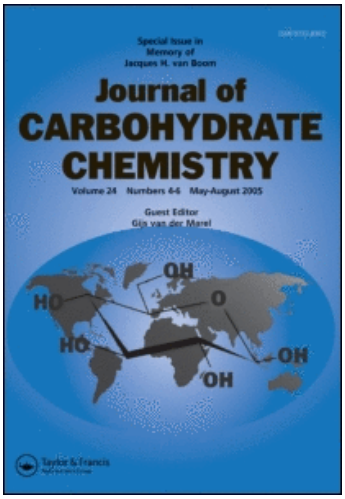

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SYNTHESIS OF 3e- AND 6e-MONOSULFATED AND 3e,6e-DISULFATED LEWIS x PENTASACCHARIDES, CANDIDATE LIGANDS FOR HUMAN L-SELECTIN

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ABSTRACT

Condensation of perbenzyl fucosyl bromide **4** with the known 2-acetamido derivative **1** and with the 2-phthalimido analog **3** gave, respectively, disaccharides **5** and **6** which, after reductive opening of the benzylidene group were glycosylated using peracetylated galactose trichloroacetimidate to give trisaccharides **10** and **11**. After removal of the anomeric *p*-methoxybenzyl group and subsequent activation as the trichloroacetimidate, condensation onto the known lactose derivative **16** afforded protected pentasaccharides **18** and **17** in 24 and 70% yields, respectively. Compound **17** was transformed into **18** by a conventional method in 77% yield making the phthalimido route overall more attractive. The terminal galactose was then selectively deprotected and sulfated at the 3e, 6e and both 3e,6e positions to give the title compounds after complete deprotection.

INTRODUCTION

The selectins (E, P and L-selectins) are mammalian C-type lectins which mediate cellular adhesion between blood cells or cancer cells and vascular endothelium and participate in a variety of normal or pathological phenomena.[1,2] Whereas E- and P-selectin are transiently expressed on activated endothelial cells, L-selectin is constitutively

expressed on most leucocytes. L-selectin is an important target because it has a key role in the initial cell-adhesive events in the inflammatory response and homing to peripheral lymph nodes. Since the initial characterization of the selectins in the early nineties, a number of carbohydrate ligands have been identified, and most of them derive from the Lewis blood group family. Although the exact structures of the natural ligands are still debated, early studies have shown that E-selectin binds strongly to sialyl Lewis ^{x} and sialyl Lewis ^{a} [3,4] which were shown to have in common the same positioning of the NeuAc, Gal and Fuc residues.[5] Furthermore, it was shown that sialic acid can be advantageously replaced by a sulfate group at O-3 of the terminal galactose. Thus, 3e-sulfated Lewis ^{a} pentasaccharide appeared as one of the most potent monovalent ligands for human E-selectin.[6] Following this finding, this same oligosaccharide was shown to bind to L-selectin as well and remains a good candidate for therapeutic purposes.[7] For example, it was recently found to reduce significantly the ischemia-reperfusion lung injury in rat.[8] More recently, and following the partial elucidation of the structure of the *O*-glycan chains of the natural ligand of L-selectin in mouse lymph nodes, the GLYCAM-1 glycoprotein, Rosen proposed as a natural ligand, a 3e-sialylated Le^{x} structure containing 6-*O*-sulfate at the outer galactose (e) or at the penultimate GlcNAc (c) or at both of these positions.[9] In the case of the isomeric sulfated sialyl Le^{x}, it has already been demonstrated that 6c-sulfated sialyl Le^{x} sequence is a strong ligand for L-selectin whereas the 6e-sulfated analog is not bound. Moreover, the presence of the 6e-sulfate group in the 6c-sulfated sialyl Le^{x} even impairs the L-selectin binding.[10] So, having in mind the biological results concerning the 3e-sulfated Lewis^{a} pentasaccharide toward E- and L-selectins in which the 3e-*O*-sulfate group replaces the sialic acid residue, we decided to prepare the two isomeric Lewis ^{x} pentasaccharides having two sulfate groups in 3e,6e or 3e,6c positions as an alternative to the natural major capping group of the GLYCAM 1 counter-receptor. We recently described the chemoenzymatic synthesis of the 3e,6c-disulfated Le^{x} pentasaccharide and the purpose of this paper is to describe the synthesis of the isomeric 3e,6e-disulfated analogs along with the synthesis of both 3e- and 6e-monosulfated derivatives for comparison.[11]

RESULTS AND DISCUSSION

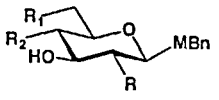
In contrast to the synthesis of the 3e,6c disulfated derivative, we could not envisage a chemoenzymatic synthesis as the fucosyl transferase (FUT III) which transfers a fucose

residue at the 3-position of GlcNAc, accepts a sulfate group at 6c but not at 6e;[12] therefore a purely chemical synthesis was undertaken.

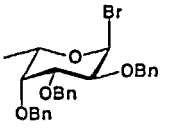
The retrosynthetic analysis led us to prepare first the protected trisaccharides **12** and **13**[13] having either an *N*-acetyl or an *N*-phthaloyl group at the 2-position of glucosamine which, after activation as anomeric trichloroacetimidate, would be condensed onto the known lactose derivative **16** to give finally the same pentasaccharide **18** in both ways. Indeed, Ogawa *et al.*[13] have already prepared the protected Lewis ^{x} precursor **17** through the phthalimido route but starting from an allyl glycoside of trisaccharide **13**. In our case, we used the *p*-methoxybenzyl group as an anomeric protecting group according to our methodology that we found very convenient in the Lewis^a case,[15] and chose to compare the relative overall efficacy of both routes using either *N*-acetyl or *N*-phthaloyl derivatives, as it is well known that an *N*-phthaloyl group at the 2-position of glucosamine gives better yields of β-glycosylation but that the regeneration of the natural *N*-acetyl group is sometimes problematic.

In the 2-acetamido series, we started from the disaccharide **5** that we recently[14] prepared from *p*-methoxybenzyl 2-acetamido-4,6-*O*-benzylidene-2-deoxy glucoside **1**[15] using the perbenzylated bromofucose **4**[16] under *in situ* anomerization conditions followed by reductive opening of the benzylidene acetal ($NaBH_3CN$, HCl_g in THF) in 63% overall yields. Then, BF_3-Et_2O catalyzed galactosylation using the trichloroacetimidate **9**[17] gave the protected trisaccharide **10** in 77% yield. Cleavage of the *p*-methoxybenzyl group using ammonium and cerium nitrate in acetonitrile-water (9:1)[18] gave the trisaccharide **12** (85%) which was transformed in the usual way into the trichloroacetimidate **14** in a 68% yield, used directly in the next step. The crucial condensation onto the known protected lactose derivative **16**,[19] was then performed using BF_3-Et_2O as catalyst in CH_2Cl_2. After de-*O*-acetylation (NEt_3-MeOH-H_2O, 1:8:1), the pentasaccharide **18** was obtained in 24% overall yield as a white foam which crystallized from MeOH.

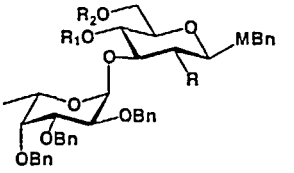
The same pentasaccharide **18** was prepared for comparison through the phthalimido route. Starting from the known *p*-methoxybenzyl 2-deoxy-2-phthalimidoglucoside,[20] acetalation under standard conditions (benzaldehyde dimethyl acetal, TsOH in acetonitrile) gave the benzylidene derivative **3** (92%). Then, fucosylation using the same conditions as above, employing the perbenzylated bromofucose **4** under *in situ* anomerization conditions gave the protected disaccharide **6** in a 97% yield. Reductive opening of the benzylidene acetal ($NaBH_3CN$, HCl_g in THF, 74%) followed by BF_3-Et_2O catalysed galactosylation using the trichloroacetimidate **9** gave the protected trisaccharide **10** in 77% yield. Cleavage of the *p*-methoxybenzyl group in the same way as above, gave the trisaccharide **13**[13] (92%) which was activated as the trichloroacetimidate (95%). Condensation onto the same



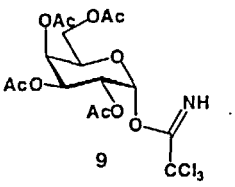
R = NHAc, R_1, R_2 = PhCH 1
R =NPhth, R_1 = R_2 = H 2
R =NPhth, R_1, R_2 = PhCH 3



4



R = NHAc, R1, R2 = PhCH 5
R = NPhth, R1, R2 = PhCH 6
R = NHAc, R1 = H, R2 = Bn 7
R = NPhth, R1 = H, R2 = Bn 8



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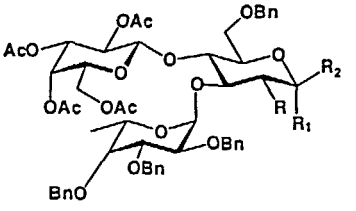
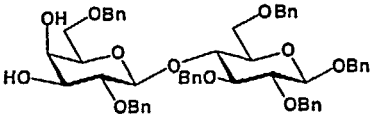
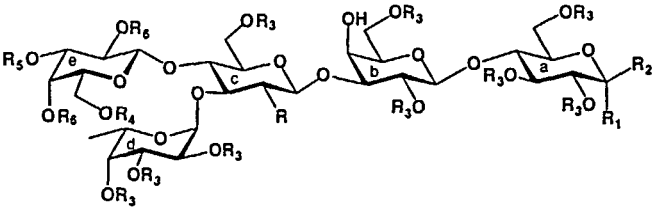




16

R = NHAc, R1 = H, R2 = OMBn 10
R = NPhth, R1 = H, R2 = OMBn 11
R = NHAc, R1, R2 = H, OH 12
R = NPhth, R1, R2 = H, OH 13
R = NHAc, R1 = OC(=NH)CCl3, R2 = H 14
R = NPhth, R1 = H, R2 = OC(=NH)CCl3 15



R = NPhth, R1 = H, R2 = OBn, R3 = Bn, R4 = R5 = R6 = Ac 17
R = NHAc, R1 = H, R2 = OBn, R3 = Bn, R4 = R5 = R6 = H 18
R = NHAc, R1 = H, R2 = OBn, R3 = Bn, R4 = R6 = H, R5 = SO3Na 19
R = NHAc, R1 = H, R2 = OBn, R3 = Bn, R4 = SO3Na, R5 = R6 = H 20
R = NHAc, R1 = H, R2 = OBn, R3 = Bn, R4, R5 = SO3Na, R6 = H 21
R = NHAc, R1, R2 = H, OH, R3 = R4 = R6 = H, R5 = SO3Na 22
R = NHAc, R1, R2 = H, OH, R3 = R5 = R6 = H, R4 = SO3Na, 23
R = NHAc, R1, R2 = H, OH, R3 = R6 = H, R4 = R5 = SO3Na, 24

protected lactose derivative **16** using the same method as above gave the pentasaccharide **17**[13] in 70% yield, which was directly treated with hydrazine in refluxing ethanol (13 h) for the *N*-dephthaloylation. Peracetylation (pyridine, Ac_2O) followed by de-*O*-acetylation then gave **18**, identical as above, in 54% overall yield for the last three steps, making the phthalimido route definitively more attractive in the Lewis^x case.

The protected pentasaccharide **18** was then transformed into 3e-, 6e-monosulfates and 3e, 6e-disulfate. First, the 3e monosulfate was prepared using the stannylene methodology.[21] Thus, the protected pentasaccharide **18**, treated first with dibutyltin oxide under Dean-Stark conditions in refluxing toluene for 15 h, gave the stannylene which after reaction with sulfur trioxide-trimethylamine complex in DMF furnished the expected 3e-monosulfated protected pentasacharide **19** in 73% yield along with a 16% yield of recovered starting material. Complete deprotection by hydrogenolysis (H_2, 10% Pd/C) gave the 3e-monosulfate Lewis x pentasaccharide in 94% yield as a white powder. The presence of the sulfate group at OH-3 of the terminal galactose was verified by NMR spectroscopy which indicated a displacement of 0.67 ppm of the H-3 signal toward a low field compared to the unsulfated Lewis x pentasaccharide.

The 6e-monosulfate derivative **20** was prepared by reacting sulfur trioxide-trimethylamine complex (1 equiv) with compound **18**, 3 h at 40 °C in DMF. Then, hydrogenolysis (H_2, 10% Pd/C) gave the expected 6e-monosulfate Lewis x pentasaccharide in 74% yield. Attempts to increase the yields in the sulfation step by adding more sulfur trioxide-trimethylamine complex afforded several oversulfated compounds including the 3e, 6e-disulfate derivative. Finally, the disulfate was prepared in better yields starting from **18** by first introducing the 3e-sulfate through the stannylene methodology and adding in two portions to the same pot more sulfur trioxide-trimethylamine complex (2 x 3 equiv). In this way, the disulfated protected pentasaccharide was obtained in 78% yield. Hydrogenolysis as above then gave the 3e, 6e-disulfate Lewis^x pentasaccharide in 94% yield. All sulfated pentasaccharides were prepared at the 50 mg scale allowing full biological screening.[22] In fact, it was shown that the 6e-monosulfated derivative give no binding signal with L-selectin and that in the serie of 3e-sulfated Lewis^x pentasaccharides, the 6e-sulfation does not enhance (as the 6c-sulfation does) but in contrary virtually abolishes the binding with L-selectin.

EXPERIMENTAL

General methods. NMR spectra were recorded using a Bruker AC-250 (at 250 MHz for ^1H NMR or at 62.9 MHz for ^{13}C NMR) and AM-400 (at 400 MHz for ^1H NMR and at 100 MHz for ^{13}C NMR) spectrometers. Most of the ^1H NMR assignments were

based on 2D homonuclear correlation spectroscopy experiments (COSY). Data matrices of 1Kx2K points were used to digitize spectral widths of either 4000, 3500, 2000, 1900, or 1700 Hz. 16 scans were used per increment with a relaxation delay of 1.5 s; the 90° pulse width was 7.5 μs. When using $CDCl_3$ as deuterated solvent, the spectra were referenced to $(CH_3)_4Si$ (δ_H=0 ppm) and to $CDCl_3$ (central line δ_C=77 ppm). When using CD_3OD as deuterated solvent, the spectra were referenced to $(CH_3)_4Si$ (δ_H=0 ppm) and to CD_3OD (central line δ_C=49 ppm). When using $(CD_3)_2SO$ as deuterated solvent, the spectra were referenced to $(CH_3)_4Si$ (δ_H=0 ppm) and to $(CD_3)_2SO$ (central line δ_C=39.5 ppm). When using D_2O as the solvent, spectra were referenced to $(CH_3)_2CO$ (δ_H=2,225 ppm) and to CD_3OD (central line δ_C=49 ppm). Optical rotations were determined using a Jasco DIP-370 digital polarimeter. Flash chromatography was performed using 6-35 μ silica gel (60) purchased from S.D.S. company. TLC was run using Merck 60 F254 plates, and visualized first with UV light and second by heating after alcoholic sulfuric or phosphomolybdic acid treatment. Melting points were measured on a Reichert apparatus and are uncorrected. Elementary analyses were performed at the "Service Central de Microanalyse du C.N.R.S."

***p*-Methoxybenzyl 4,6-*O*-benzylidene-2-deoxy-2-phthalimido-β-D-glucopyranoside (3).** TsOH (O.16 g, 0.84 mmol) was added to a stirred mixture of **2** (1.69 g, 3.94 mmol) and benzaldehyde dimethyl acetal (2.96 mL, 19.7 mmol) in acetonitrile (15 mL). After 0.5 h at room temperature, the mixture was neutralized by addition of triethylamine and then concentrated. After several coevaporations with toluene, flash chromatography of the residue (65:35 hexane-ethyl acetate) gave **3** (1.87 g, 92%) which crystallized from methanol: mp 109 °C; $[\alpha]_D^{27}$ -72° (*c* 2.1, CH_2Cl_2); ^1H NMR ($CDCl_3$, 400 MHz) δ 3.68 (s, 3 H, CH_3-O), 3.55-3.70 (m, 2 H, H-4, H-6'), 3.86 (m, 1 H, H-5), 4.25 (dd, 1 H, $J_{1,2}$ = 8.5 Hz, $J_{2,3}$ = 10.5 Hz, H-2), 4.42 (dd, 1 H, $J_{5,6}$ = 4.0 Hz, $J_{6,6'}$ = 11.0 Hz, H-6), 4.44 (d, 1 H, J_{gem} = 12.0 Hz, Ph-CH, 4.62 (d, 1 H, $J_{2,3}$ = 10.5 Hz, $J_{3,4}$ = 8.5 Hz, H-3), 4.76 (d, 1 H, J_{gem} = 12.0 Hz, Ph-CH, 5.24 (d, 1 H, $J_{1,2}$ = 8.5 Hz, H-1), 5.57 (s, 1 H, H-7), 6.53 (d, 2 H, J 8,5 Hz, H-10, H-10'), 7.00 (d, 2 H, J 8,5 Hz, H-9, H-9'),7.32-7.55 (m, 5 H, arom 4.6 benz), 7.65-7.80 (m, 4 H, arom Pht); ^{13}C NMR ($CDCl_3$, 62.9 MHz) δ 54.87 (CH_3-O), 56.62 (C-2), 65.94 (C-5), 68.13 (C-3), 68.49 (C-2), 70.91 (CH_2benz), 81;91 (C-4), 97;55 (C-1), 101.06 (C-7), 113.38 (C-10, C-10'), 123.11-126.19, 128.19-133.77 (CH arom), 129.22 (C-9, C-9'), 136.90 (C-8), 128.75-131.84 (C arom), 158.90 (C-11) 167.81 (C=O).

Anal. Calcd for $C_{29}H_{27}NO_8$: C, 67.60; H, 5.26; N, 2.71; O, 24.73. Found: C, 67.60; H, 5.38; N, 2.63; O, 24.64.

***p*-Methoxybenzyl *O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-4,6-*O*-benzylidene-2-deoxy-2-phthalimido-β-D-glucopyranoside (6).** A solu-

tion of **4** (4.97 g, 10 mmol) in CH_2Cl_2 (16 mL) was added to a stirred mixture of **3** (2.59 g, 5 mmol), tetrabutylammonium bromide (1.61 g, 5 mmol) and diisopropylamiine (1.57 mL, 9 mmol) in DMF (4 mL). After 14 h at room temperature, the mixture was diluted with CH_2Cl_2, washed with water then concentrated. Flash chromatography of the residue (8:2 hexane-ethyl acetate) gave **6** (4.53 g, 97%): $[\alpha]_D^{20}$ -30° (*c* 0.86, CH_2Cl_2); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 0.85 (d, 3 H, $J_{5b.\ 6b}$ = 6.5 Hz, CH_{3b}), 3.46 (d, 1 H, H-4b), 3.67 (s, 3 H, CH_3-O), 3.60-3.73 (m, 3 H, H-4a, H-2b, H-5a), 3.73 (dd, 1 H, $J_{2b.\ 3b}$ = 10.0 Hz, $J_{3b.\ 4b}$ = 3.0 Hz, H-3b), 3.82 (d, 1 H, J_{gem} = 12.5 Hz, Ph-CH), 3.87 (t, 1 H, $J_{5a.\ 6'a}$ = $J_{6a.\ 6'a}$ = 10.0 Hz, H-6'a), 4.04 (q, 1 H, H-5b), 4.24 (d, 1 H, J_{gem} = 12.5 Hz, Ph-CH, 4.03 (dd, 1 H, $J_{1a.\ 2a}$ = 8.5 Hz, $J_{2a.\ 3a}$ = 10.0 Hz, H-2b), 4.37 (dd, 1 H, $J_{1b.\ 2b}$ = 3.5 Hz, $J_{2b.\ 3b}$ = 10.0 Hz, H-2a), 4.39, 4.41 (2d, 2 H, J_{gem} = 11.5 Hz, 2 Ph-CH), 4.46 (dd, 1 H, $J_{5a.\ 6a}$ = 9.5 Hz, $J_{6'a.\ 6a}$ = 10.0 Hz, H-6a), 4.47, 4.49 (2d, 2 H, J_{gem} = 11.5 Hz, J_{gem} = 12.0 Hz, 2 Ph-CH), 4.65 (dd, 1 H, $J_{2a.\ 3a}$ = 10.0 Hz, $J_{3a.\ 4a}$ = 8.0 Hz, H-3a), 4.77 (d, 1 H, $J_{1b.\ 2b}$ = 3.0 Hz, H-1b), 4.78, 4.79 (2d, 2 H, J_{gem} = 11.5 Hz, J_{gem} = 12.0 Hz, 2 Ph-CH), 5.32 (d, 1 H, $J_{1a.\ 2a}$ = 8.5 Hz , H-1a), 5.56 (s, 1 H, H-7), 6.53 (d, 2 H, J = 8.5 Hz, H-10, H-10'), 7.00 (d, 2 H, J 8.5 Hz, H-9, H-9'), 7.10-7.80 (m, 20 H, arom); ^{13}C NMR ($CDCl_3$, 50 MHz) δ 16.33 (C-6b), 54.96 (CH_3-O), 55.79 (C-2a), 66.12 (C-5a), 67.11 (C-5b), 68.66 (C-6a), 71.12-72.79, 73.02-74.63 (CH_2benz), 75.18 (C-3a), 75.27 (C-2b), 77.86 (C-4b), 79.50 (C-4a), 81.81 (C-3b), 97.74 (C-1a), 99.20 (C-1b), 101.06 (C-7), 113.48 (C-10, C-10'), 122.96-125.99, 127.35 à 128.73-133.56 (CH arom), 137.09 (C-8), 128.95-131.84, 138.21, 138.45-138.75 (C arom), 159.02 (C-11), 167.92-168.50 (C=O).

Anal. Calcd for $C_{56}H_{55}NO_{12}$: C, 72.01; H, 5.93; N, 1.50; O, 20.56. Found: C, 71,62; H, 5.91; N, 1.50; O, 20.31.

***p*-Methoxybenzyl *O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranoside (8).** Sodium cyanoborohydride (1.41 g, 22.48 mmol) was added to a cooled (0 °C) mixture of **6** (3.5 g, 3.75 mmol) and molecular sieves (3 A°) in THF (15 mL). Then, a saturated solution of hydrogen chloride in ether was slowly added until pH 1. After 15 min at 0 °C, the reaction mixture was diluted with CH_2Cl_2 then filtered through celite. The filtrate was washed with 10% aq K_2CO_3 then with water. After evaporation of the solvents, flash chromatography of the residue (75:25 hexane-ethyl acetate) gave **8** (2.6 g, 74%) as a colorless gum: $[\alpha]_D^{20}$ 25° (*c* 0.92, CH_2Cl_2); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.05 (d, 3 H, $J_{5b.\ 6b}$ = 6.5 Hz, CH_{3b}), 3.40 (d, 1 H, J_{gem} = 13.0 Hz, Ph-CH), 3.49 (d, 1 H, H-4b), 3.54 (t, 1 H, $J_{3a.\ 4a}$ = $J_{4a.\ 5a}$ = 8.5 Hz, H-4a), 3.70 (s, 3 H, CH_3-O), 3.62-3.80 (m, 4 H, H-2b, H-3b, H-5a, H-6'a), 3.91 (dd, 1 H, $J_{5a.\ 6a}$ = 2.0 Hz, $J_{6'a.\ 6a}$ = 11.0 Hz, H-6a), 4.06 (q, 1, J_{gem} = 11.0 Hz, J_{gem} = 11.5 Hz, H-5b), 4.10 (d, 1 H, J_{gem} = 13.0 Hz, Ph-CH), 4.16 (dd, 1 H, $J_{2a.\ 3a}$ = 11.0 Hz, $J_{3a.\ 4a}$ = 8.5 Hz, H-2a), 4.58 (d, 1 H, $J_{1b.\ 2b}$ = 3.5 Hz, H-1b), 4.51, 4.52, 4.54, 4.58,

4.63, 4.68, 4.83, 4.85 (8d, 8 H, $J_{1b,2b}$ = 3.5 Hz, H-1b), 5.33 (d, 1 H, $J_{1a,2a}$ = 8.5 Hz, H-1a), 6.64 (d, 2 H, J = 9.0 Hz, H-9, H-9'), 7.10 (d, 2 H, J = 9.0 Hz, H-8, H-8'), 7.21-7.49 (m, 20 H, arom); ^{13}C NMR ($CDCl_3$ 62.9 MHz) δ 16.40 (C-6b), 54.54 (C-2a), 55.05 (CH_3-O), 68.35 (C-5b), 69.33 (C-6a), 70.68 (CH_2benz), 71.12 (C-4a), 72.25-73.25-73.42 (CH_2benz), 73.74 (C-2b), 74.66 (CH_2benz), 75.16 (C-5a), 77.73 (C-4b), 78.78 (C-3b), 83.03 (C-3a), 97.21 (C-1a), 100.74 (C-1b), 113.49 (C-9,C-9'), 122.96-127.52 à 128.37-133.46 (CH arom), 129.42 (C-8, C-8), 137.09 (C-7), 129,29-131.89, 138.06-138.21, 138.43-138.65 (C arom), 159.01 (C-10), 167.96-168.46 (C=O).

Anal. Calcd for $C_{56}H_{57}NO_{12}$: C, 71.85; H, 6.14; N, 1.50; O, 20.51. Found: C, 71.45; H, 6.01; N, 1.43; O, 21.08.

***p*-Methoxybenzyl *O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-(1→4)]-2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranoside (10).** BF_3-Et_2O (0.109 mL, 0.885 mmol) was added to a mixture of **7** (1.50 g, 1.77 mmol) and the trichloroacetimidate **9** (1.17 g, 2.65 mmol) in CH_2Cl_2 (15 mL). After stirring for 12 h at room temperature, the reaction mixture was diluted with CH_2Cl_2 and washed with aq K_2CO_3, then with water. After evaporation of the solvents, flash chromatography of the residue (8:2 ether-toluene) gave **10** (1.595 g, 77%) as a colorless foam. $[\alpha]_D^{29}$ -7° (*c* 1, CH_2Cl_2); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.52 (d, 3 H, $J_{5,6}$ = 6.5 Hz, CH_3b), 1.52 (s, 3 H, NHAc), 1.93, 1.96, 1.99, 2.01 (4 s, 12 H, 4 OAc), 3.52 - 3.66 (m, 4 H, H-2a, H-5a, H-4b, H-5c), 3.70 - 3.86 (m, 5 H, H-6a, H-6'a, OCH_3), 3.88 (dd, 1 H, $J_{2b,3b}$= 10 Hz, $J_{3b,4b}$ = 2.5 Hz, H-3b), 3.96 (t, 1 H, $J_{3a,4a}$ = $J_{3b,4b}$ = 7 Hz, H-4a), 4.01 (dd, 1 H, $J_{6c,6'c}$ = 10.5 Hz, $J_{5c,6'c}$ = 6 Hz, H-6'c), 4.09 - 4.16 (m, 2 H, H-2b, H-6c), 4.18 (t, 1 H, $J_{2a,3a}$ = $J_{3a,4a}$ = 7 Hz, H-3a), 4.34 (bs, 1 H, H-5b), 4.41-4.46 (2d, 2 H, J_{gem} = 11.5 Hz and 12 Hz, PhCH), 4.55 (d, 1H, $J_{1c,2c}$ = 8 Hz, H-1c), 4.64, 4.69, 4.71, 4.75, 4.76, 4.81 (6d, 6 H, J_{gem} = 11 Hz and 11.5 Hz, PhCH), 4.83 (m, 2 H, PhCH, H-3c), 4.93 (d, 1 H, $J_{1a,2a}$ = 6 Hz, H-1a), 4.96 (d, 1 H, J_{gem} = 12 Hz, PhCH), 5.04 (dd, 1 H, $J_{2c,3c}$ = 10.6 Hz, $J_{1c,2c}$ = 8 Hz, H-2c), 5.09 (d, 1 H, $J_{1b,2b}$ = 3.5 Hz, H-1b), 5.28 (d, 1 H, $J_{3c,4c}$ = 3.5 Hz, H-4c), 5.88 (d, 1 H, $J_{NH,2a}$ = 8 Hz, NH), 6.81 (d, 2 H, J = 8.5 Hz, arom), 7.20 (d, 2 H, J = 8.5 Hz, arom), 7.32 - 7.42 (m, 20 H, arom); ^{13}C NMR (CDCl3, 62.9 MHz) δ 23.10 (C-6b), 20.48, 20.61 (CH3CO), 23.10 (CH3CONH), 55.10 (C-2a, CH3O), 60.25, 68.51, 70.33, 72.51, 73.34, 73.41, 74.19 (C-6a, C-6c, CH2), 66.41, 66.61, 68.72, 70.33, 70.50, 73.26, 73.96, 74.22, 76.27, 76.92, 79.69 (C-2b, C-2c, C-3a, C-3b, C-3c, C-4a, C-4b, C-4c, C-5a, C-5b, C-5c), 97.30 (C-1b), 98.75, 99.37 (C-1a, C-1c), 113.60 (arom), 127.03-128.54 (arom), 129.21 (arom), 137.83 (arom), 138.52-138.78 (arom), 159.10 (arom), 169.28, 169.86, 169.97 (COCH3).

Anal. Calcd for $C_{64}H_{75}NO_{20}$: C, 65.24; H, 6.42; N, 1.19; O, 27.16. Found: C, 65.03; H, 6.21; N, 1.18; O, 27.41.

***p*-Methoxybenzyl *O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-(1→4)]-6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranoside (11).** A mixture of **8** (0.25 g, 0.27 mmol), **9** (0.236 g, 0.54 mmol) and molecular sieves (3A°) in CH_2Cl_2 (2mL) was stirred for 1 h at room temperature and then cooled to -70 °C. Trimethylsilyl triflate (5.2 µL, 26.7 µmol) was then added, and the reaction mixture was warmed up to -30 °C over 3 h. Pyridine (10 µL) was then added, and the mixture was allowed to warm to room temperature. After evaporation of the solvents, flash chromatography of the residue (65:35 hexane-ethyl acetate) gave **11** (0.257 g, 76%) along with recovered **8** (32 mg, 13%): $[\alpha]_D^{20}$ (*c* 0.89, CH_2Cl_2); ^1H NMR ($CDCl_3$, 400 MHz) δ 1,117 (d, 3 H, $J_{5b,\ 6b}$ = 6.5 Hz, CH_{3b}), 1.81, 1.95, 2.01, 2.02 (3s, 12 H, CH_3-CO), 3;47 (dd, 1 H, $J_{5c,\ 6'c}$ = 5.5 Hz, $J_{5c,\ 6c}$ = 8.5 Hz, H-5c), 3.51 (ddd, 1 H, $J_{4a,\ 5a}$ = 9.0 Hz, $J_{5a,\ 6a}$ = 2.5 Hz, $J_{5a,\ 6'a}$ = 1.0 Hz, H-5a), 3.61 (s, 1 H, H-4b), 3.67 (s, 3 H, CH_3-CO), 3.78 (dd, 1 H, $J_{1b,\ 2b}$ = 3.5 Hz, $J_{2b\ 3b}$ 10.5 Hz, H-2b), 3.83 (dd, 1 H, $J_{5a,\ 6'a}$ = 1.0 Hz, $J_{6a,\ 6'a}$ = 10.0 Hz, H-6'a), 3.88 (dd, 1 H, $J_{5a,\ 6a}$ = 2.5 Hz, $J_{6'a,\ 6a}$ = 10.0 Hz, H-6a), 3.91 (dd, 1 H, $J_{2b,\ 3b}$ = 10.5 Hz, $J_{3b,\ 4b}$ = 3.5 Hz, H-3b), 3;96 (dd, 1 H, $J_{5c,\ 6'c}$ = 5.5 Hz, $J_{6c,\ 6'c}$ = 11.0 Hz, H-6'c), 4.13 (dd, 1 H, $J_{5c,\ 6'c}$ = 8.5 Hz, $J_{6'c,\ 6'c}$ = 11.0 Hz, H-6c), 4.17 (t, 1 H, $J_{3a,\ 4a} = J_{4a,\ 5a}$ = 9.0 Hz, H-4a), 4.24-4.39 (2d, 2 H, J_{gem} = 12.5 Hz, 2 Ph-CH), 4.43 (dd, 1 H, $J_{1a,\ 2a}$ = 9.0 Hz, $J_{2a,\ 3a}$ = 10.5 Hz, H-2a), 4.44-4.48-4.57 (3d, 3 H, J_{gem} = 12 Hz, J_{gem} = 12.5 Hz, 3 Ph-CH), 4.61 (q, 1 H, H-5b), 4.66 (s, 2 H, $J_{1c,\ 2c}$ = 8.5 Hz, H-1c) 4.71 (dd, 1 H, $J_{2a,\ 3a} = J_{3a,\ 4a}$ = 9.5 Hz, H-3a), 4.75 (d, 1 H,J_{gem} = 12.5 Hz, Ph-CH), 4.76 (dd, 1 H, $J_{2c,\ 3c}$ = 10 Hz, $J_{3c\ 4c}$ = 3.5 Hz, H-3c), 4.77 (d, 1 H, $J_{1b,\ 2b}$ = 3.5 Hz, 2 Ph-CH), 4.80-4.87 (2d, 2 H, J_{gem} = 12.0 Hz, 2 Ph-CH), 4.99 (dd, 1 H, $J_{1c,\ 2c}$ = 8.5 Hz, $J_{2c,\ 3c}$ = 10.0 Hz, H-2c), 5.03 (d, 1 H, $J_{1a,\ 2a}$ = 9.0 Hz, H-1a), 5.22 (d, 1 H, $J_{3c,\ 4c}$ 3.5 Hz, H-4c), 6.48 (d, 2 H, J = 8.5 Hz, H-9, H-9'), 6.96-7.70 (m, 24 H, arom); ^{13}C NMR ($CDCl_3$ 62.9 MHz) δ 16.53 (C-6b), 20.41, 20.49-20.59 (CH_3-CO), 54.90 (CH_3-O), 56.32 (C-2a), 59.99 (C-6c), 66.09 (C-5b), 66.54 (C-4c), 67;53 (C-6a), 68.78 (C-2c), 70.09 (C-5c), 70.52 (CH_2benz), 70.79 (C-3a), 72.19-72.60, 73.43-73.92 (CH_2benz), 74.21 (C-2b), 74.87 (C-4a), 74.95 (C-5a), 76.81 (C-4b), 79.61 (C-3b), 96.92 (C-1a), 96.99 (C-1b), 99.34 (C-1c), 113.36 (C-9, C-9'), 123.26-126.80 à 128.14-128.51, 129.24-133.82 (CH arom), 128.96-131.51, 137.69-137.93, 138.48-138.74 (C arom), 168.58, 169.73-169.90 (C=O).

Anal. Calcd for $C_{70}H_{75}NO_{21}$: C, 66.39; H, 5.97; N, 1.11; O, 26.53. Found: C, 66.21; H, 6.27; N, 1.31; O, 26.26.

***O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-(1→4)]-2-acetamido-6-*O*-benzyl-2-deoxy-β-D-glucopyranose (12).** Ammonium and cerium nitrate (2.79 g, 5.09 mmol) was added to a vigorously stirred solution of compound **10** (0.6 g, 0.51 mmol) in 9:1 acetonitrile-water (5 mL) maintained at -5 °C. After 5 min at the same temperature, the

reaction mixture was washed with aq K_2CO_3 then with water. After evaporation of the solvents, flash chromatography of the residue (8:2 ethyl acetate - hexane) gave **12** (0.464 g, 85%) which crystallized from ethyl acetate: $[\alpha]_D^{27}$ -50° (*c* 0.6, CH_2Cl_2); mp 186-187 °C (ethyl acetate); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.12 (d, 1.26 H, $J_{5b.6b}$ = 6,5 Hz, CH_3b (β)), 1.19 (d, 1.74 H, $J_{5.6}$ = 6.5 Hz, CH_3b (α)), 1.72 (s, 1.26 H, NHAc (β)), 1.83 (s, 1.74 H, NHAc (α)), 1.95 - 2.02 (6s, 9H, OAc (α,β)), 2.04 (s, 1.74 H, OAc (α)), 2.11 (s, 1.26 H, OAc (β)), 3.50 - 4.18 (m, 12.42 H), 4.22 (bq, 0.58 H, H-5b (α)), 4.42, 4.44, 4.46 (3d, J_{gem} = 12 Hz, 3 PhCH), 4.50 (d, 0.42 H, $J_{1c.2c}$ = 8 Hz, H-1c (β)), 4.52 (d, 0.42 H, $J_{1c.2c}$ = 8 Hz, H-1c (α)), 4.61 (dd, 0.42 H, $J_{1a.OH}$ = 7 Hz, $J_{1a.2a}$ = 5 Hz, H-1a (β)), 4.62 - 4.80 (m, 3 H, 3 PhCH), 4.81 - 4.91 (2dd, 1 H, $J_{2c.3c}$ = 10.5 Hz, $J_{3c.4c}$ = 3.5 Hz, H-3c (α, β)), 4.87, 4.93, 4.96 (3d, 3 H, J_{gem} = 11.5 Hz, H-3c (α,β)), 5.01 (d, O.42 H, $J_{1b.2b}$ = 3.5 Hz, H-1b (β)), 5.04, 5.09 (2dd, 1 H, $J_{2c.3c}$ = 10.5, $J_{1c.2c}$ = 8 Hz, H-2c (α,β)), 5.13 (d, 0.58 H, $J_{1b.2b}$ = 3.5 Hz, H-1b (α)), 5.28 (d, 0.42 H, $J_{3c.4c}$ = 3.5 Hz, H-4c (β)), 5.32 (d, 0.58 H, $J_{3c.4c}$ = 3.5 Hz, H-4c (α)), 5.34 (dd, 0.58 H, $J_{1a.OH}$ = 7 Hz, $J_{1a.2a}$ = 5 Hz, H-1a (α)), 5.92 (d, 0.42 H, $J_{1a.OH}$ = 7 Hz, OH (β)), 6.71 (d, 1 H, $J_{2a.NH}$ = 7 Hz, NH), 7.44 - 7.23 (m, 20 H, arom); ^{13}C NMR ($CDCl_3$, 62.9 MHz) δ 16.42 (C-6b), 20.32, 20.49, 20.58 (CH_3CO), 22.24, 22.73 (CH_3CONH (α,β)), 90.55 (C-1a (β)), 95,86 (C-1a (α)), 97.76, 97.94 (C-1b (α,β)), 99.17, 99.37 (C-1c (α,β)), 126.81 - 128.37 (arom), 136.98 - 138.55 (arom), 169.22, 169.72, 169.87, 170.96 (CO).

Anal. Calcd for $C_{56}H_{67}NO_{19}$, H_2O: C, 63.57; H, 6.38; N, 1.32; O, 28.73. Found: C, 62.50; H, 6.46; N, 1.30; O, 29.73.

***O*-(2,3,4-Tri-*O*-benzyl-β-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β -D-galactopyranosyl)-(1→4)]-6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranose (13).** Ammonium and cerium nitrate (5.89 g, 10.74 mmol) was added to a vigorously stirred solution of compound 11 (1.7 g, 1.34 mmol) in 9:1 acetonitrile-water (15 mL) maintained at -5 °C. After 5 min at the same temperature, the reaction mixture was washed with 10% aq K_2CO_3 then with water. After evaporation of the solvents, flash chromatography of the residue (53:27 ethyl acetate - hexane) gave 13 (1.42 g, 92%) which crystallized from ethanol: mp 101 °C (lit[13]: n.d.); $[\alpha]_D^{30}$ -10° (*c* 1.64, CH_2Cl_2) (lit[13]: n.d.); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.14 lit[13]: 1.23 (d, 3 H, $J_{5b.6b}$ = 6.5 Hz, CH_{3b}), 1.74, 1.89, 1.94, 1.96 (4s, 12 H, CH_3-CO), 3.43 (dd, 1 H, $J_{5c.6c}$ = 8.5 Hz, $J_{5c.6'c}$ = 5.5 Hz, H-5c), 3.51 (m, 1 H, H-5a), 3.57 (s, 1 H, H-4b), 3.72 (dd, 1 H, $J_{5a.6'a}$ = 1.5 Hz, $J_{6'a.6a}$ = 10.5 Hz, H-6'a), 3.78-3.85 (m, 2 H, $H_{3b}H_{6a}$), 3.91 (dd, 1 H, $J_{5c.6'c}$ = 5.5 Hz, $J_{6'c.6c}$ = 10.5 Hz, H-6'c), 4.07 (dd, 1 H, $J_{5c.6c}$ = 8.5 Hz, $J_{6'c.6c}$ = 10.5 Hz, H-6c), 4.08 (t, 1 H, $J_{3a.4a} = J_{4a.5a}$ = 9.0 Hz, H-4a), 4.21(d, 1 H, J_{gem} = 12.0 Hz, Ph-CH), 4.25 (dd, 1 H, $J_{1a.2a}$ = 8.5 Hz, $J_{2a.3a}$ = 10.5 Hz, H-2a), 4.34, 4.37, 4.53 (3d, 3 H, J_{gem} = 12.0 Hz, 3 Ph-CH), 4.56 (d, 1 H, $J_{1c.2c}$ = 8.0 Hz, H-1c), 4.59 (q, 1 H, H-5b), 4.60, 4.61 (2s,

4 H, 2 Ph-CH_2), 4.65 (dd, 1 H, $J_{2c,3c}$ = 10.5 Hz, $J_{3c,4c}$ = 3.5 Hz, H-3c), 4.74 (d, 1 H, $J_{1b,2b}$ = 3.5 Hz, H-1b), 4.75, 4.76 (2d, 2 H, J_{gem} = 12, 2 Ph-CH), 4.93 (dd, 1 H, $J_{1c,2c}$ = 8.0 Hz, $J_{2c,3c}$ = 10.5 Hz, H-2c), 5.16 (lit[13]: 5.22) (d, 1 H, $J_{3c,4c}$ = 3.5 Hz, H-4c), 5.20 (d, 1 H, $J_{1a,2a}$ = 8.5 Hz, H-1a), 6.90-7.70 (m, 24 H, arom) ; ^{13}C NMR ($CDCl_3$, 62.9 MHz) δ 16.55 (lit[13]: 16.7) (C-6b), 20.37, 20.47-20.55 (CH_3-CO), 57.98 (C-2a), 59.92 (C-6c), 66.20 (C-5b), 66.48 (C-4c), 67.63 (C-6a), 68.69 (C-2c), 70.06 (C-5c), 70.76 (C-3c), 71.83 (C-3a), 72.11-72.64, 73.43-73.89 (CH_{2benz}), 74.20 (C-2b), 74.85 (C-4a, C-5a), 76.73 (C-4b), 79.61 (C-3b), 92.80 (lit[13]: 93.0) (C-1a), 97.15 lit[13]: 97.4 (C-1b), 99.37 (lit[13]: 99.6) (C-1c), 123.42, 126.78-128.52, 134.06 (CH arom), 131.44, 137.41-137.91, 138.41-138.63 (C arom), 168.00, 168.07-168.64, 169.72-169.90 (C=O).

***O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-(1→4)]-2-acetamido-6-*O*-benzyl-2-deoxy-α-D-glucopyranosyl Trichloroacetimidate (14).** Sodium hydride (60% in oil) (2.8 mg, 0.069 mmol) was added to a cooled (0 °C) solution of **12** (0.728 g, 0.69 mmol) and trichloroacetonitrile (0.345 mL, 3.44 mmol) in CH_2Cl_2 (5 mL). After 2 h at 0°C, the reaction mixture was concentrated under reduced pressure. Chromatography of the residue (5.5: 4.5: 0.01 hexane-ethyl acetate-triethylamine) afforded **14** (0.567 g, 68%) as a colorless foam which was directly used for the coupling reaction with **16**. $[\alpha]_D^{26}$ -6 ° (*c* 2.9, CH_2Cl_2); ^{1}H NMR ($CDCl_3$, 400 MHz) δ 1.03 (d, 3 H, $J_{5b,6b}$ 6.5 Hz, CH_3b, 1.78 (s, 3 H, NHAc), 1.94, 1.95, 2.00 (3s, 12H, OAc), 3.55 (t, 1 H, $J_{5c,6c}$ = $J_{5c,6'c}$ 7 Hz, H-5c), 3.69 (dd, 1 H, $J_{5a,6'a}$ = 1.5 Hz, $J_{6a,6'a}$ = 11 Hz, H-6'a), 3.73 (bs, 1 H, H-4b), 3.78 (m, 1 H, H-5a), 3.83 (dd, 1 H, $J_{5a,6a}$ = 2.5 Hz, $J_{6a,6'a}$ = 11 Hz, H-6a), 3.94 - 4.16 (m, 6 H), 4.23 (q, 1 H, H-5b), 4.32 (ddd, 1 H, $J_{1a,2a}$ = 3.5 Hz, $J_{2a,NH}$ = 6.5 Hz, $J_{2a,3a}$ = 10 Hz, H-2a), 4.44 (d, 1 H, J_{gem} = 12 Hz, PhCH), 4.61 (d, 1 H, $J_{1c,2c}$ = 8 Hz, H-1c), 4.64, 4.70 (2d, 2 H, J_{gem} = 12 Hz, 2PhCH), 4.73, 4.74 (2d, 2 H, J_{gem} = 11.5 Hz, 2PhCH), 4.78 (dd, 1 H, $J_{2c,3c}$ = 10 Hz, $J_{3c,4c}$ = 3.5 Hz, H-3c), 4.78, 4.83, 4.93 (3d, 3 H, J_{gem} = 11.5 Hz, 3 PhCH), 5.03 (dd, 1 H, $J_{1c,2c}$ = 8 Hz, $J_{2c,3c}$ = 10 Hz, H-2c), 5.21 (d, 1 H, $J_{1b,2b}$ = 3.5 Hz, H-1b), 5.25 (d, 1 H, $J_{3c,4c}$ = 3.5 Hz, H-4c), 6.52 (d, 1 H, $J_{1a,2a}$ = 3.5 Hz, H-1a), 6.97 (d, 1H, $J_{2a,NH}$ = 6.5 Hz, NH), 7.23 - 7.43 (m, 20 H, arom), 8.66 (s, 1 H, C=NH); ^{13}C NMR ($CDCl_3$, 100 MHz) δ 16.77 (C-6b), 20.48, 20.71 (CH_3CO), 22.77 (CH_3CONH), 53.06 (C-2a), 60.78, 67.50, 72.45, 73.67, 73.86, 74.72, 66.88, 67.41, 69.42, 70.87, 70.93, 73.67, 74.24, 75.37, 76.95, 77.24, 79.61, 90.99 (CCl_3), 94.57 (C-1a), 99.01 (C-1c), 99.42 (C-1b), 127.05 - 128.56 (CH arom), 137.59, 137.68, 138.43, 138.51 (arom), 160.43 (C=NH),. 169.01, 169.92, 170.09, 170.18, 170.32 (CH_3CO).

***O*-(2,3,4-Tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)-[*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-galactopyranosyl)-(1→4)]-6-*O*-benzyl-2-deoxy-2-phthalimido-β-D-glucopyranosyl Trichloroacetimidate (15).** Sodium hydride (60% in oil)

(34.8 mg, 0.87 mmol) was added to a cooled (0 °C) solution of **12** (1 g, 0.87 mmol) and trichloroacetonitrile (0.437 mL, 4.36 mmol) in CH_2Cl_2 (5 mL). After 2 h at 0 °C, the reaction mixture was concentrated under reduced pressure. Chromatography of the residue (6: 4: 0.01 hexane-ethyl acetate-triethylamine) afforded **15** (1.054 g, 92%) as a colorless foam which was directly used for the coupling reaction with **16**. $[\alpha]_D^{30}$ -11° (*c* 1.6, CH_2Cl_2) (Lit[13]: $[\alpha]_D^{25}$ +16° (*c* 1.5, CH_2Cl_2)); ^{1}H NMR ($CDCl_3$, 200 MHz) δ 1.21 (d, 3 H, $J_{6b,\ 5b}$ = 6.5 Hz, CH-$_3$b), 1.83, 1.95, 2.03 (lit: 1.83, 1.95, 2.02) (3s, 12 H, CH_3-CO), 3.50 (dd, 1 H, $J_{5c,\ 6c}$ = 8.5 Hz, $J_{5c.6'c}$ = 5.5 Hz), 3.63 (s, 1 H, H-4b), 3.74 (m, 1 H, H-5a), 3.81 (dd, 1 H, $J_{1b,\ 2b}$ = 3.5 Hz, $J_{2b,\ 3b}$ = 10.5 Hz, H-2b), 3.84-3.93 (m, 3 H, H-3b, H-6a, H-6'a), 3.95 (dd, 1 H, $J_{5c,\ 6'c}$ = 5.5 Hz, $J_{6c.6'c}$ = 10.5 Hz, H-6'c), 4.13 (dd, 1 H, $J_{5c,\ 6c}$ = 8.5 Hz, $J_{6c.6'c}$ = 10.5 Hz, H-6'c), 4.25 (t, 1 H, $J_{3a,\ 4a} = J_{4a,\ 5a}$ = 9 Hz, H-4a), 4.28, 4.43, 4.49, 4.59 (4d, 4 H, J_{gem} = 11.5 Hz, J_{gem} = 12.0 Hz, J_{gem} = 12.5 Hz, 4 Ph-CH, 4.63 (q, 1 H, H-5b), 4.65 (s, 2 H, Ph-CH_2), 4.70 (dd, d, 2 H, $J_{1a,\ 2a}$ = 8.5 Hz, $J_{2a,\ 3a}$ = 10.5 Hz, $J_{1c,\ 2c}$ = 8 Hz, H-2a, H-1c), 4.75 (dd, 1 H, $J_{2c,\ 3c}$ = 10.5 Hz, $J_{3c,\ 4c}$ = 3.5 Hz, H-3c), 4.81 (dd, 1 H, $J_{2a,\ 3a}$ = 10.5 Hz, $J_{3a,\ 4a}$ = 9 Hz, H-3a), 4.82 (dad, 2 H, J_{gem} = 11.5 Hz, $J_{1b,\ 2b}$ = 3.5 Hz, Ph-CH, H-1b), 4.84 (d, 1 H, J_{gem} = 12 Hz, Ph-CH), 5.02 (lit: 5.01) (dd, 1 H, $J_{1c,\ 2c}$ = 8 Hz, $J_{2c,\ 3c}$ = 10.5 Hz, H-2c), 5.24,(lit: 5.23) (d, 1 H, $J_{1a,\ 2a}$ = 8.5 Hz, H-4c), 7.00-7.70 (m, 24 H, arom), 8.54 (s, 1 H, C=NH); ^{13}C NMR ($CDCl_3$, 62.9 MHz) δ 16.52 lit[13]: 16.7 (C-6b), 30.35-20.45-20.54 (CH_3CO), 54.85 (lit[13]: 55.2) (C-2a), 60.02 (lit[13]: 60.05) (C-6c), 66.31 (C-5b), 66.52 (C-4c); 67.15 (C-6a), 68.61 (C-2c), 70.11 (C-5c), 70.76 (C-3c), 71.89 (C-3a), 72.14-73.71, 73.37-73.92 (CH_2benz), 74.38 (C-2b), 74.58 (C-4a), 75.90 (C-5a), 76.78 (C-4b), 79.58 (C-4b), 90.14 (lit[13]: 90.5) (C-8), 93.90 (lit: 94.3) (C-1a), 97.44 (lit[13]: 97.7) (C-1b), 99.19 (lit[13]: 99.5) (C-1c), 123.37-126.79 à 128.48-134.09 (CH arom), 131.28, 137.39-137.95, 138.38-138.57 (C arom), 167.45, 168.59-169.67, 169.82-169.90 (C=O).

Benzyl *O*-(β-D-Galactopyranosyl)-(1→4)-[*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (18). From **14**. A solution of the trichloroacetimidate **14** (0.46 g, 0.38 mmol) in CH_2Cl_2 (1.25 mL) was added to a cooled (-50 °C) mixture of **16** (1.35 g, 1.53 mmol) and BF_3-Et_2O (23 μL, 0.19 mmol) in CH_2Cl_2 (0.75 mL). The reaction mixture was then slowly brought to room temperature over 3 h, diluted with CH_2Cl_2 and washed successively with 10% aq K_2CO_3 then with water. After evaporation of the solvents, the residue was dissolved in a mixture of triethylamine-methanol-water (1:8:1, 50 mL) and left for 12 h at room temperature. After evaporation of the solvents, flash chromatography of the residue (90:6:4 CH_2Cl_2 - ethyl acetate - methanol) gave **18** (0.160 g, 24%) as a colorless foam which crystallized from methanol.

$[\alpha]_D^{33}$ -11 ° (*c* 2.72, CH_2Cl_2); mp 90-91 °C (methanol); ^1H NMR ($CDCl_3$, 400 MHz) δ 1.10 (d, 3 H, $J_{5d.6d}$ = 6.5 Hz, CH_3d), 1.34 (s, 3 H, CH_3CONH), 5.04 (d, 1 H, $J_{1d.2d}$ = 3.5 Hz, H-1d), 5.15 (d, 1 H, $J_{H.OH}$ = 7.5 Hz, OH), 5.73 (d, 1 H, $J_{2c.NH}$ = 7 Hz, NH), 7.17 - 7.45 (m, 50 H, arom); ^{13}C NMR ($CDCl_3$ 100 MHz) δ 16.68 (C-6d), 22.92 (CH_3CONH), 57.35 (C-2c), 62.94, 67.48, 67.91, 68.28, 68.89, 69.36, 69.90, 70.90, 71.69, 72.42, 73.00, 73.19, 73.41, 73.58, 73.64, 74.05, 74.72, 74.80, 74.96, 75.08, 75.14, 75.33, 75.94, 76.34, 76.50, 77.27, 79.07, 79.41, 81.86, 82.22, 82.90, 97.97, 99.75, 100.25, 102.15, 102.47, 127.23 - 128.57 (CH arom), 137.49 - 139.15 (C arom), 170.92 (CH_3CO).

Anal. Calcd for $C_{102}H_{115}NO_{25}$, 3 H2O: C, 67.72; H, 6.74; N, 0.77; O, 24.76. Found: C, 67.82; H, 6.61; N, 0.84; O, 24.04.

From **15**. A solution of the trichloroacetimidate **15** (1 g, 0.77 mmol) in CH_2Cl_2 (3.5 mL) was added to a cooled (-60 °C) mixture of **16** (1.368 g, 1.55 mmol) and BF_3- Et_2O (24 µL, 0.19 mmol) in CH_2Cl_2 (1.5 mL). After stirring the reaction mixture at -40 °C over 0.5 h, pyridine (50 µL) was added, and the mixture was brought to room temperature, then diluted with CH_2Cl_2 and finally washed with water. After evaporation of the solvents, flash chromatography of the residue gave **17** (1.085 g,, 70%); ^1H NMR ($CDCl_3$, 400 MHz) δ 1.04 (d, 3 H, $J_{5d.\ 6d}$ = 6.7 Hz, CH_{3d}), 1.49 (s, 3 H, CH_3-CO-NH), 1.99 (s, 3 H, CH_3-CO), 2.21 (d, 1 H, $J_{OH.\ H-4b}$, OH), 5.04 (d, 1 H, $J_{1d.\ 2d}$ = 3.5 Hz, H-1d), 5.07 (d, 1 H, $J_{NH.2c}$ = 8 Hz, NH), 5.38 (d, 1 H, $J_{3e.\ 4e}$ = 3 Hz, H-4e), 7.10-7.45 (m, 65 H, arom) ; ^{13}C NMR ($CDCl_3$ 62.9 MHz) δ 16.59 (C-6d), 20.40-20.58 (CH_3-CO), 56.05 (C-2a), 60.12, 67.55, 67.73, 68.27, 70.69, 72.15, 72.74, 72.84, 73.20, 73.58, 74.00, 74.84, 75.29 (CH_2benz, C-6a, C-6b, C-6c, C-6d), 66.37, 66.56, 67.38, 68.84, 70.30, 70.80, 72.36, 72.40, 74.48, 74.52, 74.84, 75.08, 75.66, 76.50, 77.93, 79.51, 81.56, 82.67, 83.27 (C-2b, C-2c, C-2d, C-2e, C-3a, C-3b, C-3c, C-3d, C-3e, C-4a, C-4b, C-4c, C-d, C-4e, C-5a, C-5b, C-5c, C-5d, C-5e), 68.83, 97.39, 99.42, 101.82, 102.24 (C-1a, C-1b, C-1c, C-1d, C-1e), 123.18, 126.16, 128.56, 133.77 (CH arom), 131.03, 137.38, 137.96, 138.12, 138.42, 138.61, 138.84 (C arom), 167.64, 167.75, 168.58, 169.72, 169.88, 169.94 (C=O). **17** was immediately dissolved in a mixture of anhydrous hydrazine-ethanol (1:9, 25 mL). After heating at reflux for 13 h, the reaction mixture was concentrated, and the residue dissolved in 10 mL of a 1:1 mixture of acetic anhydride and pyridine. After 12 h at room temperature, methanol was added and the reaction mixture was concentrated several time by co-evaporation with toluene. Finally, the residue was dissolved in a solution of sodium methylate in methanol (O.5 M, 10 mL). After 1.5 h, the reaction mixture was neutralized with acidic resin (AG50WX8, H^+ form) then filtered. After evaporation of the solvents, flash chromatography (as above) of the residue gave **18** (0.67 g, 77%) identical to above.

Benzyl *O*-(3-*O*-Sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside sodium salt (19). A mixture of pentasaccharide **18** (0.05 g, 28.5 μmol) and dibutyltin oxide (0.008 g, 31.3 μmol) in toluene (5 mL) was boiled for 15 h under reflux with continual removal of water using a Dean-Stark apparatus. After solvent evaporation, a solution of sulfur trioxide in dimethylformamide (0.45 M, 0.2 mL) was added, and the mixture was stirred for 7 h at room temperature. Then, ethyl acetate was added and the resulting mixture washed with saturated aqueous $NaHCO_3$. The aqueous phase was extracted with ethyl acetate, and finally, the combined organic phases washed with water. After evaporation of the solvents, flash chromatography of the residue (95:5 ethyl acetate - methanol) gave **19** (0.038 g, 73%) as a colorless foam along with recovered starting material **18** (0.008 g, 16%). $[\alpha]_D^{33}$ - 23 ° (*c* 2.38, CH_2Cl_2); ^1H NMR ($CDCl_3$, 400 MHz) δ 1.14 (d, 3 H, $J_{3d.5d}$ = 6.5 Hz, CH_3d), 1.64 (s, 3 H, CH_3CONH), 5.15 (d, 1 H, $J_{1d.2d}$ = 3.5 Hz, H-1d), 7.15 - 7.45 (m, 50 H, arom). ^{13}C NMR ($CDCl_3$ 62.9 MHz) δ 15.88 (C-6d), 22,46 (CH_3CONH), 55.21 (C-2c), 61.75, 67.48, 67.91, 68.28, 68.89, 69.36, 69.90, 70.90, 71.69, 72.42, 7300, 73.19, 73.41, 73.58, 73.64, 74.05, 74.72, 74.80, 74.96, 75.08, 75.14, 75.33, 75.94, 76.68, 77.48, 78.71, 78.88, 80.06, 81.04, 81.35, 82.39, 96.49, 101.31, 101.51, 101.93, 102.09, 126.85 - 128.17 (CH arom), 137.53 - 139.73 (C arom), 171.25 (CH_3CO).

Anal. Calcd for $C_{102}H_{114}NO_{28}NaS$, 4 H_2O: C, 63.51; H, 6.37; N, 0.73; S, 1.66. Found: C, 63.21; H, 6.43; N, 0.74; S, 1.80.

Benzyl *O*-(6-*O*-Sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside Sodium Salt (20). A solution of the pentasaccharide **18** (0.05 g, 28.5 μmol) and sulfur trioxide-trimethylamine complex (0.016 g, 28.55 μmol) in 1.5:1 DMF-pyridine (0.25 mL) was stirred for 3 h at 40 °C then brought to room temperature. Ethyl acetate was then added and the resulting mixture washed with saturated aqueous $NaHCO_3$. The aqueous phase was extracted with ethyl acetate, and finally, the combined organic phases washed with water. After evaporation of solvents, flash chromatography of the residue (95:5 ethyl acetate-methanol) gave crude **19** which was dissolved in methanol and passed through acidic resin (AG50WX8, Na^+ form). The resulting methanolic solution was concentrated to give **20** (0.039 g, 74%) as a colorless foam. $[\alpha]_D^{28}$ -47° (*c* 1.09, CH_2Cl_2); ^1H NMR ($CDCl_3$-CD_3 OD-8-2, 400 MHz) δ 1.16 (d, 3 H, $J_{5d.6d}$ = 6.5 Hz, CH-3d), 1.76 (s, 3 H, CH_3 CO NH), 5.21 (d, 1 H, $J_{1d.2d}$ =

4 Hz, H-1d), 7.18 - 7.53 (m, 50 H, arom) ; ^{13}C NMR ($CDCl_3$ -CD_3OD-8-2, 100 MHz) δ 16.06 (C-6d), 22.09 (CH_3-CO-NH), 53.77 (C-2c), 66.67, 67.64, 67.69, 67.89, 67.99, 68.31, 68.42, 70.80 (CH_2benz), 71.10, 71.62, 72.73, 73.04 (C-6a, C-6b, C-6c, C-6e), 73.12, 73.25, 73.43, 74.15 (C-5a, C-5b, C-5c, C-5d, C-5e), 74.78, 74.89, 74.94, 75.18 (C-4a, C-4b, C-4c, C-4d, C-4e), 76.07, 76.29, 76.84, 78.18 (C-3a, C-3b, C-3c, C-3d, C-3e), 78.94, 79.56, 81.41, 82.54 (C-2a, C-2b, C-2d, C-2e), 96.03, 99.50, 100.75, 102.07, 102.18 (C-1a, C-1b, C-1c, C-1d, C-1e), 126.97-128.44 (CH arom), 137.20, 137.22, 137.31, 137.88, 137.97, 138.20, 138.43, 138.73 (C arom), 170.80 (CH_3-CO).

Anal. Calcd for $C_{102}H_{114}NO_{28}SNa$, 3 H_2O: C, 64.72; H, 6.28; S, 1.69. Found: C, 64.68; H, 6.06; S, 1.68.

Benzyl *O*-(3,6-di-*O*-Sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(2,3,4-tri-*O*-benzyl-α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-6-*O*-benzyl-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside Sodium Salt (21). A mixture of pentasaccharide **18** (0.05 g, 28.5 μmol) and dibutyltin oxide (0.008 g, 31.3 μmol) in toluene (5 mL) was boiled for 15 h under reflux with continual removal of water using a Dean-Stark apparatus. The solution was concentrated, diluted with DMF (0.25 mL) and heated at 40 °C. Sulfur trioxide-trimethylamine complex (0.012 g, 85.5 mmol) was then added and the resulting mixture was stirred at 40 °C. After 1 h, more sulfur trioxide-trimethylamine complex (0.012 g, 85.5 mmol) was added, and the stirring was continued for 3 h at the same temperature. After cooling, the mixture was diluted with ethyl acetate and then washed with saturated aqueous $NaHCO_3$. The aqueous phase was extracted with ethyl acetate and finally the combined organic phases washed with water. After evaporation of the solvents, flash chromatography of the residue gave **21** which was converted to its sodium salt by passage of a methanolic solution through acidic resin (AG50WX8, Na^+ form). The resulting solution was concentrated to give **21** (0.043 g, 78%). $[\alpha]_D^{28}$ –29° (*c* 1, CH_2Cl_2). ^{1}H NMR ($CDCl_3$-CD_3 OD-8-2, 400 MHz) δ 1.16 (d, 3 H, $J_{5d,\ 6d}$ = 6.5 Hz, CH-3d), 1.72 (s, 3 H, CH_3 CO NH), 5.17 (d, 1 H, $J_{1d,\ 2d}$ = 3.5 Hz, H-1d), 7.20-7.50 (m, 50 H, arom); ^{13}C NMR ($CDCl_3$ -CD_3 OD-8-2, 100 MHz) δ 15.96 (C-6d), 22.17 (CH_3-CO-NH), 66.81, 67.17, 67.96, 68.04,68;26 (CH_2benz), 68.56, 69.59, 70.77, 71.16 (C-6a, C-6b, C-6c, C-6e), 72.02, 72.61, 72.78, 73.04, 73.14, 73.26, 73.61, 73.95 (C-5a, C-5b, C-5c, C-5d, C-5e), 74.45, 74.71, 73.83, 74.91 (C-4a, C-4b, C-4c, C-4d, C-4e), 74.94, 75.72, 76.00, 76.69 (C-3a, C-3b, C-3c, C-3d, C-3e), 76.01, 77.18, 77.33, 78.94, 79.44, 79.95, 81.43, 82.54 (C-2a, C-2b, C-2d, C-2e), 96.28-99.94 (C-1d, C-1e), 100.93, 102.00, 102.19 (C-1a, C-1b, C-1c), 127.01-128.41 (CH arom), 137.24, 137.32, 137.51, 137.93, 138.13, 138.18, 138.26, 138.42, 138.61, 138.70 (C arom), 170.04 (CH_3-CO).

Anal. Calcd for $C_{102}H_{113}NO_{31}Na_2S_2$, 3 H_2O: C, 60.86; H, 5.96; N, 0.70; S, 3.19. Found: C, 60.85; H, 5.93; N, 0.98; S, 2.99.

***O*-(3-*O*-Sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(α-L-fucopyranosyl)-(1→3)] -*O*-(2-acetamido-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(β-D-galactopyranosyl)-(1→4)-β-D-glucopyranose Sodium Salt (22).** A solution of the protected pentasaccharide **19** (0.130 g, 70 μmol) in a 2.5:1 mixture of ethanol and water (3.5 mL) was stirred at room temperature under H_2 (1 atm) in the presence of Pd/C (10%, 0.150 g). After 60 h, the reaction mixture was then filtered and concentrated. An aqueous solution of the residue was then passed through acidic resin (AG50WX8, Na^+ form), concentrated, then lyophilized to give **22** (0.063 g, 94%) as a white powder. $[\alpha]_D^{29}$ -7 °(*c* 1.54, H_2O); ^1H NMR (D_2O, 400 MHz) δ 1.17 (d, 3 H, $J_{5d.6d}$ = 6.7 Hz, CH_3d), 2.02 (s, 3 H, CH_3CONH), 4.16 (d, 1 H, $J_{3b.4b}$ = 2.6 Hz, H-4b), 4.26 (d, 1 H, $J_{3e.4e}$ = 3.25 Hz, H-4e), 4.32 (dd, 1 H, $J_{2e.3e}$ = 9.9 Hz, $J_{3e.4e}$ = 3.25 Hz, H-3e), 4.43 (d, 1 H, $J_{1b.2b}$ = 7.78 Hz, H-1b), 4.58 (d, 1 H, $J_{1e.2e}$ = 7,8 Hz, H-1e), 4.66 (d, 1 H, $J_{1a.2a}$ = 7.95 Hz, H-1a (β)), 4.70 (d, 0.66 H, $J_{1c.2c}$ = 8.3 Hz, H-1c), 4.82 (bq, 1 H, H-5d), 5.13 (d, 1 H, $J_{1d.2d}$ = 3.8 Hz, H-1d), 5.22 (d, 0.34 H, $J_{1a.2a}$ = 3.8 Hz, H-1a (α)); ^{13}C NMR (D_2O 100 MHz) δ 16.09 (C-6d), 23.11 (CH_3CONH), 56.82 (C-2c), 60.45 (C-6c), 60.84 (C-6a (β)), 60.96 (C-6a (α)), 61.78 (C-6b), 62.14 (C-6e), 67.47, 67.53, 68.55, 69.11, 69.96, 70.03, 70.80, 70.84, 71.97, 72.22, 70.80, 70.94, 71.97, 72.22, 72.73, 74.01, 74.64, 75.18, 75.41, 75.61, 75.61, 75.69, 75.86, 79.23, 79.33, 79.33, 81,86 (C-3e) 82.90, 92.62 (C-1a(α)), 96.55 (C-1a(β)), 99.31 (C-1d), 102.23 (C-1e), 103.29 (C-1c), 103.74 (C-1b), 175.48 (NHAc). MS (FAB$^-$) Calcd for $C_{32}H_{54}NO_{28}NaS$: 955.25. Found: 932.1 (M-Na)$^-$.

***O*-(6-*O*-Sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(β-D-galactopyranosyl)-(1→4)-β-D-glucopyranose Sodium Salt (23).** A solution of the protected pentasaccharide **20** (0.080 g, 36.9 μmol) in a 2.5:1 mixture of ethanol and water (3.5 mL) was stirred at room temperature under H_2 (1 atm) in the presence of Pd/C (10%, 0.1 g). After 60 h, the reaction mixture was filtered and concentrated. An aqueous solution of the residue was then passed through acidic resin (AG50WX8, Na^+ form), concentrated then lyophilized to give **23** (0.040 g, 98%) as a white powder. $[\alpha]_D^{29}$ -15° (*c* 0.8, H_2O); ^1H NMR (D_2O, 400 MHz) δ 1.176 (d, 3 H, $J_{5d.6b}$ = 6.55 Hz, CH-3d), 2.020 (s, 3 H, CH_3-CO-NH), 3.28 (m, 0.66 H, H-2ab), 4.10-4.20 (m, 3 H, H- 4b , H- 6e, H- 6'e), 4.43 (d, 1 H, $J_{1b.2b}$ = 7.84 Hz, H-1b), 4.48 (d, 1 H, $J_{1e.2e}$ = 7.85 Hz, H- 1e), 4.664(d, 1 H, $J_{1aβ.\ 2aβ}$ = 7.97 Hz, H-1ab), 4.71 (d, 0.66 H, $J_{1c.\ 2c}$ = 8.37 Hz, H-1c), 5.11 (d, 1 H, $J_{1d.\ 2d}$ = 3.96 Hz, H-1d), 5.22 (d, 0.34 H, $J_{1aα.\ 2aα}$ = 3.73 Hz, H-1aα) ; ^{13}C NMR (D_2O, 100 MHz) δ 16.16 (C-6d), 23.12 (CH_3-CO-NH), 56.83 (C-2c), 60.64 (C-6c), 60.87 (C-6aα), 60.98 (C-6aβ), 61.78 (C-6b), 67.79 (C-6e), 67.49, 68.70, 69.12, 70.01, 70.81, 70.65, 71.80,

71.99, 72.23, 72.85, 3.01, 73.16, 74.36, 74.64, 75.19, 75.61, 75.70, 75.79, 76.03, 79.27, 79.37, 82.87, 92.64 (C-1aα), 96.57 (C-1aβ), 99.31 (C-1d), 102.53 (C-1e), 103.26 (C-1c), 103.76 (C-1b), 175.45 (CH_3-CO-NH). MS (FAB$^-$) Calcd for $C_{32}H_{54}NO_{28}NaS$: 955.25. Found: 932.2 (M-Na)$^-$.

***O*-(3,6-Di-*O*-sulfo-β-D-galactopyranosyl)-(1→4)- [*O*-(α-L-fucopyranosyl)-(1→3)]-*O*-(2-acetamido-2-*O*-deoxy-β-D-glucopyranosyl)-(1→3)-*O*-(β-D-galactopyranosyl)-(1→4)-β-D-glucopyranose Sodium Salt (24).** A solution of the protected pentasaccharide **21** (0.077 g, 39.3 μmol) in a 2.5:1 mixture of ethanol and water (3.5 mL) was stirred at room temperature under H_2 (1 atm) in the presence of Pd/C (10%, 0.1 g). After 60 h, the reaction mixture was then filtered through celite and concentrated. An aqueous solution of the residue was then passed through acidic resin (AG50WX8, Na^+ form), concentrated then lyophilized to give **24** (0.039 g, 94%) as a white powder. ^{1}H NMR (D_2O, 400 MHz) δ 1.212 (d, 3 H, CH-3d, 2.056 (s, 3 H, CH_3-CO-NH), 3.317 (m, 0.64 H, H-2aβ), 4.15-4.25 (m, 3 H, H-4b, H-6b, and H-6b'e), 4.35 (d, 1 H, $J_{3e,4e}$ = 3.23 Hz, H-4e), 4.38 (dd, 1 H, $J_{2e,3e}$ = 9.69 Hz, $J_{3e,4e}$ = 3.23 Hz, H-3e), 4;47 (d, 1 H, $J_{1e,2b}$ = 7.79 Hz, H-1b) 4.63 (d, 1 H, $J_{1e,2e}$ = 7.85 Hz, H-1e), 4.69 (d, 0.64 H, $J_{1aβ,2β}$ = 7.97 Hz, H-1aβ), 4.47 (d, 1 H, $J_{1c,2c}$ = 8.20 Hz, H-1c), 5.15 (d, 1 H, $J_{1c,2c}$ = 8.20 Hz, H-1d) 5.25 (d, 0.36 H, $J_{1aα,2aα}$ = 4.06 Hz, H-1aα) ; ^{13}C NMR ((D_2O, 100 MHz) δ 16.14 (C-6d), 23.13 (CH_3-CO-NH), 56.84 (C-2c), 60.58 (C-6c), 60.87 (C-6aβ), 61.00 (C-6aα), 61.79 (C-6b), 67.81 (C-6e), 67.19, 67.47, 68.72, 69.11, 69.90, 70.00, 70.82, 70.95, 72.00, 72.23, 72.81, 74.45, 74.66, 75.20, 75.63, 75.67, 75.71, 75.95, 79.30, 79.40, and 82.91 (C-2a (α et β), C-2b, C-2c, C-2d, C-2e, 3a (α et β), C-3b, C-3c, C-3d, C-4a (α et β), C-4b, C-4c, C-4d, C-4e, C-5a (α et β), C-5b, C-5c, C-5e), 80.76 (C-3e), 92.64 (C-1aβ), 96.57 (C-1aα), 99.28 (C-1d), 102.17 (C-1e), 103.27 (C-1c), 103.76 (C-1b), 175.44 (CH_3-CO-NH). MS (FAB$^-$) Calcd for $C_{33}H_{53}NO_{31}Na_2S_2$: 1057.8. Found: 1034.1 (M-Na)$^-$.

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