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Remote control of α- or β-stereoselectivity in (1→3)-glucosylations in the presence of a C-2 ester capable of neighboring-group participation

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Abstract

In (1→3)-glucosylation the glycosyl bond originally present in either donor or acceptor is shown to control the stereoselectivity of the forthcoming bond, i.e., the newly formed glycosidic linkage has the opposite anomeric configuration of that of either the donor or acceptor. Therefore, with α-(1→3)-linked disaccharides with nonreducing ends that have the 3-OH free as the acceptor and an acetylated glucosyl trichloroacetimidate as the donor, or with an α-(1→3)-linked acetylated disaccharide trichloroacetimidate as the donor and a glucoside with 3-OH free as the acceptor, β-linked trisaccharides were obtained. Meanwhile, with β-(1→3)-linked disaccharides that have nonreducing ends with the 3-OH free as the acceptor and an acetylated glucosyl trichloroacetimidate as the donor, or with a β-(1→3)-linked acetylated disaccharide trichloroacetimidate as the donor and a glucoside with the 3-OH free as the acceptor, α-linked trisaccharides were obtained in spite of the C-2 neighboring group participation.

Keywords: Remote control; Trichloroacetimidates; Neighboring-group participation

1. Introduction

The stereospecific formation of glycosidic bonds is the central challenge in carbohydrate chemistry. The chemical formation of a glycosidic linkage involves activation of a glycosyl donor to create a reactive electrophilic species that couples with a nucleophilic acceptor hydroxyl. This coupling reaction can take two possible pathways resulting in formation of either α or β anomers. Current methods to control the stereochemistry of the anomeric center rely on the participation of a neighboring-group functionality, such as an ester protecting group on the C-2 hydroxyl. Formation of a cyclic oxonium ion intermediate then shields one face of the molecule, leading exclusively to the formation of trans-glycosidic linkage, whereas cis-glycosidic bonds are difficult to construct in the presence of neighboring group participation. A non-participating group (e.g., a benzyl or azido group) at C-2 of a glycosyl donor is a prerequisite for the synthesis of virtually all 1,2-*cis*-glycopyranosidic linkages. However, Flowers reported that under forcing conditions, i.e., with $HgCN_2$ (3 equiv) as the promoter in nitromethane–benzene at 60 °C for 3 days, coupling of 2,3,4-tri-*O*-acetyl-α-L-fucopyranosyl bromide with benzyl 6-*O*-benzoyl-3,4-*O*-isopropylidene-β-D-galactopyranoside gave the α-linked disaccharide.[1]

2. Results and discussion

As part of our research to develop an immune stimulant, we have been dealing with the synthesis of the β-(1→3)- and α-(1→3)-D-glucooligosaccharides. These oligosaccharides are fragments of medically important natural β-(1→3)-linked glucans such as the antitumor-active schizophyllan, scleroglucan and lentinan,[2] and α-(1→3)-linked glucans such as those from *Cryphonectrini parasitica* and *Ganoderma lucidum*.[3] For investigation of structure, function relationships, a series of

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β-(1→3)- and -α-(1→3)-linked gluco-oligosaccharides were needed as probes. Our preceding communication[4] reported that pure α-linked products can be obtained in high yields in glycosylation with glucosyl trichloroacetimidate donors with a C-2 ester capable of neighboring group participation. Also, it was found that sugar orthoesters were the intermediates that were transformed to α-linked oligosaccharides in the presence of TMSOTf through C-1 and O-1 bond breaking. However, the rationale concerning the stereoselectivity control factor in (1→3)-glucosyl linkage formation is still obscure. To explore the puzzle encountered in the synthesis of (1→3)-linked gluco-oligosaccharides, a series of experiments was carried out as described in the following sections.

Table 1
(1→3)-Glycosylation results with different pairs of donors and acceptors

1	**1** + **2**	**3** 75% α:β = 3:7
2	**3** + **2**	**4** 78% α:β = 7:3
3	**3** + **5**	**6** 84% α:β = 0:1
4	**3** + **7**	**8** 73% α:β = 1:0
5	**9** + **2**	**8** 74% α:β = 0:1
6	**10** + **2**	**6** 62% α:β = 1:0

Table 1 (*Continued*)

9 + **5**	**11** 76% α:β = 0:1
10 + **7**	**12** 72% α:β = 1:0
9 +	**13**
	14 72% α:β = 0:1

As indicated in the Table 1, glucosylation of methoxyphenyl 2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (**2**) with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl trichloroacetimidate (**1**) in the presence of TMSOTf (3% equiv) gave an inseparable mixture consisting of the α- and β-linked disaccharides in a ratio of 3:7. However, with 2,4,6-tri-*O*-acetyl-3-*O*-allyl-α-D-glucopyranosyl trichloroacetimidate (**3**) as the donor instead of **1**, a separable mixture consisting of predominantly the α (70%) together with the β anomer (30%) was obtained, indicating the effect of 3-*O*-alkylation of the donor. The α- and β-linked disaccharides obtained from entry 2 were defined as **4**α and **4**β that were used to prepare the required disaccharide acceptors **5** and **7** and donors **9** and **10**, respectively. With these disaccharides in hand, a series of reactions was carried out for investigating the effect of the 3-*O*-glucosyl group of the donor, and the effect of 1-*O*-glucosylation of the acceptor, on the stereoselectivity of the forthcoming glycosyl bond. The newly constructed bond is drawn with a bold line in the Table 1 for reading convenience.

Coupling of **3** with an α-linked disaccharide **5** (entry 3) gave a completely β-linked trisaccharide **6**. Compared to entry 2, entry 3 indicated the influence of the α-linked glucosyl residue in the acceptor. Furthermore, coupling of **3** with a β-linked disaccharide **7** (entry 4) afforded a sole α-linked trisaccharide **8**. The results of these two entries revealed that the 1-*O*-glycosyl bond of the acceptor controlled the stereoselectivity, i.e., the α-bond of the acceptor led to a forthcoming β-linkage, while the β-bond of the acceptor led to a forthcoming α-linkage. Next, a question is to estimate the effect of 3-*O*-glucosylation of the donor. Entries 5 and 6 answered this. In entry 5, with 3-*O*-α-glucosylated disaccharide **9** as the donor and **2** as the acceptor, a sole β-linked trisaccharide **8**, the same as the coupling product of **3** with **7**, was obtained. In contrast, with 3-*O*-β-glucosylated disaccharide **10** as the donor (entry 6) and **2** as the acceptor, coupling gave α-linked trisaccharide **6**, the same as the coupling product of **3** with **5**. These two entries also revealed that the α-bond of the 3-*O*-glucosylated donor led to a forthcoming β-linkage, while the β-bond of the donor led to a forthcoming α-linkage. Coupling results in entries 7 and 8 further confirmed the above observations. Condensation of the α-linked disaccharide donor **9** with the α-linked disaccharide acceptor **5** readily afforded a β-linked tetrasaccharide **11**, since the two disaccharides had a synergistic effect leading to the β-linkage formation. Meanwhile, coupling of the β-linked disaccharide **10** with the β-linked disaccharide **7**, in spite of C-2 neighboring group participation, gave an α-linked tetrasaccharide, as expected. Logically, people would ask what happened when the disaccharide donor and the disaccharide acceptor had contradictory effects, i.e., when an α-(1→3)-linked disaccharide was used as the donor and a β-(1→3)-linked disaccharide as the acceptor, or when a β-(1→3)-linked disaccharide was used as the donor and an α-(1→3)-linked disaccharide as the acceptor. In fact, the two couplings were carried out, giving a complex product. The main problem in these couplings was that the reaction rate was very slow, and decomposed byproduct was obtained in substantial amount.

It was found from the above experiments that the stereoselectivity outcome in the construction of the (1→3)-glucosyl bond was defined by the 3-*O*-glucosyl linkage in the donor or the glucosyl bond at the nonreducing end of the acceptor. Either the donor or the acceptor tended to give a product with a glycosyl bond with configuration opposite to that of the established bond in the donor or the acceptor. Clearly, this effect overruled the C-2 ester neighboring group participation. To illustrate the mechanism in detail for the remote interaction, complex calculations on the transition state of the coupling reactions are needed, and that is our future project.

The new findings could be used in the synthesis of (1→3)-linked high oligosaccharides with alternative α- and β-linkages. For example, hexasaccharide **14** was synthesized readily by coupling of the disaccharide donor **9** with the tetrasaccharide acceptor **13**.

The coupling reactions described above were carried out under normal conditions with catalytic TMSOTf as the promoter at -20 °C to rt for several hours. A long reaction time (overnight) for entries 7 and 8 did not change the outcome, indicating that anomerization under reaction conditions was excluded. The oligosaccharides obtained were characterized with ^{1}H and ^{13}C NMR spectroscopy, and mass spectroscopy, and elemental analysis. For the di- and trisaccharides, ^{1}H NMR spectra usually gave clear identification since the signals in the 4–6 ppm region were well resolved, and H-1α and H-1β showed coupling constants of ~ 3 Hz and ~ 8 Hz, respectively. For higher oligosaccharides, ^{13}C NMR spectra were also recorded giving the C-1 α in the δ 94.8–96.05 ppm with J_{C1-H1} at 174–177 Hz, and the C-1 β in the δ 99.7–100.8 ppm with J_{C1-H1} at 161–166 Hz.

Control of the glycosyl linkage by means of a remote substituent has been discussed in several reports,[5] and in these reports, no C-2 neighboring group participation was involved. However, Spijker and van Boeckel reported that double stereodifferentioation affected α/β ratio in carbohydrate coupling reactions in the presence of neighboring-group participation.[6]

In summary, this Note has revealed the exitence of remote control of the stereoselectivity in construction of the (1→3)-glucosyl bond by the glycosyl bond in either donor or acceptor. The newly built glycosyl bond has a configuration opposite to that of the established bond in either donor or acceptor in spite of C-2 neighboring group participation. Stereospecific synthesis of a (1→3)-glucan with alternative α- and β-linkages was achieved by this method.

3. Experimental

3.1. General methods

Optical rotations were determined at 25 °C with a Perkin–Elmer Model 241-Mc automatic polarimeter. ^{1}H NMR ^{13}C NMR and ^{1}H-^{13}C COSY spectra were recorded with Bruker ARX 400 spectrometers (400 MHz for ^{1}H, 100 MHz for ^{13}C) at 25 °C for solutions in $CDCl_3$ 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 × 240 mm, 18 × 300 mm, 35 ×

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.

3.2. General procedure for deallylation to prepare acceptors

To a solution of **4**α (1.2 g, 1.7 mmol) or **4**β (1.85 g, 2.6 mmol) in MeOH was added $PdCl_2$ (60 mg). After stirring for several h at rt, TLC indicated that the reaction was complete. The mixture was filtered, and the combined filtrate and washings were concentrated to dryness. The resultant residue was purified by flash chromatography to give acceptor **5** (931 mg, 82%) or **7** (1.48 g, 85%).

3.3. General procedure for preparation of donors

Oxidative cleavage of 1-OMP of **4**α (3.08 g, 4.16 mmol) or **4**β (2.20 g, 2.97 mmol) was carried out with CAN (4.5 equiv) in 4:1 CH_3CN–H_2O at rt for 30 min. The reaction mixture was diluted with water, and extracted with CH_2Cl_2. The extracts were washed with water, satd aq Na_2CO_3 and satd aq NaCl. The organic phase was dried over anhyd Na_2SO_4, then concentrated to dryness. Purification of the residue on a silica gel column gave disaccharide with the 1-OH free. A mixture of the product, trichloroacetonitrile, and DBU in dry CH_2Cl_2 was stirred for 3 h and then concentrated. The residue was purified by flash chromatography readily afforded **9** (2.46 g, 76% for two steps) or **10** (1.73 g, 75% for two steps).

3.4. General procedure for the glycosidations

The mixture of donor and acceptor was dried together under high vacuum for 2 h, then dissolved in anhyd CH_2Cl_2. TMSOTf (0.05 equiv) was added dropwise at -20 °C with N_2 protection. The reaction mixture was stirred for 3 h, 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.

3.5. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (4β)

Donor **3** (2.50 g, 5 mmol) was coupled with acceptor **2** (2.10 g, 5 mmol) to give **4**β (900 mg, 23%): $[\alpha]_D$ $-72.5°$ (*c* 0.2, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 6.92–6.79 (m, 4 H, C_6H_4), 5.74 (m, 1 H, –C*H*=), 5.29–5.11 (m, 3 H), 5.05 (t, 1 H, *J* 9.6 Hz), 5.02 (t, 1 H, *J* 9.2 Hz), 4.90 (t, 1 H, *J* 9.0 Hz), 4.81 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.53 (d, 1 H, *J* 8.4 Hz, β-H-1), 4.30 (m, 1 H), 4.28–4.26 (m, 2 H), 4.17–4.06 (m, 3 H), 3.95 (m, 1 H), 3.81–3.77 (m, 4 H), 3.59–3.53 (m, 2 H), 2.16 (s, 3 H, CH_3CO), 2.10 (s, 3 H, CH_3CO), 2.08 (s, 6 H, 2 CH_3CO), 2.06 (s, 3 H, CH_3CO), 2.04 (s, 3 H, CH_3CO). Anal. Calcd for $C_{34}H_{44}O_{18}$: C, 55.14; H, 5.95. Found: C, 55.01; H, 5.80.

3.6. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (4α)

Donor **3** (2.50 g, 5 mmol) was coupled with acceptor **2** (2.08 g, 5 mmol) to give **4**α (2.05 g, 55%): $[\alpha]_D$ $+44.2°$ (*c* 0.6, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 6.93–6.79 (m, 4 H, C_6H_4), 5.78 (m, 1 H, –C*H*=), 5.27 (d, 1 H, *J* 4.0 Hz, α-H-1), 5.27–5.11 (m, 4 H), 5.05 (t, 1 H, *J* 9.6 Hz), 4.80 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.70 (dd, 1 H, *J* 3.4, 10.4 Hz, H-2′), 4.24–3.95 (m, 8 H), 3.73 (s, 3 H, CH_3O), 3.74 (m, 1H), 3.72 (m, 1 H), 2.11 (s, 3 H, CH_3CO), 2.10 (s, 3 H, CH_3CO), 2.08 (s, 3 H, CH_3CO), 2.07 (s, 3 H, CH_3CO), 2.06 (s, 3 H, CH_3CO), 2.04 (s, 3 H, CH_3CO). ^{13}C NMR ($CDCl_3$): δ 170.65, 170.65, 170.65, 169.97, 169.94, 169.62, 156.00, 152.10, 134.43, 118.69, 116.69, 114.68, 100.65 (β-C-1, J_{C1-H1} 161 Hz), 96.05 (α-C-1, J_{C1-H1} 176 Hz), 76.25, 73.96, 73.17, 72.18, 71.88, 70.30, 69.47, 68.42, 62.12, 61.70, 55.71, 20.93. Anal. Calcd for $C_{34}H_{44}O_{18}$: C, 55.14; H, 5.95. Found: C, 54.95; H, 5.80.

3.7. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (6)

Compound **6** was obtained (185 mg, 84%) by coupling of donor **3** (100 mg, 0.21 mmol) with acceptor **5** (150 mg, 0.21 mmol), or obtained (130 mg, 62%) from donor **10** (160 mg, 0.20 mmol) and acceptor **2** (85 mg, 0.20 mmol): $[\alpha]_D$ $+6.7°$ (*c* 0.86, $CHCl_3$); ^{1}H NMR ($CDCl_3$): δ 6.93–6.80 (m, 4 H, C_6H_4), 5.74 (m, 1 H, –C*H*=), 5.27 (t, 1 H, *J* 9.6 Hz), 5.25 (t, 1 H, *J* 9.6 Hz), 5.21 (d, 1 H, *J* 4.0 Hz, α-H-1), 5.20–5.10 (m, 2 H, CH_2=), 5.02 (t, 1 H, *J* 9.6 Hz), 5.00 (t, 1 H, *J* 9.2 Hz), 4.88 (t, 1 H, *J* 9.0 Hz), 4.81 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.75 (dd, 1 H, *J* 3.8, 10.4 Hz, H-2′), 4.54 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.28–4.21 (m, 2 H), 4.17–4.16 (m, 2 H), 4.12–3.92 (m, 7 H), 3.77 (s, 3 H, CH_3O), 3.67–3.59 (m, 2 H), 3.52 (t, 1 H, *J* 9.2 Hz), 2.19, 2.11, 2.10, 2.09, 2.07, 2.06, 2.02, 2.00. ^{13}C NMR ($CDCl_3$): δ 170.34, 170.25, 170.10, 170.07, 169.09, 169.27, 168.83, 168.64, 168.64, 168.37, 156.10, 151.2, 133.69, 118.06, 116.46, 114.14, 100.45 (β-C-1, J_{C1-H1} 165 Hz), 100.19 (β-C-1, J_{C1-H1} 166 Hz), 94.93 (α-C-1, J_{C1-H1} 175 Hz), 79.52, 74.70, 74.57, 72.08, 71.92, 71.70, 71.56, 70.93, 70.13, 68.73, 67.54, 67.17, 61.59, 61.45, 61.08, 55.21, 20.95, 20.87, 20.76, 20.69, 20.66, 20.57, 20.42. Anal. Calcd for $C_{46}H_{60}O_{26}$: C, 53.70; H, 5.84. Found: C, 53.57; H, 5.77.

3.8. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glycopyranoside (8)

Compound **8** was obtained (160 mg, 73%) by coupling of donor **3** (100 mg, 0.21 mmol) with acceptor **7** (150 mg, 0.21 mmol), or obtained (155 mg, 74%) from donor **9** (160 mg, 0.20 mmol) and acceptor **2**: $[\alpha]_D$ −19° (*c* 1.2, $CHCl_3$); ^1H NMR ($CDCl_3$): δ 6.98–6.79 (m, 4 H, C_6H_4), 5.77 (m, 1 H, –C*H*=), 5.23 (d, 1 H, *J* 3.6 Hz, α-H-1), 5.22–5.11 (m, 4 H), 5.06–4.97 (m, 3 H), 4.81 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.66 (dd, 1 H, *J* 3.6, 12.0 Hz, H-2″), 4.49 (d, 1 H, *J* 8.0 Hz, β-H-1), 3.77 (s, 3 H, CH_3O), 3.69 (t, 1 H, *J* 9.6 Hz), 3.55 (m, 1 H), 2.14, 2.10, 2.09, 2.08, 2.07, 2.06, 2.05; ^{13}C NMR ($CDCl_3$): δ 170.21, 170.21, 168.90, 168.70, 168.65, 168.56, 168.22, 133.87, 116.25, 100.41 (β-C-1), 99.74 (β-C-1), 95.28 (α-C-1), 77.80, 75.61, 75.46, 73.50, 72.61, 72.45, 71.63, 71.39, 71.00, 68.90, 67.99, 67.89, 61.85, 61.32, 61.13, 55.21, 20.45, 20.41, 20.35, 20.24, 20.19, 20.05. Anal. Calcd for $C_{46}H_{60}O_{26}$: C, 53.70; H, 5.84. Found: C, 53.89; H, 5.95.

3.9. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (11)

Donor **9** (390 mg, 0.5 mmol) was coupled with acceptor **5** (350 mg, 0.5 mmol) to give **11** (500 mg, 76%): $[\alpha]_D$ +42° (*c* 1.1, $CHCl_3$); ^1H NMR ($CDCl_3$): δ 5.75 (m, 1 H, –C*H*=), 5.28–5.17 (m, 5 H, 2 α-H-1), 4.80 (d, 1 H, *J* 7.8 Hz, β-H-1), 4.73 (dd, 1 H, *J* 3.6, 10.2 Hz, H-2′), 4.66 (dd, 1 H, *J* 4.0, 10.2 Hz, H-2‴), 4.49 (d, 1 H, 8.4 Hz, β-H-1), ^{13}C NMR ($CDCl_3$): δ 100.21 (β-C-1, J_{C1-H1} 161 Hz), 100.14 (β-C-1, J_{C1-H1} 161 Hz), 95.50 (α-C-1, J_{C1-H1} 177 Hz), 94.89 (α-C-1, J_{C1-H1} 174 Hz). Anal. Calcd for $C_{58}H_{76}O_{34}$: C, 52.89; H, 5.78. Found: C, 53.05; H, 5.90.

3.10. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (12)

Donor **10** (340 mg, 0.43 mmol) was coupled with acceptor **7** (300 mg, 0.43 mmol) to give **11** (405 mg, 72%): $[\alpha]_D$ +9.9° (*c* 0.8, $CHCl_3$); ^1H NMR ($CDCl_3$): δ 5.75 (m, 1 H, –C*H*=), 5.23–5.09 (m, 5 H, α-H-1), 4.82 (m, 1 H, *J* 8.0 Hz, β-H-1), 4.71 (dd, 1H, *J* 3.6, 10.2 Hz, H-2″), 4.50 (d, 2 H, *J* 8.4 Hz, 2 β-H-1). ^{13}C NMR: δ 100.76 (β-C-1), 100.69 (β-C-1), 100.01 (β-C-1), 94.96 (α-C-1). Anal. Calcd for $C_{58}H_{76}O_{34}$: C, 52.89; H, 5.78. Found: C, 52.78; H, 5.90.

3.11. 4-Methoxyphenyl 2,4,6-tri-*O*-acetyl-3-*O*-allyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-α-D-glucopyranosyl-(1→3)-2,4,6-tri-*O*-acetyl-β-D-glucopyranoside (14)

Donor **9** (60 mg, 0.078 mmol) was coupled with acceptor **13** (100 mg, 0.078 mmol) to give **14** (106 mg, 72%): $[\alpha]_D$ +98.7° (*c* 0.4, $CHCl_3$); ^1H NMR ($CDCl_3$): δ 5.75 (m, 1 H, –C*H*=), 5.26–5.17 (m, 5 H, 3 α-H-1), 4.81 (d, 1 H, *J* 8.0 Hz, β-H-1), 4.51 (d, 1 H, *J* 8.4 Hz, β-H-1), 4.44 (d, 1 H, *J* 8.4 Hz, β-H-1). ^{13}C NMR: δ 100.54 (β-C-1), 100.44 (2 β-C-1), 95.81 (α-C-1), 95.2 (α-C-1), 95.00 (α-C-1). Anal. Calcd for $C_{82}H_{108}O_{50}$: C, 52.01; H, 5.71. Found: C, 52.34; H, 5.63.

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