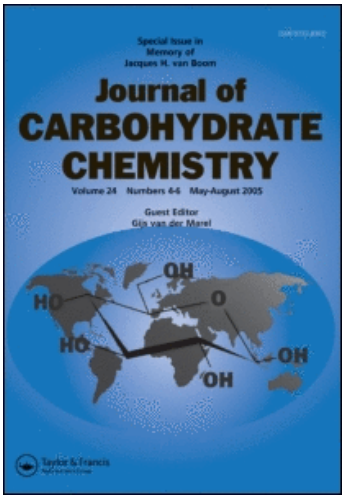

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Studies on the Thioglycosides of N-Acetylneuraminic Acid 7: Synthesis of S-(α-Sialyl)-(26)-β-D-Hexopyranosyl and -(26)-β-D-Lactosyl Ceramides and their Biological Activity

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STUDIES ON THE THIOGLYCOSIDES OF N-ACETYLNEURAMINIC ACID 7: SYNTHESIS OF S-(α-SIALYL)-(2→6)-ß-D-HEXOPYRANOSYL AND -(2→6)-ß-D-LACTOSYL CERAMIDES AND THEIR BIOLOGICAL ACTIVITY

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ABSTRACT

The coupling of the sodium salt of methyl 5-acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-2-thio-D-glycero-α-D-galacto-2-nonulopyranosonate (17) with 2-(trimethylsilyl)ethyl 2,3,4-tri-O-acetyl-6-bromo-6-deoxy-ß-D-galactopyranoside (5), glucopyranoside (10), and 2-(trimethylsilyl)ethyl 2,3,6,2',3',4'-hexa-O-acetyl-6'-bromo-6'-deoxy-ß-D-lactoside (16), gave the corresponding α-thioglycosides 18, 21, and 24 of the 2-thio-N-acetylneuraminic acid derivative in good yields, which were converted, via selective removal of the 2-(trimethylsilyl)ethyl group, trichloroacetimidation, and coupling with (2S,3R,4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol (27), into the ß-glycosides 28, 32, and 36, respectively.

Compounds 28, 32, and 36 were transformed, via selective reduction of the azide group, coupling with octadecanoic acid, O-deacetylation, and de-esterification, into the title compounds 31, 35, and 39, which showed potent inhibitory effect for sialidases from influenza and other viruses.

INTRODUCTION

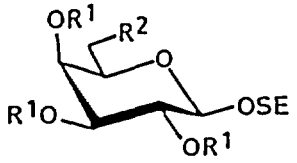
Sialic acids are well known as constituents of glycoproteins and glycolipids, and play an important role in biological processes.[1] It is also known that naturally occurring sialo compounds contain sialic acids in α-glycosidic linkage, except for CMP-N-acetylneuraminic acid. In view of these facts, derivatives, analogs and glycosides of sialic acids are of

interest as substrates and inhibitors[2-4] for sialidases or sialyl transferases, and potential modifiers of cell-surface sialic acid. In previous papers,[5] we demonstrated the stereoselective and high yield syntheses of a series of α- and ß-thioglycosides of 2-thio-N-acetylneuraminic acid, including ganglioside GM_4 thio-analogs. In addition, we achieved regio- and α-stereo-selective glycosidation[6] of Neu5Ac by using the methyl α-2-thioglycoside of Neu5Ac derivative as the glycosyl donor in the presence of dimethyl(methylthio)sulfonium triflate, and synthesized[7] a variety of gangliosides. As part of a program on the synthesis of sialoglycoconjugates containing α-thioglycoside of sialic acid we are trying to elucidate the role of sialic acid in the functions of sialoglycoconjugates, and attempting to obtain a sialidase inhibitor which, because of the α-thioglycosidic linkage of Neu5Ac, might be resistant to enzyme degradation. Toward that end we describe here the synthesis of S-(α-N-acetylneuraminyl)-(2→6)-ß-D-galactopyranosyl, -glucopyranosyl, and -(2→6')-ß-D-lactosyl ceramides.

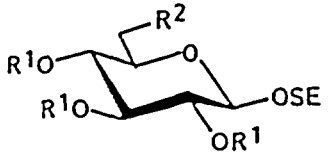
RESULTS AND DISCUSSION

For the synthesis of S-α-sialyl-(2→6)-ß-D-hexopyranosyl and -(2→6')-ß-D-lactosyl ceramides, we set out to prepare the per-O-acetylated-2-(trimethylsilyl)ethyl 6-bromo-6-deoxy-ß-D-galactopyranoside (5), glucopyranoside (10), and 6'-bromo-6'-deoxy-ß-D-lactoside (16) as glycosyl acceptors, for coupling with the sodium salt of methyl 5-acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-2-thio-D-glycero-α-D-galacto-2-nonulopyranosonate[5a] (17). The intermediate could then, by introduction of the ceramide moiety, be converted to the end products.

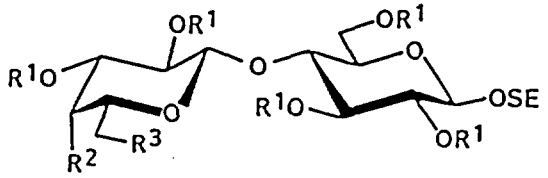
Treatment of 2-(trimethylsilyl)ethyl ß-D-galactopyranoside[8] (1) with t-butyldimethylsilyl chloride in pyridine gave the 6-O-TBDMS derivative 2 quantitatively, which was converted to 3 by acetylation. Selective removal of the TBDMS group in 3 under mild acidic conditions, and subsequent bromination[9] with N-bromosuccinimide in N,N-dimethylformamide in the presence of triphenylphosphine gave 2-(trimethylsilyl)ethyl 2,3,4-tri-O-acetyl-6-bromo-6-deoxy-ß-D-galactopyranoside (5) in good yield. In a similar way, compound 10 was prepared from 2-(trimethylsilyl)ethyl ß-D-glucopyranoside[8] (6). Treatment of 2-(trimethylsilyl)ethyl O-(ß-D-galactosyl)-(1→4)-ß-D-glucopyranoside[10] (11) with 2-methoxypropene in N,N-dimethylformamide in



1 R^1 = H, R^2 = OH
2 R^1 = H, R^2 = OTBDMS
3 R^1 = Ac, R^2 = OTBDMS
4 R^1 = Ac, R^2 = OH
5 R^1 = Ac, R^2 = Br

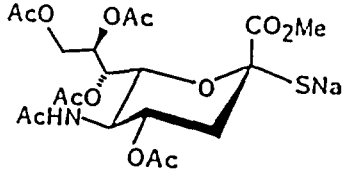


6 R^1 = H, R^2 = OH
7 R^1 = H, R^2 = OTBDMS
8 R^1 = Ac, R^2 = OTBDMS
9 R^1 = Ac, R^2 = OH
10 R^1 = Ac, R^2 = Br



11 R^1 = H, R^2 = R^3 = OH
12 R^1 = H, R^2 R^3 = $OCMe_2O$
13 R^1 = Ac, R^2 R^3 = $OCMe_2O$
14 R^1 = Ac, R^2 = R^3 = OH
15 R^1 = Ac, R^2 =OH, R^3 = Br
16 R^1 = Ac, R^2 = OAc, R^3 = Br

SE = $Me_3SiCH_2CH_2$-
TBDMS = $Me_3CSi(Me)_2$-

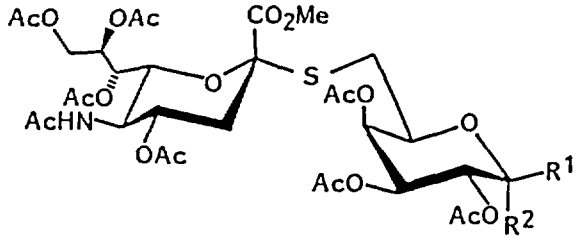


17

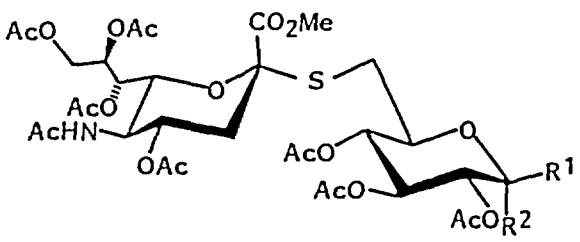
the presence of p-toluenesulfonic acid monohydrate, and subsequent acetylation gave 2-(trimethylsilyl)ethyl O-(2,3-di-O-acetyl-4,6-O-isopropylidene-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-ß-D-glucopyranoside (13) in 93% yield. The O-deisopropylidenation of 13 by heating with 80% aqueous acetic acid for 10 h at 45 °C gave crystalline 14 in 91% yield. Significant signals in the ^{1}H NMR spectrum of 14 were five three-proton singlets at δ 1.99, 2.01, 2.03, 2.06, and 2.09 (O-acetyl), three one-proton doublet of doublets at δ 4.85, 4.86, and 5.18 ($J_{2',3'}$ = 10.3 Hz, $J_{3',4'}$ = 3.7 Hz, H-3'; $J_{1,2}$ = 8.1 Hz, $J_{2,3}$ = 9.2 Hz, H-2; $J_{1',2'}$ = 7.9 Hz, H-2'), and a one-proton triplet at δ 5.16 ($J_{2,3}$ = $J_{3,4}$ = 9.2 Hz, H-3). Other ^{1}H NMR data are consistent with structure 14. Selective C-6' bromination of 14 with N-bromosuccinimide in the presence of triphenylphosphine and subsequent acetylation afforded compound 16 as crystals in good yield.

Treatment of compound 17, freshly derived from methyl 5-acetamido-4,7,8,9-tetra-O-acetyl-2-S-acetyl-3,5-dideoxy-2-thio-D-glycero-α-D-galacto-2-nonulopyranosonate[5a] by selective S-deacetylation with sodium methoxide, with 5 in N,N-dimethylformamide under a nitrogen atmosphere, yielded 2-(trimethylsilyl)ethyl S-(methyl 5-acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-β-D-galactopyranoside (18) in 89% yield, after column chromatography. The structure of 18 was unambiguously proved by 270 MHz ^{1}H NMR spectroscopy. The observed signals exhibited nine sharp singlets, each integrating for three protons, which demonstrated the presence of one-N-acetyl (δ 1.83), seven O-acetyl (δ 1.90-2.13), and one methyl ester (δ 3.79) groups; H-3e appeared at δ 2.66 ($J_{3a,3e}$ = 14.3 Hz, $J_{3e,4}$ = 4.8 Hz, Neu5Ac unit) and H-4 at δ 4.86 (ddd, $J_{3a,4}$ = 11.5 Hz, $J_{4,5}$ = 10.1 Hz; Neu5Ac unit), indicating the α-configuration[5] of the glycosidic linkage; H-6,6' (Gal unit) appeared at δ 2.60 and 2.85 each as a doublet of doublets ($J_{5,6}$ = $J_{5,6'}$ = 7.1 Hz, $J_{6,6'}$ = 14.5 Hz), showing the glycosidic position.

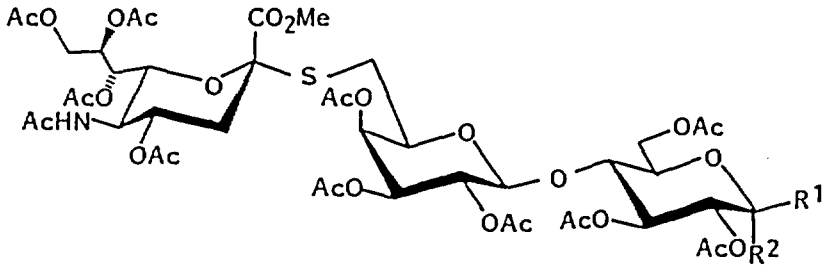
By essentially the same way described for 18, condensation of 17 with 10 or 16 afforded the corresponding α-thioglycosides 21 and 24 of N-acetylneuraminic acid derivative in 97 and 87% yields, respectively. NMR data from 21 and 24 demonstrated the fully blocked glycosides; each H-3e signal appeared at δ 2.69 and 2.70 as a one-proton doublet of doublets, and H-4 at δ 4.83 and 4.93 as a multiplet, indicating the α-thioglycoside



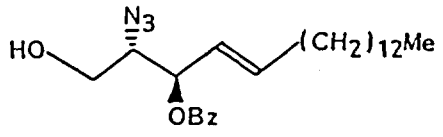
18 R^1 = OSE, R^2 = H
19 R^1, R^2 = H, OH
20 R^1 = H, R^2 = OC(=NH)CCl_3



21 R^1 = OSE, R^2 = H
22 R^1, R^2 = H, OH
23 R^1 = H, R^2 = OC(=NH)CCl_3



24 R^1 = OSE, R^2 = H
25 R^1, R^2 = H, OH
26 R^1 = H, R^2 = OC(=NH)CCl_3



27

Bz = benzoyl

of Neu5Ac derivative; H-6,6' of Glc unit in 21 and Gal unit in 24 at δ 2.83-2.92, demonstrating the assigned linkage position of Neu5Ac.

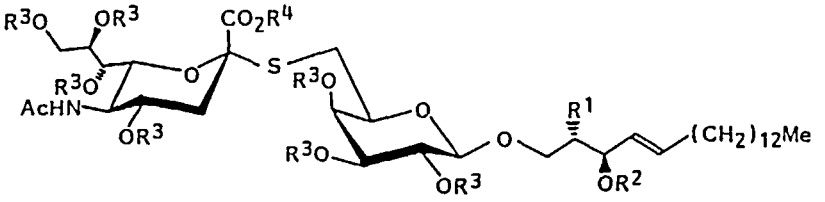
Selective removal[7,11] of the 2-(trimethylsilyl)ethyl group in 18 was performed by treatment of 18 with boron trifluoride etherate in dichloromethane for 2 h at -20 °C, to give 19 in 91% yield. When treated with trichloroacetonitrile[7,12,13] in the presence of 1,8-diazabicyclo[5.4.0]-undec-7-ene (DBU) for 2 h at 0 °C, compound 19 gave the trichloroacetimidate 20 as the α-anomer in 81% yield, after column chromatography. In a similar way, selective removal of the 2-(trimethylsilyl)ethyl group in 21 or 24, followed by trichloroacetimidation, yielded the corresponding α-imidates 23 and 26 in high yields.

The glycosylation of (2S,3R,4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol[14,15] (27) with 20 in the presence of boron trifluoride etherate for 6 h at -20 °C, yielded only the expected ß-glycoside 28 in 93% yield. A one-proton doublet at δ 4.73 ($J_{1,2}$ = 7.9 Hz, H-1) in the ^{1}H NMR spectrum of 28 showed the newly formed ß-glycosidic linkage. Other ^{1}H NMR data are consistent with structure 28. In the same way, when coupled with the acceptor 27, compounds 23 and 26 gave the desired ß-glycosides 32 and 36 in 84 and 82% yields, respectively.

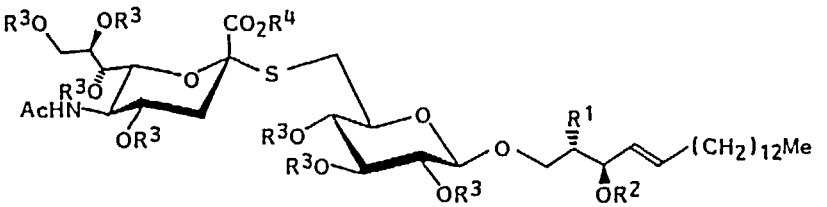
Selective reduction[7,16] of the azide group in 28 with hydrogen sulfide in 5:1 pyridine-water gave the amine 29, which, on condensation with octadecanoic acid using 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (WSC) in dichloromethane, gave the S-(α-N-acetylneuraminyl)-(2→6)-O-(6-thio-ß-D-galactopyranosyl)-(1→1)-ceramide derivative (30) in 96% yield. According to the same procedure described for 30, selective reduction of the azide group in compounds 32 and 36, and subsequent condensation with octadecanoic acid afforded the corresponding desired products 34 and 38 in high yields, respectively.

Finally, O-deacetylation of compounds 30, 34, and 38 with sodium methoxide in methanol, and subsequent saponification of the methyl ester group, yielded almost quantitatively the end products 31, 35, and 39, respectively.

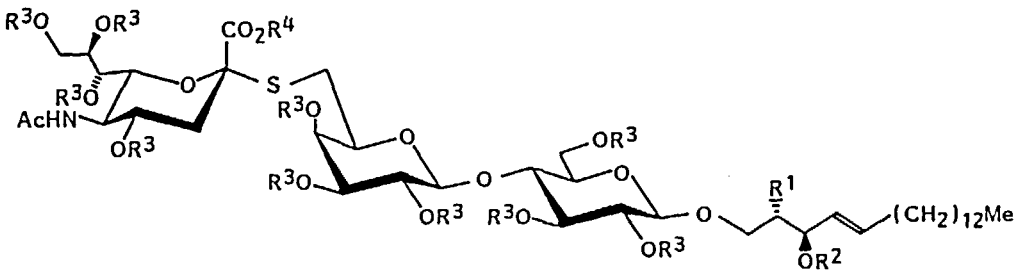
Compounds 31, 35, and 39 showed potent inhibition against sialidases from several kinds of influenza virus, and were competitive inhibitors. The order of decreasing inhibition was 39, 31, and 35. Detailed results[17] of the biological investigations will be published elsewhere.



28 $R^1 = N_3$, R^2 = Bz, R^3 = Ac, R^4 = Me
29 $R^1 = NH_2$, R^2 = Bz, R^3 = Ac, R^4 = Me
30 $R^1 = NHCO(CH_2)_{16}Me$, R^2 = Bz, R^3 = Ac, R^4 = Me
31 $R^1 = NHCO(CH_2)_{16}Me$, $R^2 = R^3 = R^4$ = H



32 $R^1 = N_3$, R^2 = Bz, R^3 = Ac, R^4 = Me
33 $R^1 = NH_2$, R^2 = Bz, R^3 = Ac, R^4 = Me
34 $R^1 = NHCO(CH_2)_{16}Me$, R^2 = Bz, R^3 = Ac, R^4 = Me
35 $R^1 = NHCO(CH_2)_{16}Me$, $R^2 = R^3 = R^4$ = H



36 $R^1 = N_3$, R^2 = Bz, R^3 = Ac, R^4 = Me
37 $R^1 = NH_2$, R^2 = Bz, R^3 = Ac, R^4 = Me
38 $R^1 = NHCO(CH_2)_{16}Me$, R^2 = Bz, R^3 = Ac, R^4 = Me
39 $R^1 = NHCO(CH_2)_{16}Me$, $R^2 = R^3 = R^4$ = H

EXPERIMENTAL

General procedures. Melting points were determined with a Yanagimoto micro melting point apparatus and are uncorrected. Specific rotations were determined with a Union PM-201 polarimeter at 25 °C, and IR spectra were recorded with a JASCO A-100 spectrometer. ^{1}H NMR spectra were recorded with a JEOL JNM-GX 270 spectrometer. Preparative chromatography was performed on silica gel (Wako Co., 200 mesh) with the solvent systems specified. Concentrations were conducted in vacuo.

2-(Trimethylsilyl)ethyl 6-O-t-Butyldimethylsilyl-ß-D-galactopyranoside (2). To a solution of 2-(trimethylsilyl)ethyl ß-D-galactopyranoside[8] (1; 500 mg, 1.78 mmol) in pyridine (5 mL), cooled to -5 °C, was added, with stirring, t-butyldimethylsilyl chloride (500 mg, 3.3 mmol), and the mixture was stirred for 3 h at room temperature. Methanol (2 mL) was added to the mixture, and concentrated to a syrup, which was chromatographed on a column of silica gel (60 g) with 1:3 ethyl acetate-hexane to give 2 (700 mg, quantitative) as a syrup: $[\alpha]_D$ -26.5° (c, 0.5, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.88 (s, 9H, Me_3CSi), 1.00 (m, 2H, $Me_3SiCH_2CH_2$), 3.46 (near t, 1H, H-5), 3.82 (dd, 1H, $J_{5,6}$ = 5.4 Hz, $J_{6,6'}$ = 10.3 Hz, H-6), 3.87 (dd, 1H, $J_{5,6'}$ = 5.6 Hz, H-6'), 3.96 (d, 1H, $J_{3,4}$ = 1.5 Hz, H-4), and 4.22 (d, 1H, $J_{1,2}$ = 7.3 Hz, H-1).

Anal. Calcd for $C_{17}H_{38}O_6Si_2$ (394.7): C, 51.74; H, 9.70. Found: C, 51.60; H, 9.91.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-6-O-t-butyldimethylsilyl-ß-D-galactopyranoside (3). A solution of 2 (670 mg, 1.7 mmol) in pyridine (6 mL) and acetic anhydride (3 mL) was stirred overnight at room temperature, and concentrated. The residue was chromatographed on a column of silica gel (80 g) with 1:4 ethyl acetate-hexane to give 3 (840 mg, 95%) as crystals. Recrystallization from ether-hexane gave needles: mp 95-97 °C, $[\alpha]_D$ -13.0° (c 0.6, chloroform); IR (KBr) 1760 and 1240 (ester), and 850 cm^{-1} (TMS); ^{1}H NMR ($CDCl_3$) δ 0.85 (s, 9H, Me_3CSi), 0.94 (m, 2H, $Me_3Si-CH_2CH_2$), 1.96, 2.03, 2.11 (3s, 9H, 3AcO), 3.53, 3.99 (2m, 2H, $Me_3SiCH_2CH_2$), 4.47 (d, 1H, $J_{1,2}$ = 7.8 Hz, H-1), 5.02 (dd, 1H, $J_{2,3}$ = 10.5 Hz, $J_{3,4}$ = 3.4 Hz, H-3), 5.17 (dd, 1H, H-2), and 5.45 (broad d, 1H, H-4).

Anal. Calcd for $C_{23}H_{44}O_9Si_2$ (520.8): C, 53.05; H, 8.52. Found: C, 52.88; H, 8.63.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-ß-D-galactopyranoside (4). A solution of 3 (482 mg, 0.925 mmol) in 80% aqueous acetic acid (10 mL) was kept for 2 days at 45 °C, and concentrated to a syrup which was chromatographed on a column of silica gel (50 g) with 100:1 dichloromethane-methanol, to give 4 (354 mg, 94%) as an amorphous mass: $[\alpha]_D$ -0.5° (c 0.6, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.89 (m, 2H, $Me_3SiCH_2CH_2$), 1.93, 1.99, 2.11 (3s, 9H, 3AcO), 3.51, 3.95 (2m, 2H, $Me_3SiCH_2CH_2$), 4.45 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.98 (dd, 1H, $J_{2,3}$ = 10.4 Hz, $J_{3,4}$ = 3.5 Hz, H-3), 5.12 (dd, 1H, H-2), and 5.33 (broad d, 1H, H-4).

Anal. Calcd for $C_{17}N_{30}O_9Si$ (406.6): C, 50.22; H, 7.44. Found: C, 50.12, H, 7.60.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-6-bromo-6-deoxy-ß-D-galactopyranoside (5). To a solution of 4 (250 mg, 0.615 mmol) in N,N-dimethylformamide (DMF; 5 mL), cooled to 0 °C, were added, with stirring, triphenylphosphine (160 mg, 0.6 mL) and N-bromosuccinimide (300 mg, 1.69 mmol), and the mixture was stirred for 5 h at 50 °C. Methanol (1 mL) was added to the mixture and this was stirred for 10 min, and concentrated. The residue was chromatographed on a column of silica gel (40 g) with dichloromethane to give 5 (220 mg, 76.2%) as a syrup: $[\alpha]_D$ +2.1° (c 0.5, chloroform); IR (film) 1760 and 1250 (ester), 1210 (CH_2Br), and 860 cm^{-1} (TMS); ^{1}H NMR ($CDCl_3$) δ 0.95 (m, 2H, $Me_3SiCH_2CH_2$), 1.97, 2.03, 2.15 (3s, 9H, 3AcO), 3.33, 3.41 (2dd, 2H, $J_{5,6} = J_{5,6'} = 6.6$ Hz, $J_{6,6'} = 10.5$ Hz, H-6,6'), 3.57, 4.00 (2m, 2H, $Me_3SiCH_2CH_2$), 3.86 (t, 1H, H-5), 4.48 (d, 1H, $J_{1,2}$ = 7.8 Hz, H-1), 5.01 (dd, 1H, $J_{2,3}$ = 10.3 Hz, $J_{3,4}$ = 3.1 Hz, H-3), 5.17 (dd, 1H, H-2), and 5.52 (broad d, 1H, H-4).

Anal. Calcd for $C_{17}H_{29}O_8BrSi$ (469.4): C, 43.50; H, 6.23. Found: C, 43.48; H, 6.19.

2-(Trimethylsilyl)ethyl 6-O-t-Butyldimethylsilyl-ß-D-glucopyranoside (7). To a solution of 2-(trimethylsilyl)ethyl ß-D-glucopyranoside[8] (6; 500 mg, 1.78 mmol) in pyridine (5 mL) was added t-butyldimethylsilyl chloride (54 mg, 3.58 mmol) at 0 °C, and the mixture was stirred for 3 h at room temperature. Methanol (1 mL) was added to the mixture and stirred for 20 min, and then concentrated. The residue was chromatographed on a column of silica gel (60 g) with 1:3 ethyl acetate-hexane to give 7 (720 mg, 86%) as crystals. Recrystallization from ether-hexane gave needles: mp 95-96 °C, $[\alpha]_D$ -4.4° (c 0.71, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.88 (s, 9H, Me_3CSi), 0.99 (m, 2H, $Me_3SiCH_2CH_2$), and 4.26 (d, 1H, $J_{1,2}$ = 7.8 Hz, H-1).

Anal. Calcd for $C_{17}H_{38}O_6Si_2$ (394.7): C, 51.74; H, 9.70. Found: C, 51.68; H, 9.81.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-6-O-t-butyldimethylsilyl-ß-D-glucopyranoside (8). Acetylation of 7 (810 mg, 2.1 mmol) with acetic anhydride (5 mL)-pyridine (10 mL) as described for 3, gave 8 (1.06 g, quantitative) as crystals. Recrystallization from ether-hexane gave needles: mp 88-89 °C, $[\alpha]_D$ -8.4° (c 0.29, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.83-0.96 (m, 11H, Me_3CSi, $Me_3SiCH_2CH_2$), 1.99, 2.01, 2.03 (3s, 9H, 3AcO), 3.64-3.73 (m, 2H, H-6,6'), 4.49 (d, 1H, $J_{1,2}$ = 8.1 Hz, H-1), 4.93 (dd, 1H, $J_{2,3}$ = 9.5 Hz, H-2), 4.99 (d, 1H, $J_{3,4}$ = 9.5 Hz, $J_{4,5}$ = 9.4 Hz, H-4), and 5.18 (t, 1H, H-3).

Anal. Calcd for $C_{23}H_{44}O_9Si_2$ (520.8): C, 53.05; H, 8.52. Found: C, 53.01; H, 8.75.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-ß-D-glucopyranoside (9). A solution of 8 (1.7 g, 3.26 mmol) in 80% aqueous acetic acid (20 mL) was heated for 3 h at 45 °C, and concentrated to a syrup, which was chromatographed on a column of silica gel (150 g) with 100:1 dichloromethane-methanol, to give crystalline 9 (1.1 g, 83%). Recrystallization from ether-hexane gave needles: mp 109-111 °C, $[\alpha]_D$ -2.6° (c 0.69, chloroform); IR (KBr) 3450 (OH), 1750 and 1230 (ester), and 860 and 840 cm^{-1} (TMS); ^{1}H NMR ($CDCl_3$) δ 0.88 (m, 2H, $Me_3SiCH_2CH_2$), 1.96, 1.99, 2.00 (3s, 9H, 3AcO), 3.45-3.59 (m, 4H, H-5,6,6', one proton in $Me_3SiCH_2CH_2$), 3.70 (broad d, 1H, OH), 3.95 (m, 1H, one proton in $Me_3SiCH_2CH_2$), 4.50 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.90 (dd, 1H, $J_{2,3}$ = 9.5 Hz, H-2), 4.98 (t, 1H, $J_{3,4}$ = $J_{4,5}$ = 9.5 Hz, H-4), and 5.18 (t, 1H, H-3).

Anal. Calcd for $C_{17}H_{30}O_9Si$ (406.6): C, 50.22; H, 7.44. Found: C, 50.18; H, 7.53.

2-(Trimethylsilyl)ethyl 2,3,4-Tri-O-acetyl-6-bromo-6-deoxy-ß-D-glucopyranoside (10). To a solution of 9 (1.1 g, 2.7 mmol) in DMF (15 mL), cooled to 0 °C, were added triphenylphosphine (79 mg, 3 mmol) and N-bromosuccinimide (535 mg, 3 mmol), and the mixture was stirred for 8 h at 40 °C. The same procedure described for 5 gave 10 (880 mg, 70%) as crystals. Recrystallization from ether-hexane gave needles: mp 106-107 °C, $[\alpha]_D$ -1.4° (c 0.5, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.93 (m, 2H, $Me_3SiCH_2CH_2$), 1.97, 2.01, 2.03 (3s, 9H, 3AcO), 3.36 (dd, 1H, $J_{5,6}$ = 7.3 Hz, $J_{6,6'}$ = 11.2 Hz, H-6), 3.44 (dd, 1H, $J_{5,6'}$ = 2.8 Hz, H-6'), 3.65, 3.99 (2m, 2H, $Me_3SiCH_2CH_2$), 3.67 (m, 1H, H-5), 4.52 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.94 (dd, 1H, $J_{2,3}$ = 9.5 Hz, H-2), 4.96 (t, 1H, $J_{3,4}$ = $J_{4,5}$ = 9.5 Hz, H-4), and 5.17 (t, 1H, H-3).

Anal. Calcd for $C_{17}H_{29}O_8BrSi$ (469.4): C, 43.50; H, 6.23. Found: C, 43.48; H, 6.21.

2-(Trimethylsilyl)ethyl O-(2,3-Di-O-acetyl-4,6-O-isopropylidene-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-ß-D-glucopyranoside (13). To a solution of 2-(trimethylsilyl)ethyl ß-D-lactoside[10] (11; 1.5 g, 3.39 mmol) in DMF (15 mL), cooled to 0 °C, were added, with stirring, 2-methoxypropene (0.6 mL) and p-toluenesulfonic acid monohydrate (30 mg), and the mixture was stirred for 2 h at 0 °C; the progress of the reaction being monitored by TLC. Acetic anhydride (7 mL) and pyridine (10 mL) were added to the mixture, and this was stirred for 5 h at room temperature and concentrated to a syrup, which was chromatographed on a column of silica gel (150 g) with 1:4 ethyl acetate-hexane to give 13 (2.14 g, 93%) as an amorphous mass: $[\alpha]_D$ +14.0° (c 1.0, chloroform); ^{1}H NMR ($CDCl_3$) δ 0.92 (m, 2H, $Me_3Si\underline{CH_2}CH_2$), 1.37, 1.42 (2s, 6H, Me_2C), 2.03, 2.04, 2.06, 2.10, 2.11 (5s, 15H, 5AcO), 3.29 (broad s, 1H, H-5'), 3.55, 3.94 (2m, 2H, $Me_3SiCH_2\underline{CH_2}$), 3.59 (m, 1H, H-5), 3.74 (t, 1H, $J_{3,4} = J_{4,5} = 9.9$ Hz, H-4), 3.93 (dd, 1H, $J_{5',6a'} = 1.8$ Hz, $J_{6a',6b'} = 12.8$ Hz, H-6a'), 4.02 (dd, 1H, $J_{5',6b'} = 1.8$ Hz, H-6b'), 4.10 (dd, 1H, $J_{5,6a} = 4.8$ Hz, $J_{6a,6b} = 11.7$ Hz, H-6a), 4.29 (broad d, 1H, H-4'), 4.37, 4.47 (2d, 2H, $J_{1,2} = 8.1$ Hz, $J_{1',2'} = 8.1$ Hz, H-1,1'), 4.50 (dd, 1H, $J_{5,6b} = 1.9$ Hz, H-6b), 4.78 (dd, 1H, $J_{3',4'} = 3.7$ Hz, H-3'), 4.89 (dd, 1H, $J_{2,3} = 9.9$ Hz, H-2), 5.19 (t, 1H, $J_{3,4} = 9.9$ Hz, H-3), and 5.21 (dd, 1H, $J_{2',3'} = 10.3$ Hz, H-2').

Anal. Calcd for $C_{30}H_{48}O_{16}Si$ (692.8): C, 52.01; H, 6.98. Found: C, 51.99; H, 6.86.

2-(Trimethylsilyl)ethyl O-(2,3-Di-O-acetyl-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-ß-D-glucopyranoside (14). A solution of 13 (2.34 g, 3.38 mmol) in 80% aqueous acetic acid (30 mL) was kept for 10 h at 45 °C, and concentrated to a syrup, which was chromatographed on a column of silica gel (200 g) with 1:1 ethyl acetate-hexane to give 14 (2.0 g, 91%) as crystals. Recrystallization from ether-hexane gave needles: mp 197 °C, $[\alpha]_D$ -8.1° (c 0.6, chloroform); IR (KBr) 3450 (OH), 1750 and 1240 (ester), and 860 and 840 cm^{-1} (TMS); ^{1}H NMR ($CDCl_3$) δ 0.89 (m, 2H, $Me_3Si\underline{CH_2}CH_2$), 1.99, 2.01, 2.04, 2.06, 2.09 (5s, 15H, 5AcO), 2.80 (broad t, OH), 3.32 (d, 1H, $J_{4',OH} = 4.8$ Hz, OH-4'), 3.52 (dd, 1H, $J_{5',6a'} = 6.8$ Hz, $J_{6a',6b'} = 9.7$ Hz, H-6a'), 3.54, 3.92 (2m, 2H, $Me_3SiCH_2\underline{CH_2}$), 3.52 (m, 1H, H-5), 3.80 (t, 1H, $J_{3,4} = J_{4,5} = 9.3$ Hz, H-4), 3.86 (dd, 1H, $J_{5',6b'} = 6.0$ Hz, H-6b'),

4.07 (dd, 1H, $J_{5,6a}$ = 5.9 Hz, $J_{6a,6b}$ = 12.3 Hz, H-6a), 4.12 (broad d, 1H, $J_{3',4'}$ = 3.7 Hz, H-4'), 4.47 (d, 1H, $J_{1,2}$ = 8.1 Hz, H-1), 4.48 (d, 1H, $J_{1',2'}$ = 7.9 Hz, H-1'), 4.85 (dd, 1H, $J_{2',3'}$ = 10.3 Hz, H-3'), 4.86 (dd, 1H, $J_{2,3}$ = 9.2 Hz, H-2), 5.16 (t, 1H, $J_{2,3}$ = $J_{3,4}$ = 9.2 Hz, H-3), and 5.18 (dd, 1H, H-2').

Anal. Calcd for $C_{27}H_{44}O_{16}Si$ (652.7): C, 49.68; H, 6.79. Found: C, 49.64; H, 6.64.

2-(Trimethylsilyl)ethyl O-(2,3-Di-O-acetyl-6-bromo-6-deoxy-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-ß-D-glucopyranoside (15). Selective bromination of C-6' of 14 (500 mg, 0.77 mmol) with N-bromosuccinimide (267 mg, 1.5 mmol) and triphenylphosphine (262 mg, 1 mmol) in DMF (10 mL) for 2 days at 0 °C gave 15 (380 mg, 69%) as an amorphous mass after silica gel (60 g) column chromatography with 2:1 ethyl acetate-hexane: $[\alpha]_D$ -2.8 (c 0.86, chloroform); IR (KBr) 3500 (OH), 1750 and 1250 (ester), and 850 and 830 cm^{-1} (TMS); ^1H NMR ($CDCl_3$) δ 0.92 (m, 2H, $Me_3Si\underline{CH_2}CH_2$), 2.03, 2.05 (2), 2.08, 2.11 (5s, 15H, 5AcO), 3.46, 3.59 (2dd, 2H, H-6a',6b'), 3.56, 3.94 (2m, 2H, $Me_3SiCH_2\underline{CH_2}$), 3.69 (broad t, 1H, H-5'), 3.81 (t, 1H, $J_{3,4}$ = $J_{4,5}$ = 9.5 Hz, H-4), 4.10, 4.49 (2dd, 2H, H-6a,6b), 4.21 (broad d, 1H, H-4'), 4.46 (d, 1H, $J_{1,2}$ = 8.1 Hz, H-1), 4.47 (d, 1H, $J_{1',2'}$ = 7.9 Hz, H-1'), 4.89 (d, 1H, $J_{2,3}$ = 9.4 Hz, H-2), 4.92 (dd, 1H, $J_{2',3'}$ = 10.1 Hz, $J_{3',4'}$ = 4.3 Hz, H-3'), 5.14 (dd, 1H, H-2'), and 5.19 (t, 1H, $J_{3,4}$ = 9.4 Hz, H-3).

Anal. Calcd for $C_{27}H_{43}O_{15}BrSi$ (715.6): C, 45.45; H, 5.79. Found: C, 45.30; H, 5.84.

2-(Trimethylsilyl)ethyl O-(2,3,4-Tri-O-acetyl-6-bromo-6-deoxy-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-ß-D-glucopyranoside (16). Acetylation of 15 (329 mg, 0.46 mmol) with acetic anhydride (1 mL) in pyridine (2 mL) overnight at room temperature gave 16 (345 mg, quantitative) as crystals. Recrystallization from ether-hexane gave needles: mp 208-209 °C, $[\alpha]_D$ -11.9° (c 1.0, chloroform); ^1H NMR ($CDCl_3$) δ 0.90 (m, 2H, $Me_3Si\underline{CH_2}CH_2$), 3.54, 3.93 (2m, 2H, $Me_3SiCH_2\underline{CH_2}$), 3.59 (m, 1H, H-5), 3.84 (broad t, 1H, H-5'), 4.46 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.50 (d, 1H, $J_{1',2'}$ = 7.7 Hz, H-1'), 4.86 (dd, 1H, $J_{2,3}$ = 9.3 Hz, H-2), 4.98 (dd, 1H, $J_{2',3'}$ = 10.4 Hz, $J_{3',4'}$ = 5.6 Hz, H-3'), 5.09 (dd, 1H, H-2'), 5.18 (t, 1H, $J_{3,4}$ = 9.3 Hz, H-3), and 5.66 (d, 1H, H-4').

Anal. Calcd for $C_{29}H_{45}O_{16}BrSi$ (757.7): C, 45.97; H, 5.99. Found: C, 45.80; H, 6.22.

2-(Trimethylsilyl)ethyl S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranoside (18). A solution of 5 (295 mg, 0.63 mmol) and 17 (500 mg, 0.94 mmol) in dry DMF (3 mL) was stirred overnight at room temperature under nitrogen atmosphere, and another 17 (200 mg, 0.38 mmol) was added to the mixture. The mixture was stirred for 8 h; the course of the reaction being monitored by TLC. Acetic anhydride (2 mL) and pyridine (4 mL) were added to the solution, and the mixture was stirred overnight at room temperature. Dichloromethane (200 mL) was added, and the solution was successively washed with M sodium carbonate, 2M hydrochloric acid, and water, dried (sodium sulfate), and concentrated. The residue was chromatographed on a column of silica gel (100 g) with 1:1 ethyl acetate-hexane to give 18 (498 mg, 88.5%) as an amorphous mass: $[\alpha]_D$ +1.5° (c 0.67, chloroform); IR (KBr) 3260 (NH), 1740 and 1220 (ester), 1660 and 1540 (amide), and 860 and 840 cm^{-1} (TMS); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.83 (s, 3H, AcN), 2.66 (dd, 1H, $J_{3a,3e}$ = 14.3 Hz, $J_{3e,4}$ = 4.8 Hz, H-3e), 3.79 (s, 3H, MeO), 3.85 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH}$ = 10.1 Hz, H-5), 4.09 (dd, 1H, $J_{8,9}$ = 4.2 Hz, $J_{9,9'}$ = 12.8 Hz, H-9), 4.23 (dd, 1H, $J_{8,9'}$ = 2.3 Hz, H-9'), 4.86 (ddd, 1H, $J_{3a,4}$ = 11.5 Hz, H-4), 5.22-5.28 (m, 2H, H-7,8), and 5.35 (d, 1H, NH); Gal unit δ 0.89 (m, 2H, $Me_3Si\underline{CH_2}CH_2$), 2.60 (dd, 1H, $J_{5,6}$ = 7.1 Hz, $J_{6,6'}$ = 14.5 Hz, H-6), 2.85 (dd, 1H, $J_{5,6'}$ = 7.1 Hz, H-6'), 3.57, 3.97 (m, 2H, $Me_3SiCH_2\underline{CH_2}$), 3.81 (near t, 1H, H-5), 4.58 (d, 1H, $J_{1,2}$ = 7.7 Hz, H-1), 5.00 (dd, 1H, $J_{2,3}$ = 10.4 Hz, $J_{3,4}$ = 3.3 Hz, H-3), 5.10 (dd, 1H, H-2), and 5.47 (near d, 1H, H-4); O-acetyl groups δ 1.90, 1.97, 1.99 (2), 2.08, 2.09, and 2.13 (7s, 21H, 7AcO).

Anal. Calcd for $C_{37}H_{57}NO_{19}SSi$ (896.0): C, 49.60; H, 6.41; N, 1.56. Found: C, 49.55; H, 6.41; N, 1.49.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-D-glucopyranose (19). To a solution of 18 (250 mg, 0.28 mmol) in dry dichloromethane (3 mL), cooled to -20 °C, was added boron trifluoride etherate (0.8 mL), and the mixture was stirred for 2 h at -20 °C; the progress of the reaction being monitored by TLC. Dichloromethane (100 mL) was added to the mixture, and the solution was successively washed with M sodium carbonate, water, dried (sodium sulfate), and concentrated to a syrup, which was chromatographed on a column of silica gel (80 g) with 100:1 dichloromethane-methanol to give 19 (202 mg, 91%) as an amorphous

mass: $[\alpha]_D$ +2.1° (c 1.9, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.88 (s, 3H, AcN), 2.75 (dd, 1H, $J_{3a,3e}$ = 12.8 Hz, $J_{3e,4}$ = 4.8 Hz, H-3e), 3.78 (s, 3H, MeO), 4.05 (dd, 1H, $J_{8,9}$ = 5.7 Hz, $J_{9,9'}$ = 12.5 Hz, H-9), 4.09 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH}$ = 8.3 Hz, H-5), 4.32 (dd, 1H, $J_{8,9'}$ = 2.6 Hz, H-9'), and 4.91 (m, 1H, H-4); Gal unit δ 2.53 (dd, 1H, $J_{5,6}$ = 9.7 Hz, $J_{6,6'}$ = 12.5 Hz, H-6), 2.84 (dd, 1H, $J_{5,6'}$ = 5.5 Hz, H-6'), 5.11 (dd, 1H, $J_{2,3}$ = 10.8 Hz, H-3), and 5.61 (broad d, 1H, $J_{3,4}$ = 3.5 Hz, H-4); O-acetyl groups δ 1.97, 2.02 (2), 2.08, 2.10, 2.16, and 2.22 (7s, 21H, 7AcO).

Anal. Calcd for $C_{32}H_{45}NO_{20}S$ (795.8): C, 48.30; H, 5.70; N, 1.76. Found: C, 48.21; H, 5.84; N, 1.75.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-α-D-galactopyranosyl trichloroacetimidate (20). To a stirred solution of 19 (200 mg, 0.25 mmol) in dry dichloromethane (2 mL), cooled to 0 °C, were added trichloroacetonitrile (0.08 mL) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 0.02 mL). The mixture was stirred for 2 h at 0 °C and then concentrated. The residue was chromatographed on a column of silica gel (30 g) with 120:1 dichloromethane-methanol, to give 20 (192 mg, 81.3%) as an amorphous mass: $[\alpha]_D$ +52.4° (c 0.9, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.87 (s, 3H, AcN), 2.71 (dd, 1H, $J_{3a,3e}$ = 9.3 Hz, $J_{3e,4}$ = 4.2 Hz, H-3e), 3.71 (s, 3H, MeO), 3.95 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH}$ = 10.3 Hz, H-5), 4.06 (dd, 1H, $J_{8,9}$ = 4.0 Hz, $J_{9,9'}$ = 12.3 Hz, H-9), 4.20 (dd, 1H, $J_{8,9'}$ = 2.4 Hz, H-9'), and 4.86 (ddd, 1H, $J_{3a,4}$ = 11.5 Hz, H-4); Gal unit δ 2.66, 3.04 (m, 2H, H-6,6'), 6.59 (d, 1H, $J_{1,2}$ = 2.0 Hz, H-1), and 8.66 (s, 1H, NH); O-acetyl groups δ 2.01, 2.02 (2), 2.03, 2.12, 2.13, and 2.20 (7s, 21H, 7AcO).

Anal. Calcd for $C_{34}H_{45}N_2O_{20}Cl_3S$ (940.2): C, 43.44; H, 4.82; N, 2.98. Found: C, 43.29; H, 5.00; N, 2.93.

2-(Trimethylsilyl)ethyl S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-ß-D-glucopyranoside (21). Coupling of 10 (195 mg, 0.415 mmol) with 17 (330 mg, 0.62 mmol) in DMF (2 mL) and subsequent acetylation as described for 18, gave 21 (360 mg, 97%) as an amorphous mass: $[\alpha]_D$ +27.2° (c 0.64, chloroform); IR (KBr) 3300 (NH), 1750 and 1220 (ester), 1660 and 1550 (amide), and 860 and 840 cm^{-1} (TMS); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.96 (s, 3H, AcN), 2.69 (dd, 1H, $J_{3a,3e}$ = 12.8 Hz, $J_{3e,4}$ = 4.8 Hz, H-3e), 3.79 (s, 3H, MeO), 3.98 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH}$ = 10.3 Hz, H-5),

4.07 (dd, 1H, $J_{8,9}$ = 4.6 Hz, $J_{9,9'}$ = 12.3 Hz, H-9), 4.27 (dd, 1H, $J_{8,9'}$ = 2.0 Hz, H-9'), 4.83 (ddd, 1H, $J_{3a,4}$ = 11.5 Hz, H-4), 5.24-5.33 (m, 2H, H-7,8), and 5.56 (d, 1H, NH); Glc unit δ 0.88 (m, 2H, $Me_3SiCH_2CH_2$), 2.86-2.92 (m, 2H, H-6,6'), 3.53, 3.90 (m, 2H, $Me_3SiCH_2CH_2$), 3.54 (m, 1H, H-5), 4.45 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.90 (broad 2t, 2H, $J_{2,3}$ = 9.2 Hz, H-2,4), and 5.13 (t, 1H, $J_{3,4}$ = 9.3 Hz, H-3); O-acetyl groups δ 1.99, 2.00, 2.02, 2.04, 2.05, and 2.10 (2) (7s, 21H, 7AcO).

Anal. Calcd for $C_{37}H_{57}NO_{19}SSi$ (896.0): C, 49.60; H, 6.41; N, 1.56. Found: C, 49.51; H, 6.63; N, 1.50.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-D-glucopyranose (22). Selective removal of the 2-(trimethylsilyl)ethyl group in 21 (220 mg, 0.25 mmol) with boron trifluoride etherate (0.6 mL) as described for 19, gave 22 (185 mg, 95%) as an amorphous mass: $[\alpha]_D$ +51° (c 1.1, chloroform); IR (KBr) 3370 (OH, NH), 1740 and 1220 (ester), and 1670 and 1550 cm^{-1} (amide); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.84 (s, 3H, AcN), 2.67 (dd, 1H, $J_{3a,3e}$ = 12.8 Hz, $J_{3e,4}$ = 4.8 Hz, H-3e), 3.77 (s, 3H, MeO), 3.83 (dd, 1H, $J_{5,6}$ = 10.3 Hz, $J_{6,7}$ = 1.7 Hz, H-6), 3.99 (q, 1H, $J_{4,5}$ = $J_{5,6}$ = $J_{5,NH}$ = 10.3 Hz, H-5), 4.87 (td, 1H, $J_{3a,4}$ = $J_{4,5}$ = 10.3 Hz, H-4), 5.33 (m, 1H, H-8), 5.35 (dd, 1H, $J_{7,8}$ = 8.4 Hz, H-7), and 5.95 (d, 1H, NH); Glc unit δ 2.81-2.88 (m, 2H, H-6,6'), 4.95 (t, 1H, $J_{3,4}$ = $J_{4,5}$ = 9.5 Hz, H-4), and 5.26 (t, 1H, $J_{2,3}$ = 9.5 Hz, H-3); O-acetyl groups δ 1.97, 2.00, 2.02, 2.04, 2.05, 2.06, and 2.11 (7s, 21H, 7AcO).

Anal. Calcd for $C_{32}H_{45}NO_{20}S$ (795.8): C, 48.30; H, 5.70; N, 1.76. Found: C, 48.09; H, 5.86; N, 1.75.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-2,3,4-tri-O-acetyl-6-thio-α-D-glucopyranosyl trichloroacetimidate (23). To a solution of 22 (530 mg, 0.67 mmol) in dry dichloromethane (6 mL), cooled to -5 °C, were added trichloroacetonitrile (0.5 mL) and DBU (0.05 mL), and the mixture was stirred for 3 h at 0 °C. The product was purified by chromatography on a column of silica gel (50 g) with 120:1 dichloromethane-methanol to give 23 mg, 93.3%) as an amorphous mass: $[\alpha]_D$ +80.3° (c 0.64, chloroform); IR (KBr) 3300 (NH), 1750 and 1230 (ester), and 1660 and 1540 cm^{-1} (amide); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.87 (s, 3H, AcN), 2.72 (dd, 1H, $J_{3a,3e}$ = 11.5 Hz, $J_{3e,4}$ = 4.4 Hz, H-3e), 3.79 (s, 3H, MeO), 4.86 (ddd, 1H, $J_{3a,4}$ = 9.5 Hz, $J_{4,5}$ = 10.3 Hz, H-4), 5.25-5.37 (m, 2H, H-7,8); Glc unit δ 2.92 (m, 2H,

H-6,6'), 5.04 (t, 1H, $J_{3,4} = J_{4,5} = 9.9$ Hz, H-4), 5.09 (t, 1H, $J_{1,2} = 3.7$ Hz, $J_{2,3} = 9.9$ Hz, H-2), 5.51 (t, 1H, H-3), and 8.44 (s, 1H, C=NH); O-acetyl groups δ 2.01 (2), 2.02, 2.03, 2.11, 2.13, and 2.22 (7s, 21H, 7AcO),

Anal. Calcd for $C_{34}H_{45}N_2O_{20}Cl_3S$ (940.2): C, 43.44; H, 4.82; N, 2.98. Found: C, 43.40; H, 4.92; N, 2.93.

2-(Trimethylsilyl)ethyl S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-β-D-glucopyranoside (24). Coupling of 16 (280 mg, 0.37 mmol) with 17 (400 mg, 0.76 mmol) in DMF (3 mL) and subsequent acetylation as described for 18, gave 24 (380 mg, 86.5%) as an amorphous mass: $[\alpha]_D$ +3.6° (c 1.4, chloroform); IR (KBr) 3300 (NH), 1740 and 1220 (ester), 1660 and 1540 (amide), and 860 and 840 cm^{-1} (TMS); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.89 (s, 3H, AcN), 2.70 (dd, 1H, $J_{3a,3e} = 12.8$ Hz, $J_{3e,4} = 4.8$ Hz, H-3e), 3.85 (s, 3H, MeO), 4.15 (dd, 1H, $J_{8,9} = 7.5$ Hz, $J_{9,9'} = 12.6$ Hz, H-9), 4.26 (dd, 1H, $J_{8,9'} = 2.4$ Hz, H-9'), 4.93 (m, 1H, H-4), 5.23 (m, 1H, H-8), and 5.31 (dd, 1H, $J_{6,7} = 1.8$ Hz, $J_{7,8} = 9.4$ Hz, H-8); Gal unit δ 2.83 (m, 2H, H-6,6'), 4.69 (d, 1H, $J_{1,2} = 7.0$ Hz, H-1), 5.53 (near d, 1H, H-4); Glc unit δ 0.90 (m, 2H, $Me_3SiCH_2CH_2$), 3.57, 3.90 (m, 2H, $Me_3SiCH_2CH_2$), 4.16 (dd, 1H, $J_{5,6} = 4.1$ Hz, $J_{6,6'} = 12.3$ Hz, H-6), 4.46 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.91 (dd, 1H, $J_{2,3} = 9.5$ Hz, H-2), and 5.17 (t, 1H, $J_{3,4} = 9.5$ Hz, H-3); O-acetyl groups δ 1.97, 2.03 (2), 2.04 (2), 2.08, 2.12, 2.13, 2.17, and 2.18 (10s, 30H, 10AcO).

Anal. Calcd for $C_{49}H_{73}NO_{28}SSi$ (1184.3): C, 49.70; H, 6.21; N, 1.18. Found: C, 49.72; H, 6.30; N, 1.15.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-D-glucopyranose (25). Selective removal of 2-(trimethylsilyl)ethyl group in 24 (904 mg, 0.76 mmol) with boron trifluoride etherate (1.2 mL) in dichloromethane (10 mL) as described for 19, gave 25 (695 mg, 84%) as an amorphous mass: $[\alpha]_D$ +22.7° (c 0.9, chloroform); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.87 (s, 3H, AcN), 2.72 (dd, 1H, $J_{3a,3e} = 12.5$ Hz, $J_{3e,4} = 4.0$ Hz, H-3e), 3.80 (s, 3H, MeO), 4.12, 4.29 (m, 2H, H-9,9'); Gal unit δ 2.57 (dd, 1H, $J_{5,6} = 6.2$ Hz, $J_{6,6'} = 15.0$ Hz, H-6), 2.84 (dd, 1H, $J_{5,6'} = 7.7$ Hz, H-6'), 4.67 (d, 1H, $J_{1,2} = 7.7$ Hz, H-1), and 5.48 (d, 1H, $J_{3,4} = 2.9$ Hz, H-4); O-acetyl groups

δ 1.89, 1.94, 2.04 (2), 2.07, 2.09, 2.11, 2.13, 2.14, and 2.17 (10s, 30H, 10AcO).

Anal. Calcd for $C_{44}H_{61}NO_{28}S$ (1084.0): C, 48.75; H, 5.67; N, 1.29. Found: C, 48.61; H, 5.76; N, 1.30.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranosyl)-(1→4)-2,3,6-tri-O-acetyl-α-D-glucopyranosyl trichloroacetimidate (26). To a solution of 25 (403 mg, 0.37 mmol) in dichloromethane (5 mL), cooled to 0 °C, were added trichloroacetonitrile (0.075 mL) and DBU (0.03 mL), and the mixture was stirred for 12 h at 0 °C. A similar procedure described for 20 gave 26 (420 mg, 92%) as an amorphous mass: $[\alpha]_D$ +23.3° (c 2.65, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.89 (s, 3H, AcN), 2.73 (dd, 1H, $J_{3a,3e}$ = 12.6 Hz, $J_{3e,4}$ = 4.6 Hz, H-3e), 4.28 (dd, 1H, H-9), 4.95 (m, 1H, H-4); Gal unit δ 2.56 (dd, 1H, $J_{5,6}$ = 7.0 Hz, $J_{6,6'}$ = 14.5 Hz, H-6), 2.84 (dd, 1H, $J_{5,6'}$ = 7.3 Hz, H-6'), and 4.69 (dd, 1H, $J_{1,2}$ = 7.3 Hz, H-1); Glc unit δ 6.50 (d, 1H, $J_{1,2}$ = 3.9 Hz, H-1) and 8.66 (s, 1H, C=NH); O-acetyl groups δ 1.95, 2.04 (2), 2.05, 2.06, 2.07, 2.09, 2.15, 2.17, and 2.18 (10s, 30H, 10AcO).

Anal. Calcd for $C_{46}H_{61}N_2O_{28}Cl_3S$ (1228.4): C, 44.97; H, 5.01; N, 2.28. Found: C, 44.69; H, 5.21; N, 2.25.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranosyl)-(1→1)-(2S, 3R, 4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol (28). To a solution of 20 (123 mg, 0.13 mmol) and (2S, 3R, 4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol[14] (27; 90 mg, 0.21 mmol) in dry dichloromethane (5 mL) was added molecular sieves 4A (MS-4A; 200 mg), and the mixture was stirred for 1 h at room temperature, and cooled to -20 °C. Boron trifluoride etherate (0.02 mL) was added to the cooled mixture, and this was stirred for 6 h at -20 °C; the progress of the reaction being monitored by TLC. The precipitate was filtered off and washed with chloroform. The filtrate and washings were combined, and the solution was successively washed with M sodium carbonate and water, dried (sodium sulfate), and concentrated. The residue was chromatographed on a column of silica gel (20 g) with 120:1 dichloromethane-methanol to give 28 (148 mg, 92.5%) as an amorphous mass: $[\alpha]_D$ +0.9° (c 0.56, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.89 (s, 3H, AcN), 2.69 (dd, 1H, $J_{3a,3e}$ = 12.6 Hz, $J_{3e,4}$ = 4.6 Hz, H-3e), 3.79 (s, 3H, MeO), 4.15 (dd, 1H, $J_{8,9}$ = 4.2 Hz,

$J_{9,9'}$ = 12.5 Hz, H-9), 4.26 (dd, 1H, $J_{8,9'}$ = 2.9 Hz, H-9'), 4.92 (m, 1H, H-4), 5.56 (m, 1H, H-8), and 5.63 (dd, 1H, $J_{6,7}$ = 3.4 Hz, $J_{7,8}$ = 7.9 Hz, H-7); Gal unit δ 2.60 (dd, 1H, $J_{5,6}$ = 7.9 Hz, $J_{6,6'}$ = 14.3 Hz, H-6), 2.83 (dd, 1H, $J_{5,6'}$ = 7.0 Hz, H-6'), 4.73 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 5.08 (dd, 1H, $J_{2,3}$ = 10.6 Hz, H-3), and 5.57 (near d, 1H, H-4); Sphingosine unit δ 0.89 (t, 3H, Me), 1.25 (s, 22H, 11CH_2), 5.55 (dd, 1H, $J_{3,4}$ = 8.1 Hz, $J_{4,5}$ = 14.7 Hz, H-4), 5.92 (td, 1H, $J_{5,6}$ = $J_{5,6'}$ = 6.8 Hz, H-5), and 7.42-8.08 (m, 5H, Ph); O-acetyl groups δ 1.97, 2.04 (2), 2.10, 2.14 (2), and 2.19 (7s, 21H, 7AcO).

Anal. Calcd for $C_{57}H_{82}N_4O_{12}S$ (1207.4): C, 56.70; H, 6.84; N, 4.64. Found: C, 56.73; H, 6.91; N, 4.55.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranosyl)-(1→1)-(2S, 3R, 4E)-3-O-benzoyl-2-octadecanamido-4-octadecene-1,3-diol (30). Hydrogen sulfide was bubbled through a solution of 28 (345 mg, 0.29 mmol) in pyridine (5 mL) and water (1 mL) for 2 days while the solution was stirred at room temperature. The mixture was concentrated to give the syrupy amine 29, which was used for the next reaction without further purification. To a solution of 29 in dry dichloromethane (5 mL) were added octadecanoic acid (170 mg, 0.6 mmol) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (WSC; 110 mg, 0.57 mmol), and the mixture was stirred overnight at room temperature. After completion of the reaction, dichloromethane (50 mL) was added to the mixture, and the solution was washed with water, dried (sodium sulfate), and concentrated to a syrup that was chromatographed on a column of silica gel (20 g) with 90:1 dichloromethane-methanol, to give 30 (395 mg, 96%) as an amorphous mass: $[\alpha]_D$ +8.0° (c 0.4, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.89 (s, 3H, AcN), 2.64 (dd, 1H, $J_{3a,3e}$ = 12.6 Hz, $J_{3e,4}$ = 4.8 Hz, H-3e), 3.77 (s, 3H, MeO), 4.13 (dd, 1H, $J_{8,9}$ = 4.2 Hz, $J_{9,9'}$ = 12.3 Hz, H-9), 4.25 (dd, 1H, $J_{8,9'}$ = 2.6 Hz, H-9'), 4.92 (m, 1H, H-4), 5.10 (m, 1H, H-8), and 5.25 (m, 1H, H-7); Gal unit δ 2.52 (dd, 1H, $J_{5,6}$ = 7.5 Hz, $J_{6,6'}$ = 14.5 Hz, H-6), 2.73 (dd, 1H, $J_{5,6'}$ = 7.0 Hz, H-6'), 4.63 (d, 1H, $J_{1,2}$ = 7.1 Hz, H-1), 5.07 (dd, 1H, $J_{2,3}$ = 10.4 Hz, $J_{3,4}$ = 3.3 Hz, H-3), 5.13 (dd, H-2), and 5.54 (near d, H-4); Cer unit δ 0.88 (t, 6H, 2Me), 1.26 (s, 50H, 25CH_2), 1.60 (m, 2H, $COCH_2\underline{CH_2}$), 5.51 (dd, 1H, $J_{3,4}$ = 8.0 Hz, $J_{4,5}$ = 14.5 Hz, H-4), 5.86 (td, 1H, $J_{5,6}$ = $J_{5,6'}$ = 7.1 Hz, H-5), and 7.41-8.05 (m, 5H,

Ph); O-acetyl groups δ 1.95, 2.02, 2.03, 2.04, 2.08, 2.14, and 2.18 (7s, 21H, 7AcO).

Anal. Calcd for $C_{75}H_{118}N_2O_{23}S$ (1447.8): C, 62.22; H, 8.22; N, 1.94. Found: C, 62.10; H, 8.34; N, 1.99.

S-(5-Acetamido-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosyl-onic acid)-(2→6)-O-(6-thio-ß-D-galactopyranosyl)-(1→1)-(2S, 3R, 4E)-2-octadecanamido-4-octadecene-1,3-diol (31). To a solution of 30 (125 mg, 0.086 mmol) in dry methanol (5 mL) was added sodium methoxide (25 mg) and the mixture was stirred overnight at room temperature. After completion of the reaction, water (0.2 mL) was added to the mixture at 0 °C, and this was stirred for 1 h, and treated with Amberlite IR-120 (H^+) resin to remove the base. The solution was concentrated, and the residue was chromatographed on a column of Sephadex LH-20 (100 g) with 1:1 chloroform-methanol, to give compound 31 (82.5 mg, 92%) as an amorphous mass: $[\alpha]_D$ +16.5° (c 1.5, 1:1 chloroform-methanol); IR (KBr) 3500-3300 (OH, NH), 2930 and 2840 (Me, methylene), 1700 (C=O), and 1660 and 1540 cm^{-1} (amide); ^1H NMR (1:1 $CDCl_3$-CD_3OD) Neu5Ac unit δ 2.04 (s, 3H, AcN), 2.16 (t, 1H, $J_{3a,3e} = J_{3a,4} = 11.5$ Hz, H-3a), and 2.84 (dd, 1H, $J_{3e,4} = 4.4$ Hz, H-3e); Gal unit δ 3.01 (m, 2H, H-6,6'), 4.10 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1); Cer unit δ 0.89 (t, 6H, 2Me), 1.28 (s, 50H, $25CH_2$), 1.58 (m, 2H, $COCH_2\underline{CH_2}$), 5.45 (dd, 1H, $J_{3,4} = 7.3$ Hz, $J_{4,5} = 15.2$ Hz, H-4), and 5.70 (td, 1H, $J_{5,6} = J_{5,6'} = 6.8$ Hz, H-5).

Anal. Calcd for $C_{53}H_{98}N_2O_{15}S$ (1035.4): C, 61.48; H, 9.54; N, 2.71. Found: C, 61.49; H, 9.70; N, 2.63.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-glucopyranosyl)-(1→1)-(2S, 3R, 4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol (32). Condensation of 23 (140 mg, 0.15 mmol) with 27 (132 mg, 0.3 mmol), as described for 28, gave compound 32 (151 mg, 84%) as an amorphous mass: $[\alpha]_D$ +26.6° (c 1.0, chloroform); IR (KBr) 3350 (NH), 2100 (N_3), 1750 and 1220 (ester), 1660 and 1550 (amide), and 720 cm^{-1} (Ph); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.88 (s, 3H, AcN), 2.64 (dd, 1H, $J_{3a,3e} = 12.8$ Hz, $J_{3e,4} = 4.6$ Hz, H-3e), 3.71 (s, 3H, MeO), 4.43 (dd, 1H, $J_{8,9} = 2.6$ Hz, $J_{9,9'} = 11.9$ Hz, H-9), 4.85 (m, 1H, H-4), 5.30 (m, 1H, H-8), 5.70 (dd, 1H, $J_{6,7} = 3.6$ Hz, $J_{7,8} = 7.7$ Hz, H-7), and 6.28 (d, 1H, NH); Glc unit δ 2.74 (dd, 1H, $J_{5,6} = 8.8$ Hz, $J_{6,6'} = 14.7$ Hz, H-6), 2.89 (dd, 1H, $J_{5,6'} = 2.3$ Hz, H-6'), 4.74 (d, 1H, $J_{1,2} = 8.4$ Hz, H-1), 4.89 (near t, 1H, $J_{2,3} = 9.0$ Hz,

H-2), 5.21 (t, 1H, $J_{3,4} = J_{4,5} = 9.3$ Hz, H-4), and 5.30 (t, 1H, H-3); Sphingosine unit δ 0.88 (t, 3H, Me), 1.24 (s, 22H, $11CH_2$), 5.55 (dd, 1H, $J_{3,4} = 7.9$ Hz, $J_{4,5} = 15.4$ Hz, H-4), 5.91 (td, 1H, $J_{5,6} = J_{5,6'} = 6.8$ Hz, H-5), and 7.41-8.08 (m, 5H, Ph); O-acetyl groups δ 1.95, 2.02 (2), 2.04, 2.11, 2.14, and 2.18 (7s, 21H, 7AcO).

Anal. Calcd for $C_{57}H_{82}N_4O_{22}S$ (1207.4): C, 56.70; H, 6.84; N, 4.64. Found: C, 56.77; H, 6.98; N, 4.63.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-glucopyranosyl)-(1→1)-(2S, 3R, 4E)-3-O-benzoyl-2-octadecanamido-4-octadecene-1,3-diol (34). Selective reduction of the azide group in 32 (137 mg, 0.113 mmol) with hydrogen sulfide, and subsequent condensation of the amine 33 with octadecanoic acid (70 mg, 0.25 mmol) using WSC (50 mg, 0.26 mmol), as described for 30, gave compound 34 (155 mg, 94%) as an amorphous mass: $[\alpha]_D$ +1.1° (c 2.1, chloroform); ^{1}H NMR ($CDCl_3$) Neu5Ac unit δ 1.88 (s, 3H, AcN), 2.57 (dd, 1H, $J_{3a,3e} = 12.6$ Hz, $J_{3e,4} = 4.6$ Hz, H-3e), 3.77 (s, 3H, MeO), 4.00 (q, 1H, $J_{4,5} = J_{5,6} = J_{5,NH} = 10.3$ Hz, H-5), 4.10 (dd, 1H, $J_{8,9} = 4.0$ Hz, $J_{9,9'} = 11.7$ Hz, H-9), 4.27 (dd, 1H, $J_{8,9'} = 2.6$ Hz, H-9), 4.85 (m, 1H, H-4), and 5.25-5.35 (m, 2H, H-7,8); Glc unit δ 2.57 (dd, 1H, $J_{5,6} = 4.6$ Hz, $J_{6,6'} = 14.1$ Hz, H-6), 2.90 (dd, 1H, $J_{5,6'} = 3.9$ Hz, H-6'), 3.52-3.61 (m, 1H, H-5), 4.47 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.91 (dd, 1H, $J_{2,3} = 9.4$ Hz, H-2), 5.17 (t, 1H, $J_{3,4} = 9.4$ Hz, H-4), and 5.21 (t, 1H, H-3); Cer unit δ 0.88 (t, 6H, 2Me), 1.24 (s, 50H, $25CH_2$), 1.60 (m, 2H, $COCH_2CH_2$), 5.55 (dd, 1H, $J_{3,4} = 7.3$ Hz, $J_{4,5} = 15.4$ Hz, H-4), 5.85 (td, 1H, $J_{5,6} = J_{5,6'} = 6.2$ Hz, H-5), and 7.43-8.05 (m, 5H, Ph); O-acetyl groups δ 2.00, 2.01, 2.03, 2.04, 2.08, 2.11, and 2.14 (7s, 21H, 7AcO).

Anal. Calcd for $C_{75}H_{118}N_2O_{23}S$ (1447.8): C, 62.22; H, 8.22; N, 1.94. Found: C, 62.21; H, 8.48; N, 1.92.

S-(5-Acetamido-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonic acid)-(2→6)-O-(6-thio-ß-D-glucopyranosyl)-(1→1)-(2S, 3R, 4E)-2-octadecanamido-4-octadecene-1,3-diol (35). O-Deacylation and subsequent saponification of the methyl ester group in 34 (62 mg, 42.8 μmol), as described for 31, gave 35 (42 mg, 95%) as an amorphous mass: $[\alpha]_D$ +15.5° (c 0.68, 1:1 chloroform-methanol); IR (KBr) 3600-3300 (OH, NH), 2930 and 2840 (Me, methylene), 1700 (C=O), and 1650 and 1550 cm^{-1} (amide); ^{1}H NMR (1:1 $CDCl_3$-CD_3OD) Neu5Ac unit δ 2.05 (s, 3H, AcN) and 2.90 (dd, 1H, H-3e); Glc unit δ 2.90 (m, 2H, H-6,6') and 4.28 (d, 1H, $J_{1,2} = 8.0$ Hz, H-1);

Cer unit δ 0.89 (t, 6H, 2Me), 1.27 (m, 50H, $25CH_2$), 1.59 (m, 2H, $COCH_2\underline{CH_2}$), 5.45 (dd, 1H, $J_{3,4}$ = 6.6 Hz, $J_{4,5}$ = 15.0 Hz, H-4), and 5.70 (td, $J_{5,6}$ = $J_{5,6'}$ = 7.3 Hz, H-5).

Anal. Calcd for $C_{53}H_{98}N_2O_{15}S$ (1035.4): C, 61.48; H, 9.54; N, 2.71. Found: C, 61.33; H, 9.70; N, 2.59.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranosyl)-(1→4)-O-(2,3,6-tri-O-acetyl-ß-D-glucopyranosyl)-(1→1)-(2S, 3R, 4E)-2-azido-3-O-benzoyl-4-octadecene-1,3-diol (36). Condensation of 26 (453 mg, 0.37 mmol) with 27 (320 mg, 0.74 mmol), as described for 28, afforded compound 36 (452 mg, 82%) as an amorphous mass: $[\alpha]_D$ -16.0° (c 1.2, chloroform); IR (KBr) 3400 (NH), 2120 (N_3), 1750 and 1230 (ester), 1650 and 1540 (amide), and 720 cm^{-1} (Ph); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.89 (s, 3H, AcN), 2.73 (dd, 1H, $J_{3a,3e}$ = 12.5 Hz, $J_{3e,4}$ = 4.0 Hz, H-3e), 3.86 (s, 3H, MeO), 4.16, 4.28 (2m, 2H, H-9,9'), 4.95 (m, 1H, H-4), and 5.20-5.35 (m, 2H, H-7,8); Gal unit δ 2.54 (dd, 1H, $J_{5,6}$ = 7.7 Hz, $J_{6,6'}$ = 14.7 Hz, H-6), 2.80 (dd, 1H, $J_{5,6'}$ = 7.0 Hz, H-6'), 5.03 (dd, 1H, H-3), 5.54 (broad d, 1H, H-4); Glc unit δ 3.59 (m, 1H, H-5), 4.45 (d, 1H, $J_{1,2}$ = 7.7 Hz, H-1), 5.00 (dd, 1H, $J_{2,3}$ = 9.2 Hz, H-2), and 5.19 (t, 1H, $J_{3,4}$ = 9.2 Hz, H-3); Sphingosine unit δ 0.88 (t, 3H, Me), 1.24 (s, 22H, $11CH_2$), 5.92 (td, 1H, $J_{4,5}$ = 14.7 Hz, $J_{5,6}$ = $J_{5,6'}$ = 6.6 Hz, H-5), and 7.42-8.06 (m, 5H, Ph); O-acetyl groups δ 1.94, 2.01, 2.03, 2.04, 2.05, 2.07, 2.09, 2.13, 2.18, and 2.19 (10s, 30H, 10AcO).

Anal. Calcd for $C_{69}H_{98}N_4O_{30}S$ (1495.6): C, 47.38; H, 6.60; N, 3.75. Found: C, 47.33; H, 6.84; N, 3.68.

S-(Methyl 5-Acetamido-4,7,8,9-tetra-O-acetyl-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosylonate)-(2→6)-O-(2,3,4-tri-O-acetyl-6-thio-ß-D-galactopyranosyl)-(1→4)-O-(2,3,6-tri-O-acetyl-ß-D-glucopyranosyl)-(1→1)-(2S, 3R, 4E)-3-O-benzoyl-2-octadecanamido-4-octadecene-1,3-diol (38). The azide group in 36 (100 mg, 66.9 μmol) was converted into the amine 37 as described for 30, which was then condensed with octadecanoic acid (40 mg, 0.14 mmol) in the presence of WSC (35 mg), to give 38 (106 mg, 94%) as an amorphous mass: $[\alpha]_D$ -2.2° (c 2.0, chloroform); IR (KBr) 3300 (NH), 1740 and 1240 (ester), 1660 and 1540 (amide), and 710 cm^{-1} (Ph); ^1H NMR ($CDCl_3$) Neu5Ac unit δ 1.90 (s, 3H, AcN), 2.73 (dd, 1H, $J_{3a,3e}$ = 12.6 Hz, $J_{3e,4}$ = 4.2 Hz, H-3e), 3.86 (s, 3H, MeO), 4.15 (dd, 1H, $J_{8,9}$ = 4.0 Hz, $J_{9,9'}$ = 12.3 Hz, H-9), 4.28 (dd, 1H, $J_{8,9'}$ = 2.2 Hz, H-9'), 4.95

(m, 1H, H-4), 5.17-5.28 (m, 2H, H-7,8); Gal unit δ 2.54 (dd, 1H, $J_{5,6}$ = 7.2 Hz, $J_{6,6'}$ = 14.3 Hz, H-6), 2.80 (dd, 1H, $J_{5,6'}$ = 6.9 Hz, H-6'), 4.65 (d, 1H, $J_{1,2}$ = 7.0 Hz, H-1), and 5.78 (broad d, 1H, H-4); Glc unit δ 3.63 (m, 1H, H-5), 4.40 (d, 1H, $J_{1,2}$ = 7.9 Hz, H-1), 4.92 (dd, 1H, $J_{2,3}$ = 9.3 Hz, H-2), and 5.18 (t, 1H, $J_{3,4}$ = 9.3 Hz, H-3); Cer unit δ 0.88 (t, 6H, 2Me), 1.25 (s, 50H, $25CH_2$), 1.60 (m, 2H, $COCH_2\underline{CH_2}$), 5.47 (dd, 1H, $J_{3,4}$ = 7.3 Hz, $J_{4,5}$ = 14.7 Hz, H-4), 5.86 (td, 1H, $J_{5,6}$ = $J_{5,6'}$ = 6.8 Hz, H-5), and 7.41-8.05 (m, 5H, Ph); O-acetyl groups δ 1.91, 1.93, 2.02, 2.03, 2.04 (2), 2.06, 2.13, 2.18, and 2.19 (10s, 30H, 10AcO).

Anal. Calcd for $C_{83}H_{126}N_2O_{31}S$ (1680.0): C, 59.33; H, 7.56; N, 1.67. Found: C, 59.31; H, 7.68; N, 1.65.

S-(5-Acetamido-3,5-dideoxy-D-glycero-α-D-galacto-2-nonulopyranosyl-onic acid)-(2→6)-O-(6-thio-ß-D-galactopyranosyl)-(1→4)-O-(ß-D-glucopyrano-syl)-(1→1)-(2S, 3R, 4E)-2-octadecanamido-4-octadecene-1,3-diol (39). Treatment of 38 (121 mg, 72 μmol), as described for the preparation of 31 , gave 39 (79.6 mg, 97%) as an amorphous mass: $[\alpha]_D$ +13.8° (c 1.5, 1:1 chloroform-methanol); IR (KBr) 3600-3200 (OH, NH), 2930 and 2840 (Me, methylene), 1710 (C=O), and 1650 and 1550 cm^{-1} (amide); ^1H NMR (1:1 $CDCl_3$-CD_3OD) Neu5Ac unit δ 1.86 (t, 1H, $J_{3a,3e}$ = $J_{3a,4}$ = 11.2 Hz, H-3a), 2.04 (s, 3H, AcN), and 2.84 (dd, 1H, $J_{3e,4}$ = 3.4 Hz, H-3e); Gal unit δ 2.90-3.02 (m, 2H, H-6,6') and 4.31 (d, 1H, $J_{1,2}$ = 7.5 Hz, H-1); Glc unit δ 4.08 (d, 1H, $J_{1,2}$ = 7.5 Hz, H-1); Cer unit δ 0.89 (t, 6H, 2Me), 1.27 (s, 50H, $25CH_2$), 1.59 (m, 2H, $COCH_2\underline{CH_2}$), 5.45 (dd, 1H, $J_{3,4}$ = 6.9 Hz, $J_{4,5}$ = 15.4 Hz, H-4), and 5.70 (td, 1H, $J_{5,6}$ = $J_{5,6'}$ = 7.1 Hz, H-5).

Anal. Calcd for $C_{55}H_{100}N_2O_{20}S$ (1141.5): C, 57.87; H, 8.83; N, 2.49. Found: C, 57.69; H, 8.86; N, 2.48.

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