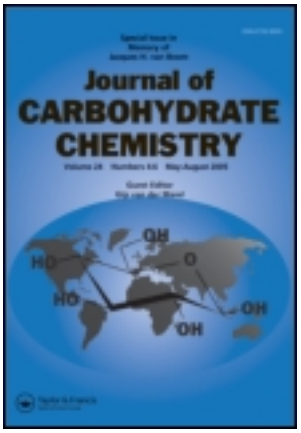

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Synthesis of Analogues of (1 → 6)-Branched (1 → 3)-Glucohexaose

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Synthesis of Analogues of (1 → 6)-Branched (1 → 3)-Glucohexaose

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CONTENTS

ABSTRACT

β-D-Gal*p*-(1 → 3)-[β-D-Gal*p*-(1 → 6)-]α-D-Glc*p*-(1 → 3)-β-D-Glc*p*-(1 → 3)-[α-D-Man*p*-(1 → 6)-]D-Glc*p* **16** and β-D-Gal*p*-(1 → 3)-[β-D-Glc*p*-(1 → 6)-]α-D-Glc*p*-

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(1 → 3)-β-D-Glc*p*-(1 → 3)-[α-D-Man*p*-(1 → 6)-]D-Glc*p* **18** were synthesized as the analogues of the immunomodulator β-D-Glc*p*-(1 → 3)-[β-D-Glc*p*-(1 → 6)-]α-D-Glc*p*-(1 → 3)-β-D-Glc*p*-(1 → 3)-[β-D-Glc*p*-(1 → 6)-]D-Glc*p* through coupling of trisaccharide donors **8** and **13** with trisaccharide acceptor **14** followed by deprotection, respectively.

Key Words: Oligosaccharide; Mannose; Galactose; Glucose.

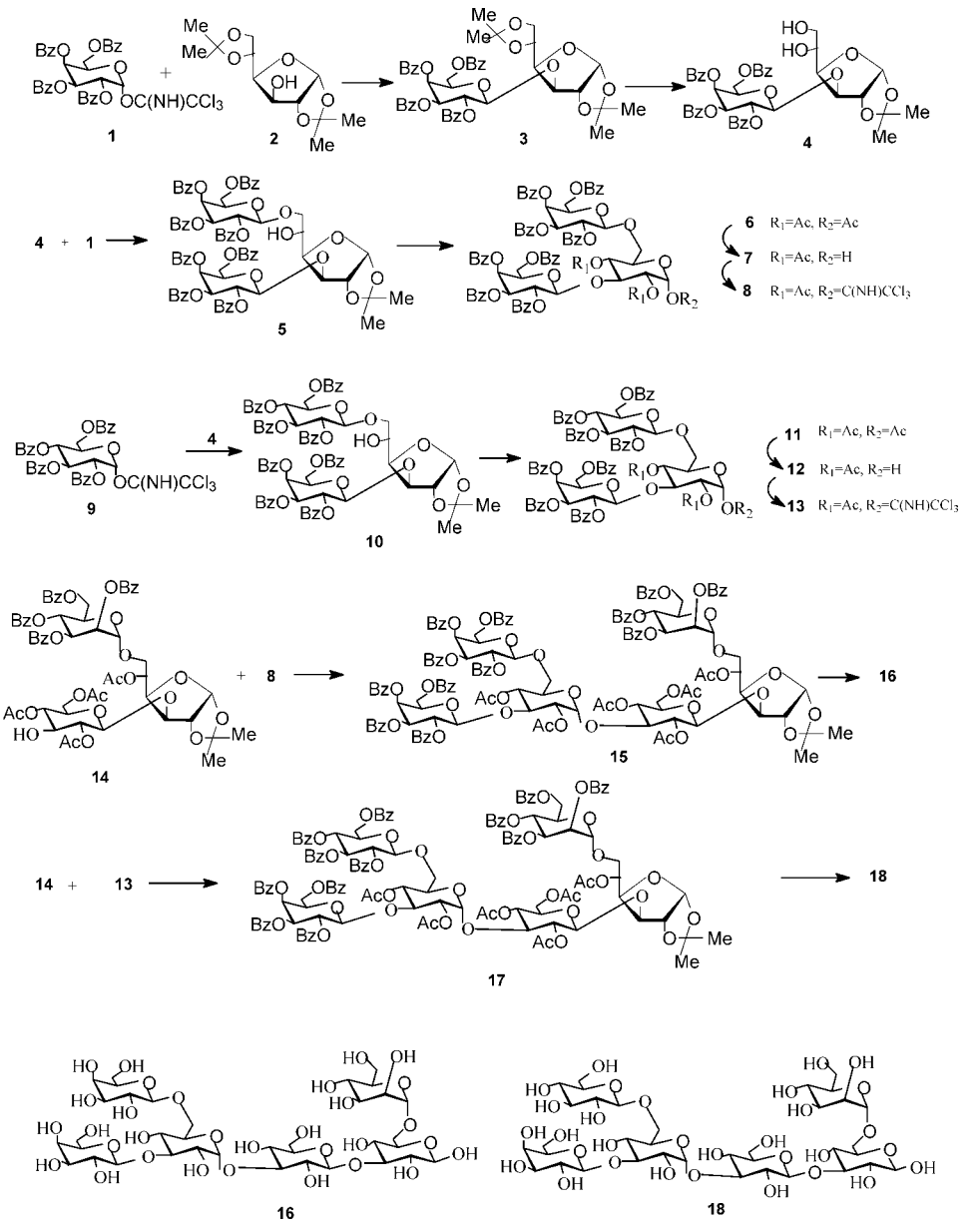
INTRODUCTION

Polysaccharides with antitumor activity separated from fungi such as *Ganoderma lucidum*, *Schizophyllum commune*, and *Lentinus edodes* have a β-(1 → 3)-linked glucosyl backbone with β-(1 → 6)-branched glucosyl side chains.[1] Recent studies revealed that α-(1 → 3)-linked glucans also exist in some medically important fungi such as *Cryphonectrini parasitica* and *G. lucidum*.[2] It was also reported that only higher molecular-weight fractions (MW > 16,000) obtained from partial hydrolysis of lentinan with formic acid showed antitumor activity.[3] However, an interesting result in our research revealed[4] that a synthetic hexasaccharide **I**, β-D-Glc*p*-(1 → 3)-[β-D-Glc*p*-(1 → 6)-]α-D-Glc*p*-(1 → 3)-β-D-Glc*p*-(1 → 3)-[β-D-Glc*p*-(1 → 6)-]D-Glc*p*, in combination with the chemotherapeutic agent cyclophosphamide (CPA), at a dose of 0.5–1 mg/kg substantially increased the inhibition of S_{180} for CPA, but decreased the toxicity caused by CPA. This inspired us to carry out more research regarding the study on structure function relationships of oligosaccharides. We present herein the synthesis of two analogues of **I**.

RESULTS AND DISCUSSION

Preliminary bioassay of the synthetic samples revealed that replacement of the branch glucose of **I** with mannose showed similar activity, while replacement of the branch glucose with galactose decreased the activity substantially.[5] In the present research, replacement of the upstream end β-D-Glc*p* of the (1 → 3)-linked backbone with a β-D-Gal*p* (**18**) or replacement of both the upstream end β-D-Glc*p* of the (1 → 3)-linked backbone and the upstream end β-D-Glc*p* branch with β-D-Gal*p* (**16**) and also replacement of the downstream end β-D-Glc*p* branch with α-D-Man*p*, were carried out, respectively.

As shown in Sch. 1, reaction of 1,2 : 5,6-di-*O*-isopropylidene-α-D-glucofuranose (**2**) with 1,2,3,4-tetra-*O*-benzoyl-α-D-galactopyranosyl trichloroacetimidate (**1**)[6] smoothly afforded β-(1 → 3)-linked disaccharide **3** (86%). Selective removal of the 5,6-*O*-isopropylidene group of **3** gave the disaccharide diol acceptor **4** in high yield (92%). Subsequent coupling of **4** with the donor **1** furnished the trisaccharide **5** (88.2%). Hydrolysis to remove 1,2-*O*-isopropylidene group was accompanied by ring expansion, and subsequent acetylation yielded the trisaccharide **6** (88.1% for two steps). Selective 1-*O*-deacetylation of **6** (82.2%), followed by trichloroacetimidation[6] with trichloroacetonitrile in the presence of potassium carbonate, produced the trisaccharide donor **8** (93.1%). The ^{1}H NMR spectrum of **8** showed a signal at δ 5.08 with $J_{3,4} = J_{4,5} = 9.6$ Hz for H-4, confirming the selective C-6-glycosylation of **5**.



Scheme 1.

The trisaccharide donor **13** with only one galactose substitution was synthesized in a similar way. Therefore, condensation of **4** with perbenzoylated glucopyranosyl trichloroacetimidate **9** gave the trisaccharide **10** in satisfactory yield (87.6%). Hydrolysis, acetylation (88.7% for two steps), selective 1-*O*-deacetylation (82.1%), and trichloroacetimidation (93.7%) afforded the another trisaccharide donor **13**.

A co-used trisaccharide acceptor **14** for both the donors **8** and **13** was synthesized by selective C-6 coupling of 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-(1 $\rightarrow$ 3)-1,2-*O*-ispropylidene-α-D-glucofuranose[4] with perbenzoylated mannopyranosyl trichloroacetimidate, followed by acetylation and deallylation. The acetylation of 5-OH of glucofuranose of the obtained trisaccharide was necessary, otherwise the subsequent deallylation gave a diol acceptor whose coupling with **8** did not show regioselectivity. Condensation of **14** with **8** produced α-linked hexasaccharide, indicating that replacement of the 3,6-branch glucose residues of the donor with galactose did not affect the α-selectivity.[4] The mechanism for obtaining α-linkage with the donors with a C-2 ester capable of neighboring group participation was given in our previous report.[4] Deprotection by conventional way afforded the hexasaccharide **16**, and the ^{1}H and ^{13}C NMR spectra of **16** showed characteristic signals such as at δ 5.16 with $J_{1,2}$ 3.2 Hz for α H-1 of Glc*p*, 5.10 with $J_{1,2}$ 1.8 Hz for α H-1 of Man*p*, 5.00, 4.86, 4.56, and 4.50 with $J_{1,2} \sim 7.8$ Hz for β H-1 of Glc*p* and Gal*p*, δ 103.1, 101.2, 100.8, 100.6, 100.4, and 95.2 for 6C-1.

The hexasaccharide **18** was obtained in a similar way. Thus, coupling of **14** with **13** also furnished α-linked hexasaccharide **17** whose deprotection produced the target hexaose **18**. The spectral data also supported the structure such as δ 5.15 with $J_{1,2}$ 3.2 Hz for α H-1 of Glc*p*, 5.09 with $J_{1,2}$ 1.8 Hz for α H-1 of Man*p*, 4.92, 4.89, 4.54, and 4.50 with $J_{1,2} \sim 7.8$ Hz for β H-1 of Glc*p* and Gal*p*, δ 103.0, 101.0, 100.6, 100.5, 100.3, and 95.4 for 6C-1.

Preliminary study of the stimulatory effects of **16** and **18** on the mouse spleen[5] showed no activity, indicating that replacement of the backbone glucose of **I** with galactose abolished the activity completely. The detailed study for elucidation of structure–stimulatory effects for the synthetic oligosaccharides is in progress.

EXPERIMENTAL

Optical rotations were determined at 25°C with a Perkin–Elmer Model 241-Mc automatic polarimeter. ^{1}H and ^{13}C NMR spectra were recorded with Bruker ARX 400 spectrometers (400 MHz for ^{1}H and 100 MHz for ^{13}C) at 25°C for solutions in $CDCl_3$ or D_2O as indicated. Mass spectra were recorded with a VG PLATFORM mass spectrometer using the ESI mode. Thin-layer chromatography (TLC) was performed on silica gel HF_{254} with detection by charring with 30% (v/v) H_2SO_4 in MeOH or in some cases by a UV lamp. Column chromatography was conducted by elution of a column (16 $\times$ 240 mm, 18 $\times$ 300 mm, 35 $\times$ 400 mm) of silica gel (100–200 mesh) with EtOAc–petroleum ether (60–90°C) as the eluent. Solutions were concentrated at $<$60°C under reduced pressure.

General Procedure for Glycosylations

A mixture of donor and acceptor was dried together under high vacuum for 2 hr, and then dissolved in anhyd. CH_2Cl_2. TMSOTf (0.05 equiv.) was added dropwise at -20°C with nitrogen protection. The reaction mixture was stirred for 3 hr, during which time the temperature was gradually raised to ambient temperature. Then the mixture was neutralized with Et_3N. Concentration of the reaction mixture, followed by purification on a silica gel column, gave the desired products.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-1,2:5,6-di-*O*-isopropylidene-α-D-glucofuranose (**3**)

Donor **1** (16.44 g, 22.2 mmol) and acceptor **2** (5.62 g, 21.6 mmol) were coupled as described in the general procedure. Purification by chromatography with 3 : 1 petroleum ether–EtOAc as the eluent gave disaccharide **3** (15.6 g, 86%): $[\alpha]_D$ +15° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.10–7.26 (m, 20H, 4Bz-*H*), 6.01 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 5.80 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.4$ Hz, H-2′), 5.63 (dd, 1H, H-3′), 5.51 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 4.96 (d, 1H, H-1′), 4.70 (dd, 1H, $J_{5,6} = 6.3$ Hz, $J_{6,6} = 11.2$ Hz, H-6′e), 4.49–4.42 (m, 2H, H-6′a, H-3), 4.40–4.34 (m, 3H, H-2, H-5′, H-6e), 4.29–4.04 (m, 3H, H-6a, H-4, H-5), 1.44, 1.43, 1.35, 1.12 (4s, 12H, 4*Me*CO).

Anal. Calcd for $C_{46}H_{46}O_{15}$: C 65.87; H 5.49. Found: C 65.99; H 5.51.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-1,2-*O*-isopropylidene-α-D-glucofuranose (**4**)

To a solution of 90% HOAc (150 mL) was added **3** (12.0 g, 14.3 mmol), and the mixture was stirred at 40°C overnight, then concentrated to dryness. The residue was passed through a short silica column (1 : 1 petroleum ether–EtOAc) to give **4** (10.5 g, 92%) as a syrup: $[\alpha]_D$ +18° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.08–7.26 (m, 20H, 4Bz-*H*), 6.01 (d, 1H, $J_{3,4} = 3.4$ Hz, H-4′), 5.79 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.4$ Hz, H-2′), 5.62 (dd, 1H, H-3′), 5.53 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 5.00 (d, 1H, H-1′), 4.59 (m, 2H), 4.44–4.39 (m, 2H), 4.24–4.10 (m, 2H), 3.87 (dd, 1H, $J_{6,6} = 11.5$ Hz, $J_{5,6} = 3.0$ Hz, H-6e), 3.70 (m, 1H), 1.42, 1.06 (2s, 6H, 2*Me*CO).

Anal. Calcd for $C_{43}H_{42}O_{15}$: C 64.66; H 5.26. Found: C 64.77; H 5.38.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 6)]-1,2-*O*-isopropylidene-α-D-glucofuranose (**5**)

Donor **1** (4.08 g, 5.50 mmol) and acceptor **4** (4.40 g, 5.52 mmol) were coupled as described in the general procedure. Purification by chromatography with 3 : 1 petroleum ether–EtOAc as the eluent gave trisaccharide **5** (6.70 g, 88.2%) as a syrup: $[\alpha]_D$ −7.2° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.10–7.23 (m, 40H, 8Bz-*H*), 6.02 (d, 2H, $J_{3,4} = 3.4$ Hz, H-4′, H-4″), 5.87 (dd, 1H, $J_{2,3} = 9.8$ Hz, H-2′), 5.79 (dd, 1H, $J_{2,3} = 9.9$ Hz, H-2″), 5.64 (dd, 2H, H-3″, H-3′), 5.48 (d, 1H, $J_{1,2} = 3.2$ Hz, H-1), 4.94 (d, 1H, $J_{1,2} = 8.2$ Hz, H-1″), 4.92 (d, 1H, $J_{1,2} = 8.1$ Hz, H-1′), 4.70 (dd, 1H, $J_{6,6} = 11.2$ Hz, $J_{5,6} = 6.4$ Hz, H-6′e), 4.50–4.20 (m, 10H, H-6″, H-6′a, H-5′, H-5″, H-6, H-2, H-3, H-4), 3.92–3.88 (m, 1H, H-5), 1.30, 1.03 (2s, 6H, 2*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.6, 165.5, 165.2, 165.1, 165.0, 164.4 (8C, 8Ph*C*O), 133.3, 133.2, 133.0, 132.9, 132.7, 129.6, 129.5, 129.4, 129.2, 129.1, 129.0, 128.9, 128.7, 128.4, 128.3, 128.2, 128.1, 127.9, 127.8 (Ph-*C*), 111.6 (1C, Me_2C), 104.6, 101.6, 101.5 (3C-1), 83.0, 82.7, 78.9, 71.7, 71.5, 71.0, 69.5, 69.3, 67.8, 67.6, 67.4, 61.7, 61.6 (C-2–6), 26.2, 25.5 (2C, Me_2C).

Anal. Calcd for $C_{77}H_{68}O_{24}$: C 67.15; H 4.94. Found: C 67.31; H 4.82.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→6)]-1,2,4-tri-*O*-acetyl-α-D-glucopyranose (**6**)

A solution of **5** (6.05 g, 4.40 mmol) in 90% CF_3COOH (50 mL) was stirred for 2 hr at rt, then concentrated to dryness. The residue was dissolved in pyridine (60 mL), and then Ac_2O (12 mL) was added. After stirring the mixture at rt for 12 hr, TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The reaction mixture was extracted with CH_2Cl_2 (80 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (2 : 1 petroleum ether–EtOAc) gave **6** (5.66 g, 88.1% for two steps) as a syrupy anomeric mixture that was used for further reaction. α-Anomer was the major product and isolated in pure form, and characterized: $[\alpha]_D$ −1.2° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.09–7.23 (m, 40H, 8Bz-*H*), 6.01 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 6.00 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 5.95 (d, 1H, $J_{3,4} = 3.4$ Hz, H-4″), 5.80 (dd, 1H, $J_{2,3} = 9.6$ Hz, $J_{1,2} = 8.0$ Hz, H-2′), 5.64 (dd, 1H, $J_{1,2} = 8.2$ Hz, $J_{3,4} = 10.0$ Hz, H-2″), 5.61–5.57 (m, 2H, H-3′, H-3″), 4.99 (d, 1H, $J_{1,2} = 8.2$ Hz, H-1″), 4.94 (d, 1H, $J_{1,2} = 8.0$ Hz, H-1′), 4.94 (m, 1H, H-4), 4.73 (dd, 1H, $J_{5,6} = 10.1$ Hz, $J_{6,6} = 3.5$ Hz, H-6′e), 4.68–4.62 (m, 2H, H-6″e, H-2), 4.47–3.65 (m, 8H, H-3, H-6″a, H-6′a, H-6a, H-6e, H-5, H-5′, H-5″), 2.10, 1.81, 1.79 (3s, 9H, 3*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.3, 169.0, 168.5 (3C, $3CH_3CO$), 166.2, 166.1, 165.6, 165.5, 165.1 (8C, 8Ph*C*O), 133.9, 133.7, 133.6, 133.4, 133.3, 130.1, 130.0, 129.8, 129.7, 129.6, 129.4, 129.1, 129.0, 128.9, 128.7, 128.5, 128.4, 128.3 (Bz-*C*), 101.7, 101.1, 88.9 (3C-1), 78.3, 77.8, 74.4, 73.2, 73.0, 72.6, 72.4, 72.3, 72.0, 71.8, 71.7, 71.4, 71.0, 69.9, 69.7, 69.3, 68.2, 68.0, 66.3, 63.5, 63.2, 62.4, 62.3 (C-2–6), 20.8, 20.6, 20.4 (3C, $3CH_3CO$).

Anal. Calcd for $C_{80}H_{70}O_{27}$: C 65.66; H 4.79. Found: C 65.79; H 4.89.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→6)]-2,4-di-*O*-acetyl-α-D-glucopyranose (**7**)

Compound **6** (5.00 g, 3.39 mmol) was dissolved in THF (60 mL), and then benzyl amine (2 mL) was added. The mixture was stirred at rt until TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was extracted with CH_2Cl_2 (50 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (2 : 1 petroleum ether–EtOAc) gave **7** (4.01 g, 82.2%) as a syrupy anomeric mixture, of which the major α-anomer was characterized: $[\alpha]_D + 12.5°$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.09–7.23 (m, 40H, 8Bz-*H*), 6.02 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 5.96 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4″), 5.77 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.3$ Hz, H-2′), 5.66 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.2$ Hz, H-2″), 5.68–5.58 (m, 2H, H-3′, H-3″), 4.99 (d, 1H, H-1″), 4.92 (d, 1H, H-1′), 4.98 (d, 1H, $J_{1,2} = 3.4$ Hz, H-1), 4.91–4.80 (m, 2H, H-2, H-3), 4.66 (dd, 1H, $J_{5,6} = 6.3$ Hz, $J_{6,6} = 11.3$ Hz, H-6′e), 4.58 (dd, 1H, $J_{5,6} = 6.0$ Hz, $J_{6,6} = 10.8$ Hz, H-6″e), 4.52–3.63 (m, 8H, 4H-6, 3H-5, H-3), 2.05, 1.88 (2s, 6H, 2*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.7, 169.5 (2C, $2CH_3CO$), 166.2, 165.7, 165.6, 165.5, 165.2 (8C, 8Ph*C*O), 133.9, 133.7, 133.6, 133.5, 133.4, 133.3, 130.1, 130.0, 129.8, 129.7, 129.6, 129.4, 129.1,

129.0, 128.9, 128.7, 128.5, 128.4 (Bz-*C*), 102.6, 101.2, 89.5 (3C-1), 75.3, 73.4, 71.9, 71.5, 71.1, 69.8, 69.0, 68.9, 68.2, 68.1, 62.4, 61.9 (C-2–6), 20.9, 20.8 (2C, 2*C*H_3CO).

Anal. Calcd for $C_{78}H_{68}O_{26}$: C 65.92; H 4.79. Found: C 65.97; H 4.82.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→6)]-2,4-di-*O*-acetyl-α-D-glucopyranosyl trichloroacetimidate (**8**)

Compound **7** (4.00 g, 2.84 mmol) was dissolved in CH_2Cl_2 (50 mL), then CCl_3CN (0.4 mL, 4.0 mmol) and K_2CO_3 (2.0 g, 14.0 mmol) were added. The reaction mixture was stirred for 10 hr, at the end of which time TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was filtered, and the filtrate was concentrated. The residue was purified by flash chromatography (2 : 1 petroleum ether–EtOAc) to give **8** (4.12 g, 93.1%) as a syrup: $[\alpha]_D + 2.5^\circ$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.38 (s, 1H, C═N*H*), 8.17–7.27 (m, 40H, 8Bz-*H*), 6.30 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 6.05 (d, 1H, $J_{3,4} = 3.2$ Hz, H-4′), 6.00 (d, 1H, $J_{3,4} = 3.0$ Hz, H-4″), 5.84 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.3$ Hz, H-2′), 5.73 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.8$ Hz, H-2″), 5.71–5.62 (m, 2H, H-3′, H-3″), 5.06–5.00 (m, 2H, H-1′, H-1″), 5.08 (dd, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4), 4.78 (dd, 1H, $J_{2,3} = 9.6$ Hz, H-2), 4.71 (dd, 1H, $J_{6,6} = 11.3$ Hz, $J_{5,6} = 4.3$ Hz, H-6′e), 4.62 (dd, 1H, $J_{5,6} = 4.2$ Hz, $J_{6,6} = 11.0$ Hz, H-6″e), 4.53–3.80 (m, 7H, 4H-6, 3H-5), 4.28 (dd, 1H, $J_{3,4} = 9.6$ Hz, H-3), 2.13, 1.86 (2s, 6H, 2*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.4, 169.2 (2C, 2CH_3*C*O), 166.2, 166.1, 165.7, 165.6, 165.5, 165.4, 165.2 (8C, 8Ph*C*O), 160.4 (1C, *C*NHCCl_3), 133.9, 133.7, 133.6, 133.5, 133.4, 133.3, 130.1, 130.0, 129.9, 129.8, 129.6, 129.5, 129.4, 129.1, 129.0, 128.9, 128.7, 128.5, 128.4 (Bz-*C*), 101.2, 101.2, 92.8 (3C-1), 90.8 (1C, CNH*C*Cl_3), 76.1, 71.9, 71.6, 71.3, 69.8, 68.4, 68.2, 67.8, 62.2 (C-2–6), 20.9, 20.4 (2C, 2*C*H_3CO).

Anal. Calcd for $C_{80}H_{68}Cl_3NO_{26}$: C 61.34; H 4.35. Found: C 61.62; H 4.51.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→6)]-1,2-*O*-isopropylidene-α-D-glucofuranose (**10**)

2,3,4,6-Tetra-*O*-benzoyl-β-D-glucopyranosyl trichloroacetimidate **9** (3.93 g, 5.30 mmol) and acceptor **4** (4.39 g, 5.50 mmol) were coupled as described in the general procedure. Purification by chromatography with 3 : 1 petroleum ether–EtOAc as the eluent gave trisaccharide **10** (6.63 g, 87.6%) as a syrup: $[\alpha]_D$ −9.8° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.07–7.27 (m, 40H, 8Bz-*H*), 6.01 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 5.90 (dd, 1H, $J_{4,5} = J_{3,4} = 9.6$ Hz, H-4″), 5.78 (dd, 1H, $J_{2,3} = 9.8$ Hz, H-2′), 5.72 (dd, 1H, $J_{2,3} = 9.9$ Hz, H-2″), 5.64 (dd, 1H, H-3′), 5.58 (dd, 1H, H-3″), 5.47 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 4.96 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1″), 4.94 (d, 1H, $J_{1,2} = 8.0$ Hz, H-1′), 4.70 (dd, 1H, $J_{5,6} = 3.1$ Hz, $J_{6,6} = 12.2$ Hz, H-6′e), 4.54–4.13 (m, 10H, H-6″, H-6′a, H-5′, H-5″, H-6, H-2, H-3, H-4), 3.87 (m, 1H, H-5), 1.32, 1.04 (2s, 6H, *Me*$_2$C); ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.7, 165.6, 165.4, 165.1, 165.0, 164.8, 164.7, 164.3 (8C, 8Ph*C*O), 133.3, 133.2, 133.0, 132.8, 132.7, 129.6, 129.5, 129.4, 129.3, 129.2, 129.0, 128.6, 128.4, 128.3, 128.2, 128.1, 128.0, 127.8 (Bz-*C*), 111.7 (1C, Me$_2$*C*), 104.5, 101.4, 101.2 (3C-1), 83.0, 82.7, 78.8, 72.6, 71.8, 71.6, 71.3, 71.0, 69.4, 69.3, 67.6, 67.3, 62.7, 61.6 (C-2–6), 26.2, 25.5 (2C, *Me*$_2$C).

Anal. Calcd for $C_{77}H_{68}O_{24}$: C 67.15; H 4.94. Found: C 67.26; H 4.99.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→6)]-1,2,4-tri-*O*-acetyl-α-D-glucopyranose (**11**)

A solution of **10** (6.22 g, 4.50 mmol) in 90% CF_3COOH (50 mL) was stirred for 2 hr at rt, then concentrated to dryness. The residue was dissolved in pyridine (60 mL), and then Ac_2O (12 mL) was added. After stirring the mixture at rt for 12 hr, TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The reaction mixture was extracted with CH_2Cl_2 (80 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (1 : 1 petroleum ether–EtOAc) gave **11** (5.86 g, 88.7% for two steps) as a syrupy anomeric mixture. α-Anomer was the major product and isolated in pure form, and characterized: $[\alpha]_D$ −2.4° (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.04–7.23 (m, 40H, 8Bz-*H*), 6.02 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 6.01 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 5.90 (dd, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4″), 5.80 (dd, 1H, $J_{2,3} = 9.4$ Hz, $J_{1,2} = 8.1$ Hz, H-2′), 5.64 (dd, 1H, $J_{2,3} = J_{3,4} = 9.6$ Hz, H-3″), 5.71–5.50 (m, 2H, H-3′, H-2″), 4.96 (d, 1H, $J_{1,2} = 8.2$ Hz, H-1″), 4.95 (d, 1H, $J_{1,2} = 8.1$ Hz, H-1′), 4.95 (m, 1H, H-4), 4.75 (dd, 1H, $J_{5,6} = 3.5$ Hz, $J_{6,6} = 10.1$ Hz, H-6′e), 4.66–4.59 (m, 2H, H-6″e, H-2), 4.53–3.62 (m, 8H, H-3, H-6″a, H-6′a, H-6, H-5, H-5′, H-5″), 2.07, 1.81, 1.77 (3s, 9H, 3*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.4, 169.0, 168.6 (3C, $3CH_3CO$), 166.2, 165.8, 165.7, 165.5, 165.3, 165.1 (8C, 8Ph*C*O), 133.6, 133.5, 133.3, 130.1, 130.0, 129.8, 129.7, 129.6, 129.4, 129.1, 128.9, 128.7,128.6, 128.5, 128.4, 128.3 (Bz-*C*), 101.2, 101.1, 88.9 (3C-1), 75.4, 74.7, 73.0, 72.4, 72.3, 72.0, 71.8, 71.5, 71.3, 71.0, 70.4, 70.2, 69.9, 68.4, 68.1, 67.9, 67.6, 63.1, 61.8, 61.6 (C-2–6), 20.8, 20.6, 20.4 (3C, $3CH_3CO$).

Anal. Calcd for $C_{80}H_{70}O_{27}$: C 65.66; H 4.79. Found: C 65.87; H 4.91.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→6)]-2,4-di-*O*-acetyl-α-D-glucopyranose (**12**)

Compound **11** (4.97 g, 3.40 mmol) was dissolved in THF (60 mL), and then benzyl amine (2 mL) was added. The mixture was stirred at rt until TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was extracted with CH_2Cl_2 (50 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (1 : 1.5 petroleum ether–EtOAc) gave **12** (3.96 g, 82.1%) as a syrupy anomeric mixture, of which the major α-anomer was characterized: $[\alpha]_D + 10.5°$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.09–7.23 (m, 40H, 8Bz-*H*), 5.95 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4′), 5.92 (d, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4″), 5.73 (dd, 1H, $J_{3,4} = J_{2,3} = 9.6$ Hz, H-3″), 5.64 (dd, 1H, $J_{1,2} = 8.0$ Hz, $J_{2,3} = 10.2$ Hz, H-2′), 5.60–5.47 (m, 2H, H-3′, H-2″), 5.01 (d, 1H, $J_{1,2} = 3.4$ Hz, H-1), 4.97 (d, 1H, H-1″), 4.93 (d, 1H, H-1′), 4.80–4.74 (m, 2H, H-2, H-3), 4.62–4.53 (m, 2H, H-6′e, H-6″e), 4.44–3.63 (m, 8H, H-6′a, H-6″a, H-6, H-5′, H-5″, H-5, H-3), 2.05, 1.90 (2s, 6H, 2*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.7, 169.5 (2C, $2CH_3CO$), 166.4, 166.1, 165.8, 165.6, 165.5, 165.2, 165.2, 165.1 (8C, 8Ph*C*O), 133.8, 133.5, 133.3, 130.1, 130.0, 129.8, 129.7, 129.5, 128.9, 128.7, 128.6, 128.5, 128.4 (Bz-*C*), 102.4, 101.3, 89.6 (3C-1), 75.2, 73.4, 72.7, 72.5, 72.3, 71.8, 71.1, 70.3, 70.2, 69.3, 69.0, 68.9, 68.1, 62.9, 61.8 (C-2–6), 20.9, 20.8 (2C, $2CH_3CO$).

Anal. Calcd for $C_{78}H_{68}O_{26}$: C 65.92; H 4.79. Found: C 65.98; H 4.85.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1→3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-glucopyranosyl-(1→6)]-2,4-di-*O*-acetyl-α-D-glucopyranosyl trichloroacetimidate (**13**)

Compound **12** (1.95 g, 1.37 mmol) was dissolved in CH_2Cl_2 (50 mL), then CCl_3CN (0.2 mL, 2.0 mmol) and K_2CO_3 (1.0 g, 7.0 mmol) were added. The reaction mixture was stirred for 10 hr, at the end of which time TLC (3 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was filtered, and the filtrate was concentrated. The residue was purified by flash chromatography (1 : 1 petroleum ether–EtOAc) to give **13** (2.02 g, 93.7%) as a syrup: $[\alpha]_D + 3.4^\circ$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 8.34 (s, 1H, C=N*H*), 8.11–7.21 (m, 40H, 8Bz-*H*), 6.22 (d, 1H, $J_{1,2} = 3.6$ Hz, H-1), 5.93 (d, 1H, $J_{3,4} = 3.2$ Hz, H-4′), 5.86 (dd, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4″), 5.67–5.53 (m, 3H, H-2′,H-3′, H-3″), 5.48 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 9.6$ Hz, H-2″), 5.00 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1″), 4.96 (d, 1H, $J_{1,2} = 8.1$ Hz, H-1′), 4.92 (dd, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4), 4.68 (dd, 1H, $J_{2,3} = 9.6$ Hz, H-2), 4.55–3.70 (m, 9H, 6H-6, 3H-5), 4.30 (dd, 1H, $J_{3,4} = 9.6$ Hz, H-3), 2.00, 1.78 (2s, 6H, 2*Me*CO); ^{13}C NMR (100 MHz, $CDCl_3$): δ 169.4, 169.2 (2C, $2CH_3CO$), 166.2, 165.8, 165.7, 165.4, 165.2, 165.1 (8C, 8Ph*C*O), 160.5 (1C, *C*NHCCl$_3$), 133.8, 133.7, 133.6, 133.5, 133.4, 133.3, 130.0, 129.9, 129.8, 129.6, 129.4, 128.9, 128.7, 128.6, 128.5, 128.4 (Bz-*C*), 101.3, 100.6, 92.6 (3C-1), 90.8 (1C, CNH*C*Cl$_3$), 76.1, 73.0, 72.3, 72.0, 71.8, 71.6, 71.3, 70.4, 69.9, 63.1, 62.0 (C-2–6), 20.9, 20.4 (2C, $2CH_3CO$).

Anal. Calcd for $C_{80}H_{68}Cl_3NO_{26}$: C 61.34; H 4.35. Found: C 61.50; H 4.46.

2,4,6-Tri-*O*-acetyl-β-D-glucopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-α-D-mannopyranosyl-(1 → 6)]-5-*O*-acetyl-1,2-*O*-isopropylidene-α-D-glucofuranose (**14**)

Coupling[7] of 2,3,4,6-tetra-*O*-benzoyl-α-D-mannopyranosyl trichloroacetimidate (2.35 g, 3.18 mmol) with 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-glucopyranosyl-(1 → 3)-1,2-*O*-isopropylidene-α-D-glucofuranose (1.74 g, 3.18 mmol) under the same conditions as described in the general procedure. Purification on a silica gel column with 2 : 1 petroleum ether–EtOAc as the eluent gave the trisaccharide (2.28 g, 64.0%) as a syrup. The syrup (1.50 g, 1.33 mmol) was dissolved in pyridine (30 mL), and then Ac_2O (7.5 mL) was added. After stirring the mixture at 60–70°C for 24 hr, TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The reaction mixture was extracted with CH_2Cl_2 (50 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (2 : 1 petroleum ether–EtOAc) gave 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-glucopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-α-D-mannopyranosyl-(1 → 6)]-5-*O*-acetyl-1,2-*O*-isopropylidene-α-D-glucofuranose (1.25 g, 81%) as a syrup. The obtained trisaccharide (1.00 g, 0.86 mmol) was dissolved in MeOH (20 mL), and $PdCl_2$ (75 mg, 0.42 mmol) was added. After stirring the mixture for 3 hr at rt, TLC (3 : 2 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was filtered and the solution was concentrated to dryness, and the resultant residue was purified by flash chromatography (1 : 1 petroleum ether–EtOAc) to give **14** (0.75 g, 39%) as a syrup: $[\alpha]_D -17^\circ$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.16–7.25 (m, 20H, 4Bz-*H*), 6.14 (dd, 1H, $J_{3,4} = J_{4,5} = 10.2$ Hz, H-4″), 5.89 (dd, 1H, $J_{2,3} = 3.2$ Hz, $J_{3,4} = 9.6$ Hz, H-3″), 5.85 (d, 1H, $J_{1,2} = 3.2$ Hz, H-1), 5.76 (dd, 1H, $J_{1,2} = 1.6$ Hz,

$J_{2,3} = 3.1$ Hz H-2″), 5.29 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.2$ Hz, H-2′), 5.26–5.23 (m, 1H, H-5), 5.18 (d, 1H, $J_{1,2} = 1.7$ Hz, H-1″), 4.95 (dd, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4′), 4.63 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1′), 2.12, 2.10, 2.10, 2.09 (3s, 12H, 4CH_3CO), 1.55, 1.33 (2s, 6H, Me_2C); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.6, 170.3, 169.9, 169.7 (4C, 4CH_3CO), 166.2, 165.4, 165.4, 165.3 (4C, 4Ph*C*O), 105.1, 98.3, 97.0 (3C-1).

Anal. Calcd for $C_{57}H_{60}O_{24}$: C 60.64; H 5.36. Found: C 60.36; H 5.28.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 6)]-2,4-di-*O*-acetyl-α-D-glucopyranosyl-(1 → 3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-α-D-mannopyranosyl-(1 → 6)]-5-*O*-acetyl-1,2-*O*-isopropylidene-α-D-glucofuranose (**15**)

Donor **8** (500 mg, 0.32 mmol) and acceptor **14** (360 mg, 0.32 mmol) were coupled as described in the general procedure. Purification by chromatography with 1 : 2 petroleum ether–EtOAc as the eluent gave hexasaccharide **15** (700 mg, 76.5%): $[\alpha]_D + 14^\circ$ (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.04–7.21 (m, 60H, 12Bz-*H*), 6.17 (dd, 1H, $J_{3,4} = J_{4,5} = 10.1$ Hz, H-4), 6.01 (d, 1H, $J_{3,4} = 3.2$ Hz, H-4), 6.00 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4), 5.92 (dd, 1H, $J_{3,4} = 9.7$ Hz, $J_{2,3} = 3.4$ Hz, H-3), 5.80 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.3$ Hz, H-2), 5.79 (dd, 1H, $J_{2,3} = 3.4$ Hz, H-2), 5.79 (d, 1H, $J_{1,2} = 3.4$ Hz, H-1), 5.64 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.8$ Hz, H-2), 5.63–5.50 (m, 2H, H-3, H-3), 5.11 (d, 1H, $J_{1,2} = 1.8$ Hz, H-1), 5.04 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.98 (d, H, $J_{1,2} = 3.4$ Hz, H-1), 4.93 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.90–3.37 (m, 27H), 4.00 (d, 1H, $J_{1,2} = 9.6$ Hz, H-1), 2.22, 2.11, 2.09, 2.08, 1.90, 1.89 (6s, 18H, 6*Me*CO), 1.55, 1.15 (2s, 6H, Me_2C); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.1, 170.0, 169.1, 168.9, 168.9, 168.4 (6C, 6CH_3CO), 165.9, 165.6, 165.5, 165.3, 165.2, 165.1, 165.0, 164.9, 164.8, 164.7 (12C, 12Ph*C*O), 133.5, 133.2, 133.0, 132.9, 132.7, 132.6, 130.0, 129.5, 129.4, 129.3, 129.2, 129.1, 129.0, 128.8, 128.7, 128.4, 128.3, 128.1, 128.0, 127.9, 127.8 (Bz-*C*), 111.6 (1C, Me_2C), 104.8, 101.0, 100.6, 97.8, 96.8, 94.1 (6C-1), 81.7, 78.5, 75.9, 74.1, 74.0, 71.9, 71.6, 71.2, 71.0, 70.8, 70.3, 70.2, 70.0, 69.9, 69.3, 69.0, 68.5, 68.4, 68.1, 67.8, 67.5, 66.3, 65.7, 62.4, 61.5, 61.4, 61.1, 60.0 (C-2–6), 26.6, 25.3 (2C, Me_2C), 20.6, 20.4, 20.3, 20.2 (6C, 6CH_3CO).

Anal. Calcd for $C_{135}H_{126}O_{49}$: C 64.03; H 5.01. Found: C 64.22; H 5.20.

β-D-Galactopyranosyl-(1 → 3)-[β-D-galactopyranosyl-(1 → 6)]-α-D-glucopyranosyl-(1 → 3)-β-D-glucopyranosyl-(1 → 3)-[α-D-mannopyranosyl-(1 → 6)]-β-D-glucopyranose (**16**)

A solution of **15** (700 mg, 0.270 mmol) in 90% CF_3COOH (10 mL) was stirred for 2 hr at rt until TLC (1 : 1 petroleum ether–EtOAc) indicated that the reaction was complete, and then concentrated to dryness. The residue was dissolved in pyridine (15 mL), and then Ac_2O (10 mL) was added. After stirring the mixture at rt for 12 hr, TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The reaction mixture was extracted with CH_2Cl_2 (50 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (2 : 1 petroleum ether–EtOAc) gave the hexasaccharide as a syrup, which was dissolved in a satd solution of NH_3in MeOH (25 mL). After a week at rt, the reaction mixture was concentrated, and the residue was

purified by chromatography on Sephadex LH-20 (MeOH) to afford **16** (200 mg, 86.5%) as a foamy solid: $[\alpha]_D + 30^\circ$ (*c* 1.0, H_2O); ^1H NMR (D_2O, 400 MHz): δ 5.16 (d, 1H, $J_{1,2} = 3.2$ Hz, H-1), 5.10 (d, 1H, $J_{1,2} = 1.8$ Hz, H-1), 5.00 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.86 (d, 1H, $J_{1,2} = 7.8$ Hz, H-1), 4.56 (d, 1H, $J_{1,2} = 7.7$ Hz, H-1), 4.50 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.22–3.40 (m, 36H, H-2–6); ^{13}C NMR (100 MHz, D_2O): δ 103.1, 101.2, 100.8, 100.6 100.4, 95.2 (6C-1), 82.5, 79.1, 78.1, 76.4, 76.3, 75.9, 72.6, 72.3, 72.1, 72.0, 70.5, 70.2, 70.0, 69.9, 68.8, 68.4, 68.38, 66.8, 66.0, 65.7, 62.9 (C-2–6).

Anal. Calcd for $C_{36}H_{62}O_{31}$: C 43.64; H 6.30. Found: C 43.36, H 6.42.

2,3,4,6-Tetra-*O*-benzoyl-β-D-galactopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-β-D-glucopyranosyl-(1 → 6)]-2,4-di-*O*-acetyl-α-D-glucopyranosyl-(1 → 3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1 → 3)-[2,3,4,6-tetra-*O*-benzoyl-α-D-mannopyranosyl-(1 → 6)]-5-*O*-acetyl-1,2-*O*-isopropylidene-α-D-glucofuranose (**17**)

Donor **13** (511 mg, 0.33 mmol) and acceptor **14** (366 mg, 0.33 mmol) were coupled as described in the general procedure. Purification by chromatography with 3 : 1 petroleum ether–EtOAc as the eluent gave hexasaccharide **17** (715 mg, 76.2%): $[\alpha]_D + 15^\circ$ (*c* 1.0, $CHCl_3$); ^1H NMR ($CDCl_3$, 400 MHz): δ 8.04–7.21 (m, 60H, 12Bz-*H*), 6.18 (dd, 1H, $J_{3,4} = J_{4,5} = 10.1$ Hz, H-4), 5.89 (d, 1H, $J_{3,4} = 3.3$ Hz, H-4), 5.88 (d, 1H, $J_{3,4} = J_{4,5} = 9.6$ Hz, H-4), 5.87 (d, 1H, $J_{1,2} = 3.4$ Hz, H-1), 5.87 (dd, 1H, $J_{3,4} = 10.1$ Hz, $J_{2,3} = 3.4$ Hz, H-3), 5.80 (dd, 1H, $J_{1,2} = 1.8$ Hz, $J_{2,3} = 3.4$ Hz, H-2), 5.70 (dd, 1H, $J_{1,2} = 7.9$ Hz, $J_{2,3} = 10.4$ Hz, H-2), 5.63–5.50 (m, 3H, H-2, H-3, H-3), 5.10 (d, 1H, $J_{1,2} = 1.8$ Hz, H-1), 5.00 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.96 (d, H, $J_{1,2} = 3.4$ Hz, H-1), 4.91 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.90–3.37 (m, 27H), 4.02 (d, 1H, $J_{1,2} = 8.1$ Hz, H-1), 2.10, 2.09, 2.07, 2.04, 1.90, 1.86 (6s, 18H, 6*Me*CO), 1.57, 1.14 (2s, 6H, Me_2C); ^{13}C NMR (100 MHz, $CDCl_3$): δ 170.5, 170.3, 169.5, 169.4, 169.3, 168.7 (6C, 6CH_3CO), 166.2, 165.9, 165.8, 165.5, 165.4, 165.3, 165.2, 165.1, 165.0 (12C, 12Ph*C*O), 133.5, 133.4, 133.3, 132.9, 132.8, 132.6, 130.0, 129.4, 129.3, 129.2, 129.1, 129.0, 128.9, 128.8, 128.7, 128.6, 128.5, 128.4, 128.3, 128.1, 128.0 (Bz-*C*), 112.1 (1C, Me_2C), 105.2, 101.0, 101.0, 98.2, 97.1, 94.1 (6C-1), 82.2, 79.0, 77.2, 76.2, 73.8, 73.0, 72.2, 72.0, 71.7, 71.5, 71.5, 71.1, 70.8, 70.4, 70.3, 70.0, 69.3, 68.8, 68.7, 68.6, 68.4, 67.8, 66.6, 66.0, 62.7, 62.6, 61.7, 61.4, 60.3 (C-2–6), 27.1, 26.2 (2C, Me_2C), 20.9, 20.7, 20.6, 20.5 (6C, 6CH_3CO).

Anal. Calcd for $C_{135}H_{126}O_{49}$: C 64.03; H 5.01. Found: C 64.12; H 5.27.

β-D-Galactopyranosyl-(1 → 3)-[β-D-glucopyranosyl-(1 → 6)]-α-D-glucopyranosyl-(1 → 3)-β-D-glucopyranosyl-(1 → 3)-[α-D-mannopyranosyl-(1 → 6)]-β-D-glucopyranose (**18**)

A solution of **17** (710 mg, 0.275 mmol) in 90% CF_3COOH (10 mL) was stirred for 2 hr at rt until TLC (1 : 1 petroleum ether–EtOAc) indicated that the reaction was complete, then concentrated to dryness. The residue was dissolved in pyridine (15 mL), and then Ac_2O (10 mL) was added. After stirring the mixture at rt for 12 hr, TLC (2 : 1 petroleum ether–EtOAc) indicated that the reaction was complete. The reaction mixture was extracted with CH_2Cl_2 (50 mL), washed with dil. HCl and satd aq. $NaHCO_3$. The organic phase was dried over anhyd. Na_2SO_4, then concentrated to dryness. Purification by silica gel column chromatography (2 : 1 petroleum ether–EtOAc) gave the hexasaccharide

as a syrup, which was dissolved in a satd solution of NH_3in MeOH (25 mL). After a week at rt, the reaction mixture was concentrated, and the residue was purified by chromatography on Sephadex LH-20 (MeOH) to afford **18** (210 mg, 86.7%) as a foamy solid: $[\alpha]_D + 33^\circ$ (*c* 1.0, H_2O); ^1H NMR (D_2O, 400 MHz): δ 5.15 (d, 1H, $J_{1,2} = 3.2$ Hz, H-1), 5.09 (d, 1H, $J_{1,2} = 1.8$ Hz, H-1), 4.92 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.89 (d, 1H, $J_{1,2} = 7.7$ Hz, H-1), 4.54 (d, 1H, $J_{1,2} = 7.6$ Hz, H-1), 4.50 (d, 1H, $J_{1,2} = 7.9$ Hz, H-1), 4.26–3.33 (m, 36H, H-2–6); ^{13}C NMR (100 MHz, D_2O): δ 103.0, 101.0, 100.6, 100.5, 100.3, 95.4 (6C-1), 82.8, 79.0, 78.6, 76.6, 76.1, 75.7, 72.5, 72.4, 72.2, 72.0, 70.3, 70.2, 70.0, 69.9, 68.6, 68.2, 68.0, 66.2, 66.0, 65.5, 62.0 (C-2–6).

Anal. Calcd for $C_{36}H_{62}O_{31}$: C 43.64; H 6.30. Found: C 43.92; H 6.41.

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