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Synthesis of a heptasaccharide fragment of the O-deacetylated GXM of *C. neoformans* serotype C

Wei Zhao and Fanzuo Kong*

Research Center for Eco-Environmental Sciences, Academia Sinica, PO Box 2871, Beijing 100085, China

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Abstract—β-D-Xyl*p*-(1→2)-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→2)][β-D-Xyl*p*-(1→4)]-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→4)]-α-D-Man*p*, the fragment of the exopolysaccharide from *Cryptococcus neoformans* serovar C, was synthesized as its methyl glycoside. Thus, chloroacetylation of allyl 3-*O*-acetyl-4,6-*O*-benzylidene-α-D-mannopyranoside (**1**) followed by debenzylidenation and selective 6-*O*-benzoylation afforded allyl 2-*O*-chloroacetyl-3-*O*-acetyl-6-*O*-benzoyl-α-D-mannopyranoside (**4**). Glycosylation of **4** with 2,3,4-tri-*O*-benzoyl-D-xylopyranosyl trichloroacetimidate (**5**) furnished the β-(1→4)-linked disaccharide **6**. Dechloroacetylation gave the disaccharide acceptor **7** and subsequent coupling with **5** produced the trisaccharide **8**. Deacetylation of **8** gave the trisaccharide acceptor **9** and subsequent coupling with a disaccharide **10** produced the pentasaccharide **11**. Reiteration of deallylation and trichloroacetimidate formation from **11** yielded the pentasaccharide donor **12**. Coupling of a disaccharide acceptor **13** with **12** afforded the heptasaccharide **14**. Subsequent deprotection gave the heptaoside **16**, while selective 2-*O*-deacetylation of **14** gave the heptasaccharide acceptor **15**. Condensation of **15** with glucopyranosyluronate imidate **17** did not yield the expected octaoside, instead, an orthoester product **18** was obtained. Rearrangement of **18** did not give the target octaoside; but produced **15**. Meanwhile, there was no reaction between **15** and the glycosyl bromide donor **19**.

Keywords: Mannose; Xylose; Glucuronic acid

1. Introduction

An important virulence factor of the pathogenic fungus *Cryptococcus neoformans* is its polysaccharide capsule. In the capsular polysaccharides, glucuronoxylomannan (GXM), galactoxylomannan (GalXM), and the mannoproteins (MPs) display various immunomodulatory effects on the host response, such as the inhibition of phagocytosis, suppression of T-cell mediated immunity, and induction of immunogenic tolerance.[1] Moreover, these capsular polysaccharides are able to interfere with the migration of phagocytes despite adequate stimulation of chemokine production, and their concerted action accounts for the mild inflammatory response often observed in cryptococcosis. GXM induces L-selectin shedding from the surface of leukocytes; hence, interference with leukocyte rolling on the endothelium can be expected. GXM also interferes with the subsequent process of firm leukocyte adhesion to the endothelium and modulates the inflammatory response of human monocytes in vitro.[2] The capacity to reduce neutrophil influx makes cryptococcal polysaccharides interesting compounds to study in clinical models of inflammation (i.e., sepsis and autoimmune disorders) in which leukocyte influx can be potentially damaging to host tissues. As the major component of *C. neoformans*, GXM is a primary cause of opportunistic infections associated with AIDS.[3,4]

GXM is composed of a linear α-(1→3)-linked mannosyl backbone with 2-branched β-glucopyranosyluronic acid, 2- and 4-branched β-xylopyranosyl, and 6-*O*-acetyl substituents.[5] Of the four major serotypes[6] A–D for GXM, D has the simplest pentaose structure, while C has the most complex octaose structure. Since GXM is

* Corresponding author. Tel.: +86 10 62936613; fax: +86 10 62923563; e-mail: fzkong@mail.rcees.ac.cn

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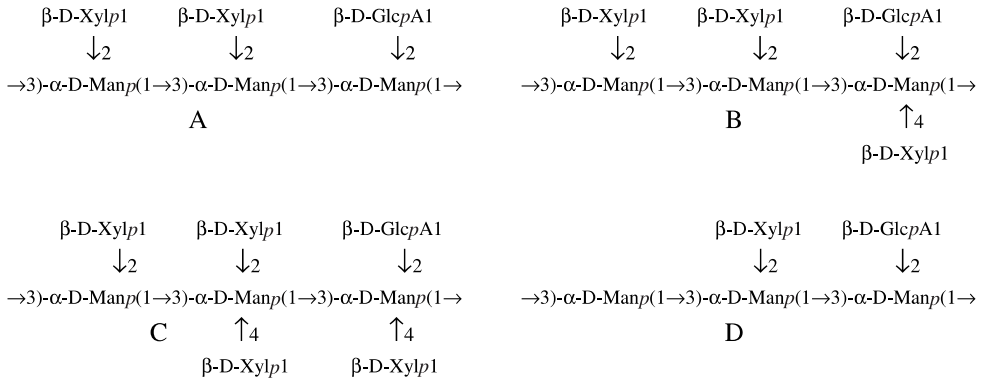


Figure 1. Structures of deacetylated GXM of *C. neoformans* serotypes A–D.

consisting of A–D oligosaccharide repeating units, it is reasonable to suppose that the bioactivity of GXM actually depends on its repeating oligosaccharide fragments. Our previous research on the lentinan repeating glucoheptaose[7a,b] and on the arabinogalactan oligosaccharide fragments[7c] indicates that this hypothesis is correct. For a study on the structure–activity relationships of GXM, it is necessary to synthesize all of the four serotype A–D repeating oligosaccharides.

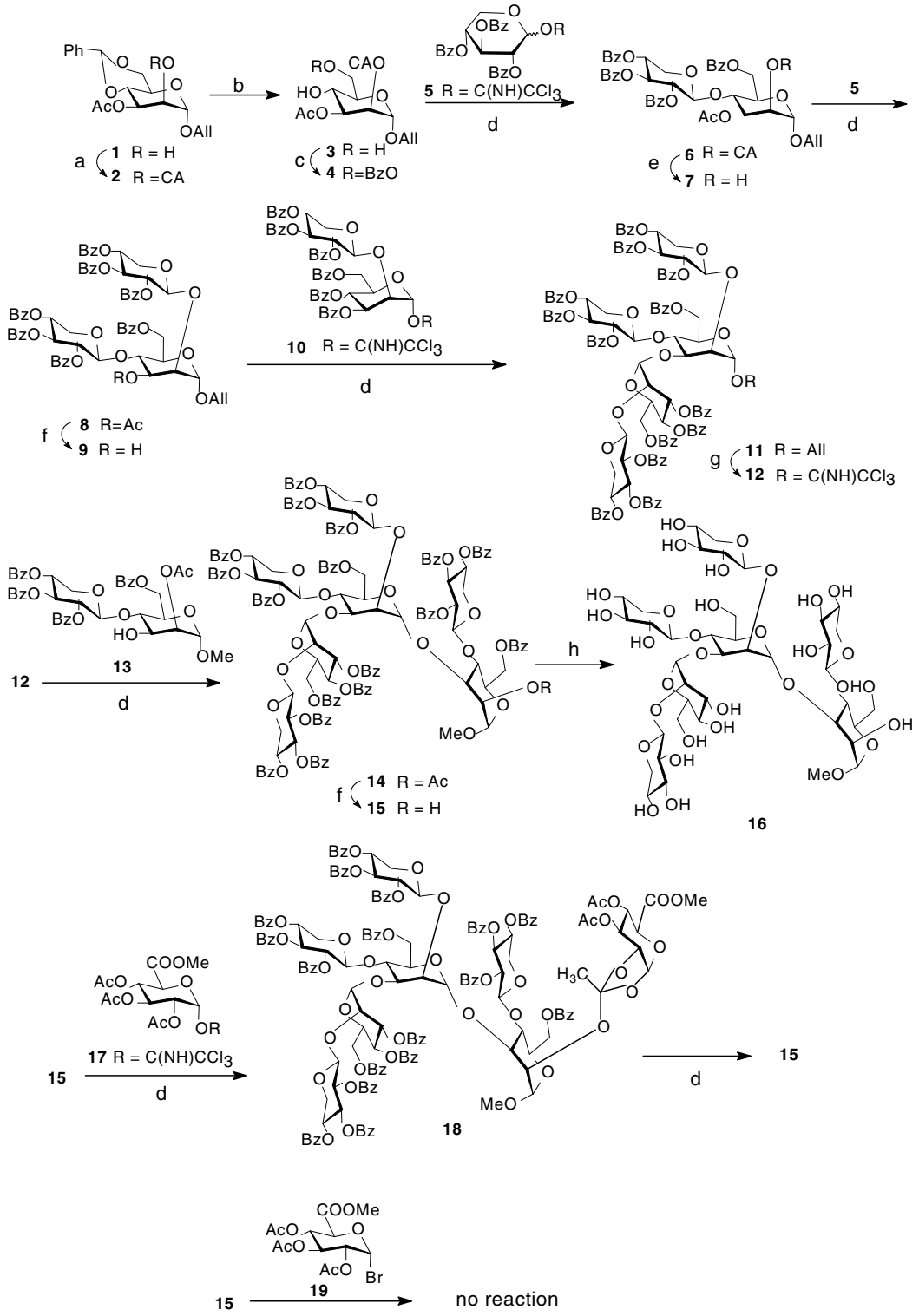
In our previous work,[8] the successful syntheses of the hexasaccharide repeating unit of O-deacetylated GXM of *C. neoformans* serotype A and its frame-shifted hexaoside were reported. Very recently, the syntheses of the heptasaccharide[9a] repeating unit and a hexasaccharide fragment[9b] of the O-deacetylated GXM of *C. neoformans* serotype B were reported. Earlier, the synthesis of trisaccharide and tetrasaccharide fragments[10] of GXM, and the synthesis of a pentasaccharide[11]—the repeating unit of the polysaccharide in *C. neoformans* serovar D—were described. We now report a trial for the synthesis of the repeating unit of the serotype C and a convergent synthesis of the heptasaccharide fragment of O-deacetylated GXM of *C. neoformans* serotype C (Fig. 1).

2. Results and discussion

Our strategy for the synthesis of the octaose repeating unit is to construct a heptaose acceptor of β-D-Xyl*p*-(1→2)-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→2)][β-D-Xyl*p*-(1→4)]-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→4)]-α-D-Man*p* with 2-free hydroxyl group at the downstream mannose residue first, then condense it with a glucopyranosyluronate trichloroacetimidate donor. Our previous experience[9a,b] indicated that such an acceptor would have smaller steric hindrance compared with the frame-shifted heptaose acceptor, β-D-Xyl*p*-(1→4)-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→2)][β-D-Xyl*p*-(1→4)]-α-D-Man*p*-(1→3)-[β-D-Xyl*p*-(1→2)]-α-D-Man*p*, with the 2-free hydroxyl group at the upstream mannose unit. For obtaining the heptaose, synthesis of the middle trisaccharide block, β-D-Xyl*p*-(1→2)[β-D-Xyl*p*-(1→4)]-α-D-Man*p*, then extension of the chain on nonreducing end of the mannose residue with a disaccharide donor (2+3), followed by extension of the pentasaccharide chain thus obtained with a disaccharide acceptor on the reducing end (5+2) were carried out. Assembly of the glucuronic acid was conducted at the final stage (7+1). If the glucuronate group was assembled first at C-2 of the mannose residue to make a trisaccharide acceptor, serious steric hindrance may occur at the coupling of the pentasaccharide donor with the trisaccharide acceptor. Our pervious study[12] reported a similar unsuccessful coupling of a fully benzoylated trisaccharide donor, α-L-Rha*p*-(1→3)-α-L-Rha*p*-(1→2)-α-L-Rha*p*-1-OC(NH)CCl$_3$, with a 2,4-di-xylosylated tetrasaccharide acceptor with a 3′-free hydroxyl group, allyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-α-L-rhamnopyranosyl-(1→3)-2,4-di-*O*-benzoyl-α-L-rhamnopyranoside, due to the serious steric hindrance.

Scheme 1 showed the synthesis in detail. Chloroacetylation (90%) of allyl 3-*O*-acetyl-4,6-*O*-benzylidene-α-D-mannopyranoside[13] (**1**), followed by debenzylidenation (89%) and selective 6-O-benzoylation (95%), gave the glycosyl acceptor **4**. Condensation of **4** with 2,3,4-tri-*O*-benzoyl-D-xylopyranosyl trichloroacetimidate[14] (**5**) afforded β-(1→4)-linked disaccharide **6** (80%), and subsequent dechloroacetylation[15] produced disaccharide acceptor **7** (85%). Coupling of **7** with **5** afforded the trisaccharide **8** (80%) and subsequent deacetylation[16] produced the trisaccharide acceptor **9** (85%). Coupling of **9** with a disaccharide donor **10**[9a] afforded the pentasaccharide **11** (90%), and subsequent deallylation and trichloroacetimidate formation (68% over two steps) produced the pentasaccharide donor **12**. Coupling of **12** with a disaccharide acceptor **13**[9a] afforded the heptasaccharide **14** (80%), and its deprotection in ammonia-saturated methanol gave the free heptaoside fragment of *C. neoformans* serotype C.

A trial for the synthesis of the octaose repeating unit of the serotype C was carried out. Thus, selective 2-*O*-deacetylation of **14** with a mixture of MeCOCl



Scheme 1. Reagents and conditions: (a) $ClCH_2COCl$, Pyridine (CH_2Cl_2); (b) 90% HOAc–H_2O; (c) BzCl–Pyridine; (d) TMSOTf, CH_2Cl_2, −10 °C to rt; (e) thiourea, 2,4-lutidine, CH_2Cl_2, CH_3OH, reflux; (f) CH_3COCl in CH_2Cl_2–CH_3OH, 0 °C to rt; (g) $PdCl_2$, CH_2Cl_2–MeOH, rt, 4 h; CCl_3CN, K_2CO_3, CH_2Cl_2, 10 h; (h) satd NH_3–MeOH, rt, 72 h; (i) silver triflate, CH_2Cl_2, 2,4-lutidine.

(3.5 mL) in CH_2Cl_2 (10 mL) and MeOH (40 mL) for 3 days afforded the heptasaccharide acceptor **15** in a fair yield (50%). Reaction of **15** with methyl 2,3,4-tri-*O*-acetyl-α-D-glucopyranosyluronate trichloroacetimidate (**17**) under the coupling condition gave a neat product. Unfortunately, it was not the expected octaoside.

Instead, an orthoester **18** was obtained (85%) as indicated by the characteristic signal at δ 122.7 ppm in its ^{13}C NMR spectrum, and by its easy decomposition in acidic media. Rearrangement[17] of **18** under normal conditions in the presence of TMSOTf (2–5% equiv) did not occur at all. Increasing the TMSOTf to 0.2 equiv caused decomposition, and acceptor **15** was isolated. Meanwhile, no reaction between **15** and methyl 2,3,4-tri-*O*-acetyl-α-D-glucopyranosyluronate bromide (**19**) occurred. However, as reported in our previous work,[9a] a similar hexaoside acceptor being lacking in the β-(1→4)-Xyl*p* branch at the middle mannose residue smoothly reacted with **19** . These facts revealed that a subtle change in the substitution of oligosaccharides, not even in the sugar residue to be reacted, can marvelously effect the coupling reaction. We hypothesized that the additional attached (1→4)-Xyl*p* changed the conformation of the acceptor **15**, substantially making a serious steric hindrance at the O-2 of the downstream mannose unit.

In summary, a convergent synthesis of the heptasaccharide fragment of *C. neoformans* serotype C was achieved, but the strategy presented here could not be used for the synthesis of the repeating unit of GXM of *C. neoformans* serotype C.

3. Experimental

3.1. General methods

Melting points were determined with a 'Mel-Temp' apparatus. Optical rotations were determined with a Perkin–Elmer model 241-MC automatic polarimeter for solutions in a 1-dm, jacketed cell. ^1H NMR and ^{13}C NMR spectra were recorded with Varian XL-400 and Varian XL-200 spectrometers, for solutions in $CDCl_3$ or in D_2O as indicated. Chemical shifts are expressed in parts per million downfield from the Me_4Si absorption. Mass spectra were recorded with a VG PLATFORM mass spectrometer using the ESI mode. Thin-layer chromatography (TLC) was performed on silica gel HF with detection by charring with 30% (v/v) sulfuric acid in MeOH or by UV detection. Column chromatography was conducted by elution of a column (8×100 mm, 16×240 mm, 18×300 mm, 35×400 mm) of silica gel (100–200 mesh) with EtOAc–petroleum ether (bp 60–90 °C) as the eluent. Analytical LC was performed with a Gilson HPLC consisting of a pump (model 306), a stainless steel column packed with silica gel (Spherisorb SiO_2, 10×300 mm or 4.6×250 mm), a differential refractometer (132-RI Detector), and a UV/vis detector (model 118). EtOAc–petroleum ether (bp 60–90 °C) was used as the eluent at a flow rate of 1–4 mL/min. Solutions were concentrated at a temperature <60 °C under diminished pressure.

3.2. Allyl 3-*O*-acetyl-4,6-*O*-benzylidene-2-*O*-chloroacetyl-α-D-mannopyranoside (2)

Compound **1** (3.50 g, 10 mmol) was dissolved in anhyd CH_2Cl_2 (50 mL) containing pyridine (4.1 mL, 50 mmol). Then under N_2 protection and stirring, a solution of $ClCH_2COCl$ (1.2 mL, 20 mmol) in anhyd CH_2Cl_2 (6 mL) was added dropwise within 30 min at 0 °C. The reaction temperature slowly raised to rt. After stirring the mixture for 8 h, TLC (3:1 petroleum ether–EtOAc) indicated that the reaction was complete. Then the mixture was neutralized with Et_3N and concentrated to dryness. Purification of the residue by silica gel column chromatography (3:1 petroleum ether–EtOAc) gave **2** (3.86 g, 90%) as a syrup: $[\alpha]_D$ +46.1 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ 7.46–7.34 (m, 5H, 1Ph*H*), 5.90 (m, 1H, CH_2=C*H*CH_2O), 5.57 (s, 1H, PhC*H*), 5.46 (dd, 1H, $J_{2,3}$ 3.6 Hz, $J_{3,4}$ 10.0 Hz, H-3), 5.38 (dd, 1H, $J_{1,2}$ 1.5 Hz, H-2), 5.34–5.22 (m, 2H, CH_2=CHCH_2O), 4.84 (d, 1H, H-1), 4.33–4.08 (m, 3H, H-5, H-6a, H-6b), 4.16, 4.10 (ABq, 2H, *J* 14.8 Hz, $ClCH_2O$), 4.12 (m, 1H, CH_2=CHCH_2O), 4.00 (m, 1H, CH_2=CHCH_2O), 3.82 (dd, 1H, $J_{3,4} = J_{4,5} = 10.0$ Hz, H-4), 2.00 (s, 3H, CH_3CO). Anal. Calcd for $C_{20}H_{23}ClO_8$: C, 56.20; H, 5.39. Found: C, 56.31; H, 5.34.

3.3. Allyl 3-*O*-acetyl-2-*O*-chloroacetyl-α-D-mannopyranoside (3)

A mixture of **2** (3.30 g, 8.9 mmol) and 90% HOAc–H_2O (50 mL) was stirred for 10 h at 40 °C, then concentrated to dryness. Purification of the residue by silica gel column chromatography (1:1 petroleum ether–EtOAc) gave **3** (2.72 g, 89%) as a syrup: $[\alpha]_D$ +42.0 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ 5.89 (m, 1H, CH_2=C*H*CH_2O), 5.29 (dd, 1H, $J_{1,2}$ 1.4 Hz, H-2), 5.22 (dd, 1H, $J_{2,3}$ 3.3 Hz, $J_{3,4}$ 9.9 Hz, H-3), 5.33–5.20 (m, 2H, CH_2=CHCH_2O), 4.86 (d, 1H, H-1), 4.20 (m, 1H, CH_2=CHCH_2O), 4.16, 4.10 (ABq, 2H, *J* 14.8 Hz, $ClCH_2CO$), 4.00 (dd, 1H, $J_{3,4} = J_{4,5} = 9.9$ Hz, H-4), 4.00 (m, 1H, CH_2=CHCH_2O), 3.88–3.87 (m, 2H, H-6a, H-6b), 3.74 (m, 1H, H-5), 2.07 (s, 3H, CH_3CO). Anal. Calcd for $C_{13}H_{19}ClO_8$: C, 46.02; H, 5.60. Found: C, 46.12; H, 5.56.

3.4. Allyl 3-*O*-acetyl-6-*O*-benzoyl-2-*O*-chloroacetyl-α-D-mannopyranoside (4)

Compound **3** (2.62 g, 7.7 mmol) was dissolved in anhyd CH_2Cl_2 (40 mL) containing pyridine (4.1 mL, 50 mmol), then under N_2 protection and stirring, a solution of PhCOCl (0.6 mL, 7.7 mmol) in anhyd CH_2Cl_2 (6 mL) was added dropwise within 30 min at 0 °C. The temperature of the mixture was slowly raised to rt. After stirring the mixture for 8 h, TLC (3:1 petroleum

ether–EtOAc) indicated that the reaction was complete. The reaction mixture was concentrated to give a residue that was purified by silica gel column chromatography (3:1 petroleum ether–EtOAc) to give **4** (3.25 g, 95%) as a syrup: $[\alpha]_D$ +46.1 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ 8.09–7.44 (m, 5H, 1Ph*H*), 5.89 (m, 1H, CH_2=C*H*CH_2O), 5.54 (dd, 1H, $J_{2,3}$ 3.3 Hz, $J_{3,4}$ 9.8 Hz, H-3), 5.38 (dd, 1H, $J_{1,2}$ 1.7 Hz, H-2), 5.29 (m, 1H, CH_2=CHCH_2O), 5.20 (m, 1H, CH_2=CHCH_2O), 4.89 (d, 1H, H-1), 4.78 (dd, 1H, $J_{5,6a}$ 4.1 Hz, $J_{6a,6b}$ 12.1 Hz, H-6a), 4.55 (dd, 1H, $J_{5,6b}$ 1.7 Hz, $J_{6a,6b}$ 12.1 Hz, H-6b), 4.23 (m, 1H, CH_2=CHCH_2O), 4.10, 4.04 (ABq, 2H, *J* 14.8 Hz, ClCH_2CO), 4.00 (m, 1H, CH_2=CHCH_2O), 4.00 (m, 1H, H-5), 3.96 (dd, 1H, $J_{3,4} = J_{4,5}$ = 9.8 Hz, H-4), 2.07 (s, 3H, CH_3CO). Anal. Calcd for $C_{20}H_{23}ClO_9$: C, 54.18; H, 5.19. Found: C, 54.08; H, 5.21.

3.5. Allyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)-3-*O*-acetyl-6-*O*-benzoyl-2-*O*-chloroacetyl-α-D-mannopyranoside (6)

Compound **4** (3.10 g, 7.0 mmol) and 2,3,4-tri-*O*-benzoyl-D-xylopyranosyl trichloroacetimidate (**5**, 4.85 g, 8.0 mmol) were dried together under high vacuum for 2 h, then dissolved in anhyd CH_2Cl_2 (70 mL). TMSOTf (15 μL, 0.14 mmol) was added dropwise at −10 °C with nitrogen protection. The reaction mixture was stirred for 3 h, during which time the temperature was gradually warmed to ambient temperature. Then the mixture was neutralized with Et_3N and concentrated to dryness. Purification of the residue by silica gel column chromatography (3:1 petroleum ether–EtOAc) gave **6** (4.96 g, 80%) as a foamy solid: $[\alpha]_D$ −25.5 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ 8.00–7.21 (m, 20H, 4Ph*H*), 5.85 (m, 1H, CH_2=C*H*CH_2O), 5.76 (dd, 1H, $J_{2,3} = J_{3,4}$ = 7.2 Hz, H-3 of Xyl*p*), 5.51 (dd, 1H, $J_{2,3}$ 3.3 Hz, $J_{3,4}$ 9.8 Hz, H-3 of Man*p*), 5.36 (dd, 1H, $J_{1,2}$ 5.2 Hz, H-2 of Xyl*p*), 5.37 (dd, 1H, $J_{1,2}$ 1.6 Hz, H-2 of Man*p*), 5.27–5.18 (m, 3H, H-4 of Xyl*p*, CH_2=CHCH_2O), 4.94 (d, 1H, $J_{1,2}$ 5.2 Hz, H-1 of Xyl*p*), 4.82 (d, 1H, $J_{1,2}$ 1.6 Hz, H-1 of Man*p*), 4.58 (dd, 1H, $J_{5,6a}$ 1.6 Hz, $J_{6a,6b}$ 12.1 Hz, H-6a of Man*p*), 4.45–4.41 (m, 2H, H-5a of Xyl*p*, H-6b of Man*p*), 4.20–3.96 (m, 4H, CH_2=CHCH_2O, H-4, H-5 of Man*p*), 4.07, 4.04 (ABq, 2H, *J* 14.8 Hz, ClCH_2CO), 3.67 (dd, 1H, $J_{4,5b}$ 6.8 Hz, $J_{5a,5b}$ 11.4 Hz, H-5b of Xyl*p*), 2.08 (s, 3H, CH_3CO). Anal. Calcd for $C_{46}H_{43}ClO_{16}$: C, 62.23; H, 4.85. Found: C, 62.37; H, 4.81.

3.6. Allyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)-3-*O*-acetyl-6-*O*-benzoyl-α-D-mannopyranoside (7)

Compound **6** (4.82 g, 5.4 mmol) was dissolved in mixed solvents of CH_2Cl_2 (10 mL) and MeOH (40 mL). To the solution were added thiourea (230 mg, 300 mmol) and 2,4-lutidine (60 μL, 0.54 mmol), and the reaction mixture was boiled under reflux for 16 h, at the end of which time TLC (2:1 petroleum ether–EtOAc) indicated that the reaction was complete. The mixture was concentrated and extracted with CH_2Cl_2, the organic phase was washed sequentially with N HCl, satd aq $NaHCO_3$, and water, then dried and concentrated to dryness. Purification of the residue by column chromatography (2:1 petroleum ether–EtOAc) gave **7** (3.74 g, 85%) as a foamy solid: $[\alpha]_D$ −45.6 (*c* 1.0, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$): δ 7.99–7.23 (m, 20H, 4Ph*H*), 5.88 (m, 1H, CH_2=C*H*CH_2O), 5.74 (dd, 1H, $J_{2,3} = J_{3,4}$ 7.9 Hz, H-3 of Xyl*p*), 5.41 (dd, 1H, $J_{2,3}$ 3.1 Hz, $J_{3,4}$ 9.7 Hz, H-3 of Man*p*), 5.38 (dd, 1H, $J_{1,2}$ 6.0 Hz, H-2 of Xyl*p*), 5.30–5.16 (m, 3H, H-4 of Xyl*p*, CH_2=CHCH_2O), 4.88 (d, 1H, $J_{1,2}$ 6.0 Hz, H-1 of Xyl*p*), 4.84 (d, 1H, $J_{1,2}$ 1.4 Hz, H-1 of Man*p*), 4.50 (dd, 1H, $J_{5,6a}$ 1.8 Hz, $J_{6a,6b}$ 12.1 Hz, H-6a of Man*p*), 4.47–4.38 (m, 2H, H-5a of Xyl*p*, H-6b of Man*p*), 4.20–3.92 (m, 4H, CH_2=CHCH_2O, H-4, H-5 of Man*p*), 4.05 (dd, 1H, $J_{1,2}$ 1.4 Hz, H-2 of Man*p*), 3.60 (dd, 1H, $J_{4,5b}$ 7.5 Hz, $J_{5a,5b}$ 12.1 Hz, H-5b of Xyl*p*), 2.18 (s, 3H, CH_3CO). Anal. Calcd for $C_{44}H_{42}O_{15}$: C, 65.19; H, 5.19. Found: C, 65.30; H, 5.14.

3.7. Allyl [2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-3-*O*-acetyl-6-*O*-benzoyl-α-D-mannopyranoside (8)

Compound **7** (3.12 g, 3.85 mmol) and **5** (2.53 g, 4.2 mmol) were dried together under high vacuum for 2 h, then dissolved in anhyd CH_2Cl_2 (60 mL). TMSOTf (15 μL, 0.13 mmol) was added dropwise at −10 °C with nitrogen protection. The reaction mixture was stirred for 3 h, during which time the temperature was gradually warmed to ambient temperature. Then the mixture was neutralized with Et_3N and concentrated to dryness. Purification of the residue by silica gel column chromatography (3:1 petroleum ether–EtOAc) gave **8** (3.86 g, 80%) as a foamy solid: $[\alpha]_D$ −18.1 (*c* 0.8, $CHCl_3$); ^1H NMR (400 MHz, $CDCl_3$) δ 8.00–7.19 (m, 35H, 7Ph*H*), 5.83 (m, 1H, CH_2=C*H*CH_2O), 5.74 (dd, 1H, $J_{2,3} = J_{3,4}$ = 7.5 Hz, H-3 of Xyl*p*), 5.72 (dd, 1H, $J_{2,3} = J_{3,4}$ = 7.3 Hz, H-3 of Xyl*p*), 5.43 (dd, 1H, $J_{1,2}$ 5.7 Hz, H-2 of Xyl*p*), 5.34 (dd, 1H, $J_{1,2}$ 5.5 Hz, H-2 of Xyl*p*), 5.36–5.24 (m, 2H, H-4 of Xyl*p*), 5.32–5.12 (m, 2H, CH_2=CHCH_2O), 5.12 (dd, 1H, $J_{2,3}$ 3.3 Hz, $J_{3,4}$ 9.5 Hz, H-3 of Man*p*), 4.87 (d, 1H, $J_{1,2}$ 5.5 Hz, H-1 of Xyl*p*), 4.80 (d, 1H, $J_{1,2}$ 5.7 Hz, H-1 of Xyl*p*), 4.87 (d, 1H, $J_{1,2}$ 1.5 Hz, H-1 of Man*p*), 4.45 (dd, 1H, $J_{4,5a}$ 4.3 Hz, $J_{5a,5b}$ 12.1 Hz, H-5a of Xyl*p*), 4.44 (dd, 1H, $J_{4,5a}$ 4.2 Hz, $J_{5a,5b}$ 12.2 Hz, H-5a of Xyl*p*), 4.30 (dd, 1H, $J_{5,6a}$ 1.4 Hz, $J_{6a,6b}$ 12.0 Hz, H-6a of Man*p*), 4.14 (dd, 1H, $J_{5,6b}$ 3.8 Hz, H-6b of Man*p*), 4.18–3.80 (m, 4H, H-2 of Man*p*, H-5 of Man*p*, CH_2=CHCH_2O), 4.09 (dd, 1H, $J_{3,4} = J_{4,5}$ = 9.5 Hz, H-4 of Man*p*), 3.70

(dd, 1H, $J_{4,5b}$ 6.0 Hz, $J_{5a,5b}$ 12.1 Hz, H-5b of Xyl*p*), 3.66 (dd, 1H, $J_{4,5b}$ 6.6 Hz, $J_{5a,5b}$ 12.2 Hz, H-5b of Xyl*p*), 2.16 (s, 3H, COCH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 170.2 (*C*OCH$_3$), 165.6, 165.5, 165.5, 165.4, 165.2, 164.9, 164.8 (7C, 7*C*OPh), 118.1 (OCH$_2$CH=*C*H$_2$), 101.7, 100.0, 96.1 (3C, 3C-1), 75.7, 74.8, 70.7, 70.5, 70.4, 70.2, 70.2, 69.4, 69.2, 69.0, 68.1, 63.2, 61.6 (C-2 to C-6), 20.3 (CO*C*H$_3$). Anal. Calcd for $C_{70}H_{62}O_{22}$: C, 66.99; H, 4.94. Found: C, 67.19; H, 5.01.

3.8. Allyl [2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranoside (9)

To a solution of **8** (3.30 g, 2.6 mmol) in anhyd CH_2Cl_2 (10 mL) was added anhyd MeOH (40 mL), then AcCl (2.0 mL) was added to the reaction mixture at 0 °C. The mixture was stirred at rt overnight, TLC (2:1 petroleum ether–EtOAc) showed that the starting material had disappeared. The solution was neutralized with Et_3N, then concentrated to dryness. Purification of the residue by silica gel column chromatography (2:1 petroleum ether–EtOAc) gave **9** (2.71 g, 85%) as a foamy solid: $[\alpha]_D$ −36.3 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.96–7.15 (m, 35H, 7Ph*H*), 5.81 (m, 1H, CH$_2$=C*H*CH$_2$O), 5.78 (dd, 1H, $J_{2,3} = J_{3,4}$ = 7.5 Hz, H-3 of Xyl*p*), 5.77 (dd, 1H, $J_{2,3} = J_{3,4}$ = 7.3 Hz, H-3 of Xyl*p*), 5.48 (dd, 1H, $J_{1,2}$ 6.5 Hz, H-2 of Xyl*p*), 5.47 (dd, 1H, $J_{1,2}$ 7.0 Hz, H-2 of Xyl*p*), 5.40–5.33 (m, 2H, H-4 of Xyl*p*), 5.16–5.12 (m, 2H, C*H*$_2$=CHCH$_2$O), 4.87 (d, 1H, $J_{1,2}$ 6.5 Hz, H-1 of Xyl*p*), 4.78 (d, 1H, $J_{1,2}$ 7.0 Hz, H-1 of Xyl*p*), 4.73 (d, 1H, $J_{1,2}$ 1.2 Hz, H-1 of Man*p*), 4.56 (dd, 1H, $J_{4,5a}$ 4.3 Hz, $J_{5a,5b}$ 12.2 Hz, H-5a of Xyl*p*), 4.48 (dd, 1H, $J_{4,5a}$ 4.3 Hz, $J_{5a,5b}$ 12.2 Hz, H-5a of Xyl*p*), 4.16 (dd, 1H, $J_{5,6a}$ 1.4 Hz, $J_{6a,6b}$ 12.0 Hz, H-6a of Man*p*), 4.11 (dd, 1H, $J_{5,6b}$ 3.8 Hz, H-6b of Man*p*), 4.18–3.80 (m, 5H, H-2 of Man*p*, H-3 of Man*p*, H-5 of Man*p*, CH$_2$=CHC*H*$_2$O), 3.85 (dd, 1H, $J_{3,4} = J_{4,5}$ = 9.6 Hz, H-4 of Man*p*), 3.60 (dd, 1H, $J_{4,5b}$ 6.1 Hz, $J_{5a,5b}$ 12.2 Hz, H-5b of Xyl*p*), 3.57 (dd, 1H, $J_{4,5b}$ 6.0 Hz, $J_{5a,5b}$ 12.2 Hz, H-5b of Xyl*p*); ^{13}C NMR (100 MHz, $CDCl_3$): 165.6, 165.6, 165.5, 165.5, 165.5, 165.0, 164.9 (7C, 7*C*OPh), 118.0 (OCH$_2$CH=*C*H$_2$), 101.5, 100.3, 96.2 (3C, 3C-1), 77.4, 71.4, 71.2, 71.0, 70.7, 70.0, 69.2, 69.0, 68.7, 68.2, 63.5, 62.7, 62.3 (C-2 to C-6). Anal. Calcd for $C_{68}H_{60}O_{21}$: C, 67.33; H, 4.95. Found: C, 67.49; H, 5.00.

3.9. Allyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)-3,4,6-tri-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranoside (11)

To a cooled solution (0 °C) of **9** (2.52 g, 2.1 mmol) and **10** (2.3 g, 2.4 mmol) in anhyd CH_2Cl_2 (60 mL) was added TMSOTf (15 μL, 0.1 mmol). The mixture was stirred at this temperature for 2 h and then quenched with Et_3N (1 drop). The solution was concentrated to give a residue. Purification of the residue by silica gel column chromatography (1.5:1 petroleum ether–EtOAc) gave **11** (3.99 g, 90%) as a foamy solid: $[\alpha]_D$ −24.6 (*c* 1.0, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.20–7.08 (m, 65H, 13Ph*H*), 5.93 (dd, 1H, $J_{3,4} = J_{4,5}$ = 10.0 Hz, H-4 of Man*p*), 5.87 (dd, 1H, $J_{2,3}$ 3.2 Hz, $J_{3,4}$ 10.0 Hz, H-3 of Man*p*), 5.80 (dd, 1H, $J_{2,3} = J_{3,4}$ = 6.0 Hz, H-3 of Xyl*p*), 5.75 (dd, 1H, $J_{2,3} = J_{3,4}$ = 5.8 Hz, H-3 of Xyl*p*), 5.75 (dd, 1H, $J_{2,3} = J_{3,4}$ = 5.8 Hz, H-3 of Xyl*p*), 5.60 (m, 1H, CH$_2$=C*H*CH$_2$O), 5.57 (dd, 1H, $J_{1,2}$ 6.5 Hz, H-2 of Xyl*p*), 5.55 (dd, 1H, $J_{1,2}$ 4.2 Hz, H-2 of Xyl*p*), 5.53 (dd, 1H, $J_{1,2}$ 7.0 Hz, H-2 of Xyl*p*), 5.47–5.31 (m, 2H, H-4 of Xyl*p*), 5.36 (s, 1H, H-1 of Man*p*), 5.30 (d, 1H, $J_{1,2}$ 4.2 Hz, H-1 of Xyl*p*), 5.18 (m, 1H, H-4 of Xyl*p*), 5.07–5.00 (m, 2H, CH$_2$=CHC*H*$_2$O), 4.77 (d, 1H, $J_{1,2}$ 6.5 Hz, H-1 of Xyl*p*), 5.04 (d, 1H, $J_{1,2}$ 7.0 Hz, H-1 of Xyl*p*), 4.50 (s, 1H, H-1 of Man*p*), 4.85–3.50 (m, 18H); ^{13}C NMR (100 MHz, $CDCl_3$): 166.3, 165.7, 165.7, 165.7, 165.6, 165.5, 165.4, 165.3, 165.2, 165.1, 164.7, 164.7, 164.6 (13C, 13*C*OPh), 118.1 (OCH$_2$CH=*C*H$_2$), 102.3, 101.0, 100.0, 97.9, 95.8 (5C, 5C-1), 75.6, 74.3, 72.0, 71.7, 71.7, 71.0, 71.0, 69.8, 69.8, 69.5, 69.4, 69.0, 68.8, 68.3, 68.1, 67.9, 64.4, 63.4, 62.8, 62.5, 60.3, 59.5 (C-2 to C-6). Anal. Calcd for $C_{121}H_{102}O_{36}$: C, 68.17; H, 4.79. Found: C, 68.38; H, 4.72.

3.10. 2,3,4-Tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)-3,4,6-tri-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranosyl trichloroacetimidate (12)

To a solution of **11** (3.20 g, 1.5 mmol) in anhyd CH_2Cl_2 (10 mL) and anhyd MeOH (50 mL), $PdCl_2$ (220 mg, 1.22 mmol) was added with nitrogen protection. After stirring the reaction mixture for 4 h at rt, TLC (1:1 petroleum ether–EtOAc) indicated that the reaction was complete. Then the mixture was filtered, and the solution was concentrated to dryness. The residue was dissolved in CH_2Cl_2 (30 mL), and CCl_3CN (0.3 mL, 3 mmol) and K_2CO_3 (1.0 g) were added. The reaction mixture was stirred for 10 h, at the end of which time TLC (1.5:1 petroleum ether–EtOAc) indicated that the reaction was complete. Then the mixture was filtered, and the solution was concentrated to dryness. Purification of the residue on a silica gel column with 1.5:1 petroleum ether–EtOAc as the eluent furnished the pentasaccharide donor **12** (2.28 g, 68% for two steps) as a foamy solid: $[\alpha]_D$ −16.9 (*c* 0.5, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.66 (s, 1H, CN*H*CCl$_3$), 8.19–7.17 (m, 65H, 13Ph*H*), 6.15 (s, 1H, H-1 of Man*p*), 6.02 (dd, 1H, $J_{3,4} = J_{4,5}$ = 10.1 Hz, H-4 of Man*p*), 5.90

(dd, 1H, $J_{2,3}$ 3.2 Hz, $J_{3,4}$ 10.1 Hz, H-3 of Man*p*), 5.80–5.72 (m, 3H, 3H-3 of Xyl*p*), 5.61–5.44 (m, 3H, 3H-2 of Xyl*p*), 5.54 (m, 1H, H-4 of Xyl*p*), 5.40 (s, 1H, H-1 of Man*p*), 5.36 (m, 1H, H-4 of Xyl*p*), 5.30 (d, 1H, $J_{1,2}$ 4.2 Hz, H-1 of Xyl*p*), 5.18 (m, 1H, H-4 of Xyl*p*), 4.90 (d, 1H, $J_{1,2}$ 6.5 Hz, H-1 of Xyl*p*), 4.77 (d, 1H, $J_{1,2}$ 7.0 Hz, H-1 of Xyl*p*), 4.85–3.50 (m, 18H); ^{13}C NMR (100 MHz, $CDCl_3$): 166.1, 165.8, 165.7, 165.7, 165.6, 165.6, 165.5, 165.4, 165.2, 165.1, 165.0, 164.8, 164.8 (13C, 13*C*OPh), 102.4, 100.8, 100.1, 97.9, 95.0 (5C, 5C-1), 90.7 (–*C*Cl_3), 76.0, 75.0, 74.2, 72.3, 72.0, 71.7, 71.7, 71.0, 71.0, 70.7, 69.9, 69.5, 69.0, 68.8, 68.6, 68.1, 64.3, 63.0, 62.8, 62.7, 60.3, 59.5 (C-2 to C-6). Anal. Calcd for $C_{120}H_{98}Cl_3NO_{36}$: C, 64.43; H, 4.38. Found: C, 64.21; H, 4.48.

3.11. Methyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)-3,4,6-tri-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-2-*O*-acetyl-6-*O*-benzoyl-α-D-mannopyranoside (14)

To a cooled solution (0 °C) of **12** (2.2 g, 1.0 mmol) and **13** (0.7 g, 1.1 mmol) in anhyd CH_2Cl_2 (20 mL) was added TMSOTf (10 μL, 0.07 mmol). The mixture was stirred at this temperature for 2 h and then quenched with Et_3N (1 drop). The solution was concentrated to give a residue. Purification of the residue by silica gel column chromatography (1:1 petroleum ether–EtOAc) gave **14** (2.2g, 80%) as a foamy solid: $[\alpha]_D$ −17.0 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.22–6.87 (m, 85H, 17Ph*H*), 6.20 (dd, 1H, $J_{3,4} = J_{4,5} = 10.0$ Hz, H-4 of Man*p*), 6.01 (dd, 1H, $J_{2,3}$ 3.3 Hz, $J_{3,4}$ 10.0 Hz, H-3 of Man*p*), 6.00 (dd, 1H, $J_{3,4} = J_{4,5} = 7.2$ Hz, H-3 of Xyl*p*), 5.84–5.62 (m, 6H, 3H-3 of Xyl*p*, 2H-2 of Xyl*p*, H-4 of Xyl*p*), 5.50–5.34 (m, 5H, 2H-2 of Xyl*p*, 3H-4 of Xyl*p*), 5.43 (s, 1H, H-1 of Man*p*), 5.38 (d, 1H, $J_{1,2}$ 4.1 Hz, H-1 of Xyl*p*), 5.25 (d, 1H, $J_{1,2}$ 6.5 Hz, H-1 of Xyl*p*), 5.17 (s, 1H, H-1 of Man*p*), 5.12 (m, 1H, H-4 of Xyl*p*), 5.06 (d, 1H, H-2 of Man*p*), 4.94 (s, 1H, H-1 of Man*p*), 4.86 (d, 1H, $J_{1,2}$ 6.2 Hz, H-1 of Xyl*p*), 4.73 (d, 1H, $J_{1,2}$ 7.0 Hz, H-1 of Xyl*p*), 4.85–3.37 (m, 25H), 3.17 (s, 3H, COCH_3), 2.03 (s, 3H, OOCCH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 169.8 (*C*OCH_3), 166.1, 166.0, 165.9, 165.7, 165.6, 165.6, 165.5, 165.5, 165.4, 165.3, 165.3, 165.2, 165.2, 165.0, 164.8, 164.8, 164.6 (17C, 17*C*OPh), 102.5, 101.6, 100.3, 100.0, 98.8, 98.1, 97.0 (7C, 7C-1), 77.3, 76.6, 76.3, 76.0, 73.3, 72.8, 72.2, 71.9, 71.8, 71.4, 71.3, 71.2, 70.9, 70.6, 70.3, 69.8, 69.6, 69.5, 69.4, 69.0, 68.4, 68.0, 67.9, 63.7, 63.4, 63.1, 63.0, 62.8, 62.6, 62.5, 60.4, 59.0 (C-2 to C-6), 54.9 (OCH_3), 20.7 (COCH_3); Anal. Calcd for $C_{160}H_{136}O_{50}$: C, 67.23; H, 4.76. Found: C, 67.11; H, 4.87.

3.12. Methyl 2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)-3,4,6-tri-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→2)][2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranosyl-(1→3)-[2,3,4-tri-*O*-benzoyl-β-D-xylopyranosyl-(1→4)]-6-*O*-benzoyl-α-D-mannopyranoside (15)

To a solution of **14** (1.6 g, 0.6 mmol) in anhyd CH_2Cl_2 (10 mL) was added anhyd MeOH (40 mL), then AcCl (3.5 mL) was added to the reaction mixture at 0 °C. The mixture was stirred at rt for 3 days, TLC (1:1 petroleum ether–EtOAc) showed that the starting material disappeared. The solution was neutralized with Et_3N, then concentrated to dryness. Purification of the residue by silica gel column chromatography (1:1.4 petroleum ether–EtOAc) gave **15** (800 mg, 50%) as a foamy solid: $[\alpha]_D$ −48.9 (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.20–6.97 (m, 85H, 17Ph*H*), 6.17 (dd, 1H, $J_{3,4} = J_{4,5} = 10.2$ Hz, H-4 of Man*p*), 6.03 (dd, 1H, $J_{2,3}$ 3.2 Hz, $J_{3,4}$ 10.2 Hz, H-3 of Man*p*), 6.00 (dd, 1H, $J_{3,4} = J_{4,5} = 7.0$ Hz, H-3 of Xyl*p*), 5.83–5.58 (m, 6H, 3H-3 of Xyl*p*, 2H-2 of Xyl*p*, H-4 of Xyl*p*), 5.53-5.39 (m, 4H, 2H-2 of Xyl*p*, 2H-4 of Xyl*p*), 5.43 (s, 1H, H-1 of Man*p*), 5.40 (d, 1H, $J_{1,2}$ 4.1 Hz, H-1 of Xyl*p*), 5.22 (d, 1H, $J_{1,2}$ 6.4 Hz, H-1 of Xyl*p*), 5.16 (s, 1H, H-1 of Man*p*), 5.15 (m, 1H, H-4 of Xyl*p*), 5.04 (s, 1H, H-1 of Man*p*), 4.78 (d, 1H, $J_{1,2}$ 6.4 Hz, H-1 of Xyl*p*), 4.65 (d, 1H, $J_{1,2}$ 7.1 Hz, H-1 of Xyl*p*), 4.85–3.37 (m, 26H), 3.19 (s, 3H, OCH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 166.2, 166.0, 165.9, 165.8, 165.7, 165.7, 165.7, 165.5, 165.4, 165.3, 165.3, 165.2, 165.2, 165.1, 164.8, 164.8, 164.6 (17C, 17*C*OPh), 102.4, 102.4, 100.1, 100.1, 100.1, 98.4, 97.0 (7C, 7C-1), 76.3, 76.0, 75.7, 75.5, 73.4, 72.5, 72.2, 71.9, 71.9, 71.8, 71.8, 71.1, 70.8, 70.8, 70.4, 70.1, 70.0, 69.9, 69.3, 69.3, 69.0, 68.6, 68.0, 68.0, 67.9, 63.7, 63.5, 63.2, 63.0, 62.9, 62.8, 60.4, 59.2 (C-2 to C-6), 54.9 (OCH_3); Anal. Calcd for $C_{158}H_{134}O_{49}$: C, 67.38; H, 4.76. Found: C, 67.20; H, 4.85.

3.13. Methyl β-D-xylopyranosyl-(1→2)-α-D-mannopyranosyl-(1→3)-[β-D-xylopyranosyl-(1→2)][β-D-xylopyranosyl-(1→4)]-α-D-mannopyranosyl-(1→3)-[β-D-xylopyranosyl-(1→4)]-α-D-mannopyranoside (16)

Heptasaccharide **14** (200 mg, 0.07 mmol) was dissolved in a satd methanolic ammonia (10 mL). After stirring at rt for 72 h, the reaction mixture was concentrated and purified on a Bio-Gel P2 column (eluent: water), affording the heptasaccharide **16** (62 mg, 85%) as a foamy solid: $[\alpha]_D$ +31.4 (*c* 1.0, D_2O); ^{1}H NMR (400 MHz, $CDCl_3$): δ 5.17 (s, 1H, H-1 of Man*p*), 5.17 (s, 1H, H-1 of Man*p*), 4.67 (s, 1H, H-1 of Man*p*), 4.35 (d, 1H, $J_{1,2}$ 7.8 Hz, H-1 of Xyl*p*), 4.34 (d, 1H, $J_{1,2}$ 7.9 Hz, H-1 of Xyl*p*), 4.21 (d, 1H, $J_{1,2}$ 7.8 Hz, H-1 of Xyl*p*), 4.18 (d, 1H, $J_{1,2}$ 7.8 Hz, H-1 of Xyl*p*), 4.16–3.07 (m, 30H), 3.30

(s, 3H, CH_3O); ^{13}C NMR (100 MHz, D_2O): 104.1, 103.8, 103.5, 102.9, 100.4, 100.0, 99.3 (7C, 7C-1), 77.7, 77.2, 75.7, 75.7, 75.6, 75.5, 75.5, 74.8, 74.5, 73.6, 73.5, 73.5, 72.5, 72.5, 72.5, 71.7, 69.8, 69.7, 69.7, 69.3, 69.2, 69.1, 66.7, 65.4, 65.3, 65.2, 65.0 (C-2 to C-6), 54.9 (O*C*H$_3$). Anal. Calcd for $C_{39}H_{66}O_{32}$: C, 44.74; H, 6.31. Found: C, 44.53; H, 6.37.

3.14. Orthoester 18

To a cooled solution (0 °C) of **15** (780 mg, 0.26 mmol) and **17** (300 mg, 0.6 mmol) in anhyd CH_2Cl_2 (15 mL) was added TMSOTf (5 μL, 0.03 mmol). The mixture was stirred at this temperature for 2 h and then quenched with Et_3N (1 drop). The solution was concentrated to give a residue. Purification of the residue by silica gel column chromatography (1:1.8 petroleum ether–EtOAc) gave **18** (740 mg, 85%) as a foamy solid: $[\alpha]_D$ −28.1 (*c* 1.0, $CHCl_3$); (*c* 1.0, $CHCl_3$); ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.32–7.06 (m, 85H, 17Ph*H*), 6.13 (dd, 1H, $J_{3,4} = J_{4,5} = 9.9$ Hz, H-4 of Man*p*), 6.13–6.07 (m, 2H, H-3 of Man*p*, H-3 of Xyl*p*), 5.83–5.58 (m, 6H, 3H-3 of Xyl*p*, 2H-2 of Xyl*p*, H-4 of Xyl*p*), 5.74 (d, 1H, $J_{1,2}$ 4.7 Hz, H-1 of GluA*p*), 5.53–5.39 (m, 8H, 2H-2 of Xyl*p*, 3H-4 of Xyl*p*, H-2, H-3, H-4, of GluA*p*), 5.33 (s, 1H, H-1 of Man*p*), 5.27 (d, 1H, $J_{1,2}$ 4.2 Hz, H-1 of Xyl*p*), 5.19 (d, 1H, $J_{1,2}$ 6.0 Hz, H-1 of Xyl*p*), 5.19 (s, 1H, H-1 of Man*p*), 5.13 (d, 1H, $J_{1,2}$ 7.6 Hz, H-1 of Xyl*p*), 4.97 (s, 1H, H-1 of Man*p*), 4.76 (d, 1H, $J_{1,2}$ 7.6 Hz, H-1 of Xyl*p*), 4.95–3.47 (m, 26H), 3.65 (s, 3H, COOCH_3), 3.19 (s, 3H, OCH_3), 2.01, 1.94 (2s, 6H, 2COCH_3), 1.72 (s, 3H, OOCCH_3); ^{13}C NMR (100 MHz, $CDCl_3$): 169.4, 169.2, 168.7 (3C, 2*C*OCH$_3$, *C*OOMe), 166.2, 166.0, 166.0, 165.7, 165.7, 165.7, 165.6, 165.5, 165.4, 165.3, 165.3, 165.3, 165.3, 165.0, 164.8, 164.6, 164.4 (17C, 17*C*OPh), 122.7 (1C, OO*C*CH$_3$), 102.8, 102.6, 99.9, 99.6, 99.3, 97.7, 97.2, 96.5 (8C, 8C-1), 76.3, 76.0, 75.7, 75.5, 73.4, 72.5, 72.2, 71.9, 71.9, 71.8, 71.8, 71.1, 70.8, 70.8, 70.4, 70.1, 70.0, 69.9, 69.3, 69.3, 69.0, 68.6, 68.0, 68.0, 67.9, 63.7, 63.5, 63.2, 63.0, 62.9, 62.8, 60.4, 59.2 (C-2 to C-6), 54.9 (O*C*H$_3$), 52.6 (COO*C*H$_3$), 21.6 (1C, OOC*C*H$_3$), 20.8, 20.5 (2C, 2CO*C*H$_3$); Anal. Calcd for $C_{171}H_{150}O_{58}$: C, 65.56; H, 4.79. Found: C, 65.28; H, 4.90.

3.15. Rearrangement of 18

To a cooled solution (0 °C) of **18** (350 mg, 0.11 mmol) in anhyd CH_2Cl_2 (5 mL) was added TMSOTf (0.3–0.7 μL, 2–5 μmol). The mixture was stirred at this temperature for 2 h, and TLC indicated that no reaction occurred. Extension of the reaction time to 2 days still did not cause the rearrangement. Increasing the TMSOTf to 0.2 equiv only caused decomposition, and the product was purified by silica gel column chromatography (1:1.5 petroleum ether–EtOAc) to give a foamy solid (140 mg) whose ^{1}H NMR data were identical with those of **15**.

3.16. A trial with bromide 19 as the donor

To a cooled solution (0 °C) of **15** (120 mg, 0.04 mmol) and **19** (46 mg, 0.12 mmol) in anhyd CH_2Cl_2 (5 mL) and 2,4-lutidine (10 μL, 0.08 mmol) was added silver triflate (28 mg, 0.12 mmol). The mixture was stirred at this temperature for 6 h and no reaction occurred.

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