milk hexasaccharide derivative in two different approaches in excellent overall yield. A novel ester-type linker, which has proven to be inert to all reaction conditions all along the construction of the oligosaccharide, was successfully used. This linker offers the great advantage of releasing, after cleavage from the polymer support, a benzylic aglycon moiety which was easily removed by hydrogenolysis. Thus, the preparation of fully unprotected oligosaccharides can be carried out. We believe that our combination of linker system, protective group pattern, and glycosyl donors provides one of the most simple and efficient methodologies used until now for solid-phase oligosaccharide synthesis.

Experimental Section

The solvents were purified and dried in the usual way. All reactions were performed with dry solvents and under argon unless otherwise stated. TLC was performed on plastic plates, silica gel 60 F_{254}. Detection was achieved by treatment with a solution of 20 g of ammonium molybdate and 0.4 g of cerium(IV) sulfate in 400 mL of 10% H_2SO_4 or with 15% H_2SO_4, and heating at 150 °C. Flash chromatography was carried out on silica gel (Baker 30−60 mm). Adsorption of reaction crudes was performed using silica gel (Baker 60−200 mm). Petroleum ether was used in the boiling range 35−70 °C; toluene, CH_2Cl_2, MeOH, and EtOAc were distilled. Optical rotations were determined at 21 °C with a Perkin-Elmer 241/MC polarimeter (1 dm cell). NMR spectra were recorded with Bruker 600 DRX instruments by using tetramethylsilane as internal standard. MS spectra were recorded with a MALDI-kompakt (Kratos) instrument in the positive mode using 2,5-dihydroxybenzoic acid in THF as matrix. Microanalyses were performed in the unit of Microanalysis at the Fachbereich Chemie, Universität Konstanz.

3-(4-Bromophenyl)propyloxy-*tert*-butyldiphenylsilane (9). To a solution of commercially available alcohol **8** (3.22 g, 14.97 mmol) in CH_2Cl_2 (50 mL) were added imidazole (1.6 equiv, 1.62 g, 23.96 mmol) and TBDPSCl (1.2 equiv, 4.92 g, 17.97 mmol) under an argon atmosphere, and the mixture was stirred at room temperature for 4 h. The reaction mixture was diluted with CH_2Cl_2, washed successively with water and brine, and dried over $MgSO_4$. The solvent was removed in vacuo, and the residue was purified by flash chromatography (petroleum ether/EtOAc, 9:1) to furnish **9** (6.52 g, 14.3 mmol) as a yellow viscous oil in 96% yield: TLC (petroleum ether/EtOAc, 9:1) $R_f = 0.65$; ^{1}H NMR ($CDCl_3$) δ 7.67−7.03 (m, 14H), 3.68 (t, $J = 6.1$ Hz, 2H), 2.69 (t, $J = 7.5$ Hz, 2H), 1.84 (m, 2H), 1.08 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 141.1, 135.5, 133.8, 131.2, 130.2, 129.5, 127.6, 119.3, 62.7, 33.9, 31.4, 26.8, 19.2. Anal. Calcd for $C_{25}H_{29}BrOSi$ (453.49): C, 66.21; H, 6.44. Found: C, 66.11; H, 6.46.

3-(4-Triphenylmethyloxymethylphenyl)propyloxy-*tert*-butyldiphenylsilane (10). To a solution of **9** (2.6 g, 5.72 mmol) in THF was added *t*-BuLi (1 equiv, 3.81 mL, 1.5 M solution in pentane, 5.72 mmol) dropwise at −78 °C. After 15 min of stirring, DMF (1.2 equiv, 0.52 mL, 6.86 mmol) was added, and the reaction mixture was further stirred for 30 min and quenched by addition of a saturated solution of NH_4Cl. The solution was extracted with diethyl ether (3×), and the combined organic layers were washed with water and brine and dried over $MgSO_4$. The solvent was removed in vacuo, the crude product was dissolved in MeOH, $NaBH_4$ (1.5 equiv, 0.3 g, 8.82 mmol) was added, and the solution was stirred at room temperature for 15 min. The reaction mixture was concentrated in vacuo, diluted with EtOAc, and subsequently washed with water and brine. The organic layer was dried over $MgSO_4$ and concentrated in vacuo. To a solution of the crude alcohol dissolved in pyridine (25 mL) were added trityl chloride (1.2 equiv, 1.58 g, 6.88 mmol) and a catalytic amount of DMAP. After the resulting solution was stirred for 6 h at room temperature, the pyridine was removed azeotropically with toluene in vacuo, and the product was purified by flash chromatography (petroleum ether/EtOAc, 9:1) to afford **10** (3.04 g, 4.69 mmol) as a yellow oil in 82% yield: TLC (petroleum ether/EtOAc, 9:1) $R_f = 0.55$; ^{1}H NMR ($CDCl_3$) δ 7.67−7.14 (m, 29H), 4.13 (s, 2H), 3.69 (t, $J = 6.4$ Hz, 2H), 2.71 (t, $J = 7.2$ Hz, 2H), 1.87 (m, 2H), 1.06 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 144.1, 141.0, 136.4, 135.5, 134.0, 129.5, 128.7, 128.3, 127.8, 127.5, 127.0, 126.9, 86.8, 65.5, 63.0, 34.1, 31.7, 26.8, 19.2. Anal. Calcd for $C_{45}H_{46}O_2Si$ (646.94): C, 83.54; H, 7.16. Found: C, 83.43; H, 7.18.

3-(4-*O*-Triphenylmethyloxymethylphenyl)propanol (7). To a solution of **10** (2.8 g, 4.32 mmol) in THF (40 mL) was added a 1.0 M solution of TBAF in THF (6.91 mL, 6.91 mmol) at 0 °C. The solution was allowed to warm to room temperature and stirred for 1 h. The solvent was evaporated in vacuo, the residue diluted in CH_2Cl_2, and the organic phase washed twice with water. After the organic phase was dried over $MgSO_4$ and concentration in vacuo, the crude mixture was purified by flash chromatography (petroleum ether/EtOAc, 4:1) to produce **7** (1.57 g, 3.84 mmol) as a colorless oil in 89% yield: TLC (petroleum ether/EtOAc, 3:2) $R_f = 0.45$; ^{1}H NMR ($CDCl_3$) δ 7.58−7.24 (m, 19H), 4.20 (s, 2H), 3.70 (t, $J = 6.4$ Hz, 2H), 2.75 (t, $J = 7.5$ Hz, 2H), 1.92 (m, 2H), 1.62 (br s, 1H); ^{13}C NMR ($CDCl_3$) δ 144.0, 140.6, 136.5, 128.8, 128.6, 128.5, 128.4, 128.2, 127.9, 127.8, 127.7, 127.6, 127.0, 126.9, 86.8, 65.5, 62.1, 34.1, 31.7. Anal. Calcd for $C_{29}H_{28}O_2$ (408.53): C, 85.25; H, 6.90. Found: C, 85.20; H, 6.92.

Preparation of Tritylated Linker-Loaded Resin 11. Procedure A. To carboxypolystyrene resin commercially available from Advanced ChemTech (loading 2 mmol/g, 689 mg, 1.37 mmol) suspended in CH_2Cl_2 (4.5 mL) were added **7** (0.19 equiv, 109 mg, 0.26 mmol), DIC (5 equiv/**7**, 206 μL, 1.33 mmol), and DMAP (0.2 equiv/**7**, 6.5 mg, 0.05 mmol) under argon. The stirring was continued for 40 h. The solvent was filtered, and the resin was washed, successively, with THF (4 × 6 mL) and CH_2Cl_2 (4 × 6 mL). The resin was then dried under high vacuum.

Procedure B. To acid chloride resin **12** (loading 2 mmol/g, 670 mg, 1.27 mmol) suspended in pyridine (6 mL) was added **7** (0.24 equiv, 125 mg, 0.30 mmol) under argon. Stirring was continued for 24 h. An excess of MeOH (2 mL) was added to the mixture, and the suspension was agitated for 48 h. The resin was then filtered off, washed with CH_2Cl_2 (4 × 7 mL) and THF (4 × 7 mL), and dried under high vacuum.

Dry resin was swollen in THF (5 mL), and the resulting suspension was shaken under argon for 10 min. MeOH (500 μL) and a 2.0 M solution of Me_3SiCHN_2 in hexane (3.5 equiv, 2.06 mL, 4.12 mmol) were added to the mixture. The yellow suspension was agitated for 7 h and resin **11** filtered off, washed with CH_2Cl_2 (4 × 7 mL) and THF (4 × 7 mL), and dried under high vacuum.

Linker-Loaded Resin 2. Dry resin **11** was swollen in CH_2Cl_2 (0.40 mL/10 mg of resin), and the resulting suspension was agitated for 10 min under argon. MeOH (10% by volume) and TFA (5% of the total volume) were added, and shaking was continued for 15 min. The resin was filtered off, washed with CH_2Cl_2/MeOH (9:1) (4 × 7 mL) and THF/MeOH (9:1) (4 × 7 mL), and dried under high vacuum.

Procedure for Calculation of the Loading. Resin **11** was swollen in CH_2Cl_2 (0.40 mL/10 mg of resin), and the resulting suspension was shaken for 10 min under argon. TFA (5% of the total volume) was added, and agitation was continued for 10 min. The resin was then filtered off and washed with a CH_2Cl_2/TFA solution (95:5, v/v). UV measurement was then carried out on this solution (calculation of the concentration employing a standard straight line prepared with the UV values of TrOH in a solution of 5% TFA in CH_2Cl_2), giving the loading (0.32−0.41 mmol/g).

***p*-Methoxyphenyl *O*-(3-*O*-Allyl-2-*O*-benzyl-4,6-*O*-benzylidene-*β*-d-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-d-glucopyranoside (14).** To a suspension of *p*-methoxyphe-

nyl lactoside (**13**)[21] (13.94 g, 31.09 mmol) in MeOH (450 mL) was added dibutyltin oxide (1.1 equiv, 8.51 g, 34.19 mmol) under an argon atmosphere. The mixture was strirred for 24 h at 70 °C, MeOH was evaporated, and the residue was dried under high vacuum for 30 min. The same procedure was repeated to obtain further reaction. To a suspension of the crude mixture in toluene were added allyl bromide (10 equiv, 26.30 mL, 310.9 mmol) and *n*-tetrabutylammonium iodide (1 equiv, 11.48 g, 31.09 mmol). After being stirred at 70 °C for 40 h, the crude mixture was concentrated in vacuo and purified by flash chromatography (CH_2Cl_2/MeOH, 98:2 → 9:1) to afford *p*-methoxyphenyl *O*-(3-*O*-allyl-*β*-D-galactopyranosyl)-(1→4)-*β*-D-glucopyranoside (7.59 g, 15.54 mmol) as a white foam in 50% yield: TLC (CH_2Cl_2/MeOH, 88:12) $R_f = 0.45$; $[\alpha]_D = -12.0$ (*c* 1, MeOH); ^{1}H NMR (CD_3OD) δ 7.03 (d, $J = 9$ Hz, 2H), 6.82 (d, $J = 9$ Hz, 2H), 6.01−5.95 (m, 1H), 5.32 (dd, $J = 17.2$, 1.3 Hz, 1H), 5.15 (d, $J = 10.4$ Hz, 1H), 4.40 (d, $J = 7.9$ Hz, 1H), 4.22 (dd, $J = 5.6$, 12.7 Hz, 1H), 4.13 (dd, $J = 5.7$, 12.6 Hz, 1H), 4.00−3.99 (m, 1H), 3.92−3.85 (m, 2H), 3.73−3.69 (m, 4H), 3.67−3.59 (m, 3H), 3.57−3.52 (m, 2H), 3.49−3.47 (m, 1H), 3.32 (dd, $J = 3.1$, 9.8 Hz, 1H); ^{13}C NMR (CD_3OD) δ 156.7, 153.0, 136.4, 119.2, 117.4, 115.4, 105.0, 103.2, 82.1, 80.3, 76.9, 76.5, 76.3, 74.6, 71.7, 71.6, 67.0, 62.5, 61.7, 56.0; MALDI-MS *m*/*z* 511.4 [MNa^+]. Anal. Calcd for $C_{22}H_{32}O_{12}$ (488.48): C, 54.09; H, 6.60. Found: C, 53.98; H, 6.58.

A mixture of *p*-methoxyphenyl *O*-(3-*O*-allyl-*β*-D-galactopyranosyl)-(1→4)-*β*-D-glucopyranoside (7.0 g, 14.33 mmol), benzaldehyde dimethyl acetal (1.1 equiv, 2.36 mL, 15.76 mmol), and *p*-TsOH (0.1 equiv, 0.27 g, 1.43 mmol) in dry DMF (35 mL) was stirred at room temperature for 19 h. After neutralization with NEt_3, the solvents were evaporated in vacuo. The resulting crude was purified by flash chromatography (CH_2Cl_2/MeOH, 95:5) to afford *p*-methoxyphenyl *O*-(3-*O*-allyl-4,6-*O*-benzylidene-*β*-D-galactopyranosyl)-(1→4)-*β*-D-glucopyranoside (6.77 g, 11.75 mmol) as a white foam in 82% yield: TLC (CH_2Cl_2/MeOH, 92.5:7.5) $R_f = 0.39$; $[\alpha]_D = -13.0$ (*c* 1, pyridine); ^{1}H NMR (DMSO-d_6) δ 7.40−7.34 (m, 5H), 6.98 (d, $J = 9$ Hz, 2H), 6.84 (d, $J = 9$ Hz, 2H), 5.93−5.87 (m, 1H), 5.60 (s, 1H), 5.42 (d, $J = 5.3$ Hz, 1H), 5.40 (d, $J = 4.8$ Hz, 1H), 5.30 (dd, $J = 17.3$, 1.4 Hz, 1H), 5.12 (d, $J = 10.4$ Hz, 1H), 4.80 (d, $J = 7.8$ Hz, 1H), 4.75 (s, 1H), 4.57 (t, $J = 5.9$ Hz, 1H), 4.46 (d, $J = 7.8$ Hz, 1H), 4.32 (d, $J = 3.0$ Hz, 1H), 4.16−4.09 (m, 3H), 4.03 (d, 1H), 3.75−3.73 (m, 1H), 3.71−3.65 (m, 5H), 3.63 (s, 1H), 3.58−3.46 (m, 6H), 3.41 (dd, $J = 3.2$, 9.7 Hz, 1H), 3.27 (m, 1H); ^{13}C NMR (DMSO-d_6) δ 154.3, 151.3, 138.4, 135.6, 128.6, 127.9, 126.0, 117.5, 116.3, 114.3, 102.7, 101.0, 99.6, 78.7, 78.4, 74.8, 74.5, 73.1, 72.5, 69.7, 68.8, 68.5, 66.3, 66.1, 59.9, 55.3; MALDI-MS *m*/*z* 599.3 [MNa^+]. Anal. Calcd for $C_{29}H_{36}O_{12}$ (576.22): C, 60.41; H, 6.29. Found: C, 60.29; H, 6.31.

Dry NaH at 95% in oil (2.5 equiv/OH, 963 mg, 38.1 mmol) was added to a solution of *p*-methoxyphenyl *O*-(3-*O*-allyl-4,6-*O*-benzylidene-*β*-D-galactopyranosyl)-(1→4)-*β*-D-glucopyranoside (2.2 g, 3.81 mmol) and benzyl bromide (2.2 equiv/OH, 4 mL, 33.5 mmol) in DMF (26 mL) at 0 °C. The solution was allowed to warm to room temperature and stirred under argon for 14 h. The reaction was quenched by careful addition of MeOH, and the solvents were evaporated in vacuo. The residue was diluted in diethyl ether, and the organic phase was washed with water and brine, dried over $MgSO_4$, and concentrated in vacuo. The crude residue was purified by flash chromatography (toluene/EtOAc, 9:1) to give **14** (3.35 g, 3.58 mmol) as a gum in 94% yield: TLC (toluene/EtOAc, 9:1) $R_f = 0.28$; ^{1}H NMR ($CDCl_3$) δ 7.47−7.43 (m, 4H), 7.37−7.26 (m, 18H), 7.21−7.18 (m, 3H), 7.03 (d, $J = 9$ Hz, 2H), 6.80 (d, $J = 9$ Hz, 2H), 5.99−5.93 (m, 1H), 5.53 (s, 1H), 5.34 (dd, $J = 17.3$, 1.3 Hz, 1H), 5.24−5.19 (m, 2H), 5.02 (d, $J = 10.9$ Hz, 1H), 4.89−4.81 (m, 5H), 4.75 (d, $J = 11.2$ Hz, 1H), 4.53−4.51 (m, 2H), 4.38 (d, $J = 11.9$ Hz, 1H), 4.26−4.18 (m, 4H), 4.16−4.15 (m, 1H), 4.05−4.02 (m, 1H), 3.93−3.91 (m, 1H), 3.86 (dd, $J = 10.9$, 4.7 Hz, 1H), 3.82−3.71 (m, 7H), 3.50−3.49 (m, 1H), 3.40 (dd, $J = 3.5$, 9.7 Hz, 1H), 3.10 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 155.2, 151.6, 138.9, 138.8, 138.8, 138.4, 138.0, 135.1, 128.8, 128.5, 128.3, 128.2, 128.1, 128.0, 127.7, 127.6, 127.5, 127.4, 127.3, 127.2, 126.5, 118.4, 117.0, 114.4, 103.0, 102.8, 101.3, 83.0, 81.6, 79.7, 78.8, 77.9, 75.8, 75.3, 75.2, 75.1, 73.9, 73.0, 71.1, 68.9, 68.3, 66.4, 55.6; MALDI-MS *m*/*z* 960.0 [MNa^+]. Anal. Calcd for $C_{57}H_{60}O_{12}$ (937.08): C, 73.06; H, 6.45. Found: C, 73.13; H, 6.47.

***p*-Methoxyphenyl *O*-(3-*O*-Allyl-2,4-di-*O*-benzyl-6-*O*-*tert*-butyldiphenylsilyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-D-glucopyranoside (15).** A mixture of **14** (3.30 g, 3.52 mmol), EtSH (6 equiv, 1.56 mL, 21.1 mmol), and *p*-TsOH (0.2 equiv, 0.13 g, 0.70 mmol) in CH_2Cl_2 (23 mL) was stirred at room temperature under an argon atmosphere for 19 h. The reaction was then quenched by the addition of excess Et_3N. After evaporation of the solvents in vacuo, the residue was purified by flash chromatography (toluene/EtOAc, 7:3) to give *p*-methoxyphenyl *O*-(3-*O*-allyl-2-*O*-benzyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-D-glucopyranoside (2.86 g, 3.37 mmol) as a white foam in 96% yield: TLC (toluene/EtOAc, 7:3) $R_f = 0.28$; $[\alpha]_D = -5.2$ (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.44 (m, 2H), 7.36−7.26 (m, 15H), 7.04 (d, $J = 9$ Hz, 2H), 6.81 (d, $J = 9$ Hz, 2H), 5.96−5.90 (m, 1H), 5.31 (dd, $J = 7.3$, 1.3 Hz, 1H), 5.21 (dd, $J = 10.4$, 0.9 Hz, 1H), 5.03−5.02 (m, 2H), 4.89−4.81 (m, 3H), 4.77 (s, *2*H), 4.52 (d, $J = 12$ Hz, 1H), 4.42−4.41 (m, 2H), 4.21−4.14 (m, 2H), 3.97 (m, 1H), 3.92−3.91 (m, 1H), 3.83−3.75 (m, 5H), 3.71−3.64 (m, 3H), 3.53−3.51 (m, 1H), 3.30 (dd, $J = 9.3$, 3.3 Hz, 1H), 3.24−3.22 (m, 1H), 2.61 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 155.2, 151.5, 138.9, 138.5, 138.3, 138.2, 134.5, 128.3, 128.2, 128.1, 127.8, 127.6, 127.5, 127.4, 118.5, 117.3, 114.5, 102.8, 102.7, 82.7, 81.5, 81.0, 79.1, 77.1, 75.5, 75.3, 75.1, 73.9, 73.1, 71.3, 68.2, 67.2, 62.3, 55.6; MALDI-MS *m*/*z* 871.8 [MNa^+]. Anal. Calcd for $C_{50}H_{56}O_{12}$ (848.97): C, 70.74; H, 6.65. Found: C, 70.69; H, 6.66.

To a solution of *p*-methoxyphenyl *O*-(3-*O*-allyl-2-*O*-benzyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-D-glucopyranoside (2.41 g, 2.84 mmol) in DMF (13 mL) were added TBDPSCl (1.15 equiv, 851 *μ*L, 3.26 mmol) and Et_3N (1.15 equiv, 456 *μ*L, 3.26 mmol). The mixture was stirred at room temperature for 13 h under an inert atmosphere, the volatile compounds were evaporated in vacuo, and the residue was diluted with Et_2O. The organic phase was washed twice with water, dried over $MgSO_4$, and concentrated in vacuo. The residue was purified by flash chromatography (toluene/EtOAc, 95:5 → 9:1) to afford *p*-methoxyphenyl *O*-(3-*O*-allyl-2-*O*-benzyl-6-*O*-*tert*-butyldiphenylsilyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-D-glucopyranoside (2.96 g, 2.72 mmol) as a yellow gum in 96% yield. TLC (toluene/EtOAc, 9:1) $R_f = 0.41$; $[\alpha]_D = -7.8$ (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.66 (m, 2H), 7.61 (m, 2H), 7.39−7.37 (m, 6H), 7.36−7.24 (m, 17H), 7.04−6.99 (m, 5H), 6.77 (d, $J = 9$ Hz, 2H), 5.96−5.90 (m, 1H), 5.30 (d, $J = 17.6$ Hz, 1H), 5.20 (d, $J = 10.5$ Hz, 1H), 4.94 (d, $J = 10.7$ Hz, 1H), 4.90 (d, $J = 10.7$ Hz, 1H), 4.82 (d, $J = 7.6$ Hz, 1H), 4.77−4.68 (m, 4H), 4.51 (d, $J = 11.9$ Hz, 1H), 4.40−4.37 (m, 2H), 4.19−4.16 (m, 2H), 4.09 (s, 1H), 3.97−3.94 (m, 1H), 3.85 (dd, $J = 9.2$, 8.8 Hz, 1H), 3.77−3.75 (m, 5H), 3.71−3.69 (m, 1H), 3.61 (dd, $J = 7.8$ Hz, 1H), 3.59−3.51 (m, 2H), 3.45−3.43 (m, 1H), 3.28 (dd, $J = 9.4$, 3.3 Hz, 1H), 3.26−3.24 (m, 1H), 1.06−1.03 (m, 9H); ^{13}C NMR ($CDCl_3$) δ 155.1, 151.6, 138.6, 138.5, 135.6, 135.5, 134.8, 133.2, 129.7, 128.2, 128.0, 128.1, 127.9, 127.8, 127.7, 127.6, 127.5, 127.4, 127.2, 118.4, 117.1, 114.4, 102.7, 102.5, 82.7, 81.5, 81.1, 79.5, 76.4, 75.4, 75.3, 75.2, 75.1, 73.8, 73.1, 71.2, 68.2, 67.0, 65.6, 61.5, 55.6, 26.8, 19.1; MALDI-MS *m*/*z* 1110.3 [MNa^+]. Anal. Calcd for $C_{66}H_{74}O_{12}Si$ (1087.37): C, 72.90; H, 6.86. Found: C, 72.96; H, 6.88.

p-Methoxyphenyl *O*-(3-*O*-allyl-2-*O*-benzyl-6-*O*-*tert*-butyldiphenylsilyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-*β*-D-glucopyranoside (2.90 g, 2.61 mmol) was benzylated according to the procedure used for the preparation of **14**. The crude mixture was purified by flash chromatography (toluene/EtOAc, 98:2 → 96:4) to furnish **15** (2.92 g, 2.48 mmol) as a white foam in 95% yield: TLC (toluene/EtOAc, 95:5) $R_f = 0.42$; $[\alpha]_D = -15.0$ (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.57 (m, 2H), 7.54 (m, 2H), 7.36−7.35 (m, 2H), 7.33−7.22 (m, 26H), 7.03−7.02 (m, 1H), 7.00−6.99 (m, 2H), 6.95−6.93 (m, 2H), 6.77 (d, $J = 9$ Hz, 2H), 6.00−5.93 (m, 1H), 5.36 (dd, $J = 17.2$, 1.5 Hz, 1H), 5.19 (d, $J = 10.5$ Hz, 1H), 5.05 (d, $J = 11.3$ Hz, 1H), 4.97 (d, $J = 10.5$ Hz, 1H), 4.93 (d, $J = 10.9$ Hz, 1H), 4.81 (d, $J = 7.5$ Hz, 1H), 4.79−4.72 (m, 3H), 4.62−4.59 (m, 2H), 4.50 (d, $J = 11.9$ Hz, 1H), 4.39−4.37 (m, 2H), 4.24−4.23 (m, 2H), 4.05 (s, 1H), 3.90 (dd, $J = 9.2$ Hz, 1H), 3.85 (dd, $J = 9.3$ Hz, 1H),

3.78−3.74 (m, 5H), 3.72−3.65 (m, 2H), 3.61−3.54 (m, 2H), 3.44−3.42 (m, 1H), 3.34 (dd, J = 9.7, 2.9 Hz, 1H), 3.29−3.27 (m, 1H), 1.06−1.03 (m, 9H); ^{13}C NMR ($CDCl_3$) δ 155.1, 151.6, 139.2, 138.6, 135.5, 135.1, 133.2, 129.7, 128.2, 128.1, 128.0, 127.9, 127.7, 127.6, 127.5, 127.4, 127.2, 127.1, 127.0, 118.4, 116.3, 114.4, 102.7, 82.9, 82.5, 81.5, 80.0, 76.6, 75.6, 75.4, 75.2, 75.1, 74.5, 74.2, 73.4, 73.1, 71.6, 68.2, 61.2, 55.6, 26.9, 19.1; MALDI-MS m/z 1200.8 [MNa^+]. Anal. Calcd for $C_{73}H_{80}O_{12}Si$ (1177.49): C, 74.46; H, 6.85. Found: C, 74.42; H, 6.84.

***p*-Methoxyphenyl *O*-(2,4-Di-*O*-benzyl-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (16). 15** (2.80 g, 2.37 mmol) was desilylated according to the procedure used for the preparation of **10** to give, after purification by flash chromatography (toluene/EtOAc, 8:2), *p*-methoxyphenyl *O*-(3-*O*-allyl-2,4-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (2.03 g, 2.16 mmol) as a white foam in 91% yield: TLC (toluene/EtOAc, 75:25) R_f = 0.27; $[\alpha]_D$ = −3.3 (c 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.36−7.20 (m, 25H), 7.01 (d, J = 9 Hz, 2H), 6.77 (d, J = 9 Hz, 2H), 5.97−5.91 (m, 1H), 5.34 (dd, J = 17.2, 1.4 Hz, 1H), 5.19 (d, J = 10.5 Hz, 1H), 5.04 (d, J = 10.7 Hz, 1H), 4.99 (d, J = 10.9 Hz, 1H), 4.95 (d, J = 11.7 Hz, 1H), 4.86−4.75 (m, 5H), 4.56 (d, J = 11.7 Hz, 1H), 4.47 (d, J = 11.9 Hz, 1H), 4.39−4.37 (m, 2H), 4.19 (s, 1H), 3.90 (dd, J = 9.2, 9.0 Hz, 1H), 3.82−3.80 (m, 1H), 3.78−3.71 (m, 5H), 3.69−3.68 (m, 1H), 3.65−3.62 (m, 2H), 3.53−3.50 (m, 2H), 3.33−3.30 (m, 2H), 3.22−3.20 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 155.2, 151.5, 138.8, 138.7, 138.5, 138.3, 134.8, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.7, 127.6, 127.4, 127.3, 118.4, 116.6, 114.4, 103.0, 102.7, 82.7, 82.5, 81.5, 79.7, 77.2, 75.5, 75.2, 75.1, 74.8, 74.3, 73.4, 73.1, 71.8, 68.3, 61.8, 55.6; MALDI-MS m/z 962.3 [MNa^+]. Anal. Calcd for $C_{57}H_{62}O_{12}$ (939.09): C, 72.90; H, 6.65. Found: C, 72.86; H, 6.64.

To a solution of *p*-methoxyphenyl *O*-(3-*O*-allyl-2,4-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (3.08 g, 3.28 mmol) in CH_2Cl_2 (40 mL) were added levulinic acid (10 equiv, 3.81 g, 32.8 mmol), DCC (5 equiv, 3.38 g, 16.4 mmol), and DMAP (0.1 equiv, 0.04 g, 0.32 mmol) at room temperature under argon. After the resulting solution was stirred for 35 min, the precipitate was removed by filtration over Celite and washed with CH_2Cl_2 and the solution concentrated in vacuo. The residue was purified by flash chromatography (toluene/EtOAc, 85:15) to give *p*-methoxyphenyl *O*-(3-*O*-allyl-2,4-di-*O*-benzyl-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (3.29 g, 3.18 mmol) as a white amorphous solid in 97% yield: TLC (toluene/EtOAc, 8:2) R_f = 0.42; $[\alpha]_D$ = −13.2 (c 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.35−7.26 (m, 22H), 7.21−7.20 (m, 3H), 7.03 (d, J = 9 Hz, 1H), 6.80 (d, J = 9 Hz, 1H), 5.99−5.93 (m, 1H), 5.35 (dd, J = 17.2, 1.7 Hz, 1H), 5.21 (dd, J = 10.4, 1.2 Hz, 1H), 5.04 (d, J = 10.7 Hz, 1H), 5.00−4.98 (m, 2H), 4.87 (d, J = 7.2 Hz, 1H), 4.83−4.79 (m, 2H), 4.76−4.74 (m, 2H), 4.60 (d, J = 11.4 Hz, 1H), 4.52 (d, J = 12 Hz, 1H), 4.45 (d, J = 7.7 Hz, 1H), 4.41 (d, J = 12 Hz, 1H), 4.24−4.21 (m, 2H), 3.98−3.97 (m, 1H), 3.82−3.78 (m, 5H), 3.72 (dd, J = 9.7, 7.7 Hz, 1H), 3.68−3.63 (m, 2H), 3.51−3.49 (m, 1H), 3.40−3.38 (m, 1H), 3.33 (dd, J = 6.6 Hz, 1H), 2.69−2.67 (m, 2H), 2.48−2.42 (m, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 206.4, 155.1, 151.5, 138.9, 138.7, 138.6, 138.4, 138.3, 134.8, 128.3, 128.2, 128.0, 127.9, 127.8, 127.6, 127.4, 127.2, 118.4, 116.5, 114.4, 102.7, 102.6, 82.8, 82.3, 81.5, 79.7, 76.7, 75.3, 75.2, 75.1, 74.4, 73.0, 71.7, 68.3, 62.7, 55.6, 37.8, 29.8, 27.7; MALDI-MS m/z 1060.3 [MNa^+]. Anal. Calcd for $C_{62}H_{68}O_{14}$ (1037.19): C, 71.80; H, 6.61. Found: C, 71.74; H, 6.62.

A mixture of *p*-methoxyphenyl *O*-(3-*O*-allyl-2,4-di-*O*-benzyl-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (3.20 g, 3.08 mmol), Wilkinson's catalyst (0.1 equiv, 0.28 g, 0.30 mmol), and DBU (0.05 equiv, 0.02 mL, 0.15 mmol) in EtOH/toluene/water (8:3:1, 16 mL) was stirred at 100 °C for 12 h. The solvents were evaporated, and the residue was diluted in Et_2O. The organic phase was washed with water and brine, and the solvents were removed in vacuo. The residue was dissolved in an acetone/HCl (1 M) mixture (9:1, 26 mL), and the reaction was stirred at room temperature for 20 min. The solvents were subsequently removed in vacuo, and the residue was diluted in Et_2O. The organic layer was washed successively with saturated aqueous $NaHCO_3$ solution and water and dried with $MgSO_4$, and the solvents were removed in vacuo. The residue was adsorbed onto silica gel in toluene and purified by flash chromatography (toluene/EtOAc, 83:17 → 73:27) to afford **16** (2.57 g, 2.58 mmol) as a white amorphous solid in 84% yield: TLC (toluene/EtOAc, 75:25) R_f = 0.25; $[\alpha]_D$ = −3.2 (c 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.35−7.22 (m, 25H), 7.03 (d, J = 9 Hz, 1H), 6.80 (d, J = 9 Hz, 1H), 5.05−4.99 (m, 2H), 4.88 (d, J = 7.2 Hz, 1H), 4.85−4.82 (m, 3H), 4.77 (d, J = 10.7 Hz, 1H), 4.67−4.63 (m, 2H), 4.59 (d, J = 11.9 Hz, 1H), 4.47−4.44 (m, 2H), 4.14−4.10 (m, 2H), 4.06−4.02 (m, 1H), 3.84−3.77 (m, 6H), 3.70−3.66 (m, 2H), 3.55−3.51 (m, 3H), 3.48−3.46 (m, 1H), 2.69−2.67 (m, 2H), 2.49−2.47 (m, 2H), 2.23 (d, 1H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 206.3, 172.1, 155.2, 151.5, 138.8, 138.4, 138.3, 138.2, 138.1, 128.5, 128.3, 128.1, 128.0, 127.9, 127.6, 127.5, 127.3, 118.4, 114.4, 102.7, 102.5, 82.5, 81.5, 80.1, 76.6, 75.4, 75.3, 75.2, 75.1, 75.0, 74.1, 73.2, 72.0, 68.2, 62.5, 55.6, 37.8, 29.8, 27.7; MALDI-MS m/z 1020.0 [MNa^+]. Anal. Calcd for $C_{59}H_{64}O_{14}$ (997.13): C, 71.07; H, 6.47. Found: C, 71.09; H, 6.46.

***O*-[(2,4-Di-*O*-benzyl-3-*O*-(9-fluorenylmethoxycarbonyl)-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranosyl] Trichloroacetimidate (3).** To a solution of **16** (2.27 g, 2.28 mmol) in pyridine (15 mL) were added FmocCl (4 equiv, 2.36 g, 9.12 mmol) and DMAP (0.1 equiv, 27.9 mg, 0.22 mmol) at room temperature under argon. The yellow solution was stirred for 8 h (complete disappearance of the starting material by TLC), and the solvent was then evaporated and coevaporated three times with toluene in vacuo. The crude residue was adsorbed onto silica gel in toluene and purified by flash chromatography (toluene/EtOAc, 93:7 → 9:1) to provide *p*-methoxyphenyl *O*-(2,4-di-*O*-benzyl-3-*O*-(9-fluorenylmethoxycarbonyl)-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (2.61 g, 2.14 mmol) as a white foam in 94% yield: TLC (toluene/EtOAc, 7:3) R_f = 0.56; $[\alpha]_D$ = +1.8 (c 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.76−7.72 (m, 2H), 7.60−7.59 (m, 2H), 7.35−7.19 (m, 25H), 7.02 (d, J = 9 Hz, 1H), 6.80 (d, J = 9 Hz, 1H), 4.99 (m, 2H), 4.85 (d, J = 7.6 Hz, 1H), 4.83 (d, J = 11.9 Hz, 1H), 4.77−4.68 (m, 5H), 4.54 (d, J = 11.9 Hz, 1H), 4.50−4.46 (m, 2H), 4.44−4.40 (m, 3H), 4.24 (dd, J = 7.3 Hz, 1H), 4.09−4.07 (m, 2H), 4.03−4.00 (m, 1H), 3.87 (m, 1H), 3.81−3.77 (m, 6H), 3.67−3.63 (m, 2H), 3.47−3.43 (m, 2H), 2.72−2.65 (m, 2H), 2.50−2.46 (m, 2H), 2.16 (m, 3H); ^{13}C NMR ($CDCl_3$) δ 206.3, 171.9, 155.2, 154.6, 151.5, 143.3, 143.0, 141.2, 138.7, 138.4, 138.1, 137.8, 128.3, 128.2, 128.0, 127.9, 127.7, 127.6, 127.5, 127.3, 127.1, 125.0, 120.0, 118.4, 114.4, 102.7, 102.3, 82.6, 81.5, 79.5, 77.6, 76.8, 75.3, 75.1, 73.7, 73.1, 71.4, 69.9, 68.1, 62.0, 55.6, 46.7, 37.8, 29.8, 27.7; MALDI-MS m/z 1242.5 [MNa^+]. Anal. Calcd for $C_{74}H_{74}O_{16}$ (1219.37): C, 72.89; H, 6.12. Found: C, 72.86; H, 6.14.

To a solution of *p*-methoxyphenyl *O*-(2,4-di-*O*-benzyl-3-*O*-(9-fluorenylmethoxycarbonyl)-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (2.97 g, 2.43 mmol) in CH_3CN/H_2O/toluene (4:1:1, 50 mL) was added ceric ammonium nitrate (2 equiv, 2.66 g, 4.86 mmol). The orange solution was stirred at room temperature for 90 min and quenched by addition of solid $NaHCO_3$, and the solvents were removed in vacuo. The crude residue was then diluted in Et_2O and the organic phase washed three times with water, dried over $MgSO_4$, and concentrated in vacuo. A purification by flash chromatography (toluene/EtOAc, 82:18 → 75:25) was carried out to give an anomeric mixture (α/β, 1:1) of *O*-(2,4-di-*O*-benzyl-3-*O*-(9-fluorenylmethoxycarbonyl)-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-α/β-D-glucopyranose (2.05 g, 1.84 mmol) as a white foam in 76% yield: TLC (toluene/EtOAc, 7:3) R_f = 0.27 and 0.20; ^{1}H NMR ($CDCl_3$) δ 7.76−7.72 (m, 1H), 7.60−7.59 (m, 1H), 7.39−7.19 (m, 12.5H), 5.19 (d, J = 3.8 Hz, 0.5H), 5.02−4.97 (m, 2H), 4.88 (d, J = 11.0 Hz, 0.5H), 4.79−4.55 (m, 12H), 4.47−4.40 (m, 5H), 4.37−4.34 (m, 2H), 4.26−4.23 (m, 1H), 4.11−4.04 (m, 3H), 3.98−3.95 (m, 2H), 3.87−3.81 (m, 2.5H), 3.78−3.74 (m, 2.5H), 3.67−3.65 (m, 1H), 3.59−3.54 (m, 1.5H), 3.40−3.33 (m, 1.5H), 3.22 (s, 0.5H), 3.07 (s, 0.5H), 2.70−2.67 (m, 2H), 2.50−2.46 (m, 2H),

2.16 (m, 3H); ^{13}C NMR ($CDCl_3$) δ 206.2, 171.9, 154.6, 143.0, 141.3, 141.2, 138.7, 138.1, 137.8, 128.4, 128.3, 128.2, 128.0, 127.9, 127.6, 127.5, 127.2, 127.1, 125.0, 120.0, 102.2, 97.3, 91.5, 82.5, 82.4, 79.5, 79.1, 77.5, 76.5, 75.1, 74.9, 74.8, 73.6, 73.2, 71.4, 70.4, 69.9, 68.0, 67.9, 62.1, 46.7, 37.8, 29.8, 27.7; MALDI-MS *m/z* 1136.4 [MNa^+]. Anal. Calcd for $C_{67}H_{68}O_{15}$ (1113.25): C, 72.29; H, 6.16. Found: C, 72.25; H, 6.15.

O-(2,4-Di-*O*-benzyl-3-*O*-(9-fluorenylmethoxycarbonyl)-6-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-α/β-D-glucopyranose (1.32 g, 1.18 mmol) was dissolved in CH_2Cl_2/CCl_3CN (1:1, 15 mL) under argon. The minimum amount of NaH (95% in oil) required for the completion of the reaction (TLC monitoring) was added to the solution. After 15 min of stirring, the solution was adsorbed onto silica gel, and the residue was purified by flash chromatography (petroleum ether/EtOAc, 7:3 → 65:35) to produce an anomeric mixture of **3** (α/β, 1:1) (1.30 g, 1.03 mmol) as a white foam in 88% yield. Data for the β anomer: TLC (toluene/EtOAc, 7:3) R_f = 0.61; $[\alpha]_D$ = +5.0 (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 8.66 (s, 1H), 7.75−7.73 (m, 2H), 7.60−7.58 (m, 2H), 7.39−7.37 (m, 2H), 7.31−7.16 (m, 27H), 5.77 (d, *J* = 7.6 Hz, 1H), 4.99 (d, *J* = 10.8 Hz, 1H), 4.87 (d, *J* = 10.7 Hz, 1H), 4.78−4.64 (m, 7H), 4.59 (d, *J* = 12.2 Hz, 1H), 4.49 (d, *J* = 7.7 Hz, 1H), 4.46−4.41 (m, 5H), 4.25 (dd, *J* = 7.2 Hz, 1H), 4.12 (dd, *J* = 9.0 Hz, 1H), 4.06−4.05 (m, 2H), 3.85−3.82 (m, 2H), 3.77 (dd, *J* = 10.2, 7.7 Hz, 1H), 3.70−3.67 (m, 3H), 3.53−3.52 (m, 1H), 3.42−3.40 (m, 1H), 2.70−2.67 (m, 2H), 2.50−2.46 (m, 2H), 2.16 (s, 3H); ^{13}C NMR ($CDCl_3$) δ (selected data) 102.4, 98.6, 82.8, 80.4, 79.8, 77.6, 76.2, 76.1, 74.0, 71.8, 70.2, 67.6, 62.4, 46.9. Anal. Calcd for $C_{69}H_{68}Cl_3NO_{15}$ (1257.63): C, 65.90; H, 5.45; N, 1.11. Found: C, 65.88; H, 5.44; N, 1.10. Data for the α anomer: TLC (toluene/EtOAc, 7:3) R_f = 0.46; $[\alpha]_D$ = +25.3 (*c* 0.76, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 8.50 (s, 1H), 7.69−7.66 (m, 2H), 7.53−7.51 (m, 2H), 7.26−7.08 (m, 29H), 6.36 (d, *J* = 3.5 Hz, 1H), 4.88 (d, *J* = 10.7 Hz, 1H), 4.67−4.62 (m, 8H), 4.53 (dd, *J* = 10.1, 3.1 Hz, 1H), 4.48 (d, *J* = 12.0 Hz, 1H), 4.40−4.35 (m, 4H), 4.28−4.24 (m, 2H), 4.18−4.16 (m, 1H), 4.01−3.98 (m, 4H), 3.85−3.81 (m, 2H), 3.78−3.76 (m, 3H), 3.69 (dd, *J* = 10.1, 7.8 Hz, 1H), 3.63 (dd, *J* = 9.6, 3.5 Hz, 1H), 3.44−3.42 (m, 1H), 3.31−3.29 (m, 1H), 2.62−2.60 (m, 2H), 2.42−2.39 (m, 2H), 2.08 (m, 3H); ^{13}C NMR ($CDCl_3$) δ 206.2, 161.1, 154.6, 143.3, 141.3, 141.2, 138.9, 138.1, 137.9, 137.7, 128.4, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.7, 127.5, 127.1, 125.0, 120.1, 102.3, 94.4, 79.6, 79.3, 78.3, 77.4, 75.8, 75.3, 75.1, 73.7, 73.2, 73.1, 71.3, 69.9, 67.2, 62.0, 46.7, 37.8, 29.8, 27.7. Anal. Calcd for $C_{69}H_{68}Cl_3NO_{15}$ (1257.63): C, 65.90; H, 5.45; N, 1.11. Found: C, 65.91; H, 5.47; N, 1.10.

***O*-3,4-Di-*O*-benzyl-2-deoxy-2-dimethylmaleimido-4-*O*-(9-fluorenylmethoxycarbonyl)-β-D-glucopyranose (18).** The Fmoc group was introduced to compound **17**[19,24] according to the procedure employed for the protection of **16**, thus affording, after purification by flash chromatography (petroleum ether/EtOAc, 4:1), thexyldimethylsilyl 3,4-di-*O*-benzyl-4-*O*-(9-fluorenylmethoxycarbonyl)-2-deoxy-2-dimethylmaleimido-β-D-glucopyranoside as a yellow viscous oil in 83% yield: TLC (petroleum ether/EtOAc, 3:2) R_f = 0.65; $[\alpha]_D$ = +23.4 (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.74 (t, *J* = 8.2 Hz, 2H), 7.68 (*d*, *J* = 7.5 Hz, 1H), 7.38−7.20 (m, 9H), 7.16−7.15 (m, 3H), 7.14−7.09 (m, 2H), 5.21 (d, *J* = 8.1 Hz, 1H), 4.93 (t, *J* = 9.6 Hz, 1H), 4.63 (d, *J* = 12.3 Hz, 1H), 4.59−4.54 (m, 2H), 4.38−4.30 (m, 4H), 4.15 (t, *J* = 7.2 Hz, 1H), 3.97 (dd, *J* = 8.1 Hz, 1H), 3.80−3.76 (m, 1H), 3.67−3.65 (m, 2H), 1.81 (br s, 6H), 1.50−1.46 (m, 1H), 0.75−0.69 (m, 12H), 0.13 (s, 3H), 0.01 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 154.3, 143.2, 143.0, 141.2, 138.1, 138.0, 136.8, 128.2, 128.1, 127.8, 127.4, 127.3, 127.2, 127.1, 125.0, 124.9, 119.9, 93.3, 73.7, 73.4, 72.9, 69.8, 69.7, 57.1, 46.6, 33.9, 24.4, 19.8, 19.6, 18.3, 8.4, −1.8, −3.9; MALDI-MS *m/z* 845.3 [MNa^+]. Anal. Calcd for $C_{49}H_{51}NO_9Si$ (832.07): C, 70.73; H, 6.90; N, 1.68. Found: C, 70.75; H, 6.91; N, 1.69.

To a solution of thexyldimethylsilyl 3,4-di-*O*-benzyl-4-*O*-(9-fluorenylmethoxycarbonyl)-2-deoxy-2-dimethylmaleimido-β-D-glucopyranoside (2.1 g, 2.52 mmol) in THF (15 mL) was added HF·pyridine (3 mL) under an argon atmosphere. After being stirred at room temperature for 2 h, the reaction mixture was diluted with ethyl acetate and washed succesively with 10% $NaHCO_3$ cold aqueous solution, water, and brine. The organic layer was dried over $MgSO_4$ and concentrated in vacuo. The residue was purified by flash chromatography (petroleum ether/EtOAc, 4:1) to produce **18** (1.49 g, 2.16 mmol) as a colorless oil in 86% yield: TLC (petroleum ether/EtOAc, 3:2) R_f = 0.45; $[\alpha]_D$ = +43.6 (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 7.74 (t, *J* = 8.1 Hz, 2H), 7.58 (d, *J* = 7.4 Hz, 1H), 7.55 (d, *J* = 7.4 Hz, 1H), 7.42−7.24 (m, 8H), 7.20−7.13 (m, 4H), 7.11−7.09 (m, 2H), 5.22 (t, *J* = 7.9 Hz, 1H), 4.94 (t, *J* = 9.5 Hz, 1H), 4.63 (d, *J* = 12.4 Hz, 1H), 4.52−4.45 (m, 2H), 4.42−4.33 (m, 3H), 4.31−4.28 (m, 1H), 4.23 (d, *J* = 7.3 Hz, 1H), 4.15−4.08 (m, 1H), 3.97 (dd, *J* = 8.0, 10.8 Hz, 1H), 3.82−3.79 (m, 1H), 3.64−3.61 (m, 2H), 1.78 (br s, 6H); ^{13}C NMR ($CDCl_3$) δ 154.1, 143.1, 142.9, 141.1, 137.9, 137.5, 136.8, 128.1, 128.0, 127.7, 127.6, 127.5, 127.2, 127.0, 124.9, 124.8, 119.9, 119.7, 92.7, 76.5, 74.3, 74.0, 73.9, 73.3, 72.6, 69.7, 69.1, 68.7, 68.2, 56.5, 55.1, 46.5, 8.4; MALDI-MS *m/z* 712.9 [MNa^+]. Anal. Calcd for $C_{41}H_{59}NO_9$ (689.75): C, 71.39; H, 5.70; N, 2.03. Found: C, 71.43; H, 5.69; N, 2.02.

***O*-[3,4-Di-*O*-benzyl-2-deoxy-2-dimethylmaleimido-4-*O*-(9-fluorenylmethoxycarbonyl)-β-D-glucopyranosyl]Trichloroacetimidate (5).** Product **5** was prepared following the procedure described for the synthesis of **3**. **5** was obtained, after purification by flash chromatography (petroleum ether/EtOAc, 75:25), as a white foam in 88% yield: TLC (petroleum ether/EtOAc, 6:4) R_f = 0.70; $[\alpha]_D$ = +52.7 (*c* 1, $CHCl_3$); ^{1}H NMR ($CDCl_3$) δ 8.57 (s, 1H), 7.73−7.70 (m, 2H), 7.55−7.51 (m, 2H), 7.36−7.13 (m, 12H), 7.07−7.05 (m, 2H), 6.22 (d, *J* = 8.8 Hz, 1H), 5.02 (dd, *J* = 10.0, 8.8 Hz, 1H), 4.65−4.61 (m, 2H), 4.53−4.51 (m, 2H), 4.43 (dd, *J* = 10.8, 8.8 Hz, 1H), 4.35 (dd, *J* = 10.5, 7.4 Hz, 1H), 4.32−4.26 (m, 3H), 4.11 (dd, *J* = 7.0 Hz, 1H), 3.94−3.92 (m, 1H), 3.70−3.65 (m, 2H), 1.78−1.75 (m, 6H); ^{13}C NMR ($CDCl_3$) δ 160.7, 154.2, 143.2, 143.0, 141.3, 137.0, 128.2, 127.7, 127.6, 127.4, 127.1, 125.0, 124.9, 120.0, 93.9, 77.0, 76.3, 74.2, 73.9, 73.4, 70.0, 68.8, 54.1, 46.7, 8.5. Anal. Calcd for $C_{43}H_{39}Cl_3N_2O_9$ (834.14): C, 61.92; H, 4.71; N, 3.36. Found: C, 61.89; H, 4.72; N, 3.37.

General Procedure for the Solid-Phase Glycosylation (Procedure A). Dry acceptor-loaded resins were directly swollen under argon in a CH_2Cl_2 solution (1−1.5 mL/0.1 g of resin) containing the appropriate donor (3 equiv). The resulting suspension was cooled to −40 °C, after 10 min under agitation a freshly prepared 0.25 M TMSOTf solution in CH_2Cl_2 was added, and shaking was continued for 1 h. The mixture was allowed to warm to room temperature, and the resin was then filtered off, washed with CH_2Cl_2 (4 × 5 mL) and THF (4 × 5 mL), and dried under high vacuum (1 h, room temperature, 0.05 mbar). This procedure was repeated prior to starting the next step. Reaction completion for glycosylations and deprotections was monitored by TLC and MALDI-TOF analysis (TLC and MALDI-TOF analysis indicated disappearance of the corresponding starting material) of the crude cleavage product (MeONa, CH_2Cl_2/MeOH) from a very small resin sample (2 mg).

General Procedure for the Fmoc Removal (Procedure B). Dry resin-bound protected oligosaccharide was swollen under argon in a CH_2Cl_2 solution (1 mL/0.1 g of resin). After 10 min under agitation, NEt_3 (20% in volume) was added to the suspension, and shaking was continued for 4 h. The resin was then filtered off, washed with CH_2Cl_2 (4 × 5 mL) and THF (4 × 5 mL), and dried under high vacuum.

General Procedure for Cleavage (Procedure C). Dry resin was swollen in CH_2Cl_2 (1−1.5 mL/0.1 g of resin), and the resulting suspension was shaken under argon for 10 min. A solution of 5 equiv of MeONa in MeOH (10% of the complete volume) was added, and the resulting mixture was agitated for 6 h under an inert atmosphere. After this period, TLC analysis confirmed satisfactory cleavage. The resin was rinsed off with CH_2Cl_2/MeOH (9:1, 3 × 5 mL). This procedure was repeated to ensure complete cleavage. Amberlite IR120 (H^+ form) was added to the combined filtrate and washings to neutralize the medium and then filtered off. The solution was concentrated in vacuo and the residue purified by flash chromatography. In the case of an analytical cleavage, the crude residue was directly analyzed by TLC and MALDI-TOF.

Resin 19 was prepared according to procedure A employing 0.24 equiv of TMSOTf.

Resin 20. The Fmoc group of **19** was removed using procedure C. An elongation with lactosamine donor **4** (4 equiv) was then performed according to procedure B using 0.28 equiv of TMSOTf.

Resin 21. Resin-bound tetrasaccharide **20** was swollen under argon in a CH_2Cl_2 solution (1.5 mL/0.1 g of resin). After 10 min under shaking, MeOH (10% by volume) and NH_2NH_2-HOAc (2 equiv) were added to the suspension, and the agitation was continued for 16 h. The resin was then filtered off, washed with CH_2Cl_2/MeOH (9:1, 4 × 5 mL) and THF/MeOH (9:1, 4 × 5 mL), and dried under high vacuum. The released hydroxyl group was then glycosylated with **5** (4 equiv) employing procedure A using 0.28 equiv of TMSOTf. The Fmoc group was cleaved according to procedure B to afford resin-bound pentasaccharide **21**.

4-(3-Hydroxypropyl)benzyl (*β*-D-Galactopyranosyl)-(1→4)-(3,6-di-*O*-benzyl-2-deoxy-2-dimethylmaleimido-*β*-D-glucopyranosyl)-(1→3)-[(*β*-D-galactopyranosyl)-(1→4)-(3,6-di-*O*-benzyl-2-deoxy-2-dimethylmaleimido-*β*-D-glucopyranosyl)-(1→6)]-(2,4-di-*O*-benzyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-α,*β*-D-glucopyranoside (22). First route**: 22** was obtained from **21** using procedure A and donor **6** (0.45 equiv of TMSOTf) followed by a cleavage from the polymer support (procedure C). Second route: (1) glycosylation of **23** with **5** (4 equiv) carried out (procedure A) using 0.32 equiv of TMSOTf; (2) removal of the Fmoc group (procedure B); (3) glycosylation employing procedure A and donor **6** (0.45 equiv of TMSOTf); (4) cleavage (procedure C). The residue was purified by flash chromatography (CH_2Cl_2/MeOH, 93: 7 → 88:12) to provide **22** (42−43% overall yield from **2**) as an oil (α/*β*, 1:1): TLC (CH_2Cl_2/MeOH, 89:11) $R_f = 0.21$; ^{1}H NMR ($CDCl_3$) δ 7.21−7.01 (m, 49H), 5.09−5.04 (m, 1H), 5.02−4.97 (m, 1H), 4.92−4.68 (m, 5.5H), 4.67−4.56 (m, 2H), 4.54−4.11 (m, 19.5H), 4.09−3.87 (m, 7H), 3.81−3.68 (m, 10.5H), 3.63−2.91 (m, 32H), 2.61−2.56 (m, 2H), 1.79−1.72 (m, 2H), 1.66−1.53 (m, 6H); ^{13}C NMR ($CDCl_3$) δ 171.4, 138.9, 138.6, 138.4, 137.5, 136.7, 134.9, 128.4, 128.3, 128.2, 128.1, 128.0, 127.9, 127.8, 127.6, 127.5, 127.3, 127.2, 127.1, 126.6, 103.0, 102.4, 102.2, 102.0, 99.7, 97.4, 95.3, 91.6, 82.9, 81.6, 78.4, 78.1, 77.2, 74.8, 74.4, 74.2, 74.0, 73.8, 73.5, 73.3, 72.8, 72.1, 72.0, 70.8, 69.3, 68.5, 62.2, 62.1, 62.0, 56.1, 55.5, 34.1, 33.9, 31.8, 31.7, 31.6, 29.6, 29.3, 8.6, 8.5; MALDI-MS *m*/*z* 2187.4 [M + Na^+]. Anal. $C_{121}H_{138}N_2O_{34}$ (2164.38).

Resin 23. The Lev group of **19** was removed according to the protocol applied to resin **20**. Next, a glycosylation with **4** (4.5 equiv) was carried out (procedure A) employing 0.31 equiv of TMSOTf. The Fmoc group was removed using procedure B.

Acetyl (2,3,4,6-Tetra-*O*-acetyl-*β*-D-galactopyranosyl)-(1→4)-(2-acetamido-3,6-di-*O*-acetyl-2-deoxy-*β*-D-glucopyranosyl)-(1→3)-[(2,3,4,6-tetra-*O*-acetyl-*β*-D-galactopyranosyl)-(1→4)-(2-acetamido-3,6-di-*O*-acetyl-2-deoxy-*β*-D-glucopyranosyl)-(1→6)]-(2,4-di-*O*-acetyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-α,*β*-D-glucopyranoside (1). A mixture of **22** (0.014 g, 0.006 mmol) and sodium hydroxide (25 equiv, 0.006 g, 0.16 mmol) in a dioxane/water mixture (1:1, 1 mL) was stirred at room temperature. After 14 h, the pH was adjusted to 4.5 by addition of a 0.03 N HCl solution, and stirring was continued for 48 h with a constant monitoring of the pH with a pH meter. The solution was neutralized by addition of a solution of NaOH followed by addition of ethanolamine (2 equiv, 0.77 μL, 0.0012 mmol) and concentration in vacuo. The crude residue was then diluted in pyridine (2 mL), and Ac_2O (1 mL) was added to the solution. After the resulting solution was stirred for 8 h, the solvent was evaporated and coevaporated twice with toluene in vacuo. The crude residue was purified by flash chromatography (petroleum ether/EtOAc, 1:1 → 3:7) to furnish 4-(3-*O*-acetylpropyl)benzyl (2,3,4,6-tetra-*O*-acetyl-*β*-D-galactopyranosyl)-(1→4)-(2-acetamido-3,6-di-*O*-benzyl-2-deoxy-*β*-D-glucopyranosyl)-(1→3)-[(2,3,4,6-tetra-*O*-acetyl-*β*-D-galactopyranosyl)-(1→4)-(2-acetamido-3,6-di-*O*-benzyl-2-deoxy-*β*-D-glucopyranosyl)-(1→6)]-(2,4-di-*O*-benzyl-*β*-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-α,*β*-D-glucopyranoside (0.008 g, 0.003 mmol) in 57% yield as an oil (α/*β*, 1:1): TLC (EtOAc/petroleum ether, 7:3) $R_f = 0.17$; ^{1}H NMR ($CDCl_3$) δ 7.38−7.22 (m, 49H), 6.45 (d, J = 7.6 Hz, 0.5H), 5.98 (dd, J = 9.5, 5.4 Hz, 0.5H), 5.78 (dd, J = 9.5, 5.7 Hz, 1H), 5.53−5.49 (m, 1H), 5.39−5.37 (m, 0.5H), 5.28−5.19 (m, 2.5H), 5.12−4.97 (m, 4H), 4.90−4.29 (m, 26H), 4.25−4.19 (m, 1.5H), 4.16 (dd, J = 5.3 Hz, 1H), 4.09−3.95 (m, 5H), 3.93−3.88 (m, 4H), 3.86−3.29 (m, 23.5H), 3.25−3.22 (m, 1H), 2.65−2.62 (m, 2H), 2.17−1.78 (m, 35H); ^{13}C NMR ($CDCl_3$) δ (selected data) 170.1, 170.0, 138.8, 138.4, 138.3, 138.2, 138.1, 128.6, 128.5, 128.4, 128.2, 128.0, 127.9, 127.8, 127.7, 127.5, 126.8, 124.7, 123.1, 121.8, 107.5, 102.9, 102.7, 102.6, 102.2, 101.3, 99.9, 99.8, 95.6, 77.2, 76.9, 74.9, 74.8, 73.4, 70.7, 70.5, 69.4, 66.7, 63.7, 63.3, 60.6, 38.8, 37.4, 31.8, 30.1, 29.6, 29.3, 22.6, 21.3, 20.9, 20.8, 20.6; MALDI-MS *m*/*z* 2431.5 [M + Na^+]. Anal. $C_{131}H_{152}N_2O_{41}$ (2408.99).

The aforementioned intermediate (0.008 g, 0.003 mmol) was dissolved in a dioxane/MeOH/AcOH mixture (1:1:1, 0.9 mL) and hydrogenated in the presence of Pd−C (10%, 0.003 g). After 48 h the mixture was filtered through Celite and washed with MeOH/water (1:1), and the filtrate was evaporated in vacuo. The crude residue was then diluted in pyridine (1 mL), and Ac_2O (0.5 mL) was added to the solution. After the resulting solution was stirred for 6 h, the solvents were evaporated and coevaporated twice with toluene in vacuo. The residue was purified by flash chromatography ($CHCl_3$/acetone, 1:1) to give **1**[25] (0.005 g, 0.002 mmol) in 82% yield as an amorphous solid, which had spectroscopic data in accordance with those reported in the literature:[25] MALDI-MS *m*/*z* 1852.8 [M + Na^+]. Anal. $C_{76}H_{104}N_2O_{49}$ (1829.62).

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Supporting Information Available: Spectral data for all new compounds. This material is available free of charge via the Internet at http://pubs.acs.org.

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