# Synthesis of aminoethyl glycoside of the oligosaccharide chain of ganglioside Fuc-$GM_1$

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2-Aminoethyl glycoside of the hexasaccharide chain of ganglioside Fuc-$GM_1$ was synthesized by a [3+3] synthetic scheme. At the key step of the synthetic route, glycosylation of the only hydroxyl group at C(4) of the galactose residue in an α-(N-acetylneuraminyl)-(2→3)-β-D-galactopyranosyl-(1→4)-β-D-glucopyranoside derivative with a peracetylated thioglycoside of α-L-fucopyranosyl-(1→2)-β-D-galactopyranosyl-(1→3)-2-trichloroacetamido-2-deoxy-β-D-galactopyranose gave a protected hexasaccharide in high yield. Subsequent removal of the protecting groups gave the target 2-aminoethyl glycoside of the oligosaccharide chain of ganglioside Fuc-$GM_1$.

**Key words:** Fuc-$GM_1$, gangliosides, aminoethyl glycosides, fucosylation.

Glycolipids are membrane-associated antigens, which play an important role in many stages of cell recognition. In continuation of our studies on the synthesis of spacered carbohydrate chains of globo- and ganglioglycolipids,[1—4] here we describe the synthesis of compound **1**, *i.e.*, aminoethyl glycoside of the hexasaccharide chain of the glycolipid Fuc-$GM_1$, which is expressed specifically on some kinds of malignant cells, for example lung small cell carcinoma.[5,6] The presence of the aminoethyl aglycone in compound **1** is necessary for the subsequent conjugation with various labels and carriers, in particular, for the development of a cancer vaccine.

Despite the fact that ganglioside Fuc-$GM_1$ was first isolated from a natural source more than twenty years ago,[5,7] the first total synthesis of its oligosaccharide chain was described only in 1999 and still remains a challenge.[8,9]

The hexasaccharide chain of the glycolipid Fuc-$GM_1$, especially in the form of spacered glycoside **1**, is among the most complicated ganglioside structures from the synthetic standpoint. In this paper we consider the synthesis of aminoethyl glycoside of Fuc-$GM_1$ using the [3+3] assembly pattern starting from the previously obtained[2] sialyllactose derivative **2** and glycosyl donor **3** based on the Fucα(1→2)Galβ(1→3)GalN trisaccharide[2] (Scheme 1). The latter, in turn, can be prepared by 2′-*O*-fucosylation of the disaccharide thioglycoside **4**, which we have synthesized previously[10] and successfully used for the synthesis of globo- and ganglio-structures.

To ensure the regioselectivity of 2′-*O*-fucosylation, it was necessary to prepare the selectively protected disaccharide **4**, bearing a free hydroxyl group at the C(2) atom of the galactose residue. To this end, all the *O*-acetyl protecting groups in compound **4** were removed and the hexol thus formed was converted into di-*O*-benzylidene derivative **5** by treatment with α,α-dimethoxytoluene (Scheme 2).

We planned to protect the hydroxyl group at the C(3′) atom in compound **5** by its selective benzoylation *via* the intermediate 2′,3′-*O*-stannylidene derivative.[11] However, treatment of 2′,3′-*O*-stannylidene derivative of diol **5** with benzoyl chloride resulted in a mixture of the desired 3′-*O*-benzoyl derivative and side 2′,3′-dibenzoate. Note that this mixture was formed irrespective of the intial ratio of stannylidene derivative of diol **5** to benzoyl chloride.

Since the resulting mixture contained much dibenzoate (~30—50% according to TLC), this approach was regarded as unpractical. An alternative approach involved the selective benzoylation of diol **5** using less reactive benzoyl cyanide (BzCN) instead of benzoyl chloride.[12] This reaction with galactose 2,3-diols is known to be directed selectively at the O(3) position. In our case, the corresponding benzoyl derivative **6** was obtained in 89% yield.

For stereoselective fucosylation of the monohydroxyl derivative **6**, we used the selectively protected fucose trichloroacetimidate derivative **7**, which, as has been previously shown in our studies,[13] ensures high α-stereoselectivity of glycosylation. The coupling of imidate **7** with monohydroxyl derivative **6** in the presence of TMSOTf in $CH_2Cl_2$ gave the desired trisaccharide **8** in 93% yield.

The α-configuration of the newly formed glycosidic bond was confirmed by the characteristic coupling con-

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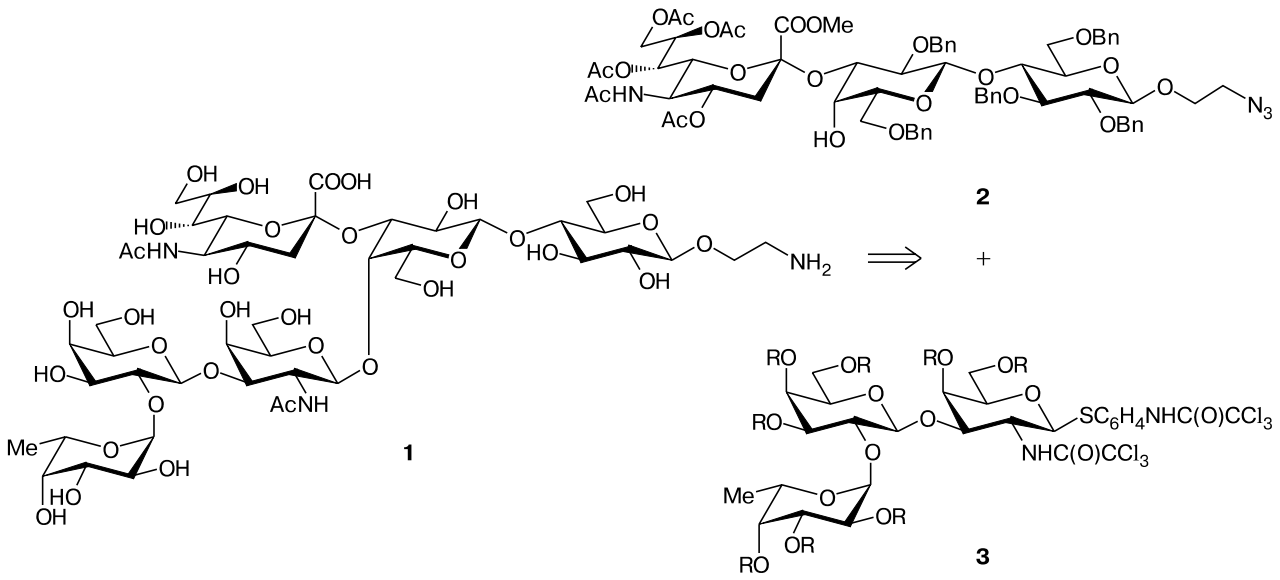
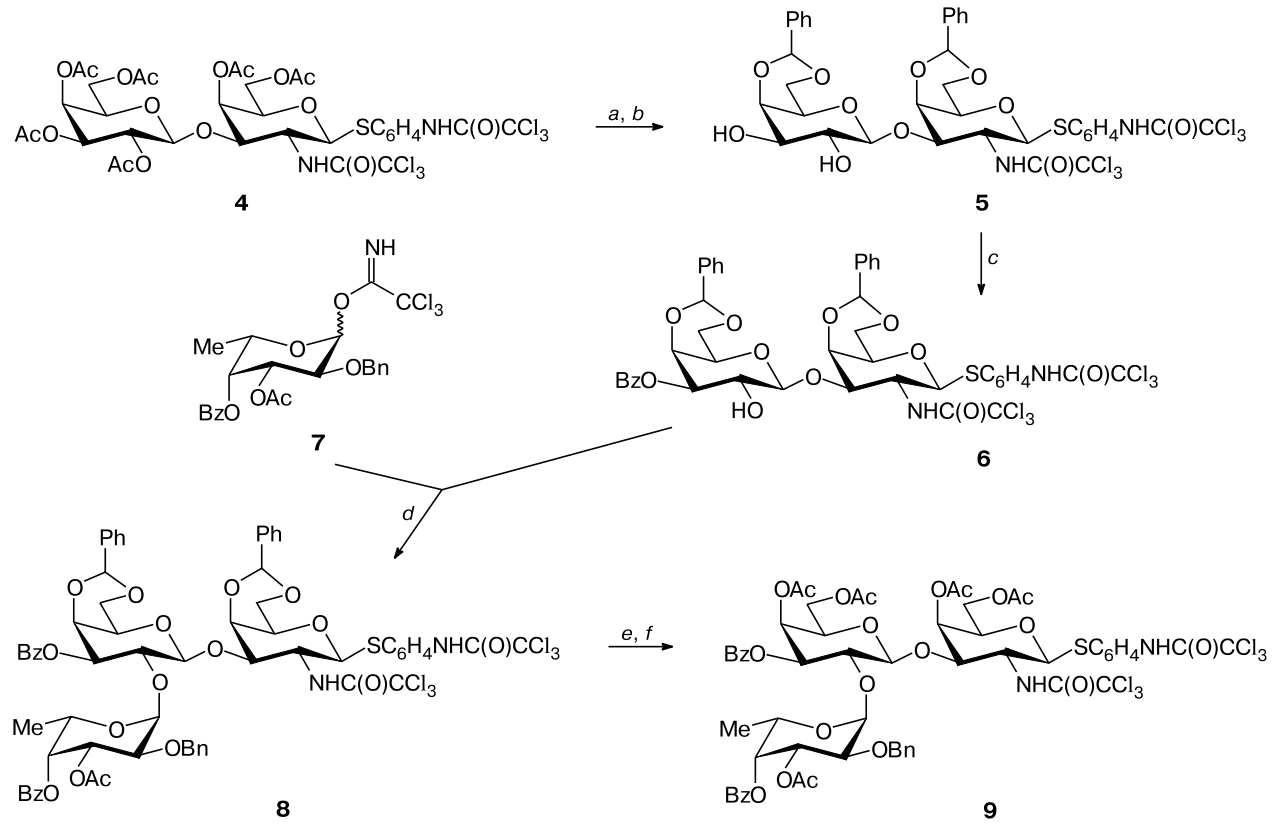
**Scheme 1**



**Scheme 2**



**Reagents:** (*a*) NaOMe/MeOH; (*b*) $PhCH(OMe)_2$, CSA; (*c*) BzCN, $Et_3N$; (*d*) TMSOTf, $CH_2Cl_2$; (*e*) 90% aq. AcOH, 80 °C; (*f*) $Ac_2O$, Py.

**Table 1.** $^1$H NMR spectral data of compounds **1**, **11** ($D_2O$), **6**, **8**, and **10** ($CDCl_3$)

| Compound | Residue | δ | | | | | | | *J*/Hz | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | H(1) | H(2) | H(3) | H(4) | H(5) | H(6a) | H(6b) | $J_{1,2}$ | $J_{2,3}$ | $J_{3,4}$ |
| **1** | Glc | 4.53 | 3.36 | 4.12 | | 3.60—4.10 | | | 7.9 | 9.6 | — |
| | Gal | 4.55 | 3.37 | 3.69 | | 3.60—4.10 | | | 8.0 | 8.4 | — |
| | GalN | 4.62 | 3.97 | — | | 3.60—4.10 | | | 7.5 | — | — |
| | Gal′ | 4.68 | 3.63 | 3.87 | | 3.60—4.10 | | | 7.8 | — | — |
| | Neu5Ac[a] | — | — | 1.91, 2.68 | 3.74 | 3.79 | 3.53 | | — | — | 4.7 |
| | Fuc[b] | 5.24 | 3.76 | — | 3.70 | 4.22 | 1.22 | | 2.8 | — | — |
| **6** | GalN[c] | 5.42 | 3.80 | 4.65 | 4.52 | 3.64 | 4.04 | 4.40 | 9.9 | 10.3 | — |
| | Gal[d] | 4.61 | 4.13 | 5.01 | 4.45 | 3.53 | 4.07 | 4.28 | 7.6 | 10.1 | 3.4 |
| **8** | GalN | 5.46 | 3.33 | 5.09 | 4.41 | 3.67 | 4.06 | 4.42 | 9.9 | 10.5 | 3.3 |
| | Gal | 4.62 | 4.34 | 5.17 | 4.54 | 3.61 | 4.15 | 4.35 | 7.7 | 9.9 | 3.5 |
| | Fuc[e] | 5.37 | 3.70 | 5.27 | 4.94 | 4.35 | 1.20 | | 3.1 | 10.5 | 3.2 |
| **10** | Glc | 4.41 | 3.39 | — | — | — | — | — | 7.5 | — | — |
| | Gal | 4.65 | 3.79 | — | — | — | — | — | 9.2 | — | — |
| | GalN | 5.13 | 4.02 | — | — | — | — | — | 10.0 | — | — |
| | Gal′ | 4.69 | 4.05 | — | — | — | — | — | 8.0 | — | — |
| | Neu5Ac[f] | — | — | 2.70 | 4.95 | — | — | — | — | — | — |
| | Fuc | 5.25 | 3.70 | 5.34 | — | 4.35 | 0.9 | | 2.6 | — | — |
| **11** | Glc | 4.51 | 3.33 | 4.12 | 3.63 | — | — | — | 7.9 | 8.8 | — |
| | Gal | 4.55 | 3.36 | 3.67 | — | — | — | — | 8.0 | 9.9 | — |
| | GalN | 4.66 | 3.98 | — | — | — | — | — | 8.1 | — | — |
| | Gal′ | 4.69 | 3.59 | — | — | — | — | — | 7.7 | — | — |
| | Neu5Ac[a] | — | — | 1.89, 2.69 | 3.73 | 3.82 | — | — | — | 4.3 | — |
| | Fuc[b] | 5.19 | 3.74 | — | 3.72 | 4.17 | 1.22 | | 3.1 | — | — |

[a] Other signals: δ 3.57—4.0 (H(7), H(8), H(9)).
[b] $J_{5,6}$ = 6.5 Hz.
[c] $J_{6a,6b}$ = 12.0 Hz.
[d] $J_{6a,6b}$ = 12.2 Hz.
[e] $J_{5,6}$ = 6.4 Hz.
[f] Other signals: ($CDCl_3$, δ): 5.29 (H(7), $J_{7,8}$ = 7.6 Hz); 5.38 (H(8)); 3.96 (H(9a)); 4.32 (H(9b)); 5.52 (NHAc).
*Note.* Other signals for compounds **6**, **8**, and **10** ($CDCl_3$, δ): 5.58—5.78 (>CH—Ph); 8.4 ($SC_6H_4NHCOCl_3$); 1.9—2.1 (MeCOO); 7.7—8.0 ($C_6H_5COO$); 6.8—7.5 ($PhCH_2$); 4.5—4.9 ($PhCH_2$); 3.38—3.58 ($OCH_2CH_2N_3$); 3.67—4.10 ($OCH_2CH_2N_3$); 6.8 ($NHC(O)CCl_3$, $J_{NH(2)}$ = 10 Hz); 3.7 (COOMe).
Other signals for compounds **1** and **11** ($D_2O$, δ): 2.0—2.1 (MeCONH); 3.9—4.2 ($OCH_2CH_2NH_2$); 3.22—3.28 ($OCH_2CH_2NH_2$); 4.10, 4.20 ($ClCH_2CO$, *J* = 14.4 Hz).

stant $J_{1'',2''}$ = 3.1 Hz in the $^1$H NMR spectrum (Table 1) and its (1→2) position, by the downfield chemical shift of the C(2′) signal (δ 76.1) in the $^{13}$C NMR spectrum of compound **8** (Table 2).

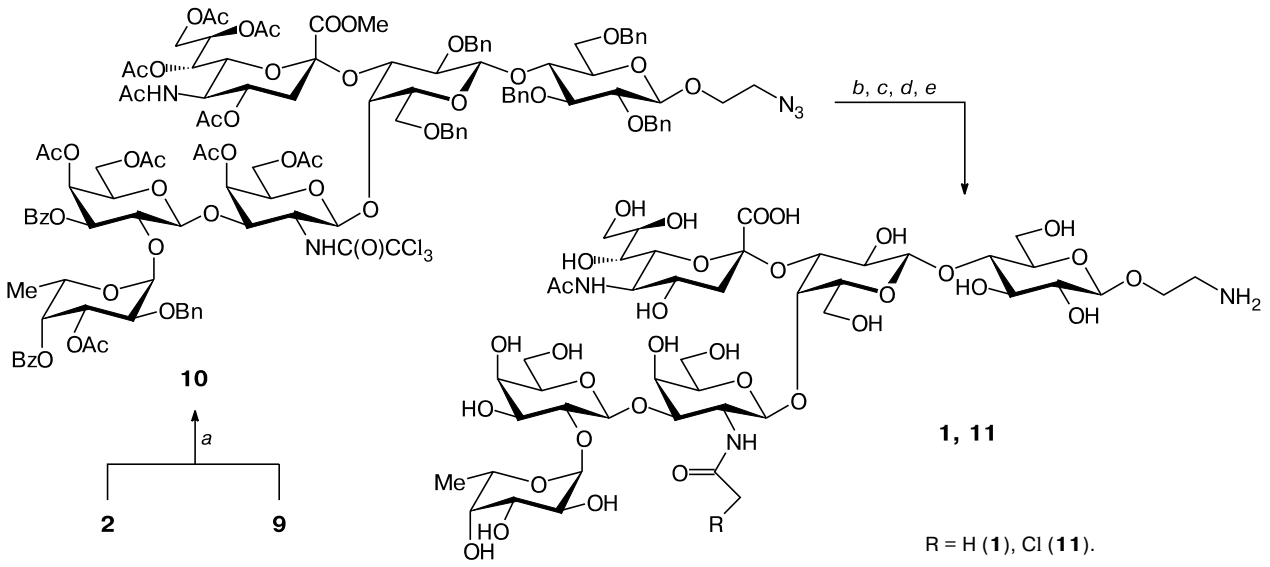
The presence of acid-labile benzylidene protecting groups in trisaccharide **8** limits its applicability as the glycosyl donor. Therefore, compound **8** was converted in 84% yield into derivative **9**, containing *O*-acetyl protecting groups, which are more stable under glycosylation conditions.

The condensation of thioglycoside **9** with the trisaccharide glycosyl acceptor **2** in the presence of *N*-iodosuccinimide and trifluoromethanesulfonic acid in $CH_2Cl_2$ gave the hexasaccharide derivative **10** in 76% yield (Scheme 3). The β-configuration of the newly formed glycosidic bond was confirmed by the characteristic coupling constant $J_{1'',2''}$ = 8.1 Hz in the $^1$H NMR spectrum of hexasaccharide **10**.

Product **10** was converted into hexasaccharide **1** using the reactions and conditions successfully employed previously[2] to prepare the spacered derivative of the pentasaccharide chain of ganglioside $GM_1$, which has a structure similar to that of hexasaccharide **1** with no α-L-fucopyranosyl substituent at the O(2) atom of the galactose residue.

The removal of all acyl groups from the protected derivative **10** was performed by treatment with a 1 *M* solution of NaOH in aqueous methanol followed by *N*-acetylation of the free amino group in the galactosamine residue with acetic anhydride (see Scheme 3). Simultaneous hydrogenolysis of the benzyl groups and reduction of the azido group with hydrogen on Pd/C were carried

**Scheme 3**




**Reagents:** (*a*) NIS/TfOH, $CH_2Cl_2$; (*b*) NaOH, MeOH/$H_2O$; (*c*) $Ac_2O$, NaOH; (*d*) $H_2$, Pd/C, $Boc_2O$; (*e*) $CF_3COOH$, $H_2O$/MeOH.

NIS is *N*-iodosuccinimide, $Boc_2O$ is di(*tert*-butyl) pyrocarbonate.

out in aqueous ethanol in the presence of $Boc_2O$ for protecting the amine formed in the reaction.[14] However, following the removal of the Boc protection from the amino group a mixture of the target Fuc-$GM_1$ **1** (24%) and its *N*-chloroacetyl derivative **11** (62%) was obtained; this was separated by reversed-phase HPLC.

The structure of the target hexasaccharide **1**, including the position and configuration of the monosaccharide residues, was confirmed by the $^1H$ and $^{13}C$ NMR data (see Tables 1 and 2) and by the data from mass spectra, which exhibited a peak with *m/z* 1210.2, corresponding to $[M + Na]^+$ for this compound. In the $^1H$ NMR spectrum of hexasaccharide **11**, the relative integral intensity of the signal at δ 2.0—2.1, corresponding to the acetyl group protons, was equal to three units instead of the required six units (two *N*-acetyl groups in the target hexasaccharide **1**), while the chemical shifts of the signals for H(2′) (δ 3.6) and C(2′) (δ 53) were typical of the galactosamine residue with the acylated amino group.

The above data suggest that the galactosamine residue of product **11** contains an *N*-acyl group other than acetyl, because, according to NMR data, the only acetyl group belongs to the Neu5Ac residue. The nature of this acyl group was established based on the combination of NMR data. The $^1H$ NMR spectrum of hexasaccharide **11** contained signals for two protons as doublets (δ 4.1 and 4.2) ($CH_2Cl$). According to HSQC and HMBC data, they were correlated with the carbon signals at δ 43.7 ($CH_2Cl$) and δ 170.9 (C(O)NH), respectively. These values are in good agreement with the known chemical shifts for the chloroacetyl group. The position of this group was unambiguously confirmed by the correlation between the signal of the carbonyl carbon atom of the chloroacetyl group and the H(2) proton of the galactosamine residue observed in the HMBC spectrum. The mass spectrum of the product, which exhibited an intense peak with *m/z* 1244.2 corresponding to $[M + Na]^+$, provided yet another piece of evidence for the structure of compound **11**.

The formation of product **11** is obviously due to the incomplete removal of the trichloroacetyl group in the alkaline treatment of compound **10** and its subsequent partial hydrogenolysis to the chloroacetyl group. Note that completeness of the removal of the trichloroacetyl group is hardly controllable by TLC for two reasons. First, the liberated amino group gave no test reaction with ninhydrin, apparently, due to steric hindrance. Second, deacylation afforded a charged polyol whose chromatographic mobility changed only slightly upon removal of the trichloroacetyl group; therefore, it was difficult to determine the completeness of its transformation into the desired amine.

The higher stability of the *N*-trichloroacetyl group in compound **10** against alkaline hydrolysis compared to the $GM_1$-analog[2] is due most likely to the steric hindrance caused by the presence of the α-L-fucopyranosyl substituent at O(2) of the galactose residue. Nevertheless, the resulting compound **11**, like the target compound **1**, is an interesting substrate for investigation of the carbohydrate specificity of lectins and other carbohydrate-binding proteins, the chloroacetyl group being suitable for the intro-

**Table 2.** $^{13}C$ NMR data of compounds **1** and **11** ($D_2O$), **6**, **8**, and **10** ($CDCl_3$)

| Compound | Residue | δ | | | | | |
|---|---|---|---|---|---|---|---|
| | | C(1) | C(2) | C(3) | C(4) | C(5) | C(6) |
| **1** | Glc | 103.7 | 71.1 | 75.5 | 79.5 | — | — |
| | Gal | 103.0 | 73.8 | 75.9 | — | — | — |
| | GalN | 104.2 | 52.8 | — | — | — | — |
| | Gal′ | 103.2 | 77.0 | — | — | — | — |
| | Neu5Ac | — | — | 38.5 | 69.3 | 52.7 | 76.0 |
| | Fuc | 100.3 | 69.8 | 70.9 | — | 67.9 | 16.5 |
| **6** | GalN | 82.5 | 52.6 | 75.1 | 75.8 | 70.2 | 69.0 |
| | Gal | 103.7 | 68.6 | 74.0 | 73.3 | 66.6 | 69.0 |
| **8** | GalN | 80.4 | 53.5 | 75.8 | 76.1 | 70.1 | 69.2 |
| | Gal | 95.9 | 76.1 | — | 73.4 | 66.6 | — |
| | Fuc | 92.2 | 72.6 | 71.2 | 71.9 | 64.7 | 14.6 |
| **10** | Glc | 103.4 | 81.7 | 82.8 | — | — | — |
| | Gal | 102.5 | 79.5 | — | — | — | — |
| | GalN | 99.1 | 52.8 | — | — | — | — |
| | Gal′ | 102.2 | — | — | — | — | — |
| | Neu5Ac | 169.6 | 98.3 | 37.1 | — | — | — |
| | Fuc | 98.3 | — | — | — | — | 15.9 |
| **11** | Glc | 103.7 | 71.0 | 75.4 | 79.3 | — | — |
| | Gal | 103.0 | 73.8 | 76.0 | — | — | — |
| | GalN | 104.0 | 53.2 | — | — | — | — |
| | Gal′ | 102.9 | 77.7 | — | — | — | — |
| | Neu5Ac | — | — | 38.7 | 69.7 | 52.7 | — |
| | Fuc | 100.6 | 69.3 | — | — | — | 16.5 |

*Note.* Other signals for compounds **6**, **8**, and **10** ($CDCl_3$), δ: 100.4—101.2 (>CH—Ph); 159.5—161.6 ($COCCl_3$); 22.6 ($\underline{C}H_3CONH$); 175.5 ($CH_3\underline{C}ONH$); 52.7 ($COO\underline{C}H_3$); 168.2 ($\underline{C}OOCH_3$); 127.5—128.5 ($\underline{C}_6H_5CH_2$); 72.1—75.6 ($C_6H_5\underline{C}H_2$); 51.0 ($OCH_2C\underline{H}_2N_3$); 68.1—68.2 ($OC\underline{H}_2CH_2N_3$); 166.3 ($C_6H_5\underline{C}OO$); 129.8—139.0 ($\underline{C}_6H_5COO$); 169.6—170.2 ($CH_3\underline{C}OO$); 20.5—20.7 ($\underline{C}H_3COO$).
Other signals for compounds **1** and **11** ($D_2O$), δ: 22.6—23.3 ($C\underline{H}_3CONH$); 67.0 ($OC\underline{H}_2CH_2NH_2$); 40.3 ($OCH_2C\underline{H}_2NH_2$); 176.0 ($CH_3\underline{C}ONH$); 174 ($\underline{C}OOH$); 43.7 ($Cl\underline{C}H_2CONH$); 170.9 ($ClCH_2\underline{C}ONH$).

duction of additional structural fragments into the molecule of hexasaccharide Fuc-$GM_1$.

## Experimental

The procedures for solvent purification and the conditions for recording the NMR spectra and determination of physicochemical parameters are similar to those reported previously.[15] Commercial $Bu_2SnO$ and NIS (Aldrich) were used. The $^1H$ and $^{13}C$ NMR spectra were recorded on Bruker DRX-500 and Bruker AM-300 instruments at 25 °C. The signals were assigned by means of 2D COSY, ROESY, HSQC, and HMBC homo- and heteronuclear correlation spectra. The optical rotation was measured on a Jasco DIP-360 digital polarimeter at 18—25 °C. Thin layer chromatography was carried out on silica gel Kieselgel-60 (Merck), the substances being visualized by spraying with a 10% (v/v) solution of orthophosphoric acid in ethanol or (for amines) a ninhydrin solution (3 g $L^{-1}$ in a 30 : 1 butanol—acetic acid mixture) with subsequent heating at ~150 °C. Column chromatography was carried out on Silica gel 60 (Fluka), 0.063—0.2 mm; reversed-phase HPLC was performed on a Chromsphere 5 C18 semipreparative column (10×250 mm) (Chrompack) using elution with water. Gel chromatography was carried out on columns with Sephadex LH-20 (2×40 cm) (elution with methanol at a flow rate of 1 mL $min^{-1}$), Bio-Beads S-X3 (68×2.5 cm, Bio-Rad) (elution with toluene), and TSK HW-40(S) (1.5×90 cm) (elution with 0.1 *M* aqueous acetic acid at a flow rate of 1 mL $min^{-1}$). Hydrogenolysis was carried out in the presence of 10% Pd/C (Merck) under atmospheric pressure. For the TLC of free aminoethyl glycosides, the mixtures butanol—propanol—0.1 *M* hydrochloric acid, 1 : 2 : 1 (*A*) and acetonitrile—methanol—water, 1 : 1 : 1 (*B*) were used.

**(4-Trichloroacetamidophenyl) 4,6-*O*-benzylidene-3-*O*-(4,6-*O*-benzylidene-3-*O*-benzoyl-β-D-galactopyranosyl)-2-deoxy-1-thio-2-trichloroacetamido-β-D-galactopyranoside (6).** A 1 *M* solution of sodium methoxide in methanol (0.1 mL) was added to a solution of peracetate **4** (40 mg, 0.04 mmol) in anhydrous methanol (3 mL). After 20 min, the solution was neutralized with the cation-exchange resin KU-2 ($H^+$), the resin was filtered off and washed with methanol, and the filtrate was concentrated. Toluene was added to the resulting crystalline mass and then evaporated (to remove methanol), and the residue was dried in vacuum of an oil pump. Without further purification, the resulting hexol was subjected to benzylidenation with α,α-dimethoxytoluene (20 μL) and CSA (5 mg) in dry acetonitrile (5 mL). The reaction mixture was kept for 14 h at 20 °C and neutralized with triethylamine (0.5 mL). Benzoyl cyanide (6 mg) was added to the resulting solution, and the mixture was kept for 15 min. The reaction mixture was concentrated, the residue was dissolved in ethyl acetate (50 mL), the solution was washed with a solution of $NaHCO_3$ (50 mL), the organic phase was separated, the solvent was evaporated, and the residue was chromatographed (chloroform—acetone, 5 : 1) to give 37 mg (89%, over three steps) of disaccharide **6**, white foam, $R_f$ 0.38 (chloroform—acetone, 4 : 1). The $^1H$ and $^{13}C$ NMR spectral data for compound **6** are presented in Tables 1 and 2.

**(4-Trichloroacetamidophenyl) *O*-(3-*O*-acetyl-4-*O*-benzoyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→2)-*O*-(3-*O*-benzoyl-4,6-*O*-benzylidene-β-D-galactopyranosyl)-(1→3)-4,6-*O*-benzylidene-2-deoxy-1-thio-2-trichloroacetamido-β-D-galactopyranoside (8).** A solution of disaccharide **6** (30 mg, 0.033 mmol) and glycosyl donor **7** (22 mg, 0.036 mmol) in anhydrous $CH_2Cl_2$ (3 mL) was stirred for 2 h under dry argon at room temperature with activated molecular sieves (MS) 4 Å (300 mg). The reaction mixture was cooled to −30 °C, and a 1 *M* solution of TMSOTf in $CH_2Cl_2$ (50 μL) was added dropwise at the same temperature. The mixture was stirred for 20 min at −30 to −20 °C, a saturated solution of $NaHCO_3$ (1 mL) was added, and the mixture was stirred for an additional 10 min. The resulting mixture was filtered through a Celite layer, the filtrate was diluted with $CH_2Cl_2$ (75 mL) and washed with a solution of $NaHCO_3$ (50 mL), the organic layer was separated, the solvent was evaporated, and the residue was chromatographed (chloroform—ethyl acetate, 10 : 1) to give 40 mg (93%) of trisaccharide **8** as a white

foam, $R_f$ 0.29 (chloroform—ethyl acetate, 10 : 1). The data of $^1H$ and $^{13}C$ NMR spectra of compounds **8** are presented in Tables 1 and 2.

**(4-Trichloroacetamidophenyl) *O*-(3-*O*-acetyl-4-*O*-benzoyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→2)-*O*-(4,6-di-*O*-acetyl-3-*O*-benzoyl-β-D-galactopyranosyl)-(1→3)-4,6-di-*O*-acetyl-2-deoxy-1-thio-2-trichloroacetamido-β-D-galactopyranoside (9).** A solution of benzylidene derivative **8** (40 mg, 0.027 mmol) in 90% AcOH (3 mL) was kept for 10 h at 80 °C. The reaction mixture was cooled to 20 °C and concentrated, and toluene was added to, and evaporated from, the residue until the acid smell was no longer present. The resulting precipitate was dissolved in dry pyridine (2 mL) and $Ac_2O$ (200 μL) was added. The reaction mixture was kept for 18 h at 20 °C and treated with methanol, the solvents were evaporated, and toluene was added to, and evaporated from, the residue until the pyridine smell was no longer present. Column chromatography using gradient elution with toluene—acetone mixtures from 5 : 1 to 5 : 2 gave 30 mg (84%) of product **9** as a white foam, $R_f$ 0.44 (toluene—acetone, 5 : 1), $[\alpha]_D$ −101.7 (c 1, $CHCl_3$).

**(2-Azidoethyl) *O*-(3-*O*-acetyl-4-*O*-benzoyl-2-*O*-benzyl-α-L-fucopyranosyl)-(1→2)-*O*-(4,6-di-*O*-acetyl-3-*O*-benzoyl-β-D-galactopyranosyl)-(1→3)-*O*-(4,6-di-*O*-acetyl-2-deoxy-2-trichloroacetamido-β-D-galactopyranosyl)-(1→4)-*O*-[{methyl(5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosyl)onate}-(2→3)]-*O*-(2,6-di-*O*-benzyl-β-D-galactopyranosyl)-(1→4)-2,3,6-tri-*O*-benzyl-β-D-glucopyranoside (10).** A solution of trisaccharide **2** (60 mg, 0.046 mmol) and thioglycoside **9** (70 mg, 0.05 mmol) in anhydrous $CH_2Cl_2$ (3 mL) was stirred with activated MS-4 Å (300 mg) for 1.5 h at room temperature. NIS (14 mg, 0.062 mmol) was added, and the mixture was stirred for an additional 30 min at room temperature. The reaction mixture was cooled to −40 °C, and a 5% (v/v) solution of TfOH in $CH_2Cl_2$ (100 μL) was added dropwise. The mixture was stirred for 1.5 h at −30 °C, a saturated solution of $NaHCO_3$ (2 mL) and a 1 *M* solution of $Na_2S_2O_3$ (2 mL) were added, cooling was discontinued, and the mixture was stirred for an additional 15 min. Then the reaction mixture was filtered through a Celite layer, the filtrate was diluted with dichloromethane (50 mL) and washed with a solution of $NaHCO_3$ (50 mL), and the organic phase was separated and concentrated. The residue was passed through a silica gel layer (chloroform—acetone, 5 : 1). The resulting mixture was separated on a column with Bio-Beads S-X3. A portion (15 mg) of glycosyl acceptor was recovered unchanged, and hexasaccharide **10** (64 mg, 76% based on converted **2**) was isolated as a white foam, $R_f$ 0.5 (chloroform—acetone, 2 : 1), $[\alpha]_D$ −18 (*c* 1, $CHCl_3$). The data of the $^1H$ and $^{13}C$ NMR spectra of compound **10** are listed in Tables 1 and 2.

**(2-Aminoethyl) *O*-α-L-fucopyranosyl-(1→2)-*O*-β-D-galactopyranosyl-(1→3)-*O*-(2-acetamido-2-deoxy-β-D-galactopyranosyl)-(1→4)-*O*-[5-acetamido-3,5-dideoxy-D-*glycero*-α-D-*galacto*-2-nonulopyranosyl-(2→3)]-β-D-galactopyranosyl-(1→4)-β-D-glucopyranoside (1).** Hexasaccharide **10** (35 mg, 0.014 mmol) was dissolved in 20% aqueous methanol (3 mL), NaOH (120 mg) was added, the mixture was stirred until the compound completely dissolved and then kept for 8 h at 40 °C and for 14 h at room temperature. The mixture was cooled to 0 °C and $Ac_2O$ was added dropwise to pH 6 (against the universal pH indicator, Merck). The mixture was deionized by treatment with the cation-exchange resin KU-2 (H+), the resin was filtered off and washed with methanol (3×10 mL), the filtrates were combined, the solvent was evaporated, and the residue was chromatographed on a column with Sephadex LH-20. Carbohydrate-containing fractions were concentrated and dried in the vacuum of an oil pump, the dry residue was dissolved in 10% aqueous ethanol (3 mL), $Boc_2O$ (100 mg) and a catalytic amount of Pd/C were added, and the mixture was stirred for 16 h under hydrogen at room temperature until the benzyl groups were completely removed (TLC monitoring). The reaction mixture was filtered through a Celite layer and washed with methanol→water gradient mixtures: (0 → 100%, 30 mL), and 90% aqueous $CF_3COOH$ (2 mL) was added to the filtrate. The mixture was kept for 30 min and concentrated, and water was added to, and evaporated from, the residue until the acid smell was no longer present. Gel chromatography on a column with the TSK HW-40(S) gel gave a mixture of aminoethyl glycoside **1** and *N*-chloroacetyl derivative **11**. This mixture was further separated by reversed-phase HPLC on a Chromsphere 5 C18 column to give 4 mg (24%) of compound **1**, $R_f$ 0.24 (*A*—*B*, 1 : 1), $[\alpha]_D$ −1 (c 0.2, $H_2O$) and 10 mg (62%) of compound **11**. Mass spectrum of hexasaccharide **1**: calculated for $[M + Na]^+$: 1210.4. Found: 1210.2. The $^1H$ and $^{13}C$ NMR data for compounds **1** and **11** are presented in Tables 1 and 2.

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