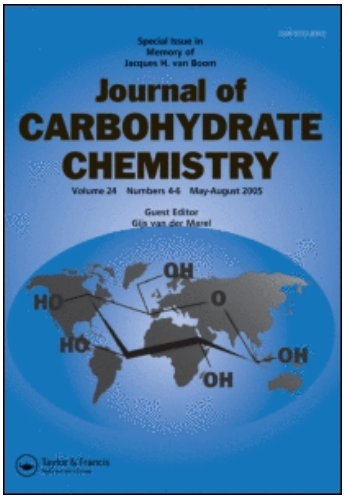


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# Synthetic Studies on Sialoglycoconjugates 60: α-Stereocontrolled, Glycoside Synthesis of Trimeric Sialic Acid with Galactose and Lactose Derivatives

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# SYNTHETIC STUDIES ON SIALOGLYCOCONJUGATES 60: α-STEREOCONTROLLED, GLYCOSIDE SYNTHESIS OF TRIMERIC SIALIC ACID WITH GALACTOSE AND LACTOSE DERIVATIVES

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## ABSTRACT

α-Stereocontrolled, glycoside synthesis of trimeric sialic acid is described toward a systematic approach to the synthesis of sialoglycoconjugates containing an α-sialyl-(2→8)-α-sialyl-(2→8)-sialic acid unit α-glycosidically linked to *O*-3 of a galactose residue in their oligosaccharide chains. Glycosylation of 2-(trimethylsilyl)ethyl 6-*O*-benzoyl-β-D-galactopyranoside (**4**) or 2-(trimethylsilyl)ethyl 2,3,6,2',6'-penta-*O*-benzyl-β-lactoside (**5**), with methyl {phenyl 5-acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-2-thio-D-*glycero*-D-*galacto*-2-nonulopyranosid}onate (**3**), using *N*-iodosuccinimide-trifluoromethanesulfonic acid as a promoter, gave the corresponding α-glycosides **6** and **8**, respectively. The glycosyl donor **3** was prepared from trimeric sialic acid by treatment with Amberlite IR-120 ($H^+$) resin in methanol, *O*-acetylation, and subsequent replacement of the anomeric acetoxy group with phenylthio. Compounds **6** and **8** were converted into the per-*O*-acyl derivatives **7** and **9**, respectively.

## INTRODUCTION

Sialic acid-containing oligosaccharides are the important constituent of cell membrane-glycoconjugates. Biologically, these membrane components are considered to be responsible for many primary physiological activities.[1] An approach toward the systematic understanding of the functions of the sialoglycoconjugates at the molecular

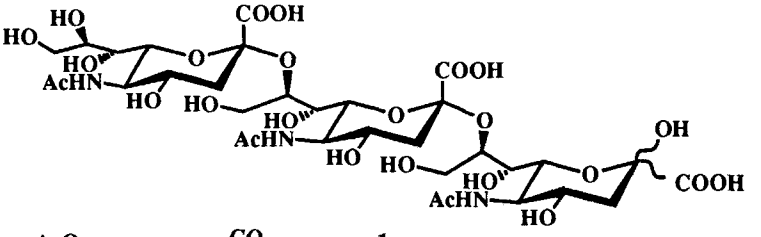
level necessitates efficient stereoselective synthetic routes, affording various sialo-oligosaccharides, their derivatives and analogs. The focal point in the synthesis of sialo-oligosaccharides has been the facile α-glycosylation of sialic acids. We have developed[2,3] a facile regio- and α-stereoselective glycosylation of sialic acids using the 2-thioglycosides of sialic acids as the glycosyl donors and the suitably protected carbohydrate acceptors with dimethyl(methylthio)sulfonium triflate[4] (DMTST) or *N*-iodosuccinimide[5,6] (NIS) as the glycosyl promoter in acetonitrile solution. This method has served us for the systematic synthesis of gangliosides[7] and their analogs,[8] useful for the elucidating the functions of these substances.

There are many sialoglycoconjugates[1a] containing an α-sialyl-(2→8)-sialic acid or α-sialyl-(2→8)-α-sialyl-(2→8)-sialic acid unit in their molecules, and these have many important biological roles.[9] In the previous paper,[10] we have demonstrated a facile, α-glycoside synthesis of a dimeric sialic acid using the phenyl 2-thioglycoside derivative of α-sialyl-(2→8)-sialic acid in the presence of NIS-TfOH in acetonitrile solution. As a continuation of our synthetic efforts, we describe here the first α-glycoside synthesis of a trimeric sialic acid with the galactose and lactose derivatives toward systematic synthesis of polysialoglycoconjugates.



## RESULTS AND DISCUSSION

Methyl {phenyl 5-acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-2-thio-D-*glycero*-D-*galacto*-2-nonulopyranosid}onate (**3**) was selected as the glycosyl donor of the trimeric sialic acid, while 2-(trimethylsilyl)ethyl 6-*O*-benzoyl-β-D-galactopyranoside[11] (**4**) and 2-(trimethylsilyl)ethyl 2,3,6,2',6'-penta-*O*-benzyl-β-D-lactoside[2b] (**5**) served as the acceptors in the syntheses of the objective tetrasaccharide **6** and pentasaccharide **8**. Treatment of *O*-(5-acetamido-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonic acid)-(2→8)-*O*-(5-acetamido-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonic acid)-(2→8)-5-acetamido-3,5-dideoxy-D-*glycero*-D-*galacto*-2-nonulopyranosonic acid (**1**), which was prepared by hydrolysis of colominic acid under mild, acidic conditions according to the literature,[12] with Amberlite IR-120 ($H^+$) resin in methanol for 2 days at 40 °C, followed by acetylation, gave an anomeric mixture (α:β ratio 1:3) of the ester-lactone **2** in 48% yield. The conversion of **2** into the phenyl thioglycoside **3** (80%; the α:β ratio was estimated as ~1:4 from the relative intensities of H-3*eq* signals) was achieved by treatment[13] with thiophenol and



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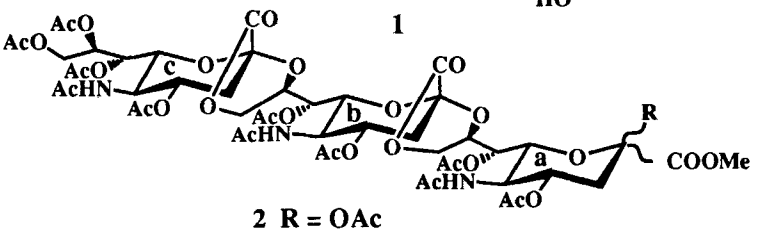
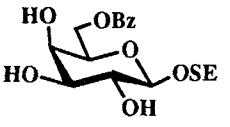


2 R = OAc
3 R = SPh



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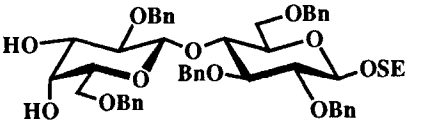

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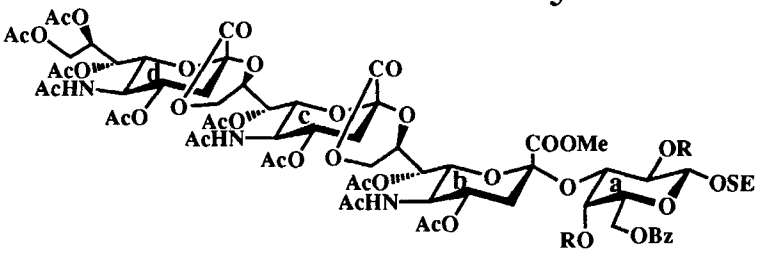
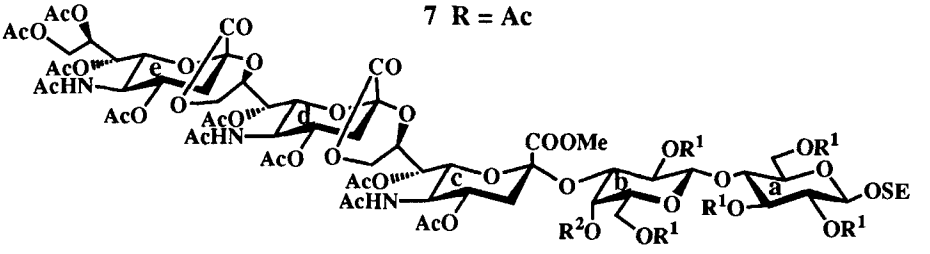


6 R = H
7 R = Ac



8 $R^1$ = Bn, $R^2$ = H
9 $R^1$ = $R^2$ = Ac

Ph = phenyl
SE = 2-(trimethylsilyl)ethyl
Bz = benzoyl
Bn = benzyl

boron trifluoride etherate for 12 h at room temperature in dichloromethane. Significant signals in the $^1$H NMR spectrum of **3** were at δ 2.45 (2m, H-3b*eq*, H-3c*eq*), 2.70 (dd, $J_{3ax,3eq}$ = 13.9 Hz, $J_{3eq,4}$ = 4.6 Hz, H-3a*eq*), 3.58 (s, 3H, MeO) and 7.28-7.54 (m, 5H, Ph).

Glycosylation of **4** with **3** thus obtained, in acetonitrile for 48 h at -35 °C in the presence of NIS-TfOH, gave the expected α-glycoside **6** in 30% yield. Acetylation of **6** gave the per-*O*-acyl derivative **7**. Characteristic signals in the $^1$H NMR spectrum of **7** were a one-proton doublet of doublets at δ 2.53 (dd, 1H, $J_{3ax,3eq}$ = 12.9 Hz, $J_{3eq,4}$ = 4.9 Hz, H-3b*eq*), 5.04 (dd, 1H, $J_{1,2}$ = 8.3 Hz, $J_{2,3}$ = 10.2 Hz, H-2a), 5.07 (m, 1H, H-4b), and 5.26 (d, 1H, $J_{3,4}$ = 3.4 Hz, H-4a), indicating the newly formed glycosidic linkage to be α at the C-3 position of the galactose residue. Other $^1$H NMR data are given in the Experimental section and are consistent with the structure assigned. In essentially the same way, glycosylation of **5** with **3** gave exclusively the α-glycoside **8** in 49% yield. Hydrogenolytic removal of the benzyl groups in **8** over 10% Pd-C in methanol-acetic acid for 3 days at 45 °C, followed by acetylation of the free hydroxy groups with acetic anhydride-pyridine, afforded the fully acetylated oligosaccharide **9** in 70% yield; significant signals in the $^1$H NMR spectrum of **9** were at δ 2.55 (dd, 1H, $J_{3ax,3eq}$ = 13.2 Hz, $J_{3eq,4}$ = 5.1 Hz, H-3c), 4.36 (dd, 1H, $J_{2,3}$ = 10.0 Hz, $J_{3,4}$ = 3.3 Hz, H-3b), 5.06 (m, 1H, H-4c), and 5.11 (d, 1H, $J_{3,4}$ = 3.3 Hz, H-4b), indicating the desired stereo- and regio-chemistry of the newly formed, glycosidic linkage.

In summary, the work showed that the use of the phenyl 2-thioglycoside derivative of trimeric sialic acid in the presence of NIS-TfOH in acetonitrile solution is effective for obtaining the α-glycosides. The α-glycosides described herein could be used as the intermediates in the synthesis of C-series of gangliosides.



## EXPERIMENTAL

**General Procedures.** Optical rotations were determined with a Union PM-201 polarimeter at 25 °C, and IR spectra were recorded with a Jasco IRA-100 spectrophotometer. $^1$H NMR spectra were recorded at 270 MHz with a JEOL JNM-GX 270 spectrometer and at 500 MHz with a Varian VXR-500S spectrometer. Preparative chromatography was performed on silica gel (Wako Chemical Co., 200 mesh) with the solvent systems specified. Concentrations were conducted *in vacuo*.

**Methyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-2,4,7-tri-*O*-acetyl-3,5-dideoxy-D-**

***glycero*-D-*galacto*-2-nonulopyranosonate (2).** To a suspension of *O*-(5-acetamido-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonic acid)-(2→8)-*O*-(5-acetamido-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonic acid)-(2→8)-5-acetamido-3,5-dideoxy-D-*glycero*-D-*galacto*-2-nonulopyranosonic acid (**1**; 100 mg, 0.1 mmol) in dry MeOH (6.0 mL) was added Amberlite IR-120 ($H^+$) resin (400 mg) and the mixture was stirred for 2 days at 40 °C; the progress of the reaction was monitored by TLC. The resin was removed by filtration, and washed with MeOH. The filtrate and washings were combined and concentrated. To a suspension of the residue in $Ac_2O$ (0.3 mL) was added dropwise pyridine (0.3 mL) at 0 °C, and mixture was stirred for 24 h at 40 °C. After the addition of MeOH (0.5 mL) at 0 °C the reaction mixture was concentrated, and the residue extracted with $CH_2Cl_2$. The extract was washed with 2M HCl and M $Na_2CO_3$, dried ($Na_2SO_4$) and concentrated. Column chromatography (25:1 $CH_2Cl_2$-MeOH) of the residue on silica gel (20 g) gave **2** (67 mg, 48%) as an amorphous mass: IR (KBr) 3300 (NH), 1740 and 1220 (ester), 1660 and 1530 $cm^{-1}$ (amide); $^1H$ NMR ($CDCl_3$) at 270 MHz δ 1.89, 1.90 and 1.91 (3s, 9H, 3AcN), 1.98-2.17 (9s, 27H, 9AcO), 2.73-2.65 (m, 3H, H-3a*eq*, H-3b*eq* and H-3c*eq*), 3.79 (s, 3H, MeO), and 5.41 and 5.55 (2m, 2H, H-4b and H-4c).

Anal. Calcd for $C_{52}H_{69}N_3O_{32}$ (1248.1): C, 60.53; H, 6.39; N, 1.59. Found: C, 60.43; H, 6.55; N, 1.59.

**Methyl {Phenyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-2-thio-D-*glycero*-D-*galacto*-2-nonulopyranosid}onate (3).** To a solution of **2** (120 mg, 0.1 mmol) in $CH_2Cl_2$ (2 mL) were added thiophenol (40 μL, 0.4 mmol) and boron trifluoride etherate (0.2 mL, 0.8 mmol), and the mixture was stirred for 12 h at room temperature. Dichloromethane (10 mL) was added, and the solution was washed with M $Na_2CO_3$ and water, dried ($Na_2SO_4$) and concentrated. Column chromatography (25:1 $CH_2Cl_2$-MeOH) of the residue on silica gel (20 g) gave **3** (100 mg, 80%) as an amorphous mass: IR (KBr) 3300 (NH), 1740 and 1220 (ester), 1660 and 1530 (amide), and 700 $cm^{-1}$ (Ph); $^1H$ NMR ($CDCl_3$) at 270 MHz δ 1.90, 1.91 and 1.92 (3s, 9H, 3AcN), 2.01-2.19 (8s, 24H, 8AcO), 2.43 and 2.48 (2m, 2H, H-3b*eq* and H-3c*eq*), 2.70 (dd, $J_{3ax,3eq}$ = 13.9 Hz, $J_{3eq,4}$ = 4.6 Hz, H-3a*eq*), 3.58 (s, 3H, MeO), and 7.28-7.54 (m, 5H, Ph).

Anal. Calcd for $C_{56}H_{71}N_3O_{30}S$ (1298.2): C, 51.81; H, 5.51; N, 3.24. Found: C, 51.67; H, 5.68; N, 3.06.

**2-(Trimethylsilyl)ethyl *O*-{Methyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate}-(2→3)-6-*O*-benzoyl-β-D-galactopyranoside (6).** To a solution of **3** (200 mg, 0.15 mmol) and 2-(trimethylsilyl)ethyl 6-*O*-benzoyl-β-D-galactopyranoside[11] (**4**; 150 mg, 0.30 mmol) in MeCN (0.5 mL) were added molecular sieves 3Å (150 mg) and the mixture was stirred for 5 h at room temperature, then cooled to -35 °C. To the cooled mixture were added, with stirring, *N*-iodosuccinimide (NIS, 70 mg, 0.3 mmol) and trifluoromethanesulfonic acid (TfOH, 3μL, 0.03 mmol), and the stirring was continued for 2 days at -35 °C. The solids were removed by filtration and washed with $CH_2Cl_2$. The combined filtrate and washings were successively washed with M $Na_2CO_3$ and M $Na_2S_2O_3$, dried ($Na_2SO_4$) and concentrated. Column chromatography (30:1 $CH_2Cl_2$-MeOH) of the residue on silica gel (40 g) gave **6** (70 mg, 30%) as an amorphous mass: $[\alpha]_D$ -20.0° (*c* 0.4, $CHCl_3$); IR (KBr) 3600-3100 (OH, NH), 1730 and 1220 (ester), 1650 and 1540 (amide), 860 and 840 ($Me_3Si$), and 710 $cm^{-1}$ (Ph); $^1H$ NMR ($CDCl_3$) at 270 MHz δ 1.00 (m, 2H, $Me_3SiCH_2CH_2$), 1.90, 1.91 and 1.93 (3s, 9H, 3AcN), 2.04-2.20 (8s, 24H, 8AcO), 2.36, 2.55 and 2.74 (3m, 3H, H-3d*eq*, H-3c*eq* and H-3b*eq*), 3.81 (s, 3H, MeO), and 7.28-8.10 (m, 5H, Ph).

Anal. Calcd for $C_{68}H_{93}N_3O_{37}Si$ (1572.6): C, 51.93; H, 5.96; N, 2.67. Found: C, 51.90; H, 5.66; N, 2.59.

**2-(Trimethylsilyl)ethyl *O*-{Methyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate}-(2→3)-2,4-di-*O*-acetyl-6-*O*-benzoyl-β-D-galactopyranoside (7).** Acetylation of **6** (70 mg, 0.04 mmol) with $Ac_2O$ (0.5 mL) and pyridine (1 mL) for 10 h at room temperature gave **7** (74 mg, quantitative): $[\alpha]_D$ -33.0° (*c* 0.03, $CHCl_3$); IR (KBr) 3300 (NH), 1730 and 1220 (ester), 1650 and 1540 (amide), 860 and 840 ($Me_3Si$), and 710 $cm^{-1}$ (Ph); $^1H$ NMR ($CDCl_3$) at 500 MHz δ 1.00 (m, 2H, $Me_3SiCH_2CH_2$), 1.83-1.90 (m, 3H, H-3b*ax*, H-3c*ax*, and H-3d*ax*), 1.83, 1.90 and 1.92 (3s, 9H, 3AcN), 2.02, 2.03, 2.04, 2.05, 2.06, 2.08, 2.12, 2.13, 2.14 and 2.20 (10s, 30H, 10AcO), 2.32 (dd, 1H, $J_{3ax,3eq}$ = 13.2 Hz, $J_{3eq,4}$ = 5.3 Hz, H-3d*eq*), 2.53 (dd, 1H, $J_{3ax,3eq}$ = 12.9 Hz, $J_{3eq,4}$ = 4.9 Hz, H-3b*eq*), 2.56 (dd, 1H, $J_{3ax,3eq}$ = 13.2 Hz, $J_{3eq,4}$ = 5.6 Hz, H-3c*eq*), 3.60 and 3.99 (2m, 2H, $Me_3SiCH_2CH_2$), 3.69 (dd, 1H, $J_{5,6}$ = 10.5 Hz, $J_{6,7}$ =

1.5 Hz, H-6b), 3.79 (s, 3H, MeO), 3.92 (dd, 1H, $J_{5,6}$ = 10.5 Hz, $J_{6,7}$ = 2.2 Hz, H-6d), 3.95 (dd, 1H, $J_{5,6}$ = 10.5 Hz, $J_{6,7}$ = 2.5 Hz, H-6c), 4.02 (dd, 1H, $J_{8,9}$ = 5.2 Hz, $J_{9,9'}$ = 11.7 Hz, H-9b), 4.04 (q, 1H, $J_{4,5}$ = $J_{5,6}$ = $J_{5,NH}$ = 10.5 Hz, H-5b), 4.09 (dd, 1H, $J_{8,9}$ = 5.4 Hz, $J_{9,9'}$ = 12.7 Hz, H-9d), 4.19 (q, 1H, $J_{4,5}$ = $J_{5,6}$ = $J_{5,NH}$ = 10.5 Hz, H-5d), 4.29 (q, 1H, $J_{4,5}$ = $J_{5,6}$ = $J_{5,NH}$ = 10.2 Hz, H-5c), 4.29 (dd, 1H, $J_{8,9'}$ = 2.7 Hz, $J_{9,9'}$ = 12.7 Hz, H-9'd), 4.39 (dd, 1H, $J_{2,3}$ = 10.2 Hz, $J_{3,4}$ = 3.4 Hz, H-3a), 4.45 (m, 1H, H-8c), 4.56 (d, 1H, $J_{1,2}$ = 8.3 Hz, H-1a), 4.57 (m, 1H, H-8b), 5.03 (dd, 1H, $J_{6,7}$ = 1.5 Hz, $J_{7,8}$ = 9.3 Hz, H-7b), 5.04 (dd, 1H, $J_{1,2}$ = 8.3 Hz, $J_{2,3}$ = 10.2 Hz, H-2a), 5.06 (dd, 1H, $J_{6,7}$ = 2.5 Hz, $J_{7,8}$ = 9.7 Hz, H-7c), 5.07 (m, 1H, H-4b), 5.14 (m, 1H, H-8d), 5.26 (d, 1H, $J_{3,4}$ = 3.4 Hz, H-4a), 5.33 (dd, 1H, $J_{6,7}$ = 2.2 Hz, $J_{7,8}$ = 8.3 Hz, H-7d), 5.37 (m, 1H, H-4d), 5.57 (m, 1H, H-4c), and 7.41-8.02 (m, 5H, Ph).

Anal. Calcd for $C_{72}H_{97}N_3O_{39}Si$ (1656.6): C, 52.20; H, 5.90; N, 2.54. Found: C, 52.17; H, 5.66; N, 2.46.

**2-(Trimethylsilyl)ethyl *O*-{Methyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate}-(2→3)-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (8).** To a solution of **3** (100 mg, 0.08 mmol) and 2-(trimethylsilyl)ethyl *O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside[2b] (**5**; 140 mg, 0.16 mmol) in MeCN (0.5 mL) were added molecular sieves 3Å (100 mg) and the mixture was stirred for 5 h at room temperature, then cooled -35 °C. To the cooled solution were added NIS (50 mg, 0.24 mmol) and TfOH (2 μL, 0.02 mmol), and the stirring was continued for 2 days at -35 °C. The solids were removed by filtration, and washed with $CH_2Cl_2$. The combined filtrate and washings were washed with M $Na_2CO_3$ and M $Na_2S_2O_3$, dried ($Na_2SO_4$) and concentrated. Column chromatography (20:1 $CH_2Cl_2$-MeOH) of the residue on silica gel (20 g) gave **8** (78 mg, 49%) as an amorphous mass: $[\alpha]_D$ -15.3° (*c* 1.6, $CHCl_3$); IR (KBr) 3600-3100 (OH, NH), 1730 and 1220 (ester), 1650 and 1540 (amide), 860 and 840 ($Me_3Si$), and 700 $cm^{-1}$ (Ph); $^1H$ NMR ($CDCl_3$) at 270 MHz δ 1.00 (m, 2H, $Me_3SiCH_2CH_2$), 1.86-2.14 (11s, 33H, 3AcN and 8AcO), 3.75 (s, 3H, MeO), 5.36 and 5.55 (2m, 2H, H-4d and H-4e), and 7.19-7.37 (m, 25H, 5Ph).

Anal. Calcd for $C_{102}H_{129}N_3O_{41}Si$ (2081.2): C, 58.87; H, 6.25; N, 2.02. Found: C, 58.73; H, 6.42; N, 1.84.

**2-(Trimethylsilyl)ethyl {Methyl 5-Acetamido-8-*O*-[5-acetamido-8-*O*-(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1",9'-lactone)-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylono-1',9-lactone]-4,7-di-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosylonate}-(2→3)-*O*-(2,4,6-tri-*O*-acetyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-acetyl-β-D-glucopyranoside (9).** A solution of **8** (78 mg, 0.04 mmol) in MeOH (8 mL) and acetic acid (8 mL) was hydrogenolyzed in the presence of 10% Pd-C (80 mg) for 3 days at 45 °C. The solids were removed by filtration and washed with MeOH. The combined filtrate and washings were concentrated, and the residue was acetylated with $Ac_2O$ (1 mL) and pyridine (2 mL) for 12 h at 45 °C. The product was purified by column chromatography (20:1 $CH_2Cl_2$-MeOH) on silica gel (20 g) to give **9** (50 mg, 70%) as an amorphous mass: $[\alpha]_D$ -20.8° (*c* 0.4, $CHCl_3$); IR (KBr) 3300 (NH), 1740 and 1220 (ester), 1660 and 1530 (amide), and 860 and 840 $cm^{-1}$ ($Me_3Si$); $^1H$ NMR ($CDCl_3$) at 500 MHz δ 1.00 (m, 2H, $Me_3SiCH_2CH_2$), 1.74 (t, 1H, $J_{3ax,3eq} = J_{3ax,4} = 12.5$ Hz, H-3c*ax*), 1.84, 1.90 and 1.93 (3s, 9H, 3AcN), 2.01, 2.02, 2.03, 2.03, 2.04, 2.06, 2.08, 2.09, 2.09, 2.11, 2.12, 2.17 and 2.19 (14s, 42H, 14AcO), 2.37 (dd, 1H, $J_{3ax,3eq} = 13.4$ Hz, $J_{3eq,4} = 5.4$ Hz, H-3e*eq*), 2.55 (dd, 1H, $J_{3ax,3eq} = 13.2$ Hz, $J_{3eq,4} = 5.1$ Hz, H-3c*eq*), 2.58 (dd, 1H, $J_{3ax,3eq} = 13.2$ Hz, $J_{3eq,4} = 5.6$ Hz, H-3d*eq*), 3.56 and 3.94 (2m, 2H, $Me_3SiCH_2CH_2$), 3.60 (ddd, 1H, $J_{4,5} = 9.8$ Hz, $J_{5,6} = 2.0$ Hz, $J_{5,6'} = 5.1$ Hz, H-5a), 3.66 (dd, 1H, $J_{5,6} = 10.7$ Hz, $J_{6,7} = 1.7$ Hz, H-6c), 3.78 (t, 1H, $J_{3,4} = J_{4,5} = 9.8$ Hz, H-4a), 3.84 (s, 3H, MeO), 3.94 (dd, 1H, $J_{5,6} = 10.3$ Hz, $J_{6,7} = 2.1$ Hz, H-6e), 3.97 (dd, 1H, $J_{5,6} = 10.4$ Hz, $J_{6,7} = 2.5$ Hz, H-6d), 4.00 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH} = 10.0$ Hz, H-5c), 4.20 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH} = 10.3$ Hz, H-5e), 4.29 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH} = 10.4$ Hz, H-5d), 4.36 (dd, 1H, $J_{2,3} = 10.0$ Hz, $J_{3,4} = 3.3$ Hz, H-3b), 4.46 (d, 1H, $J_{1,2} = 8.3$ Hz, H-1a), 4.48 (d, 1H, $J_{1,2} = 8.1$ Hz, H-1b), 4.88 (dd, 1H, $J_{1,2} = 8.3$ Hz, $J_{2,3} = 9.8$ Hz, H-2a), 4.92 (dd, 1H, $J_{1,2} = 8.1$ Hz, $J_{2,3} = 10.0$ Hz, H-2b), 5.06 (m, 1H, H-4c), 5.07 (dd, 1H, $J_{6,7} = 1.7$ Hz, $J_{7,8} = 9.4$ Hz, H-7c), 5.11 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4b), 5.15 (dd, 1H, $J_{6,7} = 2.5$ Hz, $J_{7,8} = 9.5$ Hz, H-7d), 5.15 (m, 1H, H-8e), 5.17 (t, 1H, $J_{2,3} = J_{3,4} = 9.8$ Hz, H-3a), 5.33 (dd, 1H, $J_{6,7} = 2.1$ Hz, $J_{7,8} = 8.4$ Hz, H-7e), 5.35 (m, 1H, H-4e), and 5.58 (m, 1H, H-4d).

Anal. Calcd for $C_{79}H_{111}N_3O_{47}Si$ (1882.8): C, 50.40; H, 5.94; N, 2.23. Found: C, 50.15; H, 5.79; N, 2.07.

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