Lipase-Catalysed Regioselective Acylations in Combination with Regioselective Glycosylations as a Strategy for the Synthesis of Oligosaccharides: Synthesis of a Series of Fucosyllactose Building Blocks

Anna Rencurosi,[a] Laura Poletti,[a] Giovanni Russo,[a] and Luigi Lay*[a]

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A family of five regioisomeric protected fucosyllactoses has been synthesised in only 14 overall steps from the easily available benzyllactoside. The adopted strategy combines enzymatic regioselective protection, introduction of orthogonal protecting groups and regioselective glycosylations on partially unprotected lactosidic acceptors.

Introduction

Human milk is extremely rich in oligosaccharides, more than 130 different compounds having been isolated and identified so far.[1,2] The biological significance of these compounds was largely unappreciated in the past, as they were thought to be nutritionally irrelevant and merely by-products due to the presence of glycosyl transferases in the mammary gland. Recently the great importance of these compounds for breast-fed infants has been demonstrated; during the lactation period the oligosaccharides, besides other biological roles, inhibit bacterial adhesion to the surface of epithelial cells, which has been recognized as a crucial initial step in the infection process.[3]

Recent studies demonstrated that an inhibitory effect on *E. coli* adhesion to uroepithelial cells is induced by a fraction of fucose containing low molecular weight human milk oligosaccharides (HMOs),[4] Fuc-α-(1→2)-Gal-β-(1→4)-Glc and Gal-β-(1→4)-[Fuc-α-(1→3)]-Glc being among the most abundant.[5] In order to establish whether the anti-adhesion properties of these compounds are merely due to the presence of fucose or whether glycosylation position plays a role in determining the bioactivity, we planned to synthesise a series of regioisomeric fucosyllactoses illustrated in Figure 1.[6]

The synthesis of this small trisaccharide library could be approached in different ways: (i) the classical target-oriented synthesis, consisting of the independent systematic preparation of each member of the family, would give the best results in terms of yield but would be very laborious and time consuming; (ii) the building-block approach, employed in many syntheses,[7] relies on orthogonally protected acceptor precursors, which require the selective deprotection of each single hydroxyl group followed by its glycosylation; (iii) the "random glycosylation" concept proposed by Hindsgaul[8] (one unprotected acceptor and one donor) produces mixtures of all the possible regioisomeric oligosaccharides. However, the latter is only very convenient if one is interested in testing the mixture itself in a biological assay.

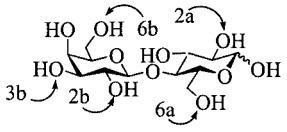

Figure 1. Fucosyllactose series: arrows indicate the fucosylation positions

In our case, as we needed pure single compounds, the building-block approach looked the most appealing. We therefore designed a protected lactosidic building block to be used as a scaffold to obtain all the target trisaccharides. One major drawback of the building-block strategy is that it implies a selective access to each single hydroxyl group, i.e. the introduction of a proper combination of numerous orthogonal protecting groups, the manipulation of which might be anything but easy. Thus, we envisaged a modified approach based on the combination of two concepts: (i) synthesis of a lactosidic scaffold containing a minimal number of orthogonal protecting groups, introduced when possible by regioselective enzymatic reactions; (ii) regioselective glycosylations on partially unprotected acceptors, which exploit the intrinsic differences in reactivity between various hydroxyl groups arising from steric and electronic effects.

Although regioselective glycosylations allow the shortening of synthetic protocols, they are generally under-ex-

[a] Dipartimento di Chimica Organica e Industriale, Centro Interdisciplinare Studi bio-molecolari e applicazioni Industriali (CISI), Università degli Studi di Milano, and CNR (Istituto di Scienze e Tecnologie Molecolari),
Via G. Venezian 21, 20133 Milano, Italy
Fax: (internat.) + 39-02/50314062
E-mail: luigi.lay@unimi.it

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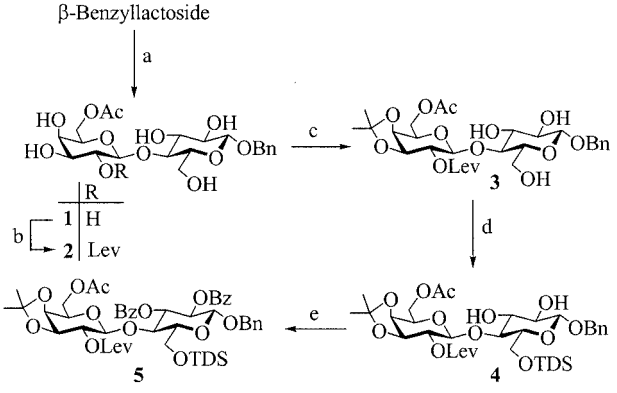
ploited in oligosaccharide syntheses.[9] In addition, the introduction of protecting groups by enzymatic acylations[10] is a highly regioselective transformation also able to shorten, dramatically, the synthetic pathway. In recent years, we have reported on the use of lipase-catalysed acylation for designing useful building blocks for oligosaccharide synthesis.[11] That approach proved to be extremely useful in the present case also. Here, we describe our results in the application of this "hybrid" strategy to the synthesis of five protected regioisomeric fucosyllactoses, obtained in only 14 overall steps from easily available β-benzyllactoside. Interestingly, a similar strategy could also be envisaged as a way towards new developments in the combinatorial synthesis of carbohydrate-based libraries.[12]

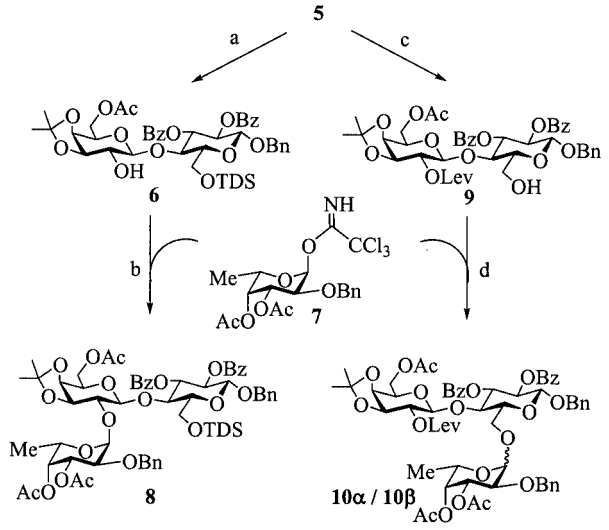
Results and Discussion

Lactoside **5** was chosen as a key building block in our strategy. The synthesis of **5** started from β-benzyllactoside,[13] which was converted into the orthogonally protected compound **2** by a double sequential acylation at 6b-OH and 2b-OH catalysed by lipase from *Candida antarctica* (Scheme 1). The introduction of an isopropylidene acetal at positions 3b, 4b afforded compound **3**. Regioselective 6a-*O*-silylation using thexyl dimethylsilyl chloride (TDSCl)[14] and imidazole in *N*,*N*-dimethylformamide gave diol **4** in 75% yield. Benzoylation of the remaining hydroxyl groups gave the lactose building block **5**.



Scheme 1. a) Vinyl acetate, THF, *Candida antartica* lipase (73%); b) trifluoroethyl levulinate, CH_3CN, *Candida antartica* lipase (72%); c) acetone, CSA, sikkon (66%); d) TDSCl, imidazole, DMF (75%); e) BzCl, Py, DMAP (94%)

The naturally occurring Fuc-α-(1→2)-Gal-β-(1→4)-Glc was synthesised as follows: Acceptor **6** was obtained in quantitative yield by chemoselective removal of the 2b-*O*-levulinoyl (Lev) group from compound **5** with hydrazinium acetate.[11c,15] A glycosylation reaction by direct procedure (DP),[16] using the α-trichloroacetimidate of the 3,4 di-*O*-acetyl-2-*O*-benzyl-L-fucopyranose **7**[17] as a donor and TMSOTf as a promoter, afforded trisaccharide **8** in 61% yield (Scheme 2). The stereochemistry at the newly formed glycosidic linkage was shown to be α by NMR analysis: the 1c-H signal appeared as a doublet at δ = 5.53 ppm with $^3J_{1c,2c}$ = 3.3 Hz as expected for a 1,2-*cis* linkage.

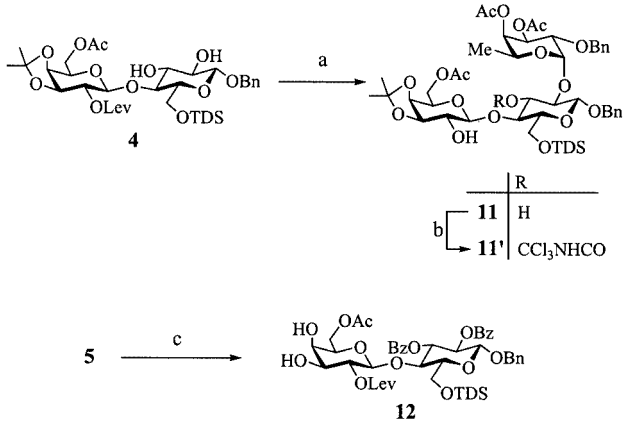


Scheme 2. a) NH_3NH_2OAc, EtOH/Et_2O (99%); b) **7**, TMSOTf (0.01eq), −10 °C (61%); c) TBAF, THF, AcOH, 0 °C (61%); d) **7**, TMSOTf (0.01 equiv.), −36 °C, (α/β = 2:1, 76%)

The synthesis of protected Gal-β-(1→4)-[Fuc-α-(1→6)]-Glc was achieved through removal of the silyl group of **5** with tetrabutylammonium fluoride (TBAF) in THF at 0 °C to give **9**, followed by glycosylation (DP) with donor **7** at −36 °C using TMSOTf as a promoter. Compound **10** was obtained in 76% yield as a separable 2:1 α/β mixture (Scheme 2).[18] The structure of the unusual β derivative was determined by NMR spectroscopy and mass spectrometry: the 1c-H signal for compound **10β** appeared as a doublet at δ = 4.59 ppm with $^3J_{1c,2c}$ = 7.8 Hz (δ = 5.04 ppm with $^3J_{1c,2c}$ = 3.2 Hz for **10α**), confirming the 1,2-*trans* linkage, whereas the MALDI-TOF spectra showed the same mass for both compounds.

For the synthesis of the remaining regioisomers we investigated the use of regioselective glycosylation reactions. Most literature data relates to the use of this strategy in the syntheses of (1→6)-linked oligosaccharides, where the marked difference in the reactivity between primary and secondary hydroxyl groups was exploited.[19] However, various examples of regioselective glycosylations of acceptors containing two or more secondary hydroxyl groups have been described.[20] In this context, diol **4** was selected as a direct precursor of Gal-β-(1→4)-[Fuc-α-(1→2)]-Glc. Previous studies indicated the higher reactivity of the 2a-OH compared to the 3a-OH of lactose in acylation reactions and this was also exploited for efficient syntheses of Gal-β-(1→4)-[Fuc-α-(1→3)]-Glc building blocks.[11e,21] Moreover, it is known that the glycosylation of methyl (or benzyl) 4,6-*O*-benzylidene-α-D-glucopyranoside with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide gives predominantly the β-(1→2)-linked disaccharide.[22] These results suggested that a similar order of reactivity might be preserved in the glycosylation of diol **4** with the fucosyl donor **7**. Gratifyingly, using the direct procedure at −30 °C in CH_2Cl_2 and

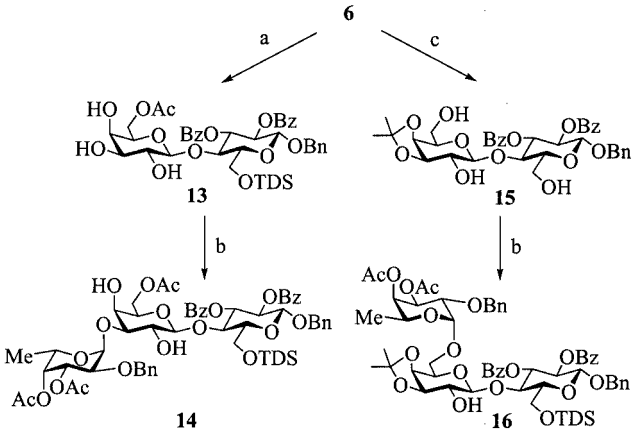
TMSOTf (0.01 equiv.) as a promoter, we obtained α-(1→2)-linked trisaccharide **11** as a single compound in 76% yield after chromatographic purification, without detection of the (1→3)-linked regioisomer (Scheme 3).



Scheme 3. a) **7**, TMSOTf (0.01 equiv.), −30 °C (76%); b) neat trichloroacetyl isocyanate, room temp., quant.; c) TFA, CH_2Cl_2, 75%

The glycosylation regiochemistry was confirmed by NMR spectroscopy by the treatment of **11** with trichloroacetyl isocyanate. The NMR spectrum of the obtained derivative **11′** showed a downfield shift of the 3a-H proton to δ = 5.25 ppm from δ = 3.87−3.91 in compound **11**, as deduced by COSY and HMQC experiments. The α configuration at the newly formed glycosidic linkage was deduced by the 1c-H/2c-H coupling constant value ($^3J_{1c,2c}$ = 3.7 Hz).

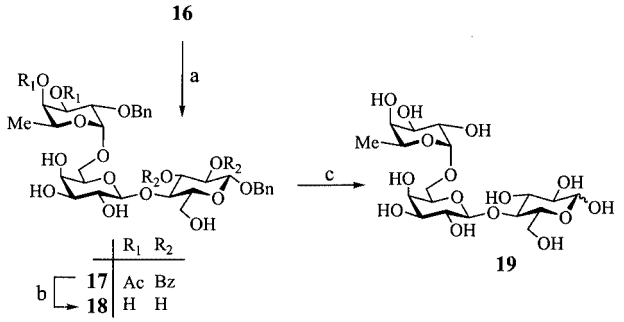
The synthesis of Fuc-α-(1→3)-Gal-β-(1→4)-Glc trisaccharide was first attempted using diol **12** as an acceptor, obtained from **5** by acidic hydrolysis of the isopropylidene acetal (Scheme 3). Both direct (−25 °C/room temp., CH_2Cl_2, TMSOTf) and inverse (0 °C/room temp., CH_3CN, SnOTf) procedures afforded an inseparable mixture of two trisaccharides in very poor yield. We conjectured that the presence of an electron-withdrawing group at the 2b-OH greatly reduced the reactivity of the 3b-OH, thus rendering the 4b-OH competitive for the glycosylation. Therefore compound **6** was submitted to acidic hydrolysis to give acceptor **13** (Scheme 4). This kind of triol has been shown to be extremely useful for regioselective sialylation reactions,[11a,22] but, to the best of our knowledge, there are no examples regarding fucosylation. The reaction was performed at −30 °C in CH_2Cl_2, with TMSOTf as a promoter. Trisaccharide **14** was recovered in 47% yield, together with some less polar products, probably tetrasaccharides, which were not isolated or characterised (Scheme 4). The structure of compound **14** was determined by NMR spectroscopy: the C-3b signal appeared at δ = 83.1 ppm as evidenced by HMQC experiment, shifted downfield with respect to the corresponding signal in compound **13** (δ ≤ 75.6, see Exp. Sect.) thus confirming the regiochemistry of the glycosylation. The α configuration at the newly formed glycosidic linkage was deduced by the 1c-H/2c-H coupling constant value ($^3J_{1c,2c}$ = 3.7 Hz).



Scheme 4. a) TFA, CH_2Cl_2 (82%); b) **7**, TMSOTf (0.01 equiv.), CH_2Cl_2 −30 °C (47%); c) K_2CO_3, dry MeOH, −20 °C/-35 °C, 24 h (83%); d) **7**, TMSOTf (0.01 equiv.), CH_2Cl_2 −35 °C (51%)

Straightforward access to Fuc-α-(1→6)-Gal-β-(1→4)-Glc trisaccharide from building block **5** required the difficult selective removal of the 6b-*O*-acetate in the presence of other acyl groups. While discrimination between acetate and benzoate is in principle possible,[23] this is not true for acetyl and levulinoyl esters as they show similar behaviour under acetate-removal conditions. Therefore, we directed our efforts to the chemoselective deacetylation of compound **6** to obtain the corresponding diol **15**, which should be regioselectively fucosylated at the most reactive primary hydroxyl group (Scheme 4). Disappointingly, when we treated compound **6** with DBU and methanol in refluxing toluene[25] we were able to isolate compound **15** in only 39% yield. In an attempt to disfavour nucleophilic attack on benzoates, we used *tert*-butyl alcohol instead of methanol, but observed no reaction. Treating **6** with methanol and AcCl[26] at 0 °C afforded only degradation by-products. Eventually, we found the best conditions to be the treatment of lactoside **6** with anhydrous K_2CO_3 in dry methanol at −20 °C.[27] The reaction proceeded slowly to afford compound **15**, but after 5 h we observed the formation of lower migrating by-products arising from partial concomitant hydrolysis of benzoate esters. We noticed that lowering the reaction temperature to −35 °C stopped this side-reaction while the formation of compound **15** continued. After 24 h, compound **15** was recovered in a very good yield (83%). Fucosylation of diol **15** was accomplished employing the direct procedure at −35 °C in CH_2Cl_2 using TMSOTf as a promoter to afford trisaccharide **16** in 51% yield, with no other regio- or stereoisomer detected (Scheme 4). The structure of compound **16** was ascertained by NMR spectroscopy: the 1c-H signal appeared as a doublet at δ = 4.52 ppm with $^3J_{1c,2c}$ = 3.4 Hz, confirming the 1,2-*cis* linkage. The regiochemistry of glycosylation was confirmed by the analysis of ^{13}C NMR spectra: the C-6b signal appeared at δ = 63.9 ppm, shifted downfield with respect to the corresponding signal in compound **15** (δ = 61.7/61.8), whereas

the C-2b chemical shift (δ = 74.0 ppm) is similar to the corresponding signal in **15** (δ = 73.9/74.0). As an illustrative example of the feasibility of our synthetic approach, compound **16** was deprotected as follows (Scheme 5). First, desilylation at position 6a was achieved by using a 1 M solution of TBAF in THF; thereafter treatment with 70% aqueous trifluoroacetic acid led to hydrolysis of the isopropylidene acetal, affording trisaccharide **17** in 67% overall yield. Compound **17** was then submitted to Zemplén deacylation to remove acetyl and benzoyl esters (85%), furnishing intermediate **18**. Hydrogenolysis of the remaining benzyl ethers, using Pd/C as a catalyst, eventually provided trisaccharide **19** (75%).



Scheme 5. a) TBAF 1M in THF, dry THF, 40 °C, then 70% aq. TFA, 0 °C, CH_2Cl_2 (67%); b) MeONa, MeOH, room temp. (85%); c) H_2, Pd/C, MeOH, room temp. (75%)

Conclusion

In conclusion, five regioisomeric protected fucosyllactoses have been prepared in only 14 overall steps from the easily available benzyllactoside, by adopting an efficient protocol which combines enzymatic regioselective protection, orthogonal protecting group strategy and regioselective glycosylations on partially unprotected acceptors. The synthesised trisaccharides together with compound Gal-β-(1→4)-[Fuc-α-(1→3)]-Glc already available in our laboratory[11d] will be deprotected and submitted to antiadhesion biological assays.

Experimental Section

General: ^{1}H NMR and ^{13}C NMR spectra were recorded on Varian Gemini 200, Bruker AC 300 and Bruker Avance 400 spectrometers at 298 K. When required for unambiguous characterisation (compounds **8**, **10α**, **10β**, **11**, **11′**, **14**, **16**–**19**), COSY, TOCSY and HMQC spectra were also recorded. In descriptions of the ^{13}C spectra, signals corresponding to aromatic carbons are omitted. MALDI-TOF spectra were carried out on a Bruker Biflex III time-of-flight mass spectrometer. Optical rotations were measured at room temperature with a Perkin–Elmer 241 polarimeter. TLC was carried out on Merck silica gel 60 F_{254} plates (0.25 mm thickness), and spots were visualised by spraying with a solution containing H_2SO_4 (31 mL), ammonium molybdate (21 g) and $Ce(SO_4)_2$ (1 g) in water (500 mL), followed by heating at 110 °C for 5 min. Column chromatography was performed by the flash procedure using Merck silica gel 60 (230–400 mesh). Elemental analyses were performed using the Carlo Erba elemental analyser 1108. Solvents were dried by standard procedures.

Benzyl (6-*O*-Acetyl-β-D-galactopyranosyl)-(1→4)-β-D-glucopyranoside (1): Benzyl β-D-lactoside[12] (5.05 g, 11.7 mmol) was suspended in dry THF (500 mL). Vinyl acetate (150 mL, 1.62 mol) and *Candida antarctica* lipase (15.1 g) were added, the suspension was mechanically stirred for 2 days at 40 °C and monitored by TLC (EtOAc/MeOH/H_2O, 8:1.5:0.5). The enzyme was filtered off and the solvent was removed under reduced pressure. Purification by flash chromatography (EtOAc/MeOH, 10:1) afforded compound **1** as a white foam (3.92 g, 73%). Optical rotation value and NMR spectroscopic data are in agreement with those previously reported.[28]

Benzyl (6-*O*-Acetyl-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-β-D-glucopyranoside (2): Compound **1** (3.06 g, 6.50 mmol) was suspended in CH_3CN (200 mL). Trifluoroethyl levulinate (48.5 mL, 245 mmol) and *Candida antarctica* lipase (9.30 g) were added, the suspension was stirred with a mechanical stirrer for 4 days at 45 °C and monitored by TLC (EtOAc/MeOH/H_2O, 8:1.5:0.5). The enzyme was filtered off and the solvent was removed under reduced pressure. Purification by flash chromatography (EtOAc/MeOH, 10:0.5) afforded unchanged compound **1** (0.57 g, 18%) and compound **2** (2.66 g, 72%) as a white foam. $[\alpha]_D^{20}$ = +15.7 (*c* = 0.8, $CHCl_3$). ^{1}H NMR (300 MHz, CD_3OD): δ = 2.10 (s, 3 H, $COCH_3$), 2.20 (s, 3 H, CH_3COCH_2), 2.73–2.77 [m, 4 H, $(CH_2)_2CO$], 3.30 (m, 1 H, 2a-H), 3.39 (ddd, $^3J_{5,6'}$ = 1.8, $^3J_{5,6'}$ = 4.0, $^3J_{4,5}$ = 9.0 Hz, 1 H, 5a-H), 3.52 (m, 2 H, 3a-H, 4a-H), 3.69 (dd, $^3J_{3,4}$ = 3.4 Hz, 1 H, 3b-H), 3.74 (dd, $^2J_{6,6'}$ = 8.3 Hz, 1 H, 6a-H), 3.87 (m, 3 H, 4b-H, 5b-H, 6′a-H), 4.24 (dd, $^3J_{6,5}$ = 4.5 Hz, 1 H, 6b-H), 4.31 (dd, $^2J_{6,6'}$ = 11.6, $^3J_{6,5}$ = 8.1 Hz, 1 H, 6′b-H), 4.39 (d, $^3J_{1,2}$ = 7.7 Hz, 1 H, 1a-H), 4.58 (d, $^3J_{1,2}$ = 8.0 Hz, 1 H, 1b-H), 4.66 (d, 1 H, C*H*HPh), 4.91 (d, ^2J = 11.8 Hz, 1 H, C*H*HPh), 5.05 (dd, $^3J_{2,3}$ = 9.9 Hz, 1 H, 2b-H), 7.20–7.35 (m, 5 H, C_6H_5) ppm. ^{13}C NMR (75.44 MHz, CD_3OD): δ = 21.0 ($COCH_3$), 29.3 (CH_2COO), 30.0 (CH_2COCH_3), 38.8 (CH_2COCH_3), 62.0, 65.0 (6a-C, 6b-C), 72.1 (CH_2Ph), 70.6, 73.2, 74.7, 75.1, 76.6, 81.6 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C, overlapped signals), 102.9, 103.4 (1a-C, 1b-C), 173.0, 174.1 (2 CH_3CO), 209.9 (CH_2COCH_3) ppm. $C_{26}H_{36}O_{14}$ (572.55): calcd. C 54.54, H 6.34; found C 54.41, H 6.30.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-β-D-glucopyranoside (3): Compound **2** (2.00 g, 3.49 mmol) was dissolved in dry acetone (150 mL) under an inert atmosphere, sikkon (2.50 g) was added and the mixture was stirred for 30 min. A catalytic amount of camphorsulfonic acid was added and the suspension was refluxed for 22 h, monitoring the reaction by TLC (EtOAc/MeOH, 9.5:0.5). After cooling to room temperature, the mixture was neutralised with TEA, sikkon was filtered off and the solvent removed under reduced pressure. Purification by flash chromatography (EtOAc) afforded compound **3** (1.42 g, 66%) as a white amorphous solid. $[\alpha]_D^{20}$ = +31.5 (*c* = 1.27, $CHCl_3$). ^{1}H NMR (200 MHz, $CDCl_3$, few drops of D_2O): δ = 1.31 (s, 3 H, CH_3CCH_3), 1.54 (s, 3 H, CH_3CCH_3), 2.11, 2.19 (2 s, 6 H, 2 $COCH_3$), 3.00–2.47 [m, 4 H, $(CH_2)_2CO$], 3.38–3.65 (m, 4 H, 2a-H, 3a-H, 4a-H, 5a-H), 3.70 (dd, $^3J_{5,6}$ = 3.2 Hz, 1 H, 6a-H), 3.89 (dd, $^2J_{6,6'}$ = 12.2, $^3J_{5,6}$ = 2.9 Hz, 1 H, 6′a-H), 4.04–4.42 (m, 5 H, 6b-H, 6′b-H, 3b-H, 4b-H, 5b-H), 4.44 (d, $^3J_{1,2}$ = 7.7 Hz, 1 H, 1a-H), 4.48 (d, $^3J_{1,2}$ = 7.8 Hz, 1 H, 1b-H), 4.65 (d, 1 H, C*H*HPh), 4.90 (d, ^2J = 11.8 Hz, 1 H, C*H*HPh), 4.98 (t, $^3J_{2,3}$ = 7.3 Hz, 1 H, 2b-H), 7.23–7.42 (m, 5 H, C_6H_5) ppm. $C_{29}H_{40}O_{14}$ (612.62): calcd. C 56.86, H 6.58; found C 56.72, H 6.55.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (4): Compound **3** (1.27 g, 2.07 mmol) and imidazole (420 mg, 6.17 mmol) were dissolved in dry DMF (8.0 mL) under an inert atmosphere. The solution was cooled to 0 °C, TDSCl (500 μL, 2.55 mmol) was added dropwise and the reaction mixture was stirred for 2 h at room temperature (TLC EtOAc/petroleum ether, 8:2). The solvent was removed under reduced pressure, and the residue was diluted with EtOAc (20.0 mL) and washed first with satd. NH_4Cl, then with water. The organic phase was separated, dried over Na_2SO_4, filtered and concentrated. Flash chromatography purification (EtOAc/petroleum ether, 4:6) afforded **4** (1.18 g, 75%) as a white amorphous solid. $[\alpha]_D^{20} = +21.6$ (c = 1.0, $CHCl_3$). ^1H NMR (200 MHz, $CDCl_3$): δ = 0.13, 0.15 [2 s, 6 H, Si(CH_3)$_2$], 0.84−0.95 [m, 12 H, C(CH_3)$_2$CH(CH_3)$_2$], 1.35 (s, 3 H, CH_3CCH$_3$), 1.55 (s, 3 H, CH$_3$CCH$_3$), 1.62 [m, 1 H, C(CH$_3$)$_2$CH(CH$_3$)$_2$], 2.11, 2.18 (2 s, 6 H, 2 COCH_3), 2.55−3.00 [m, 4 H, (CH_2)$_2$CO], 3.31−3.65 (m, 4 H, 2a-H, 3a-H, 4a-H, 5a-H), 3.86 (apparent d, 2 H, 6a-H, 6′a-H), 3.95−4.22 (m, 3 H, 3b-H, 4b-H, 5b-H), 4.22−4.45 (m, 3 H, 1a-H, 6b-H, 6′b-H), 4.48 (d, 1 H, 1b-H), 4.61 (d, 1 H, CHHPh), 4.88 (d, ^2J = 11.6 Hz, 1 H, CHHPh), 5.02 (t, $^3J_{1,2} = {}^3J_{2,3} \approx 7.2$ Hz, 1 H, 2b-H), 7.25−7.45 (m, 5 H, C$_6H_5$) ppm. ^{13}C NMR (75.44 MHz, $CDCl_3$): δ = −3.1, −3.5 [Si(CH_3)$_2$], 18.6−20.7 [C(CH_3)$_2$CH(CH_3)$_2$, COCH_3], 23.8 [C(CH$_3$)$_2$CH-(CH$_3$)$_2$], 26.1, 27.3 [C(CH_3)$_2$], 27.7 (CH_2COO), 29.6 (CH_3COCH$_2$), 34.3 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 37.7 (CH$_3$COCH_2), 61.3, 63.0 (6a-C, 6b-C), 70.7 (CH_2Ph), 71.1, 72.6, 73.2, 73.9, 74.4, 74.8, 76.9, 80.1 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C), 100.8, 101.1 (1a-C, 1b-C), 111.0 [C(CH$_3$)$_2$], 170.8, 171.2 (CH$_3$COO, CH$_2$COO), 205.8 (CH$_3$COCH$_2$) ppm. $C_{37}H_{58}O_{14}Si$ (754.93): calcd. C 58.87, H 7.74; found C 58.96, H 7.78.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (5): BzCl (620 μL, 5.34 mmol) was added to a solution of compound **4** (730 mg, 0.970 mmol) in pyridine (8.0 mL) at 0 °C. The reaction mixture was stirred at room temperature for 2 h (TLC petroleum ether/EtOAc, 1:1). After quenching excess BzCl with MeOH, solvents were removed under reduced pressure. The residue was diluted with CH_2Cl_2 and washed sequentially with 5% aq HCl, satd. $NaHCO_3$ and water. The organic phase was separated, dried over Na_2SO_4, filtered and concentrated. Flash chromatography purification (petroleum ether/EtOAc, 6.5:3.5) afforded **5** (880 mg, 94%) as a white amorphous solid. $[\alpha]_D^{20} = +37.5$ (c = 1.0, $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 0.18, 0.21 [(2s, 6 H, Si(CH_3)$_2$], 0.93 [m, 12 H, C(CH_3)$_2$CH(CH_3)$_2$], 1.25 (s, 3 H, CH_3CCH$_3$), 1.38 (s, 3 H, CH_3CCH$_3$), 1.65 [m, 1 H, C(CH$_3$)$_2$CH(CH$_3$)$_2$], 2.08, 2.26 (2 s, 6 H, 2 COCH_3), 2.53−2.88 [m, 4 H, (CH_2)$_2$CO], 3.55 (m, 2 H, 5a-H, 6a-H), 3.75 (m, 1 H, 5b-H), 3.92−4.08 (m, 5 H, 6′a-H, 3b-H, 4b-H, 6b-H, 6′b-H), 4.13 (t, 1 H, 4a-H), 4.59 (d, 1 H, 1b-H), 4.62 (d, ^2J = 11.6 Hz, 1 H, CHHPh), 4.70 (d, 1 H, 1a-H), 4.78 (t, $^3J_{1,2} = {}^3J_{2,3} \approx 7.9$ Hz, 1 H, 2b-H), 4.86 (d, 1 H, CHHPh), 5.36 (dd, $^3J_{1,2} = 7.7$ Hz, 1 H, 2a-H), 5.56 (t, $^3J_{2,3} = {}^3J_{3,4} \approx 9.5$ Hz, 1 H, 3a-H), 7.10−8.12 (m, 15 H, 3 C$_6H_5$) ppm. ^{13}C NMR (75.44 MHz, $CDCl_3$): δ = −3.0, −3.5 [Si(CH_3)$_2$], 18.5−20.8 [C(CH_3)$_2$CH(CH_3)$_2$, COCH_3], 25.0 [C(CH$_3$)$_2$-CH(CH$_3$)$_2$], 26.2, 27.3 [C(CH_3)$_2$], 27.7 (CH_2COO), 29.8 (CH_3COCH$_2$), 34.3 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 37.8 (CH$_3$COCH_2), 60.1, 63.0 (6a-C, 6b-C), 70.1 (CH_2Ph), 71.0, 72.2, 73.0, 73.3, 73.5, 74.1, 75.5, 77.1 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C), 99.3, 99.6 (1a-C, 1b-C), 110.6 [C(CH$_3$)$_2$], 165.7, 165.3, 171.0, (CH$_3$COO, CH$_2$COO, 2 C$_6$H$_5$COO overlapping signals), 206.2 (CH$_3$COCH$_2$). $C_{51}H_{66}O_{16}Si$ (963.15): calcd. C 63.60, H 6.91; found C 63.52, H 6.88.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (6): Compound **5** (203 mg, 0.210 mmol) was dissolved in EtOH/Et_2O (1:1 v/v, 4.0 mL) under Ar atmosphere, then dry $AcONH_3NH_2$ (92.0 mg, 0.240 mmol) was added and the reaction mixture was stirred at room temperature. After 2 h (HPTLC toluene/EtOAc, 8:2) the solvent was removed under reduced pressure and purification by flash chromatography (toluene/EtOAc, 8:2) afforded compound **6** as a white amorphous solid (181 mg, 99%). $[\alpha]_D^{20} = +47.8$ (c = 1.13, $CHCl_3$). ^1H NMR (200 MHz, $CDCl_3$): δ = 0.18, 0.22 [2s, 6 H, Si(CH_3)$_2$], 0.93 [m, 12 H, C(CH_3)$_2$CH(CH_3)$_2$], 1.25 (s, 3 H, CH_3CCH$_3$), 1.38 (s, 3 H, CH_3CCH$_3$), 1.65 [m, 1 H, C(CH$_3$)$_2$CH(CH$_3$)$_2$], 2.05 (s, 3 H, COCH_3), 2.60 (s, 1 H, OH), 3.49 (m, 1 H, 2b-H), 3.52 (m, 2 H, 5a-H, 6a-H), 3.69 (m, 1 H, 5b-H), 4.00 (m, 5 H, 6′a-H, 3b-H, 4b-H, 6b-H, 6′b-H), 4.22 (t, $^3J_{4,5}$ = 9.4 Hz, 1 H, H-4), 4.38 (d, $^3J_{1,2}$ = 8.2 Hz, 1 H, 1b-H), 4.65 (d, ^2J = 12.4 Hz, 1 H, CHHPh), 4.75 (d, 1 H, 1a-H), 4.87 (d, 1 H, CHHPh), 5.42 (t, $^3J_{1,2}$ = 9.4 Hz, 1 H, 2a-H), 5.58 (t, $^3J_{2,3} = {}^3J_{3,4} \approx 9.4$ Hz, 1 H, 3a-H), 7.10−8.00 (m, 15 H, 3 C$_6H_5$) ppm. $C_{46}H_{60}O_{14}Si$ (865.05): calcd. C 63.87, H 6.99; found C 63.78, H 6.96.

Benzyl (3,4-Di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→2)-(6-*O*-acetyl-3,4-isopropylidene-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (8): Compound **6** (65.0 mg, 75.0 μmol) and fucosyl donor **7**[17] (79.0 mg, 0.163 mmol) were dissolved in dry CH_2Cl_2 (500 μL) and cooled to −10 °C. A 0.05 M TMSOTf soln in dry CH_2Cl_2 (15.0 μL, 0.750 μmol) was added dropwise with vigorous stirring (TLC acetone/toluene, 2:8). After 10 min, the mixture was neutralised with TEA and concentrated. Flash chromatography purification (acetone/toluene, 0.5:10) afforded **8** (55.0 mg, 61%) as a white foam. $[\alpha]_D^{20} = -40.6$ (c = 0.97, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.15, 0.22 [2s, 6 H, Si(CH_3)$_2$], 0.89 [s, 6 H, C(CH_3)$_2$CH(CH$_3$)$_2$], 0.93 [d, ^3J = 6.1 Hz, 3 H, C(CH$_3$)$_2$CH(CH_3)(CH$_3$)], 0.95 [d, ^3J = 6.1 Hz, 3 H, C(CH$_3$)$_2$CH(CH_3)(CH$_3$)], 1.21 (d, $^3J_{5,6}$ = 6.5 Hz, 3 H, 6c-H), 1.25 (s, 3 H, CH_3CCH$_3$), 1.34 (s, 3 H, CH_3CCH$_3$), 1.63 [m, 1 H, C(CH$_3$)$_2$CH(CH$_3$)$_2$], 1.99 (s, 3 H, COCH_3), 2.02, 2.12 (2 s, 6 H, COCH_3), 3.43 (br. d, 1 H, 5a-H), 3.55 (m, 2 H, 6a-H, 2b-H), 3.78 (ddd, $^3J_{5,6}$ = 3.9, $^3J_{5,6}$ = 7.8 Hz, 1 H, 5b-H), 3.88 (dd, 1 H, 2c-H), 3.95 (dd, $^3J_{3,4}$ = 5.5, $^3J_{4,5}$ = 2.1 Hz, 1 H, 4b-H), 4.01−4.14 (m, 4 H, 6′a-H, 3b-H, 6b-H, 6′b-H), 4.27 (t, $^3J_{3,4} = {}^3J_{4,5} \approx 9.6$ Hz, 1 H, 4a-H), 4.41 (br. q, $^3J_{5,6}$ = 6.4 Hz, 1 H, 5c-H), 4.57 (d, $^3J_{1,2}$ = 8.2 Hz, 1 H, 1b-H), 4.68 (d, 1 H, CHHPh), 4.71 (d, ^2J = 12.2 Hz, 1 H, CHHPh), 4.72 (d, 1 H, 1a-H), 4.87 (d, ^2J = 12.6 Hz, 1 H, CHHPh), 5.27 (dd, $^3J_{2,3}$ = 10.4, $^3J_{3,4}$ = 3.4 Hz, 1 H, 3c-H), 5.30 (br. d, 4c-H), 5.42 (dd, $^3J_{1,2}$ = 7.7, $^3J_{2,3}$ = 10.0 Hz, 1 H, 2a-H), 5.50 (t, $^3J_{2,3} = J_{3,4} \approx 9.6$ Hz, 1 H, 3a-H), 5.53 (d, $^3J_{1,2}$ = 3.3 Hz, 1 H, 1c-H), 7.19−7.98 (m, 20 H, 4 C$_6H_5$) ppm. ^{13}C NMR (100.62 MHz, $CDCl_3$): δ = −2.6, −3.0 [Si(CH_3)$_2$], 15.6 (6c-C), 18.9−21.3 [C(CH_3)$_2$CH(CH_3)$_2$, 3 COCH_3], 27.6, 26.3 [C(CH_3)$_2$], 25.6 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 34.6 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 60.9, 63.7 (6a-C, 6b-C), 72.3, 73.4 (2 CH_2Ph), 64.9, 70.5, 71.5, 72.3, 72.3, 73.1, 73.8, 74.2, 75.2, 76.2, 77.4, 80.2 (2a-C, 3a-C,4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C, 2c-C, 3c-C, 4c-C, 5c-C), 95.2, 99.6, 100.0 (1a-C, 1b-C, 1c-C), 110.8 [C(CH$_3$)$_2$], 162.86, 165.7, 166.3, 170.6, 171.1 (3 CH$_3$COO, 2 C$_6$H$_5$COO) ppm. $C_{63}H_{80}O_{20}Si$ (1185.38): calcd. C 63.83, H 6.80; found C 63.88, H 6.77.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-β-D-glucopyranoside (9): Compound **5** (200 mg, 0.210 mmol) was dissolved in dry THF (3.5 mL) under Ar atmosphere, and cooled to 0 °C. A 1.0 M solution of glacial AcOH in THF (230 μL, 0.230 mmol) and a 1.0 M solution of TBAF in THF (450 μL, 0.450 mmol) were added

sequentially and the reaction mixture was stirred at room temperature. After 42 h (TLC, EtOAc) the reaction mixture was diluted with EtOAc and washed with satd. NaCl. The organic phase was separated, dried over anhydrous Na_2SO_4, filtered and concentrated at reduced pressure. Flash chromatography purification of the crude residue (petroleum ether/EtOAc 1:1, then EtOAc) afforded compound **9** as a white foam (104 mg, 61%). $[\alpha]_D^{20} = +47.0$ (c = 0.96, $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$,): δ = 1.23 (s, 3 H, CH_3CCH_3), 1.41 (s, 3 H, CH_3CCH_3), 2.20, 2.02 (2 s, 6 H, 2 $COCH_3$), 2.37 (OH), 2.45−2.95 [m, 4 H, $(CH_2)_2CO$], 3.54 (dd, $^2J_{6,6'} = 11.4$, $^3J_{6,5} = 6.8$ Hz, 1 H, 6a-H), 3.63−3.72 (m, 2 H, 5a-H, 5b-H), 3.82−4.07 (m, 5 H, 6′a-H, 3b-H, 4b-H, 6b-H, 6′b-H), 4.10 (t, $^3J_{4,5} = 9.5$ Hz, 1 H, 4a-H), 4.51 (d, $^3J_{1,2} = 7.3$ Hz, 1 H, 1b-H), 4.68 (d, 1 H, CHHPh), 4.76 (d, $^3J_{1,2} = 7.8$ Hz, 1 H, 1a-H), 4.82 (t, $^3J_{2,3} = 7.0$ Hz, 1 H, 2b-H), 4.88 (d, $^2J = 12.5$ Hz, 1 H, CHHPh), 5.42 (t, $^3J_{2,3} = 8.0$ Hz, 1 H, 2a-H), 5.60 (t, $^3J_{2,3} = {}^3J_{3,4} \approx$ 9.6 Hz, 1 H, 3a-H), 7.15−7.98 (m, 15 H, 3 C_6H_5) ppm. ^{13}C NMR (75.44 MHz, $CDCl_3$): δ = 20.8 (CH_3COO). 26.1, 27.3 [$C(CH_3)_2$], 27.7 (CH_2COO), 29.9 (CH_3COCH_2), 37.7 (CH_3COCH_2), 60.9, 62.6 (6a-C, 6b-C), 70.8 (CH_2Ph), 70.6, 72.1, 73.0, 73.4, 75.2, 75.4, 77.0 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C, overlapping signals), 99.6, 100.4 (1a-C, 1b-C), 110.6 [$C(CH_3)_2$], 165.3, 165.4, 170.4, 171.2 (CH_3COO, CH_2COO, 2 C_6H_5COO), 206.8 (CH_3COCH_2) ppm. $C_{43}H_{48}O_{16}$ (820.83): calcd. C 62.92, H 5.89; found C 62.88, H 5.91.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-[(3,4-di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→6)]-2,3-di-*O*-benzoyl-β-D-glucopyranoside (10α) and Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-[(3,4-di-*O*-acetyl-2-*O*-benzyl-β-L-fucopyranosyl)-(1→6)]-2,3-di-*O*-benzoyl-β-D-glucopyranoside (10β): Compound **9** (50.0 mg, 61.0 μmol) and fucosyl donor **7**[17] (59.0 mg, 122 μmol) were dissolved in dry CH_2Cl_2 (400 μL) and cooled to −36 °C. A 0.05 M TMSOTf solution in dry CH_2Cl_2 (12.0 μL, 0.610 μmol) was added dropwise with vigorous stirring (HPTLC toluene/ EtOAc, 6:4). After 15 min the reaction mixture was neutralised with TEA and concentrated. Flash chromatography purification (toluene/EtOAc, 8:2) of the crude residue afforded a mixture of **10α** and **10β** (53.0 mg, 76%). Separation by MP chromatography (toluene/EtOAc, 7:3) gave pure **10α** (35.0 mg) and **10β** (16.0 mg).

10α: Amorphous white solid. $[\alpha]_D^{20} = -13.2$ (c = 1.0, $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 1.09 (s, 3 H, CH_3CCH_3), 1.12 (d, 3 H, 6c-H), 1.30 (s, 3 H, CH_3CCH_3), 2.04, 2.10, 2.15, 2.18 (4 s, 12 H, 3 CH_3CO, CH_3COCH_2), 2.50−2.89 [m, 4 H, $(CH_2)_2CO$], 3.16 (br. d, $^3J_{3,4} = 5.3$ Hz, 1 H, 4b-H), 3.42−3.50 (m, 3 H, 3b-H, 5b-H, 6b-H), 3.67 (br. d, $^3J_{4,5} = 9.7$ Hz, 1 H, 5a-H), 3.80 (dd, $^2J_{6,6'} = 10.7$, $^3J_{6,5} = 3.9$ Hz, 1 H, 6′b-H), 3.91 (dd, $^3J_{2,3} = 10.4$ Hz, 1 H, 2c-H), 4.00 (br. d, $^2J_{6,6'} = 13.2$ Hz, 1 H, 6a-H), 4.07−4.16 (m, 2 H, 4a-H, 6′a-H), 4.44 (br. q, $^3J_{5,6} = 6.2$ Hz, 1 H, 5c-H), 4.55−4.70 (m, 6 H, 3 CHHPh, 1a-H, 1b-H, 2b-H), 4.84 (d, $^2J = 12.5$ Hz, 1 H, CHHPh), 5.04 (d, $^3J_{1,2} = 3.2$ Hz, 1 H, 1c-H), 5.36 (br. s, 4c-H), 5.40−5.49 (m, 2 H, 2a-H, 3c-H), 5.52 (t, $^3J_{2,3} = {}^3J_{3,4} \approx 9.5$ Hz, 1 H, 3a-H), 7.11−7.99 (m, 20 H, 4 C_6H_5) ppm. ^{13}C NMR (75.44 MHz, $CDCl_3$): δ = 15.8 (6c-C), 20.7, 20.9 (3 CH_3COO overlapping signals), 26.1, 27.3 [$C(CH_3)_2$], 27.8 (CH_2COO), 29.7 (CH_3COCH_2), 37.8 (CH_3COCH_2), 62.6, 65.2 (6a-C, 6b-C), 64.6, 70.0, 70.5, 71.8, 72.2, 72.7, 73.3, 74.0, 75.0, 77.0 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C, 2c-C, 3c-C, 4c-C, 5c-C overlapping signals), 70.1, 73.2, (2 CH_2Ph), 96.8, 99.0, 99.4 (1a-C, 1b-C, 1c-C), 110.1 [$C(CH_3)_2$], 165.2 165.8, 169.6, 170.4, 170.8, 171.0 (3 CH_3COO, CH_2COO, 2 C_6H_5COO), 206.3 (CH_3COCH_2) ppm. MALDI-TOF MS: m/z = 1163.46 [M + Na^+], 1179.44 [M + K^+]. $C_{60}H_{68}O_{22}$ (1141.69): calcd. C 63.15, H 6.01; found C 63.12, H 6.05.

10β: Amorphous white solid. $[\alpha]_D^{20} = -24.2$ (c = 0.80, $CHCl_3$). ^1H NMR (300 MHz, $CDCl_3$): δ = 1.18 (d, $^3J_{5,6} = 6.3$ Hz, 3 H, 6c-H), 1.38 (s, 3 H, CH_3CCH_3), 1.42 (s, 3 H, CH_3CCH_3), 1.94, 1.98, 2.12, 2.18 (4 s, 12 H, 3 CH_3CO, CH_3COCH_2), 2.42−2.92 [m, 4 H, $(CH_2)_2CO$], 3.56−3.88 (m, 6 H, 5a-H, 5b-H, 6b-H, 6′b-H, 2c-H, 5c-H), 3.96 (dd, $^3J_{3,4} = 5.5$, $^3J_{4,5} = 1.6$ Hz, 1 H, 4b-H), 4.04 (m, 2 H, 6′a-H, 3b-H), 4.25 (t, $^3J_{3,4} = {}^3J_{4,5} = 9.5$ Hz,1 H, 4a-H), 4.32 (dd, $^2J_{6,6'} = 10.9$, $^3J_{6,5} = 2.4$ Hz, 1 H, 6a-H), 4.59 (d, $^3J_{1,2} = 7.8$ Hz, 1 H, 1c-H), 4.64 (d, 1 H, CHHPh), 4.68 (d, 1 H, 1b-H), 4.69 (d, 1 H, CHHPh), 4.74 (d, 1 H, 1a-H), 4.78 (t, $^3J_{1,2} = {}^3J_{2,3} \approx$ 7.9 Hz, 1 H, 2b-H), 4.84 (d, $^2J = 12.5$ Hz, 1 H, CHHPh), 4.98 (dd, $^3J_{2,3} = 6.6$, $^3J_{3,4} = 3.5$ Hz, 1 H, 3c-H), 5.03 (d, $^2J = 11.4$ Hz, 1 H, CHHPh), 5.22 (d, $^3J_{3,4} = 3.3$ Hz, 1 H, 4c-H), 5.43 (dd, $^3J_{1,2} = 7.9$, $^3J_{2,3} = 9.6$ Hz, 1 H, 2a-H), 5.55 (t, $^3J_{2,3} = {}^3J_{3,4} = 9.5$ Hz, 1 H, 3a-H), 7.09−8.01 (m, 20 H, 4 C_6H_5) ppm. ^{13}C NMR (100.62 MHz, $CDCl_3$): δ = 16.4 (6c-C), 20.6, 20.7 (3 CH_3COO overlapping signals), 26.3, 27.4 [$C(CH_3)_2$], 27.7 (CH_2COO), 29.9 (CH_3COCH_2), 37.8 (CH_3COCH_2), 62.8, 66.6 (6a-C, 6b-C), 68.9, 70.6, 70.7, 72.0, 72.6, 72.9, 73.3, 73.4, 73.8, 74.3, 76.3, 77.2 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C, 2c-C, 3c-C, 4c-C, 5c-C), 70.2, 74.6 (2 CH_2Ph), 99.2, 99.5, 103.5 (1a-C, 1b-C, 1c-C), 110.6 [$C(CH_3)_2$], 165.2, 165.6, 170.1, 170.4, 171.0 (3 CH_3COO, CH_2COO, 2 C_6H_5COO overlapping signals), 206.4 (CH_3COCH_2) ppm. MALDI-TOF MS: m/z = 1163.21 [M + Na^+], 1179.18 [M + K^+]. $C_{60}H_{68}O_{22}$ (1141.69): calcd. C 63.15, H 6.01; found C 63.19, H 6.04.

Benzyl (6-*O*-Acetyl-3,4-*O*-isopropylidene-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-[(3,4-di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→2)]-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (11): Compound **4** (49.0 mg, 65.0 μmol) and fucosyl donor **7**[17] (47.0 mg, 97.0 μmol) were dissolved in dry CH_2Cl_2 (500 μL) and cooled to −30 °C. A 0.05 M TMSOTf solution in dry CH_2Cl_2 (13.0 μL, 0.650 μmol) was added dropwise with vigorous stirring (HPTLC toluene/EtOAc, 6:4). After 10 min the reaction mixture was neutralised with TEA and concentrated. Flash chromatography purification (toluene/EtOAc, 8:2) of the crude residue afforded **11** (53.0 mg, 76%) as a white foam. $[\alpha]_D^{20} = -41.6$ (c = 1.0, $CHCl_3$). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.17, 0.18 [2s, 6 H, $Si(CH_3)_2$], 0.67 (d, $^3J_{5,6} = 6.5$ Hz, 3 H, 6c-H), 0.89 [s, 6 H, $C(CH_3)_2$-$CH(CH_3)_2$], 0.93 [d, $^3J = 2.3$ Hz, 3 H, $C(CH_3)_2CH(CH_3)(CH_3)$], 0.94 [d, $^3J = 2.3$ Hz, 3 H, $C(CH_3)_2CH(CH_3)(CH_3)$], 1.34 (s, 3 H, CH_3CCH_3), 1.56 (s, 3 H, CH_3CCH_3), 1.67 [m, 1 H, $C(CH_3)_2CH(CH_3)_2$], 2.02, 2.08, 2.10, 2.20 (4 s, 12 H, 3 $COCH_3$, CH_3COCH_2), 2.55−2.90 [m, 4 H, $(CH_2)_2CO$], 3.39 (br. dt, 1 H, 5a-H), 3.58 (t, $^3J_{3,4} = {}^3J_{4,5} \approx 9.4$ Hz 1 H, 4a-H), 3.61 (t, $^3J_{2,3} = 8.0$ Hz, 1 H, 2a-H), 3.79 (dd, 1 H, 2c-H), 3.87−3.91 (m, 3 H, 3a-H, 6a-H, 6′a-H), 3.98 (br. s, 1-H, OH), 4.09 (m, 1 H, 5b-H), 4.19 (m, 2 H, 3b-H, 4b-H), 5.31 (dd, $^3J_{2,3} = 10.6$, $^3J_{3,4} = 3.4$ Hz, 1 H, 3c-H), 5.06 (br. d, 1 H, 4c-H), 5.04 (dd, $^3J_{2,3} = 6.3$ Hz, 1 H, 2b-H), 4.36−4.43 (m, 3 H, 6b-H, 6′b-H, 5c-H), 4.50 (d, 1 H, CHHPh), 4.51 (d, $^3J_{1,2} = 7.4$ Hz, 1 H, 1b-H), 4.59 (d, $^3J_{1,2} = 7.8$ Hz, 1 H, 1a-H), 4.61 (d, 1 H, CHHPh), 4.84 (d, $^2J = 12.2$ Hz, 1 H, CHHPh), 4.88 (d, $^2J = 10.8$ Hz, 1 H, CHHPh), 5.68 (d, $^3J_{1,2} = 3.7$ Hz, 1 H, 1c-H), 7.25−7.45 (m, 10 H, 2 C_6H_5) ppm. ^{13}C NMR (100.62 MHz, $CDCl_3$): δ = −3.0, −3.4 [$Si(CH_3)_2$], 15.3 (6c-H), 18.6, 18.7 [2 CH_3 of $C(CH_3)_2CH(CH_3)_2$], 21.0−20.3 [3 CH_3COO, 2 CH_3 of $C(CH_3)_2CH(CH_3)_2$], 25.2 [$C(CH_3)_2CH(CH_3)_2$], 26.1, 27.4 [$C(CH_3)_2$], 27.7 (CH_2COO), 29.8 (CH_3COCH_2), 34.3 [$C(CH_3)_2CH(CH_3)_2$], 37.7 (CH_3COCH_2), 61.3 (6a-C), 63.0 (6b-C), 64.1 (5c-C), 69.8 (3c-C), 71.0 (5b-C), 71.4, 71.5 (2 CH_2Ph), 71.8 (4c-C), 72.5 (2b-C), 72.9 (2c-C), 73.2 (3b-C or 4b-C), 74.3 (5a-C), 75.9 (3a-C), 76.7 (2a-C), 76.9 (3b-C or 4b-C), 80.5 (4a-C), 96.4 (1c-C), 100.4 (1a-C), 100.7 (1b-C), 111.0 [$C(CH_3)_2$], 170.0, 170.6, 170.8,

171.3 (3 CH_3COO, CH_2COO), 206.0 (CH_3COCH_2) ppm. $C_{54}H_{78}O_{20}Si$ (1075.27): calcd. C 63.32, H 7.31; found C 63.45, H 7.35.

The regiochemistry of the glycosylation was further confirmed by adding two drops of neat trichloroacetyl isocyanate into the NMR tube. The recorded spectrum of the obtained derivative **11′** showed a downfield shift of the 3a-H proton to δ = 5.25 ppm.

Benzyl (6-*O*-Acetyl-2-*O*-levulinoyl-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (12): Compound **5** (170 mg, 0.180 μmol), was dissolved in CH_2Cl_2 (8.0 mL) and cooled to − 15 °C. 60% aq. CF_3COOH (1.20 mL) was added with vigorous stirring. After 30 min at −15 °C and 2 h at − 5 °C (TLC petroleum ether/EtOAc, 3:7), the reaction mixture was diluted with CH_2Cl_2, neutralised with solid $NaHCO_3$ and partitioned between water and CH_2Cl_2. The organic phase was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 4:6) afforded **12** (123 mg, 75%) as an amorphous white solid. $[\alpha]_D^{20}$ = −18.5 (c = 1.0, $CHCl_3$). ^{1}H NMR (200 MHz, $CDCl_3$): δ = 0.25, 0.19 [2s, 6 H, $Si(CH_3)_2$], 0.93 [m, 12 H, $C(CH_3)_2CH(CH_3)_2$], 1.68 [m, 1 H, $C(CH_3)_2CH(CH_3)_2$], 2.05, 2.20 (2 s, 6 H, $COCH_3$, CH_3COCH_2), 2.53−2.85 [m, 4 H, $(CH_2)_2CO$], 3.55−3.38 (m, 4 H, 3b-H, 4b-H, 5a-H, 6a-H), 3.68−3.82 (m, 2 H, 6′a-H, 5b-H), 4.01 (br. s, 2 H, 6b-H, 6′b-H), 4.13 (t, 1 H, 4a-H), 4.58−4.72 (m, 3 H, CHPh, 1a-H, 1b-H), 4.82−4.93 (m, 2 H, CHPh, 2b-H), 5.40 (t, $^3J_{1,2}$ = 7.8 Hz, 1 H, 2a-H), 5.55 (t, $^3J_{2,3} = {}^3J_{3,4} \approx$ 9.3 Hz, 1 H, 3a-H), 7.15−8.12 (m, 15 H, 3 C_6H_5) ppm. $C_{48}H_{62}O_{16}Si$ (923.08): calcd. C 62.46, H 6.77; found C 62.33, H 6.73.

Benzyl (6-*O*-Acetyl-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (13): Compound **6** (176 mg, 0.203 mmol), was dissolved in CH_2Cl_2 (8.0 mL) and cooled to −15 °C. 60% aq. CF_3COOH (800 μL) was added with vigorous stirring. After 2 h at −15 °C and 2 h at −5 °C (TLC petroleum ether/EtOAc, 2:8) the reaction mixture was diluted with CH_2Cl_2, neutralised with solid $NaHCO_3$ and partitioned between water and CH_2Cl_2. The organic phase was dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification by flash chromatography (petroleum ether/EtOAc, 4:6), afforded **13** (138 mg, 82%) as a white foam. $[\alpha]_D^{20}$ = +45.3 (c = 1.0, $CHCl_3$). ^{1}H NMR, (300 MHz, $CDCl_3$): δ = 0.13, 0.18 [2 s, 6 H, $Si(CH_3)_2$], 0.85−0.92 [m, 12 H, $C(CH_3)_2CH(CH_3)_2$], 1.65 [m, 1 H, $C(CH_3)_2CH(CH_3)_2$], 1.96 (s, 3 H, CH_3CO), 3.24−3.61 (m, 8 H, 5a-H, 6a-H, 2b-H, 3b-H, 5b-H, 3 OH), 3.65 (d, $^3J_{4,5}$ = 3.1 Hz, 1 H, 4b-H), 3.70 (dd, $^2J_{6,6'}$ = 11.2, $^3J_{6,5}$ = 5.5 Hz, 1 H, 6′a-H), 3.95 (br. d, 1 H, $^2J_{6,6'}$ = 11.5 Hz, 6b-H), 4.15 (br. d, 1 H, 6′b-H), 4.17 (t, $^3J_{4,5}$ = 9.6 Hz, 1 H, 4a-H), 4.41 (d, $^3J_{1,2}$ = 7.7 Hz, 1 H, 1b-H), 4.60 (d, 1 H, CHPh), 4.77 (d, $^3J_{1,2}$ = 7.8 Hz, 1 H, 1a-H), 4.85 (d, ^2J = 12.1 Hz, 1 H, CHPh), 5.42 (dd, 1 H, 2a-H), 5.59 (t, $^3J_{2,3} = {}^3J_{3,4} \approx$ 9.5 Hz, 1 H, 3a-H), 7.18−7.97 (m, 15 H, 3 C_6H_5) ppm. ^{13}C NMR (50.29 MHz, $CDCl_3$): δ = −3.4, −3.1 (2 $SiCH_3$), 18.5, 18.7, 20.3, 20.5, 20.6 [$C(CH_3)_2CH(CH_3)_2$, CH_3COO], 25.3 [$C(CH_3)_2CH(CH_3)_2$], 34.3 [$C(CH_3)_2CH(CH_3)_2$], 61.0, 62.2 (6a-C, 6b-C), 70.2 (CH_2Ph), 68.3, 71.6, 72.0, 73.4, 73.5, 73.8, 74.8, 75.6 (2a-C, 3a-C, 4a-C, 5a-C, 2b-C, 3b-C, 4b-C, 5b-C), 99.5, 102.6 (1a-C, 1b-C), 165.2, 166.2, 170.4 (CH_3COO, 2 C_6H_5COO) ppm. $C_{43}H_{56}O_{14}Si$ (824.93): calcd. C 62.60, H 6.84; found C 62.52, H 6.86.

Benzyl (3,4-Di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-(6-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (14): Compound **13** (177 mg, 0.215 mmol) and fucosyl donor **7**[17] (143 mg, 0.340 mmol) were dissolved in dry CH_2Cl_2 (3.0 mL) and cooled to −30 °C. 0.05 M TMSOTf in dry CH_2Cl_2 (43.0 μL, 2.20 μmol) was added dropwise with vigorous stirring (TLC EtOAc/toluene, 1:1). After 10 min, a new aliquot of **7** was added (50.0 mg, 0.100 mmol). After 10 min, the mixture was neutralised with TEA and concentrated. Flash chromatography purification (EtOAc/toluene, 2.5:8) of the crude residue afforded **14** (116 mg, 47%) as an amorphous white solid. $[\alpha]_D^{20}$ = −9.9 (c = 0.85, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.19, 0.23 [2s, 6 H, $Si(CH_3)_2$], 0.92−0.97 [m, 12 H, $C(CH_3)_2CH(CH_3)_2$], 1.07 (d, $^3J_{5,6}$ = 6.5 Hz, 3 H, 6c-H), 1.70 [m, 1 H, $C(CH_3)_2CH(CH_3)_2$], 1.98, 2.06, 2.13 (3 s, 9 H, 3 CH_3CO), 3.33 (dd, $^3J_{2,3}$ = 9.7, $^3J_{3,4}$ = 3.2 Hz, 1 H, 3b-H), 3.38−3.44 (m, 2 H, 5b-H, 6b-H), 3.55 (br. d, 1 H, 5a-H), 3.66−3.70 (m, 2 H, 2b-H, 4b-H), 3.78 (dd, $^2J_{6,6}$ = 10.6, $^3J_{6,5}$ = 5.2 Hz, 1 H, 6a-H), 3.83 (dd, 1 H, 2c-H), 4.01 (br. d, 1 H, 6′b-H), 4.14 (br. d, $^2J_{6,6'}$ = 11.6 Hz, 1 H, 6′a-H), 4.18 (t, $^3J_{4,5}$ = 9.5 Hz, 1 H, 4a-H), 4.33 (br. q, 1 H, 5c-H), 4.49 (d, 1 H, $^3J_{1,2}$ = 7.7 Hz, 1b-H), 4.66 (appearing as a d, 2 H, CHPh), 4.67 (d, 1 H, CHPh), 4.72 (d, $^3J_{1,2}$ = 7.9 Hz, 1 H, H-1), 4.89 (d, ^2J = 12.4 Hz, 1 H, CHPh), 5.10 (d, $^3J_{1,2}$ = 3.7 Hz, 1 H, 1c-H), 5.27 (d, 1 H, 4c-H), 5.32 (dd, $^3J_{2,3}$ = 10.4, $^3J_{3,4}$ = 3.3 Hz, 1 H, 3c-H), 5.42 (t, 1 H, 2a-H), 5.61 (t, 1 H, $^3J_{2,3} = {}^3J_{3,4} \approx$ 9.6 Hz, 3a-H), 7.18−8.00 (m, 20 H, 4 C_6H_5) ppm. ^{13}C NMR (100.62 MHz, $CDCl_3$): δ = −3.4, −3.0 (2 $SiCH_3$), 15.9 (6c-H), 18.6, 18.8 [2 CH_3 of $C(CH_3)_2CH(CH_3)_2$], 20.3−20.8 [2 CH_3 of $C(CH_3)_2CH(CH_3)_2$, 3 CH_3COO], 25.3 [$C(CH_3)_2CH(CH_3)_2$], 34.3 [$C(CH_3)_2CH(CH_3)_2$], 61.0 (6a-C), 62.1 (6b-C), 65.2 (5c-C), 68.6 (4b-C), 70.1 (CH_2Ph), 70.1 (3c-C), 70.5 (2b-C), 71.4 (4c-C), 71.9 (2a-C), 72.2 (5b-C), 73.1 (CH_2Ph), 73.4 (3a-C, 2c-C), 74.7 (4a-C), 75.6 (5a-C), 83.1 (3b-C), 99.3 (1a-C), 100.1 (1c-C), 102.3 (1b-C), 165.3, 165.7, 169.9, 170.3, 170.5 (3 CH_3COO, 2 C_6H_5COO) ppm. $C_{60}H_{76}O_{20}Si$ (1145.32): calcd. C 62.92, H 6.69; found C 63.05, H 6.71.

Benzyl (3,4-*O*-Isopropylidene-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (15): Compound **6** (181 mg, 0.210 mmol) was dissolved in dry MeOH (500 μL), and cooled to −20 °C under Ar. Anhydrous K_2CO_3 (17.0 mg, 0.123 mmol) was added and the mixture was stirred for 6 h, monitoring the reaction by TLC (EtOAc/toluene, 3:7). Then the solution was cooled to −35 °C and stirred for 20 h. After diluting with CH_2Cl_2, the mixture was filtered through a Celite pad, the filtrate was concentrated and purified by flash chromatography (EtOAc/toluene, 2:8) affording **15** (143 mg, 83%) as a white foam. $[\alpha]_D^{20}$ = +39.5 (c = 0.95, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.23, 0.20 [2 s, 6 H, $Si(CH_3)_2$]; 0.92 [s, 6 H, $C(CH_3)_2CH(CH_3)_2$], 0.94 [d, ^3J = 2.6 Hz, 3 H, $C(CH_3)_2CH(CH_3)(CH_3)$], 0.95 [d, ^3J = 2.6 Hz, 3 H, $C(CH_3)_2CH(CH_3)(CH_3)$], 1.28 (s, 3 H, CH_3CCH_3), 1.44 (s, 3 H, CH_3CCH_3), 1.69 [m, 1 H, $C(CH_3)_2CH(CH_3)_2$], 3.20 (dd, $^2J_{6,6'}$ = 11.8 Hz, 1 H, 6b-H), 3.34 (br. dd, 1 H, 6a-H), 3.43 (br. t, $^3J_{2,3}$ = 7.4 Hz, 1 H, 2b-H), 3.52 (ddd, $^3J_{4,5}$ = 2.1, $^3J_{5,6}$ = 4.3, $^3J_{5,6}$ = 6.9 Hz, 1 H, 5b-H), 3.57 (dt, 1 H, $^3J_{5,6} = {}^3J_{5,6} \approx$ 2.3 Hz, H-5), 3.96−4.05 (m, 4 H, 6a-H, 6′a-H, 3b-H, 4b-H), 4.19 (t, $^3J_{4,5}$ = 9.4 Hz, 1 H, 4a-H), 4.38 (d, $^3J_{1,2}$ = 8.1 Hz, 1 H, 1b-H), 4.67 (d, 1 H, CHPh), 4.73 (d, 1 H, 1a-H), 4.89 (d, ^2J = 12.4 Hz, 1 H, CHPh), 5.43 (dd, $^3J_{1,2}$ = 7.8, $^3J_{2,3}$ = 9.7 = Hz, 1 H, 2a-H), 5.61 (t, $^3J_{3,4}$ = 9.5 Hz, 1 H, 3a-H), 7.21−7.99 (m, 15 H, 3 C_6H_5) ppm. ^{13}C NMR (100.62 MHz, $CDCl_3$): δ = 18.5, 18.6, 20.3, 20.4 [$C(CH_3)_2CH(CH_3)_2$], 25.5 [$C(CH_3)_2CH(CH_3)_2$], 27.9, 26.2 [$C(CH_3)_2$], 34.1 [$C(CH_3)_2CH(CH_3)_2$], 61.7, 61.8 (6a-C, 6b-C), 70.1 (CH_2Ph), 71.8 (2a-C), 73.4 (4b-C), 73.7 (3a-C), 73.9 (2b-C or 5c-C), 74.0 (2b-C or 5c-C), 74.8 (4a-C), 75.6 (5a-C), 78.8 (3b-C), 99.2 (1a-C), 101.8 (1b-C), 110.2 [$C(CH_3)_2$], 165.5, 166.1 (2 C_6H_5COO) ppm. $C_{44}H_{58}O_{13}Si$ (823.01): calcd. C 64.21, H 7.10; found C 64.23, H 7.13.

Benzyl (3,4-Di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→6)-(3,4-*O*-isopropylidene-β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-6-*O*-thexyldimethylsilyl-β-D-glucopyranoside (16): Compound **15** (138 mg, 0.168 mmol) and fucosyl donor **7**[17] (113 mg, 0.234 mmol) were dissolved in dry CH_2Cl_2 (3.0 mL) and cooled to −35 °C. 0.05 M TMSOTf in dry CH_2Cl_2 (34.0 μL, 1.68 μmol) was added dropwise with vigorous stirring (TLC EtOAc/toluene, 4:6). After 10 min, the mixture was neutralised with TEA and concentrated. Flash chromatography purification (EtOAc/toluene, 2.5:7.5) of the crude residue afforded **16** (98.0 mg, 51%) as a white foam. $[\alpha]_D^{20} = -9.4$ (c = 1.05, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 0.24, 0.20 [2s, 6 H, Si(CH_3)$_2$], 0.92 [s, 6 H, C(CH_3)$_2$CH(CH$_3$)$_2$], 0.94 [d, ^3J = 3.3 Hz, 3 H, C(CH$_3$)$_2$CH(CH_3)(CH$_3$)], 0.96 [d, ^3J = 3.3 Hz, 3 H, C(CH$_3$)$_2$CH(CH_3)(CH$_3$)], 1.03 (d, $^3J_{5,6}$ = 6.5 Hz, 3 H, 6c-H), 1.27, 1.39 [2 s, 6 H, C(CH_3)$_2$], 1.69 [m, 1 H, C(CH$_3$)$_2$CH(CH$_3$)$_2$], 1.98, 2.15 (2 s, 6 H, 2 COCH_3), 2.75 (m, 2 H, 6b-H, OH), 3.19 (t, 1 H, 6′b-H), 3.40 (t, 1 H, 2b-H), 3.53 (br. d, $^3J_{4,5}$ = 9.6 Hz, 1 H, 5a-H), 3.67 (ddd, 1 H, 5b-H), 3.78 (dd, $^3J_{2,3}$ = 11.5 Hz, 1 H, 2c-H), 3.94 (dd, $^3J_{2,3}$ = 7.4, $^3J_{3,4}$ = 5.6 Hz, 1 H, 3b-H), 4.00 (dd, $^3J_{5,6}$ = 1.6 Hz, 1 H, 6a-H), 4.08 (dd, $^3J_{5,6}$ = 2.9, $^2J_{6,6'}$ = 12.2 Hz, 1 H, 6′a-H), 4.12−4.17 (m, 3 H, 4a-H, 4b-H, 5c-H), 4.32 (d, $^3J_{1,2}$ = 8.2 Hz, 1 H, 1b-H), 4.52 (d, $^3J_{1,2}$ = 3.4 Hz, 1 H, 1c-H), 4.57 (d, 1 H, CHHPh), 4.65 (d, ^2J = 12.2 Hz, 1 H, CHHPh), 4.67 (d, 1 H, CHHPh), 4.72 (d, $^3J_{1,2}$ = 7.9 Hz, 1 H, 1a-H), 4.89 (d, ^2J = 12.5 Hz, 1 H, CHHPh), 5.16−5.19 (m, 2 H, 3c-H, 4c-H), 5.42 (t, 1 H, 2a-H), 5.58 (t, 1 H, $^3J_{2,3}$ = $^3J_{3,4}$ ≈ 9.6 Hz, 3a-H), 7.19−7.98 (m, 20 H, 4 C$_6H_5$) ppm. ^{13}C NMR, (100.62 MHz, $CDCl_3$): δ = −3.3, −3.0 (2 SiCH$_3$), 15.6 (6c-C), 18.5, 18.7, 20.3, 20.4 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 20.7, 20.8 (2 CH$_3$COO), 25.3 [C(CH$_3$)$_2$CH(CH$_3$)$_2$], 26.1, 28.0 [C(CH$_3$)$_2$], 34.1 [C(CH$_3$)$_2$$C$H(CH$_3$)$_2$], 61.4 (6a-C), 63.9 (6b-C), 64.0 (5c-C), 69.9 (3c-C or 4c-C), 70.1 (CH$_2$Ph), 70.3 (5b-C), 71.6 (2a-C), 71.8 (3c-C or 4c-C), 72.5 (4a-C or 4b-C), 72.8 (CH$_2$Ph), 73.3 (2c-C), 73.5 (3a-C), 74.0 (2b-C), 75.4, 75.5 (5a-C, 4a-C or 4b-C), 78.3 (3b-C), 96.5 (1c-C), 99.2 (1a-C), 102.6 (1b-C), 109.5 [C(CH$_3$)$_2$], 165.3, 165.6, 170.0, 170.5 (2 CH$_3$$C$OO, 2 C$_6H_5$$C$OO) ppm. $C_{61}H_{78}O_{19}Si$ (1143.35): calcd. C 64.08, H 6.88; found C 64.02, H 6.85.

Benzyl (3,4-Di-*O*-acetyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→6)-(β-D-galactopyranosyl)-(1→4)-2,3-di-*O*-benzoyl-β-D-glucopyranoside (17): Compound **16** (23.0 mg, 19.8 μmol) was dissolved in dry THF (1.0 mL) and cooled to −40 °C. 0.5 M HOAc in dry THF (43.0 μL, 21.8 μmol) and 1 M tetrabutylammonium bromide in dry THF (23.0 μL, 21.8 μmol) were added dropwise with vigorous stirring. The reaction was warmed to 40 °C (TLC petroleum ether/EtOAc, 1:1) and stirred for 20 h. The reaction was quenched by adding satd. NH_4Cl solution, extracted with CH_2Cl_2, dried over Na_2SO_4 and concentrated. The crude compound was dissolved in $CHCl_3$ (2.0 mL) and cooled to 0 °C. A 70% solution of CF_3COOH in water (300 μL) was added with vigorous stirring (TLC EtOAc). After 2 h the reaction was cooled to −5 °C, neutralised with solid K_2CO_3 and partitioned between water and $CHCl_3$. The organic layer was dried over Na_2SO_4 and concentrated. Flash chromatography purification (EtOAc) of the crude residue afforded **17** (12.7 mg, 67%) as a white glass. $[\alpha]_D^{20} = -16.1$ (c = 1.0, $CHCl_3$). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.02 (d, $^3J_{5,6}$ = 6.5 Hz, 3 H, 6c-H), 1.93 (s, 3 H, COCH_3), 2.09 (s, 3 H, COCH_3), 2.47 (dd, $^3J_{5,6}$ = 4.4, $^2J_{6,6'}$ = 9.1 Hz, 1 H, 6b-H), 3.14 (t, $^3J_{5,6}$ = $^2J_{6,6'}$ = 9.1 Hz, 1 H, 6′b-H), 3.26 (m, 1 H, 5b-H), 3.41 (dd, $^3J_{2,3}$ = 9.4, $^3J_{3,4}$ = 2.9 Hz, 1 H, 3b-H), 3.58 (t, 1 H, 2b-H), 3.67−3.62 (m, 2 H, 5a-H, 2c-H), 3.79 (br. d, 1 H, 4b-H), 3.95−4.16 (m, 4 H, 4a-H, 6a-H, 6′a-H, 5c-H), 4.34 (d, $^3J_{1,2}$ = 3.5 Hz, 1 H, 1c-H), 4.38 (d, $^3J_{1,2}$ = 7.5 Hz, 1 H, 1b-H), 4.48 (d, ^2J = 12.3 Hz, 1 H, CHHPh), 4.56 (d, 1 H, CHHPh), 4.64 (d, ^2J = 12.5 Hz, 1 H, CHHPh), 4.81 (d, $^3J_{1,2}$ = 8.1 Hz, 1a-H), 4.88 (d, 1 H, CHHPh), 5.12 (dd, $^3J_{2,3}$ = 10.5, $^3J_{3,4}$ = 3.4 Hz, 1 H, 3c-H), 5.18 (d, 1 H, 4c-H), 5.43 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 8.1 Hz, 1 H, 2a-H), 5.67 (t, 1 H, 3a-H), 7.10−7.97 (m, 20 H, 4 C$_6H_5$) ppm. ^{13}C NMR, (100.62 MHz, $CDCl_3$): δ = 16.1 (6c-C), 21.1, 21.2 (2 CH$_3$COO), 61.9 (6a-C), 64.6 (6b-C), 64.7 (5c-C), 68.3 (4b-C), 70.5 (3c-C), 71.2 (CH$_2$Ph), 72.0 (4c-C), 72.4 (5b-C), 72.6 (2a-C, 2b-C), 73.3 (CH$_2$Ph), 73.8 (2c-C), 73.9 (3b-C), 74.5 (3a-C), 75.6 (5a-C), 78.2 (4a-C), 97.4 (1c-C), 100.2 (1b-C), 105.0 (1a-C), 165.7, 165.9, 170.6, 170.9 (2 CH$_3$$C$OO, 2 C$_6H_5$$C$OO) ppm. $C_{50}H_{56}O_{19}$ (960.95): calcd. C 62.49, H 5.87; found C 62.40, H 5.93.

Benzyl (2-*O*-Benzyl-α-L-fucopyranosyl)-(1→6)-(β-D-galactopyranosyl)-(1→4)-β-D-glucopyranoside (18): Compound **17** (29.0 mg, 30.1 μmol) was dissolved in dry methanol (1.0 mL) and cooled to 0 °C. 0.5 M MeONa in dry methanol (30.0 μL, 15.0 μmol) was added dropwise and the reaction was vigorously stirred at room temperature (TLC EtOAc/MeOH, 6:4). After 6 h a second aliquot of MeONa solution was added (30.0 μL, 15.0 μmol). After 24 h the reaction was neutralised with IR-120 resin (H^+ form), filtered and concentrated. Flash chromatography purification (EtOAc/MeOH, 8:2) afforded **18** (17.0 mg, 85%) as a glassy solid. $[\alpha]_D^{20} = -63.7$ (c = 1.0, MeOH). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.20 (d, $^3J_{5,6}$ = 6.6 Hz, 3 H, 6c-H), 3.31 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 8.4 Hz, 1 H, 2a-H), 3.40 (ddd, $^3J_{4,5}$ = 9.4, $^3J_{5,6}$ = 4.0, $^3J_{5,6'}$ = 2.5 Hz, 1 H, 5a-H), 3.50 (dd, $^3J_{2,3}$ = 9.7, $^3J_{3,4}$ = 4.0 Hz, 1 H, 3b-H), 3.51 (t, $^3J_{2,3}$ = $^3J_{3,4}$ = 8.4 Hz, 1 H, 3a-H), 3.57 (t, $^3J_{3,4}$ = $^3J_{4,5}$ = 8.4 Hz, 1 H, 4a-H), 3.59 (dd, $^3J_{1,2}$ = 7.8, $^3J_{2,3}$ = 9.7 Hz, 1 H, 2b-H), 3.65−3.72 (m, 3 H, 5b-H, 6b-H, 2c-H), 3.75−3.89 (m, 4 H, 6a-H, 4b-H, 6′b-H, 4c-H), 3.94 (dd, $^3J_{5,6}$ = 2.5, $^2J_{6,6'}$ = 6.6 Hz, 1 H, 6′a-H), 3.98 (dd, $^3J_{2,3}$ = 10.1, $^3J_{3,4}$ = 3.4 Hz, 1 H, 3c-H), 4.05 (q, $^3J_{5,6}$ = 6.6 Hz, 1 H, 5c-H), 4.37 (d, $^3J_{1,2}$ = 8.4 Hz, 1 H, 1a-H), 4.05 (d, $^3J_{1,2}$ = 7.8 Hz, 1 H, 1b-H), 4.68 (d, ^2J = 11.8 Hz, 2 H, 2 CHHPh), 4.77 (d, ^2J = 11.8 Hz, 1 H, CHHPh), 4.81 (d, $^3J_{1,2}$ = 3.7 Hz, 1 H, 1c-H), 4.92 (d, ^2J = 11.8 Hz, 1 H, CHHPh), 7.27−7.45 (m, 10 H, 2 C$_6H_5$) ppm. ^{13}C NMR, (100.62 MHz, $CDCl_3$): δ = 15.7 (6c-C), 61.0 (6a-C), 66.6 (5c-C), 67.4 (6b-C), 69.2 (4b-C), 69.7 (3c-C), 70.8 (CH$_2$Ph), 71.4 (2b-C), 72.8 (2c-C), 72.9 (CH$_2$Ph), 73.8 (4c-C), 73.9 (2a-C, 3b-C), 75.3 (3a-C), 75.5 (5a-C), 76.7 (5b-C), 79.9 (4a-C), 98.4 (1c-C); 102.1 (1b-C), 104.2 (1a-C) ppm. $C_{32}H_{44}O_{15}$ (668.67): calcd. C 57.47, H 6.63; found C 57.41, H 6.65.

(α-L-Fucopyranosyl)-(1→6)-(β-D-galactopyranosyl)-(1→4)-α,β-D-glucopyranose (19): Compound **18** (17.0 mg, 25.4 μmol) was dissolved in methanol (2.0 mL), Pd/C catalyst (10.0 mg) was added and the reaction was vigorously stirred under a hydrogen atmosphere at room temperature. After 3 h the reaction was filtered through a Celite pad and concentrated, affording **19** (12.0 mg, 75%) as a glassy solid. $[\alpha]_D^{20}$ t = 0: −25.2; t = 12 h: −22.9 (c = 1.0, H_2O). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.44 (d, $^3J_{5,6}$ = 6.5 Hz, 3 H, 6c-H), 3.48 (t, $^3J_{1,2}$ = $^3J_{2,3}$ = 7.7 Hz, 0.6 H, 2a-Hβ), 3.75−3.90 (m, 4.4 H, 2a-Hα, 3a-Hβ, 5a-Hα, 2b-H, 3b-H, 4b-H), 3.96−4.16 (m, 10 H, 3a-Hα, aa-Hα, 6a-Hα, 6′a-Hα, 4a-Hβ, 5a-Hβ, 6a-Hβ, 6′a-Hβ, 4b-H, 6b-H, 6′b-H, 2c-H, 3c-H, 4c-H), 4.29 (q, $^3J_{5,6}$ = 6.5 Hz, 1 H, 5b-H), 4.67 (d, $^3J_{1,2}$ = 7.7 Hz, 1 H, 1b-H), 4.84 (d, $^3J_{1,2}$ = 7.9 Hz, 0.6 H, 1a-Hβ), 5.17 (d, $^3J_{1,2}$ = 3.4 Hz, 1 H, 1c-H), 5.44 (d, $^3J_{1,2}$ = 3.2 Hz, 0.4 H, 1a-Hα) ppm. ^{13}C NMR, (100.62 MHz, $CDCl_3$): δ = 16.0 (6c-C), 60.98 (6a-Cα), 60.9 (6a-Cβ), 67.5 (5c-C), 68.2 (6b-C), 68.9, 69.3, 70.3, 70.7, 71.5, 72.0, 72.2, 72.6, 73.3, 74.5, 74.7, 75.1, 75.3, 80.1, 80.2 (2a-Cα, 3a-Cα, 4a-Cα, 5a-Cα, 2a-Cβ, 3a-Cβ, 4a-Cβ, 5a-Cβ, 2b-C, 3b-C, 4b-C, 5b-C, 2c-C, 3c-C, 4c-C), 92.6 (1a-Cα), 96.4 (1a-Cβ), 100.0 (1c-C), 103.9 (1b-C) ppm. $C_{18}H_{31}O_{15}$ (487.43): calcd. C 44.35, H 6.41; found C 44.28, H 6.45.

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