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Carbohydrate Research 308 (1998) 329–338

Synthesis of the spacer-containing β-D-GalpNAc-(1→4)-β-D-GlcpNAc-(1→3)-α-D-Galp moiety, representing the non-fucosylated backbone trisaccharide of the glycocalyx glycan of the parasite *Schistosoma mansoni*

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Received 22 January 1998; accepted 30 March 1998

Abstract

The chemical synthesis of β-D-GalpNAc-(1→4)-β-D-GlcpNAc-(1→3)-α-D-Galp-(1→O)-$(CH_2)_5NH_2$ is described. This structure represents the nonfucosylated backbone trisaccharide of the glycocalyx glycan of the cercarial stage of the parasite *Schistosoma mansoni*. Synthesis of the trisaccharide was achieved via a stepwise coupling approach. 5-Azidopentyl 4-*O*-acetyl-2,6-di-*O*-benzyl-α-D-galactopyranoside was condensed with ethyl 6-*O*-benzyl-2-deoxy-3,4-di-*O*-dimethylisopropylsilyl-2-phthalimido-1-thio-β-D-glucopyranoside, using *N*-iodosuccinimide and silver trifluoromethanesulfonate as a catalyst system, followed by the removal of the silyl ether groups to afford a disaccharide acceptor. Coupling of ethyl 4,6-di-*O*-acetyl-3-*O*-allyloxycarbonyl-2-deoxy-2-phthalimido-1-thio-β-D-galactopyranoside to the disaccharide acceptor, using methylsulfenyl bromide and silver trifluoromethanesulfonate as a catalyst system, gave a protected trisaccharide. Deprotection of this compound yielded the target structure. © 1998 Elsevier Science Ltd. All rights reserved

Keywords: Oligosaccharide synthesis; Glycocalyx; *Schistosoma mansoni*

1. Introduction

Schistosomes, which are blood-dwelling flukes belonging to the class Trematode, cause in human beings the infectional disease schistosomiasis. Schistosoma species that are most important in human schistosomiasis are *Schistosoma mansoni*, *Schistosoma japonicum*, and *Schistosoma haematobium* [1]. The infective parasitic stage, the cercaria, enters the host through the skin, evoking an inflammatory response. From this stage to about 3 weeks after infection the parasite, present as a young schistosomulum, is most susceptible to immune damage [2]. During the cercarial stage of

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PII S0008-6215(98)00087-1

the life cycle of the parasite, the entire surface of the parasite is covered by a 1 μm-thick highly immunogenic, fucose-rich glycocalyx. Recently, the nonreducing terminal sequences of the O-linked carbohydrate chain as part of the glycocalyx (GCX) were elucidated by Khoo et al. [3] (Fig. 1). These epitopes are carried on type 1 or type 2 core structures via units of {→3)-β-D-Gal*p*NAc-(1→4)-[α-L-Fuc*p*-(1→2)-α-L-Fuc*p*-(1→2)-α-L-Fuc*p*-(1→3)-]β-D-Glc*p*NAc-(1→3)-α-D-Gal*p*-(1→}$_n$, where n is mainly 0 or 1.

After the cercarial stage the developing worm becomes resistant to, or even invisible to, certain parts of the host's defence system by several evasion mechanisms. Some of the evasion techniques employed by schistosomula and adult worms are camouflage by acquisition of host antigens [4], reduction of surface antigenicity by tegument antigen shedding [5], modulation of the host's immune response by eliciting blocking antibodies [6], induction of immunosuppressive mechanisms by excretion of specific T cell suppressor factors [7], and clearance from the surface by sloughing of antibody-antigen complexes or of molecules which are potentially harmful to the parasite [8]. Due to all these evasion mechanisms, the parasite can persist in the host for approximately 3–5 years. The most severe pathology of the infection is caused by the eggs of the parasite which get stuck in the human body [9]. In order to be able to treat the infection with chemotherapeutics before the onset of egg production, an early diagnostic method for schistosomiasis is needed. Serological detection of antibodies, raised against the glycocalyx of the cercarial stage of the parasite *S. mansoni*, could be such an early diagnostic method.

A vaccine against schistosomiasis would be even more desirable. Although much research has been directed to this field, no vaccine has yet been developed to the stage of application in man [10,11]. It is known that man once infected seldom become re-infected, probably due to the generation of protective antibodies against the cercarial stage of the parasite *S. mansoni*. It is speculated that both the fucosyl appendages and the α-linked galactose residue are likely to be involved in GCX's action as a very potent immunological modulator [3]. However, the exact role of the various domains of the GCX in immunological stimulation can only be assessed with testing with neoglycoconjugates prepared with fragments of the GCX.

The availability of well-defined oligosaccharides of the GCX from biological sources in sufficient amounts is limited. In order to replace isolated material in both immunological studies and diagnostic purposes, a synthetic program for the preparation of several oligosaccharide fragments present in the GCX was initiated. Here, we report the chemical synthesis of the nonfucosylated backbone trisaccharide β-D-Gal*p*NAc-(1→4)-β-D-Glc*p*NAc-(1→3)-α-D-Gal*p* **1**, having an aminopentyl spacer for conjugation to carrier molecules. In the course of our studies, a Note appeared reporting the synthesis of α-L-Fuc*p*-(1→2)-α-L-Fuc*p*-(1→3)-β-D-Gal*p*NAc-(1→O)$(CH_2)_8$COOMe [12].

Treating trisaccharide **1** with fucosyltransferases present in different schistosoma species [13], will give partially fucosylated structures which can be used in the above described biological tests. On the other hand, one of the intermediates generated along the route towards the preparation of **1**, can be coupled with chemically synthesised di- and trisaccharide fucosyl molecules which are prepared as described elsewhere [14], to achieve the total synthesis of the octasaccharide structure (Fig. 1).

2. Results and discussion

Trisaccharide **1** can be synthesised via a stepwise approach using the monosaccharide building blocks 5-azidopentyl 4-*O*-acetyl-2,6-di-*O*-benzyl-α-D-galactopyranoside (**7**) (Scheme 1), ethyl 6-*O*-benzyl-2-deoxy-3,4-di-*O*-dimethylisopropylsilyl-2-phthalimido-1-thio-β-D-glucopyranoside (**10**), and ethyl 4,6-di-*O*-acetyl-3-*O*-allyloxycarbonyl-2-deoxy-2-phthalimido-1-thio-β-D-galactopyranoside (**13**) (Scheme 2). In order to be able to conjugate

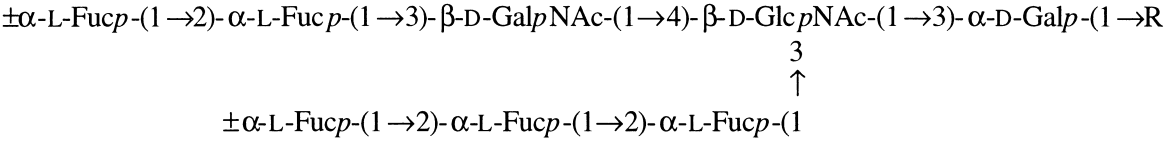
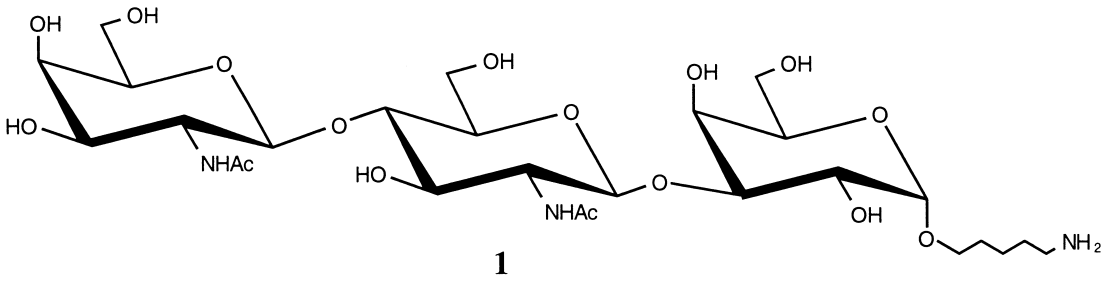
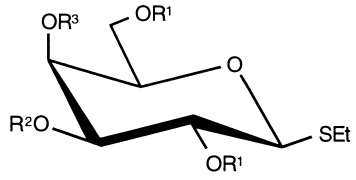


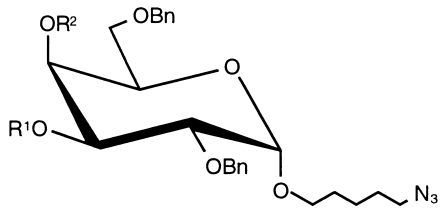
Fig. 1. Nonreducing terminus of the glycocalyx glycan of the cercarial stage of *Schistosoma mansoni*.



1

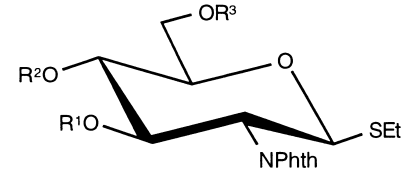


	R^1	R^2	R^3
2	Ac	Ac	Ac
3	H	CMe_2	
4	Bn	CMe_2	

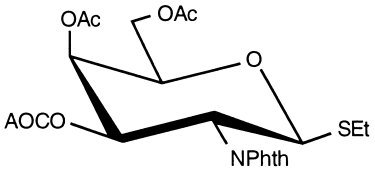


	R^1	R^2
5	CMe_2	
6	H	H
7	H	Ac

Scheme 1. Synthesis of spacer-containing galactose acceptor **7**.



	R^1	R^2	R^3
8	H	CHPh	
9	H	H	Bn
10	DMIPS	DMIPS	Bn
11	AOC	CHPh	
12	AOC	H	Ac



13

Scheme 2. Synthesis of glucosamine donor **10** and galactosamine donor **13**; DMIPS, $((CH_3)_2C)(CH_3)_2Si$; AOC, $CH_2CHCH_2OC(O)$.

deprotected oligosaccharides to a suitable carrier molecule for immunological testing, a spacer molecule is needed. As indicated by **7**, in our strategy an azidopentyl spacer has been chosen, since it is stable to all the required reaction conditions [15]. This spacer is introduced at an early stage of the synthetic route by coupling ethyl 2,6-di-*O*-benzyl-3,4-*O*-isopropylidene-1-thio-*β*-D-galactopyranoside **4** (Scheme 1) to 5-azidopentanol. The obtained product can easily be transformed into acceptor **7**.

For the synthesis of acceptor **7** (Scheme 1), donor molecule **4** was prepared by deacetylation of ethyl 2,3,4,6-tetra-*O*-acetyl-1-thio-*β*-D-galactopyranoside (**2**) using the Zemplén procedure, followed by the introduction of an isopropylidene function at HO-3,4 using 2,2-dimethoxypropane in the presence of *p*-toluenesulfonic acid (→**3**, 67%), and

benzylation of the remaining hydroxyl functions using benzyl bromide in the presence of sodium hydride (→**4**, 73%). Condensation of **4** with 5-azidopentanol [15], in the presence of methyl trifluoromethanesulfonate, yielded a mixture of the 1,2-*cis* and 1,2-*trans* glycosides, from which the desired compound **5** could be isolated in a yield of 43%. The presence of the azido group in **5** was established by FT-IR (ν 2096 cm^{-1}), and the 1,2-*cis* glycosidic linkage by ^1H NMR ($J_{1,2}$ 3.5 Hz). After removal under acidic conditions of the isopropylidene function (→**6**, quantitative), an orthoester function was introduced at HO-3,4, using trimethyl orthoacetate and *p*-toluenesulfonic acid in *N,N*-dimethylformamide, and subsequently selectively [16] opened towards the 4-position of the galactose derivative to yield acceptor molecule **7** (97%).

The starting compound for both the glucosamine donor **10** (Scheme 2) and the galactosamine donor **13** (Scheme 2) was ethyl 4,6-*O*-benzylidene-2-deoxy-2-phthalimido-1-thio-β-D-glucopyranoside [17] (**8**). Synthesis of **10** was achieved by the reductive opening of the benzylidene ring of **8** towards the primary hydroxyl function using sodium cyanoborohydride and anhydrous HCl in diethyl ether [18] (→**9**, 60%), followed by silylation of the hydroxyl groups at C-3 and C-4 with dimethylisopropylchlorosilane in pyridine to afford the desired glucosamine donor (66%).

For the preparation of the galactosamine donor **13** (Scheme 2), compound **8** was first allyloxycarbonylated [19] using allyl chloroformate in pyridine, to afford intermediate **11** (97%). Acidic removal of the benzylidene function, followed by selective acetylation of the primary hydroxyl group using acetyl chloride in pyridine, gave **12** in an overall yield of 70%. For the conversion of **12** into **13** (epimerization at C-4) use was made of an S_N2 displacement reaction of *O*-triflate by *O*-acetate [20]. To this end, **12** was treated with triflic anhydride in dichloromethane in the presence of pyridine, and then the 4-*O*-triflated intermediate was treated with tetrabutylammonium acetate in *N,N*-dimethylformamide, to yield **13** (90%).

Condensation of **7** with **10** (Scheme 3) in dichloromethane in the presence of the catalyst system *N*-iodosuccinimide and silver trifluoromethanesulfonate [21] at −60 °C afforded stereoselectively disaccharide derivative **14** (84%). Removal of both silyl ether groups under acidic conditions, using *p*-toluenesulfonic acid in acetonitrile and water, gave disaccharide acceptor **15** (93%).

Diol **15** can be used directly as an acceptor for coupling with **13**. A similar condensation of a galactosamine donor to the 4-position of a glucosamine acceptor having both the HO-3 and HO-4 functions available, and the amine groups of both the donor and acceptor protected with a phthalimido function, has been described earlier [22]. Condensation of **15** with **13** (Scheme 3), using methylsulfenyl bromide and silver trifluoromethanesulfonate [23], at −50 °C afforded in 79% yield a 1:4 mixture of the (1→3) and (1→4) coupling products, which could be separated by column chromatography, to give **16** in 63% yield. For product identification, two-dimensional rotating frame nuclear Overhauser enhancement NMR spectroscopy of the products and their acetylated derivatives was performed.

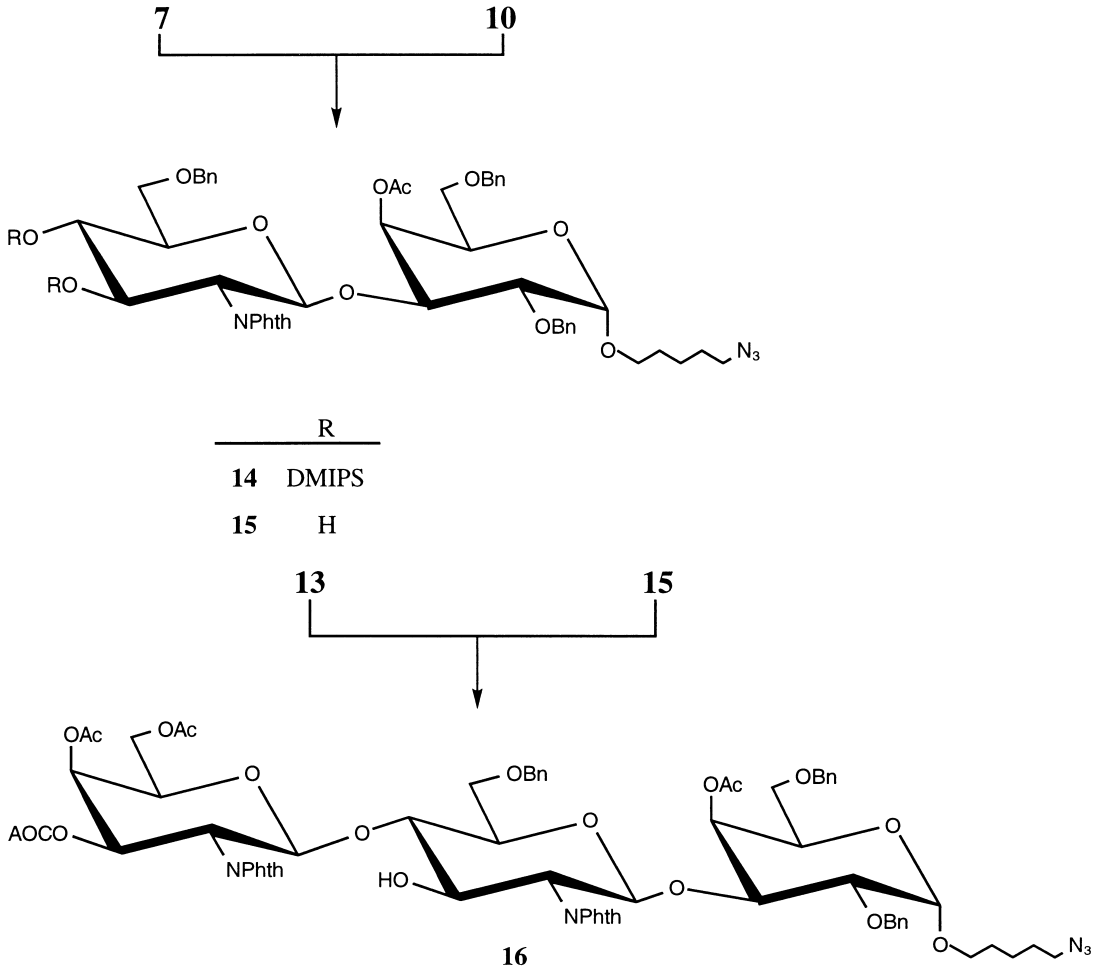
A strategy, which is under current investigation involves the chemical fucosylation of intermediate **16** at the glucosamine residue, and after deallyloxycarbonylation at the galactosamine residue, to afford the total octasaccharide structure, as depicted in Fig. 1.

In order to obtain a suitable substrate for fucosyltransferases, **16** was deprotected to yield target molecule **1**. To this end a deacylation was achieved using ethylenediamine in 1-butanol [24], and after conventional *N,O*-acetylation followed by de-*O*-acetylation, a catalytic hydrogenolysis, using palladium on carbon was carried out, to afford **1** in an overall yield of 70%. In Table 1 the ^1H NMR data of trisaccharide **1** are depicted.

3. Experimental

General methods.—Reactions were monitored by TLC on Kieselgel 60 F_{254} (E. Merck); compounds were visualised by charring with aq 50% H_2SO_4, after examination under UV light. In the work-up procedures of reaction mixtures, organic solns were washed with appropriate amounts of the indicated aq solns, then dried ($MgSO_4$), and concentrated under reduced pressure at 20–40 °C (water-bath). Column chromatography was performed on Kieselgel 60 F_{254} (E. Merck, 70-230 mesh). Size-exclusion chromatography was performed on Sephadex LH-20 or on Hi-Trap.

Optical rotations were measured at 20 °C for solns in $CHCl_3$, unless otherwise stated, with a Perkin–Elmer 241 polarimeter, using a 10 cm 1 mL cell. ^1H NMR spectra were recorded at 27 °C with



Scheme 3. Synthesis of the protected trisaccharide **16**.

Bruker AC 300 or Bruker AMX 500 spectrometers; the values of δ_H are given in ppm relative to the signal for internal Me_4Si (δ 0) for solns in $CDCl_3$, or by reference to acetone (δ 2.225) for solns in D_2O. ^{13}C (APT, 75 MHz) NMR spectra were recorded at 27 °C with a Bruker AC 300 or a Varian Gemini-300 instrument; indicated ppm values for δ_C are relative to the signal of $CDCl_3$ (δ 76.9) for solns in $CDCl_3$. Two-dimensional double-quantum filtered ^1H–^1H correlation spectra (2D DQF ^1H–^1H COSY) were recorded using a Bruker AMX 500 apparatus (500 MHz) at 27 °C. Two-dimensional

Table 1
500-MHz ^1H NMR data of β-D-Gal*p*NAc-(1→4)-β-D-Glc*p*NAc-(1→3)-α-D-Gal*p*-(1→O)$(CH_2)_5NH_2$ (**1**). Assignment was achieved using two-dimensional double-quantum filtered ^1H–^1H correlation spectroscopy (2D DQF ^1H–^1H COSY) and two-dimensional rotating frame nuclear Overhauser enhancement spectroscopy (2D ROESY)

Proton	δ (ppm)/J (Hz)		
	α-D-Gal*p*	β-D-Glc*p*NAc	β-D-Gal*p*NAc
H-1	4.903 (2.5)	4.703 (7.9)	4.522 (8.5)
H-2	3.85	3.78	3.93
H-3	3.90	3.74	3.76
H-4	4.18	3.66	3.92
H-5	—	3.51	3.73
NAc		2.029	2.068
$OCH_aH_b(CH_2)_3CH_2NH_2$	3.722,3.532		
$OCH_aH_b(CH_2)_3CH_2NH_2$	2.995		
$OCH_aH_b(CH_2)_3CH_2NH_2$	1.49–1.44, 1.72–1.64		

rotating frame nuclear Overhauser enhancement spectroscopy (2D ROESY) of **1**, **16**, and the acetylated derivative of **16** was carried out using a mixing time of 250 ms at a spin–lock field strength corresponding to a 90° pulse-width between 100–120 μs. The carrier frequency was placed at the left side of the spectrum at δ 7.3 ppm in order to minimise HOHAHA-type magnetisation transfer. The spectral width was 6580 Hz in each dimension, and 400 experiments of 2K data points were recorded. Fast-atom-bombardment mass spectrometry (FABMS) was performed on a JEOL JMS SX/SX 102A four-sector mass spectrometer, operated at 10 kV accelerating voltage, equipped with a JEOL MS-FAB 10 D FAB gun, operated at 10 mA emission current, producing a beam of 6 keV Xe atoms.

*Ethyl 3,4-*O*-isopropylidene-1-thio-*β-D*-galactopyranoside* (**3**).—To a soln of ethyl 2,3,4,6-tetra-*O*-acetyl-1-thio-*β*-D-galactopyranoside (**2**; 3.65 g, 9.30 mmol) in MeOH was added NaOMe (pH 10). After stirring for 1 h, the soln was neutralised by the addition of Dowex-50 (H^+). Then, the suspension was filtered, concentrated and twice co-concentrated with CH_2Cl_2. To a soln of the residue and 2,2-dimethoxypropane (1.37 mL, 11.2 mmol) in DMF (20 mL) was added *p*-toluenesulfonic acid (pH 2–3). The mixture was stirred overnight and then neutralised by the addition of Amberlyst A-21, filtered, and co-concentrated with toluene. In order to remove the hemiacetal at C-6, a soln of the residue in CH_2Cl_2 (40 mL) was treated with aq 50% CF_3CO_2H for 10 min, when TLC (9:1 CH_2Cl_2-MeOH) showed the formation of one lower moving spot (R_f 0.39). Et_3N was added to quench the reaction, and the mixture was concentrated. Column chromatography (9:1 CH_2Cl_2–acetone) of the residue gave **3**, isolated as a syrup (1.65 g, 67%); $[\alpha]_D$ +19.7° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 4.270 (d, 1 H, $J_{1,2}$ 10.2 Hz, H-1), 4.207 (dd, 1 H, $J_{3,4}$ 5.5, $J_{4,5}$ 2.2 Hz, H-4), 4.092 (dd, 1 H, $J_{2,3}$ 7.0 Hz, H-3), 3.560 (ddd, 1 H, $J_{2,OH}$ 1.6 Hz, H-2), 2.82–2.64 (m, 2 H, SCH_2CH$_3$), 1.519 and 1.356 (2 s, each 3 H, C(CH_3)$_2$), 1.324 (t, 3 H, SCH$_2$CH_3); ^{13}C, δ 110.1 [(CH$_3$)$_2$*C*], 85.2 (C-1), 62.2 (C-6), 27.9 and 26.1 [(*C*H$_3$)$_2$C], 24.3 (S*C*H$_2$CH$_3$), 15.1 (SCH$_2$*C*H$_3$). FABMS (positive-ion mode; $C_{11}H_{20}O_5S$): *m*/*z* 287 $[M+Na]^+$.

*Ethyl 2,6-di-*O*-benzyl-3,4-*O*-isopropylidene-1-thio-*β-D*-galactopyranoside* (**4**).—To a suspension of NaH (1.63 g, 41.33 mmol) in DMF (10 mL) was added slowly a soln of **3** (2.3 g, 7.56 mmol) and benzyl bromide (5.1 mL, 42.64 mmol) in DMF (15 mL). After stirring for 1.5 h, the reaction was quenched by addition of MeOH, and the mixture was diluted with EtOAc (300 mL) and washed with aq 10% NaCl. The organic layer was dried, filtered, concentrated, and the residue was subjected to column chromatography (95:5 CH_2Cl_2–EtOAc) to afford **4**, isolated as a syrup (2.44 g, 73%); (R_f 0.80; 95:5 CH_2Cl_2–acetone); $[\alpha]_D$ −15.8° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 7.44–7.21 (m, 10 H, 2 CH$_2$C$_6$*H*$_5$), 4.835, 4.751, 4.627, and 4.542 (4 d, each 1 H, 2 C*H*$_2$C$_6$H$_5$), 4.435 (d, 1 H, $J_{1,2}$ 9.6 Hz, H-1), 3.451 (dd, 1 H, $J_{2,3}$ 6.2 Hz, H-2), 2.79–2.65 (m, 2 H, SC*H*$_2$CH$_3$), 1.428 and 1.348 (2 s, each 3 H, C(C*H*$_3$)$_2$), 1.304 (t, 3 H, SCH$_2$C*H*$_3$); ^{13}C, δ 138.1, 137.7, 128.2 (5 C), and 127.5 (5 C) (2 CH$_2$*C*$_6$H$_5$), 109.8 [(CH$_3$)$_2$*C*], 83.6 (C-1), 73.3 (2 C) (2 *C*H$_2$C$_6$H$_5$), 69.5 (C-6), 27.7 and 26.2 [(*C*H$_3$)$_2$C], 24.6 (S*C*H$_2$CH$_3$), 14.8 (SCH$_2$*C*H$_3$). FABMS (positive-ion mode; $C_{25}H_{32}O_5S$): *m*/*z* 467 $[M+Na]^+$.

*5-Azidopentyl 2,6-di-*O*-benzyl-3,4-*O*-isopropylidene-*α-D*-galactopyranoside* (**5**).—To a mixture of **4** (1.03 g, 2.31 mmol), 5-azidopentanol [15] (0.39 g, 3.02 mmol) and 4 Å molecular sieves in Et_2O (30 mL) was added at 0 °C MeOTf (0.63 mL, 5.78 mmol). After stirring for 6 h, TLC (7:3 hexane–EtOAc) showed the formation of a new spot (R_f 0.54). Then, Et_3N (0.2 mL) was added and the mixture was diluted with CH_2Cl_2 (200 mL), washed with water, and the organic layer was dried, filtered, and concentrated. Column chromatography (7:3 hexane–EtOAc) of the residue yielded **5**, isolated as a glass (0.51 g, 43%); $[\alpha]_D$ +31.8° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 7.35–7.25 (m, 10 H, 2 CH$_2$C$_6$*H*$_5$), 4.773 (d, 1 H, $J_{1,2}$ 3.5 Hz, H-1), 4.800, 4.679, 4.640, and 4.528 (4 d, each 1 H, 2 C*H*$_2$C$_6$H$_5$), 4.165 (dd, 1 H, $J_{2,3}$ 7.8, $J_{3,4}$ 5.3 Hz, H-3), 3.511 (dd, 1 H, H-2), 3.228 (t, 2 H, O(CH$_2$)$_4$-C*H*$_2$N$_3$), 1.72–1.54 (m, 4 H, OCH$_2$C*H*$_2$CH$_2$C*H*$_2$-CH$_2$N$_3$), 1.46–1.37 (m, 2 H, O(CH$_2$)$_2$C*H*$_2$(CH$_2$)$_2$-N$_3$), 1.393 and 1.328 (2 s, each 3 H, C(C*H*$_3$)$_2$); ^{13}C, δ 137.5, 128.2, 127.7, and 127.5 (CH$_2$*C*$_6$H$_5$), 109.0 [(CH$_3$)$_2$*C*], 96.5 (C-1), 73.3 and 72.2 (2 *C*H$_2$C$_6$H$_5$), 69.5 (C-6), 67.9 and 51.2 (O*C*H$_2$(CH$_2$)$_3$*C*H$_2$N$_3$), 28.8, 28.5, and 23.3 (OCH$_2$(*C*H$_2$)$_3$CH$_2$N$_3$), 28.0 and 26.3 [(*C*H$_3$)$_2$C]. FABMS (positive-ion mode; $C_{28}H_{37}N_3O_6$): *m*/*z* 534 $[M+Na]^+$. The β anomer was isolated in a yield of 17%.

*5-Azidopentyl 2,6-di-*O*-benzyl-*α-D*-galactopyranoside* (**6**).—To a soln of **5** (0.24 g, 0.47 mmol) in CH_2Cl_2 (15 mL) were added CF_3CO_2H (0.41 mL, 5.17 mmol) and water (32 μL). After stirring for 1 h, TLC (55:45 hexane–EtOAc) showed a complete

conversion of **5** into **6** (R_f 0.15). The mixture was diluted with CH_2Cl_2 (100 mL), washed with saturated aq $NaHCO_3$, and the organic layer was dried, filtered, and concentrated. Column chromatography (55:45 hexane–EtOAc) of the residue gave **6**, isolated as a glass (0.22 g, quant.); ^{1}H NMR ($CDCl_3$): δ 7.36–7.26 (m, 10 H, 2 $CH_2C_6H_5$), 4.842 (d, 1 H, $J_{1,2}$ 3.6 Hz, H-1), 4.683 and 4.614 (2 d, each 1 H, $CH_2C_6H_5$), 4.577 (bs, 2 H, $CH_2C_6H_5$), 4.076 (dd, 1 H, $J_{3,4}$ 3.4, $J_{4,5}$ 1.1 Hz, H-4), 3.980 (dd, 1 H, $J_{2,3}$ 9.6, H-3), 3.750 (dd, 1 H, H-2), 3.656 and 3.343 (2 dt, each 1 H, $OCH_2(CH_2)_4N_3$), 3.230 (t, 2 H, $O(CH_2)_4CH_2N_3$), 2.50 and 2.83 (2 bs, 2 H, 2 OH), 1.66–1.55 (m, 4 H, $OCH_2CH_2CH_2CH_2CH_2N_3$), 1.46–1.33 (m, 2 H, $O(CH_2)_2CH_2(CH_2)_2N_3$). FABMS (positive-ion mode; $C_{25}H_{33}N_3O_6$): m/z 494 $[M+Na]^+$.

*5-Azidopentyl 4-*O*-acetyl-2,6-di-*O*-benzyl-*α*-*D*-galactopyranoside* (**7**).—A mixture of **6** (0.09 g, 0.19 mmol), trimethyl orthoacetate (49 μL) and a catalytic amount of *p*-toluenesulfonic acid in DMF (3.5 mL) was stirred for 30 min, when TLC (45:55 EtOAc–hexane) showed the formation of the orthoester (R_f 0.75). Upon addition of aq 80% HOAc (3 mL), the orthoester was opened within 10 min to the 4-position. The mixture was diluted with EtOAc (100 mL), washed with aq 10% $NaHCO_3$ and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. Column chromatography (45:55 EtOAc–hexane) of the residue afforded **7**, isolated as a glass (96 mg, 97%); $[\alpha]_D$ +75.5° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 7.34–7.26 (m, 10 H, 2 $CH_2C_6H_5$), 5.434 (dd, 1 H, $J_{3,4}$ 3.5, $J_{4,5}$ 1.3 Hz, H-4), 4.843 (d, 1 H, $J_{1,2}$ 3.6 Hz, H-1), 4.709, 4.623, 4.543, and 4.438 (4 d, each 1 H, 2 $CH_2C_6H_5$), 4.161 (ddd, 1 H, $J_{2,3}$ 10.0, $J_{3,OH}$ 2.7 Hz, H-3), 3.693 (dd, 1 H, H-2), 3.660 and 3.337 (2 dt, each 1 H, $OCH_2(CH_2)_4N_3$), 3.224 (t, 2 H, $O(CH_2)_4CH_2N_3$), 2.272 (d, 1 H, OH), 2.070 (s, 3 H, Ac), 1.64–1.52 (m, 4 H, $OCH_2CH_2CH_2CH_2CH_2N_3$), 1.46–1.37 (m, 2 H, $O(CH_2)_2CH_2(CH_2)_2N_3$); ^{13}C, δ 170.7 ($COCH_3$), 137.7 (2 C), 128.4 (5 C), and 127.6 (5 C) (2 $CH_2C_6H_5$), 96.8 (C-1), 73.4 and 72.6 (2 $CH_2C_6H_5$), 68.6 (C-6), 67.8 and 51.2 ($OCH_2(CH_2)_3CH_2N_3$), 28.8, 28.5, and 23.3 ($OCH_2(CH_2)_3CH_2N_3$), 20.7 ($COCH_3$). FABMS (positive-ion mode; $C_{27}H_{35}N_3O_7$): m/z 536 $[M+Na]^+$.

*Ethyl 6-*O*-benzyl-2-deoxy-2-phthalimido-1-thio-*β*-*D*-glucopyranoside* (**9**).—To a soln of ethyl 4,6-*O*-benzylidene-2-deoxy-2-phthalimido-1-thio-*β*-D-glucopyranoside [17] (**8**; 1.93 g, 4.37 mmol) and $NaCNBH_3$ (3.77 g, 60 mmol) in dry THF (75 mL), containing 4 Å molecular sieves (1 g), was added a 1 M HCl/Et_2O soln until the evolution of gas ceased (38 mL). After stirring for 2.5 h, TLC (9:1 CH_2Cl_2–MeOH) showed the disappearance of **8** and the formation of a new spot (R_f 0.33). Then, Et_3N (2.5 mL) was added and the mixture was filtered through Celite, diluted with CH_2Cl_2 (300 mL), washed with aq 10% $NaHCO_3$, and the organic layer was dried, filtered, and concentrated. Column chromatography (9:1 CH_2Cl_2–acetone) of the residue yielded **9**, isolated as a syrup (1.16 g, 60%); $[\alpha]_D$ −16.3° (*c* 0.8); NMR ($CDCl_3$): ^{1}H, δ 7.30–7.20 (m, 5 H, $CH_2C_6H_5$), 5.322 (d, 1 H, $J_{1,2}$ 10.4 Hz, H-1), 4.623 and 4.569 (2 d, each 1 H, $CH_2C_6H_5$), 4.152 (t, 1 H, $J_{2,3}$ 10.4 Hz, H-2), 2.72–2.58 (m, 2 H, SCH_2CH_3), 1.181 (t, 3 H, SCH_2CH_3); ^{13}C, δ 168.1, 134.1, 131.4 (Phth), 137.4, 128.3 (2 C), 127.7 (2 C), and 127.6 ($CH_2C_6H_5$), 81.0 (C-1), 73.5 and 70.2 (C-6 and $CH_2C_6H_5$), 24.0 (SCH_2CH_3), 14.8 (SCH_2CH_3).

*Ethyl 6-*O*-benzyl-2-deoxy-3,4-di-*O*-dimethylisopropylsilyl-2-phthalimido-1-thio-*β*-*D*-glucopyranoside* (**10**).—To a soln of **9** (0.372 g, 0.82 mmol) in dry pyridine (8 mL) were added in two portions dimethylisopropylchlorosilane (0.9 mL, 6.0 mmol) and a catalytic amount of 4-dimethylaminopyridine. The mixture was stirred for 48 h, then diluted with CH_2Cl_2 (200 mL), washed with aq 10% $NaHCO_3$ and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. Column chromatography (98:2 CH_2Cl_2–EtOAc) of the residue gave **10**, isolated as a syrup (0.35 g, 66%); R_f 0.84 (95:5 CH_2Cl_2–acetone); $[\alpha]_D$ +62.6° (*c* 0.8); NMR ($CDCl_3$): ^{1}H, δ 7.35–7.25 (m, 5 H, $CH_2C_6H_5$), 5.243 (d, 1 H, $J_{1,2}$ 10.5 Hz, H-1), 4.652 and 4.583 (2 d, each 1 H, $CH_2C_6H_5$), 4.234 (dd, 1 H, $J_{2,3}$ 10.3 Hz, H-2), 2.76–2.54 (m, 2 H, SCH_2CH_3), 1.182 (t, 3 H, SCH_2CH_3), 0.75 and 0.70 (2 d, each 6 H, 2 $(CH_3)_2CHSi$), 0.59–0.50 (m, 2 H, 2 $(CH_3)_2CHSi$), 0.094, 0.065, −0.045, and −0.285 (4 s, each 3 H, 2 $Si(CH_3)_2$); ^{13}C, δ 138.2, 128.1 (3 C), and 127.3 (2 C) ($CH_2C_6H_5$), 170.2, 134.0, 131.8, and 123.0 (Phth), 80.7 (C-1), 73.1 ($CH_2C_6H_5$), 69.2 (C-6), 23.7 (SCH_2CH_3), 17.0, 16.9, 16.7, and 16.6 (2 $(CH_3)_2CHSi$), 14.9 (SCH_2CH_3), 14.8 and 14.4 (2 $(CH_3)_2CHSi$). FABMS (positive-ion mode; $C_{33}H_{49}NO_6SSi_2$): m/z 666 $[M+Na]^+$.

*Ethyl 3-*O*-allyloxycarbonyl-4,6-*O*-benzylidene-2-deoxy-2-phthalimido-1-thio-*β*-*D*-glucopyranoside* (**11**).—To a stirred soln of ethyl 4,6-*O*-benzylidene-2-deoxy-2-phthalimido-1-thio-*β*-D-glucopyranoside [17] (**8**; 1.16 g, 2.63 mmol) in 1:1 dry pyridine–CH_2Cl_2 (24 mL) was added at −30 °C allyl

chloroformate (0.41 mL, 3.87 mmol). After stirring for 30 min, another portion of allyl chloroformate (0.41 mL, 3.87 mmol) was added. After stirring for 1 h, TLC (95:5 CH_2Cl_2–acetone) showed a complete conversion of **8** into **11** (R_f 0.67). Then, the mixture was diluted with CH_2Cl_2 (350 mL), washed with aq 10% $NaHCO_3$ and aq 10% NaCl, and the organic layer was dried, filtered, concentrated and co-concentrated with toluene. The residue was subjected to column chromatography (97.5:2.5 CH_2Cl_2–acetone) to give **11**, isolated as a syrup (1.31 g, 97%); $[\alpha]_D$ −6.7° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 7.48–7.26 (m, 5 H, $CH_2C_6H_5$), 5.789 (dd, 1 H, $J_{2,3}$ 9.8, $J_{3,4}$ 7.9 Hz, H-3), 5.67–5.57 (m, 1 H, $COOCH_2CH{=}CH_2$), 5.551 (s, 1 H, CHC_6H_5), 5.533 (d, 1 H, $J_{1,2}$ 10.5 Hz, H-1), 5.12–4.94 (m, 2 H, $COOCH_2CH{=}CH_2$), 4.445 (dd, 1 H, H-2), 4.38–4.36 (m, 2 H, $COOCH_2CH{=}CH_2$), 2.75–2.62 (m, 2 H, SCH_2CH_3), 1.201 (t, 3 H, SCH_2CH_3); ^{13}C, δ 173.8, 134.0, 131.5, and 123.4 (Phth), 154.0 ($COOCH_2CH{=}CH_2$), 130.7 ($COOCH_2CH{=}CH_2$), 136.6, 128.9 (2 C), 128.0 (2 C), 126.0 (CHC_6H_5), 118.4 ($COOCH_2CH{=}CH_2$), 101.4 (CHC_6H_5), 81.6 (C-1), 68.3 (C-6 and $COOCH_2CH{=}CH_2$), 24.1 (SCH_2CH_3), 14.7 (SCH_2CH_3). FABMS (positive-ion mode; $C_{27}H_{27}NO_8S$): *m*/*z* 548 $[M+Na]^+$.

*Ethyl 6-*O*-acetyl-3-*O*-allyloxycarbonyl-2-deoxy-2-phthalimido-1-thio-*β*-*D*-glucopyranoside* (**12**).—To a stirred soln of **11** (1.31 g, 2.51 mmol) in CH_2Cl_2 (40 mL) was added water (0.2 mL) and CF_3CO_2H (2 mL). After stirring for 1.5 h, the mixture was diluted with CH_2Cl_2 (300 mL), washed with aq 10% $NaHCO_3$ and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. The residue was dissolved in dry CH_2Cl_2 (15 mL) and dry pyridine (0.16 mL, 2.79 mmol), and the mixture was stirred at 0 °C under Ar, then a soln of acetyl chloride (71 μL, 3.2 mmol) in dry CH_2Cl_2 (8 mL) was added dropwise. After stirring for 1 h, TLC (95:5 CH_2Cl_2–acetone) showed a new spot (R_f 0.30), and the mixture was diluted with CH_2Cl_2 (150 mL) and washed with aq 10% $NaHCO_3$. The organic layer was dried, filtered, and co-concentrated with toluene. Column chromatography (95:5 CH_2Cl_2–acetone) of the residue afforded **12**, isolated as a glass (0.30 g, 70%); $[\alpha]_D$ +0.9° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 5.73–5.60 (m, 1 H, $COOCH_2CH{=}CH_2$), 5.558 (dd, 1 H, $J_{2,3}$ 10.3, $J_{3,4}$ 8.5 Hz, H-3), 5.449 (d, 1 H, $J_{1,2}$ 10.5 Hz, H-1), 5.17–5.00 (m, 2 H, $COOCH_2CH{=}CH_2$), 4.43–4.41 (m, 2 H, $COOCH_2CH{=}CH_2$), 4.361 (dd, 1 H, H-2), 3.050 (d, 1 H, $J_{4,OH}$ 1.2 Hz, OH), 2.76–2.58 (m, 2 H, SCH_2CH_3), 2.144 (s, 3 H, Ac), 1.208 (t, 3 H, SCH_2CH_3); ^{13}C, δ 171.4 ($COCH_3$), 167.0, 167.7, 134.1, 134.0, 131.4, 131.1, and 123.4 (2 C) (Phth), 154.6 ($COOCH_2CH{=}CH_2$), 130.6 ($COOCH_2CH{=}CH_2$), 118.6 ($COOCH_2CH{=}CH_2$), 80.9 (C-1), 68.5 and 63.2 (C-6 and $COOCH_2CH{=}CH_2$), 24.2 (SCH_2CH_3), 20.6 ($COCH_3$), 14.7 (SCH_2CH_3). FABMS (positive-ion mode; $C_{22}H_{25}NO_9S$): *m*/*z* 502 $[M+Na]^+$.

*Ethyl 4,6-di-*O*-acetyl-3-*O*-allyloxycarbonyl-2-deoxy-2-phthalimido-1-thio-*β*-*D*-galactopyranoside* (**13**).—To a soln of **12** (30 mg, 60 μmol) in dry CH_2Cl_2 (3 mL) and pyridine (61 μL) was added at 0 °C triflic anhydride (63 μL, 0.38 mmol). After 45 min, TLC (95:5 CH_2Cl_2–acetone) showed the formation of a new spot (R_f 0.65). The mixture was diluted with CH_2Cl_2 (50 mL), washed with cold aq 10% $NaHCO_3$ and aq 5% NaCl, and the organic layer was dried, filtered, and concentrated (T < 40 °C). The yellow residue was dissolved in dry DMF (1.5 mL) and tetrabutylammonium acetate (200 mg, 0.60 mmol) was added in two portions. The mixture was stirred overnight, when TLC (95:5 CH_2Cl_2–acetone) showed a complete conversion of **12** into **13** (R_f 0.61), then diluted with CH_2Cl_2 and washed with aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. The residue was subjected to column chromatography (97:3 CH_2Cl_2–acetone) to yield **13**, isolated as a glass (29 mg, 90%); $[\alpha]_D$ +60.1° (*c* 1); NMR ($CDCl_3$): ^{1}H, δ 5.81–5.68 (m, 1 H, $COOCH_2CH{=}CH_2$), 5.716 (dd, 1 H, $J_{2,3}$ 10.7, $J_{3,4}$ 3.4 Hz, H-3), 5.639 (dd, 1 H, $J_{4,5}$ < 1 Hz, H-4), 5.421 (d, 1 H, $J_{1,2}$ 10.5 Hz, H-1), 5.21–5.07 (m, 2 H, $COOCH_2CH{=}CH_2$), 4.645 (dd, 1 H, H-2), 4.55–4.41 (m, 2 H, $COOCH_2CH{=}CH_2$), 2.77–2.63 (m, 2 H, SCH_2CH_3), 2.203 and 2.069 (2 s, each 3 H, 2 Ac), 1.224 (t, 3 H, SCH_2CH_3); ^{13}C, δ 170.1 and 169.9 (2 $COCH_3$), 167.8, 166.9, 134.1 (2 C), 131.3, 131.2, 123.5, and 123.3 (Phth), 153.4 ($COOCH_2CH{=}CH_2$), 130.8 ($COOCH_2CH{=}CH_2$), 118.5 ($COOCH_2CH{=}CH_2$), 81.5 (C-1), 68.6 and 61.5 (C-6 and $COOCH_2CH{=}CH_2$), 24.3 (SCH_2CH_3), 20.4 ($COCH_3$), 14.7 (SCH_2CH_3). FABMS (positive-ion mode; $C_{24}H_{27}NO_{10}S$): *m*/*z* 544 $[M+Na]^+$.

*5-Azidopentyl (6-*O*-benzyl-2-deoxy-3,4-di-*O*-dimethylisopropylsilyl-2-phthalimido-*β*-*D*-glucopyranosyl)-(1→3)-4-*O*-acetyl-2,6-di-*O*-benzyl-*α*-*D*-galactopyranoside* (**14**).—To a soln of **10** (0.17 g, 0.26 mmol) and **7** (0.11 g, 0.21 mmol) in dry CH_2Cl_2 (20 mL), containing 4 Å molecular sieves (0.3 g), was added at −60 °C *N*-iodosuccinimide

(0.11 g) and a catalytic amount of AgOTf. The mixture was allowed to warm to −50 °C, and after 30 min, when TLC (R_f 0.67; 4:6 EtOAc–hexane) showed a complete reaction, it was neutralised with Et_3N. The mixture was diluted with CH_2Cl_2 (150 mL), washed with aq 10% $NaHSO_3$, aq 10% KI, aq 10% $NaHCO_3$, and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. Column chromatography (95:5 CH_2Cl_2–acetone) of the residue gave **14**, isolated as a glass (0.19 g, 84%); $[\alpha]_D$ +30.0° (*c* 0.8); NMR ($CDCl_3$): ^1H, δ 7.45–7.20 (m, 15 H, 3 $CH_2C_6H_5$), 5.471 (dd, 1 H, $J_{3,4}$ 3.6, $J_{4,5}$ < 1 Hz, H-4), 5.276 (d, 1 H, $J_{1',2'}$ 8.4 Hz, H-1′), 4.684, 4.620, 4.467, 4.389, 4.101, and 3.766 (6 d, each 1 H, 3 $CH_2C_6H_5$), 4.501 (dd, 1 H, $J_{2',3'}$ 10.4, $J_{3',4'}$ 8.0 Hz, H-3′), 4.394 (d, 1 H, $J_{1,2}$ 3.8 Hz, H-1), 4.105 (dd, 1 H, H-2′), 4.018 (dd, 1 H, $J_{2,3}$ 10.1 Hz, H-3), 3.448 (dd, 1 H, H-2), 3.136 (t, 2 H, $O(CH_2)_4CH_2N_3$), 2.080 (s, 3 H, Ac), 1.54–1.24 (m, 6 H, $OCH_2(CH_2)_3CH_2N_3$), 0.725 and 0.675 (2 d, each 6 H, 2 $(CH_3)_2CHSi$), 0.55–0.45 (m, 2 H, 2 $(CH_3)_2CHSi$), 0.089, 0.074, −0.054, and −0.284 (4 s, each 3 H, 2 $Si(CH_3)_2$); ^{13}C, δ 169.9 ($COCH_3$), 138.7, 138.4, 137.8, 128.0 (5 C), 127.3 (5 C), and 127.1 (5 C) (3 $CH_2C_6H_5$), 167.2, 133.8, 131.8, and 122.9 (Phth), 98.6 and 97.1 (C-1,1′), 73.1 and 72.8 (2 C) (3 $CH_2C_6H_5$), 69.4 and 69.1 (C-6,6′), 67.7 and 51.0 ($OCH_2(CH_2)_3CH_2N_3$), 28.5, 28.3, and 23.1 ($OCH_2(CH_2)_3CH_2N_3$), 20.6 ($COCH_3$), 17.0, 16.9, 16.7, and 16.5 (2 $(CH_3)_2CHSi$), 14.9 and 14.5 (2 $(CH_3)_2CHSi$). FABMS (positive-ion mode; $C_{58}H_{87}N_4O_{13}Si_2$): *m/z* 1117 $[M+Na]^+$.

*5-Azidopentyl (6-*O*-benzyl-2-deoxy-2-phthalimido-*β*-*D*-glucopyranosyl)-(1→3)-4-*O*-acetyl-2,6-di-*O*-benzyl-*α*-*D*-galactopyranoside* (**15**).—To a soln of **14** (0.19 g, 0.17 mmol) in CH_3CN (30 mL) were added water (4.5 mL) and *p*-toluenesulfonic acid (56 mg). After stirring for 2 h, TLC (8:2 CH_2Cl_2–acetone) showed the complete conversion of **14** into **15** (R_f 0.67). The mixture was diluted with CH_2Cl_2 (100 mL), washed with aq 10% $NaHCO_3$ and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. The residue was subjected to column chromatography (9:1 CH_2Cl_2–acetone) to give **15**, isolated as a glass (0.14 g, 93%); $[\alpha]_D$ +14.9° (*c* 1.2); NMR ($CDCl_3$): ^1H, δ 7.36–7.18 (m, 15 H, 3 $CH_2C_6H_5$), 5.417 (dd, 1 H, $J_{3,4}$ 3.6, $J_{4,5}$ < 1 Hz, H-4), 5.393 (d, 1 H, $J_{1',2'}$ 8.3 Hz, H-1′), 4.662, 4.592, 4.478, 4.399, 4.253, and 3.906 (6 d, each 1 H, 3 $CH_2C_6H_5$), 4.449 (d, 1 H, $J_{1,2}$ 3.6 Hz, H-1), 4.123 (dd, 1 H, $J_{2',3'}$ 11.0 Hz, H-2′), 4.036 (dd, 1 H, $J_{2,3}$ 10.0 Hz, H-3), 3.503 (dd, 1 H, H-2), 3.496 and 3.196 (2 dt, each 1 H, $OCH_2(CH_2)_4N_3$), 3.164 (t, 2 H, $O(CH_2)_4CH_2N_3$), 2.066 (s, 3 H, Ac), 1.58–1.26 (m, 6 H, $OCH_2(CH_2)_3CH_2N_3$); ^{13}C, δ 170.2 ($COCH_3$), 167.9, 133.6, 131.4, and 123.0 (Phth), 98.6 and 97.1 (C-1,1′), 73.2, 73.1, and 72.8 (3 $CH_2C_6H_5$), 69.8 and 69.1 (C-6,6′), 67.6 and 50.9 ($OCH_2(CH_2)_3CH_2N_3$), 28.4, 28.2, and 23.0 ($OCH_2(CH_2)_3CH_2N_3$), 20.5 ($COCH_3$). FABMS (positive-ion mode; $C_{48}H_{54}N_4O_{13}$): *m/z* 917 $[M+Na]^+$.

*5-Azidopentyl (4,6-di-*O*-acetyl-3-*O*-allyloxycarbonyl-2-deoxy-2-phthalimido-1-thio-*β*-*D*-galactopyranosyl)-(1→4)-(6-*O*-benzyl-2-deoxy-2-phthalimido-*β*-*D*-glucopyranosyl)-(1→3)-4-*O*-acetyl-2,6-di-*O*-benzyl-*α*-*D*-galactopyranoside* (**16**).—To a soln of **15** (60 mg, 0.070 mmol) and **13** (78 mg, 0.15 mmol) in dry CH_2Cl_2 (1.7 mL), containing 3 Å powdered molecular sieves (0.15 g), was added a soln of AgOTf (82 mg) in dry CH_3CN (2.5 mL). At −50 °C, a 1 M methylsulfenyl bromide soln (137 μL) in 1,2-dichloroethane was added in two portions with an interval of 20 min. After stirring for 1 h, TLC (35:65 EtOAc–hexane) showed the disappearance of **15** and the formation of a new spot (R_f 0.70). Then the reaction was quenched by stirring for 30 min with *N*-diisopropylethylamine (137 μL), and the mixture was diluted with CH_2Cl_2 (100 mL) and filtered through Celite. The organic phase was washed with aq 10% $NaHSO_3$, aq 10% KI, aq 10% $NaHCO_3$, and aq 10% NaCl, and the organic layer was dried, filtered, and concentrated. Purification of the residue by gel filtration over LH-20 (1:1 CH_2Cl_2–MeOH) gave a 1:4 mixture (79%) of the (1→3) and (1→4) coupling products. Column chromatography (45:55 hexane–EtOAc) of the mixture gave **16**, isolated as a glass (57 mg, 63%); $[\alpha]_D$ +18.5° (*c* 0.4); NMR ($CDCl_3$): ^1H, δ 7.30–7.07 (m, 15 H, 3 $CH_2C_6H_5$), 5.80–5.67 (m, 1 H, $COOCH_2CH=CH_2$), 5.733 (dd, 1 H, $J_{2'',3''}$ 11.5, $J_{3'',4''}$ 3.4 Hz, H-3″), 5.558 (bd, 1 H, $J_{4'',5''}$ < 1 Hz, H-4″), 5.397 (d, 1 H, $J_{1'',2''}$ 8.5 Hz, H-1″), 5.346 (bd, 1 H, $J_{3,4}$ 3.7, $J_{4,5}$ < 1 Hz, H-4), 5.298 (d, 1 H, $J_{1',2'}$ 8.4 Hz, H-1′), 5.21–5.07 (m, 2 H, $COOCH_2CH=CH_2$), 4.596 (dd, 1 H, H-2″), 4.456, 4.362, 4.227, 4.158, 4.084, and 3.923 (6 d, each 1 H, 3 $CH_2C_6H_5$), 4.283 (d, 1 H, $J_{1,2}$ 1.8 Hz, H-1), 3.941 (dd, 1 H, $J_{2,3}$ 9.9 Hz, H-3), 3.132 (t, 2 H, $O(CH_2)_4CH_2N_3$), 2.176, 1.982, and 1.863 (3 s, each 3 H, 3 Ac), 1.53–1.30 (m, 6 H, $OCH_2(CH_2)_3CH_2N_3$); ^{13}C, δ 170.3 (2 C) and 170.1 (3 $COCH_3$), 153.4 ($COOCH_2CH=CH_2$), 130.9 ($COOCH_2CH=CH_2$), 167.8 (2 C), 167.1 (2 C), 134.3, 134.0, 133.8 (2 C), 131.6 (2 C), 131.2 (2 C), 123.6 (2 C),

and 123.0 (2 C) (2 Phth), 118.8 ($COOCH_2$-$CH=CH_2$), 99.3, 99.0, and 97.3 (C-1,1′,1″), 73.3, 73.0, and 72.7 (3 $CH_2C_6H_5$), 69.3, 68.9, and 68.0 (C-6,6′,6″), 61.8 ($COOCH_2CH=CH_2$), 67.8 and 51.2 ($OCH_2(CH_2)_3CH_2N_3$), 28.6, 28.4, and 23.2 ($OCH_2(CH_2)_3CH_2N_3$), 20.7, 20.5, and 20.1 (3 $COCH_3$). FABMS (positive-ion mode; $C_{70}H_{75}N_5O_{23}$): m/z 1376 $[M+Na]^+$.

5-Aminopentyl (2-deoxy-2-acetamido-β-D-*galacto-pyranosyl)-(1→4)-(2-deoxy-2-acetamido*-β-D-*gluco-pyranosyl)-(1→3)*-α-D-*galactopyranoside* (**1**).—To a soln of **16** (80 mg, 60 mmol) in 1-butanol (8 mL) was added ethylenediamine (2 mL). The mixture was stirred overnight under Ar at 90 °C, and then co-concentrated with toluene and dried under high vacuo for 1 h. A soln of 1:1 dry pyridine–Ac_2O (10 mL) was added and the mixture was stirred overnight, and then co-concentrated with toluene. The residue was subjected to column chromatography (94:4 CH_2Cl_2–MeOH) to obtain 46 mg of the acetylated intermediate. The obtained compound was dissolved in dry MeOH (10 mL) and solid NaOMe was added (pH 10). The mixture was stirred overnight under Ar, neutralised with Dowex-50 (H^+), filtered, and concentrated. A soln of the residue in *tert*-butanol (6 mL) and water (2.3 mL), containing 10% Pd-C (100 mg) and two drops of aq 25% NH_3 (pH 9) was hydrogenated for 1 h. By flushing with N_2 for 1 h the pH of the solution decreased to 7, then HOAc was added (pH 5), and the mixture was hydrogenated for another 1.5 h. The mixture was filtered and concentrated to obtain 24 mg of the crude product **1**. HiTrap gel filtration (aq 5 mM NH_4HCO_3) afforded pure **1** (15 mg, 70%); $[\alpha]_D$ −108° (*c* 0.5, H_2O); for ^1H NMR data, see Table 1; FABMS (positive-ion mode; $C_{27}H_{49}N_3O_{16}$): m/z 672 $[M+H]^+$.

Acknowledgements

The authors thank Mrs. A.C.H.T.M. van der Kerk-van Hoof for recording FAB mass spectra.

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