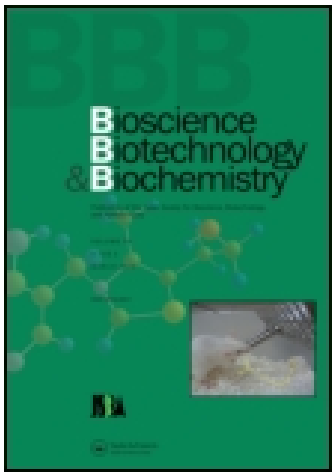

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Hiroki Shimizu[a], Yukishige Ito[a], Yuji Matsuzaki[a], Hiroyuki Iijima[a] & Tomoya Ogawa[a]
[a] The Institute of Physical ami Chemical Research (RIKEN), Wako-shi, Saitama, 351-01, Japan
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4,5-Dichlorophthaloyl Group for Amino Protection in Carbohydrate Chemistry

Hiroki SHIMIZU, Yukishige ITO,* Yuji MATSUZAKI, Hiroyuki IIJIMA, and Tomoya OGAWA*,†

The Institute of Physical and Chemical Research (RIKEN), Wako-shi, Saitama 351-01, Japan
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Phthaloyl (Phth) is a valuable amino-protecting group for use in synthetic carbohydrate chemistry. Its strong 1,2-*trans*-directing nature in a glycosylation reaction, when it is introduced to the C-2 position of a glycosyl donor, makes the construction of β-GlcNAc or β-GalNAc glycosides quite straightforward. The Phth group can be removed by using an appropriate nucleophile, most typically hydrazine; however, this transformation often requires a long reaction time at elevated temperature when applied to a large oligosaccharide. We studied the 4,5-dichlorophthaloyl (DCPhth) group as an alternative to Phth. A thioglycoside carrying a DCPhth group at the C-2 position was reacted with alcohol by the action of PhSeNPhth-TMSOTf to selectively give the corresponding β-glycoside. DCPhth could then be removed under mild conditions by using ethylenediamine or hydrazine/MeOH at room temperature.

Key words: 4,5-dichlorophthalimide; deprotection; thioglycoside; 1,2-*trans* glycosylation

Phthalimide (NPhth) is popularly used for amino protection in synthetic carbohydrate chemistry, mainly due to the fact that a glycosyl donor carrying an NPhth group at the C-2 position will predictably give a 1,2-*trans* (β)-glycoside in a highly stereoselective manner.[1] Although the origin remains controversial, such selectivity is generally apparent, making the synthesis of naturally abundant 2-amino-β-glycoside quite an easy task.[2] While deprotection into an amine can be achieved in a reasonably convenient manner by such nucleophiles[3] as hydrazine, *n*-butylamine, methylamine and $NaBH_4$, this process frequently requires a high temperature and extended reaction time, particularly when applied to a large oligosaccharide carrying multiple Phth groups. As a result, the course of dephthaloylation is often difficult to monitor, and extensive trial-and-error efforts are required to find the most favorable conditions for a specific substrate. To address this problem, the use of Phth analogues substituted on the aromatic ring with electron-withdrawing groups has recently been proposed by Tubouchi *et al.* (4-nitro-)[4] and Debenham *et al.* (tetrachloro-).[5] The use of 4,4′,4″-tris(4,5-dichlorophthalimido) trityl as a hydrazine-labile protecting group in nucleotide chemistry has also been reported by Sekine and Hata.[6] In connection with synthetic studies for producing polylactosamine-type glycoconjugates,[7] we disclose here some results of our own efforts to develop a 4,5-dichlorophthaloyl (DCPhth) group in oligosaccharide synthesis. We will show that DCPhth has as strong a 1,2-*trans*-directing nature as Phth, yet is easily removable under substantially milder conditions. Although the DCPhth group can be expected to be more stable than its tetrachloro counterpart,[5] further comparisons need to be made on the use of these protecting groups in the course of complex oligosaccharide synthesis.

To test the nature of the DCPhth group, tetraacetate **1** was synthesized from glucosamine hydrochloride, in an analogous manner to that described for Phth derivative **2**,[1] by using 4,5-dichlorophthalic anhydride. The anomeric position could be smoothly converted into a bromide (**3**) and thioglycoside (**4**). Although attempts to deacetylate **4** under Zemplen conditions (NaOMe) were not successful due to rapid destruction of DCPhth, triol **5** was obtained quite cleanly under acidic conditions. Further transformation into 4,6-*O*-benzylidene (**6**), and into 3,6-di-*O*-benzyl (**7**) and 3-*O*-levulinoyl (**9**) derivatives could be achieved under standard conditions without any problems.

Glycosylation of **10** or **11** by using **4** as a glycosyl donor was performed under the recently developed conditions (PhSeNPhth-TMSOTf).[8] As expected, coupled products **12** and **13** were obtained as a single stereoisomer in a good yield. DCPhth was cleanly removed even at room temperature, by either hydrazine hydrate or ethylenediamine.[9] Formation of the amine was confirmed by its conversion into acetamide **14** which was isolated in a >90% yield.

DCPhth was also found to be stable under the conditions required to remove a levulinoyl-protecting group.[10] Namely, compound **9** was quantitatively converted into **6** by briefly treating with hydrazine in pyridine-acetic acid.

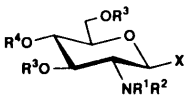
The practical use of DCPhth is now obvious, and its application to the synthesis of complx oligosaccharides will be a subject of further investigation.

Experimental

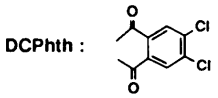
General methods. Melting point (mp) data were determined with Yanagimoto micro-melting point apparatus and are uncorrected. Optical rotation values were determined with a JASCO DIP 370 polarimeter at 20±3 C. Silica gel column chromatography was performed in columns of Merck silica gel 60 (70–230 or 230–400 mesh), while TLC was performed with silica gel 60 F_{254} (Merck). Powdered molecular sieves were purchased from Nacalai Tesque and activated at 180 C under vacuum immediately prior to use. ^{1}H- and ^{13}C-NMR spectra were measured with a JEOL EX-270 spectrometer, the values for δ_H being expressed in ppm downfield from the signal of internal Me_4Si, while those for δ_C are expressed relative to the signal of $CDCl_3$ adjusted to 77.0 ppm.

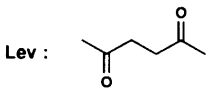
3,4,6-Tri-O-acetyl-2-deoxy-2-(4,5-dichlorophthalimido)-β-D-glucopyranosyl acetate (**1**). To a stirred mixture of D-glucosamine hydrochloride

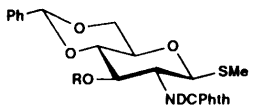
* To whom correspondence should be addressed.
† Alternative address: *Graduate School of Agriculture and Life Science, University of Tokyo, Yayoi, Bunkyo-ku, Tokyo 113, Japan.*



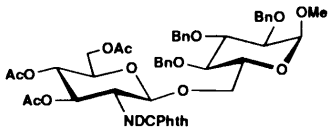
	X	R^1R^2	R^3	R^4
1	OAc	DCPhth	Ac	Ac
2	OAc	Phth	Ac	Ac
3	Br (α,β)	DCPhth	Ac	Ac
4	SMe	DCPhth	Ac	Ac
5	SMe	DCPhth	H	H
7	SMe	DCPhth	Bn	H



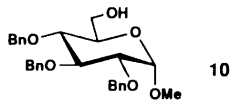




	R
6	H
8	Bn
9	Lev



12



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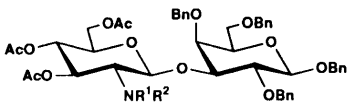

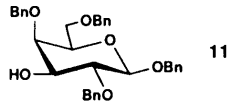

11

	R^1R^2
13	DCPhth
14	Ac,H

(6.48 g, 30.0 mmol) in MeOH (100 ml) was added NaOMe (1 M in MeOH; 30 ml, 30 mmol) at room temperature. The mixture was stirred for 10 min, and the insoluble materials were removed by filtration. To the filtrate were successively added triethylamine (4.6 ml, 33 mmol) and 4,5-dichlorophthalic anhydride (6.8 g, 31 mmol). The mixture was stirred at 50 C for 20 min and then evaporated *in vacuo*. The residue was dissolved in pyridine–Ac_2O (1 : 1, 100 ml) and stirred at room temperature overnight. The resulting mixture was evaporated *in vacuo*, and the residue was crystallized from AcOEt/Et_2O/hexane to afford 5.3 g (32%) of compound **1**; mp 179–180 C; $[\alpha]_D$ +75.4 (*c* 1.0, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.95 and 7.93 (1H × 2, s, aromatic), 6.48 (1H, d, J = 8.9 Hz, H-1), 5.82 (1H, dd, J = 10.6 and 9.2 Hz, H-3), 5.22 (1H, dd, J = 10.2 and 9.2 Hz, H-4), 4.43 (1H, dd, J = 10.6 and 8.9 Hz, H-2), 4.37 (1H, dd, J = 12.5 and 4.3 Hz, H-6), 4.15 (dd, J = 12.5 and 2.3 Hz, H-6'), 4.02 (1H, ddd, J = 10.2, 4.3, and 2.3 Hz, H-5), 2.12, 2.05, 2.01, and 1.89 (3H × 4, s, $COCH_3$); ^{13}C-NMR ($CDCl_3$) δ: 89.45 (C-1), 72.58, 70.42, 67.98, 61.39, 53.82, 20.63 (2 × CH_3), 20.51 (CH_3), 20.31 (CH_3). *Anal.* Calcd. for $C_{22}H_{21}NO_{11}Cl_2$: C, 48.37; H, 3.87; N, 2.56%. Found: C, 48.38; H, 3.93; N, 2.52%.

*3,4,6-Tri-O-acetyl-2-deoxy-2-(4,5-dichlorophthalimido)-*D*-glucopyranosyl bromide* (**3**). A hydrogen bromide solution (30% in acetic acid; 3.0 ml, 17 mmol) was added to a solution of compound **1** (3.00 g, 5.49 mmol) in a mixture of acetic acid (8 ml) and acetic anhydride (4 ml). The resulting mixture was stirred at room temperature for 2 days and then quenched with ice. The mixture was extracted with $CHCl_3$, and the organic layer was successively washed with aq. $NaHCO_3$ and brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was crystallized from ether to afford 798 mg of **3β**. The mother liquor was concentrated and purified by silica gel column chromatography (toluene–AcOEt = 14 : 1) to afford **3α** (947 mg, 30%) and an additional amount of **3β** (total yield of 1.37 g, 44%). **3β**: mp 89 C; $[\alpha]_D$ +95.8 (*c* 1.4, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.97 (2H, s, aromatic), 6.36 (1H, d, J = 9.6 Hz, H-1), 5.70 (1H, dd, J = 10.2 and 9.2 Hz, H-3), 5.26 (1H, dd, J = 10.2 and 9.2 Hz, H-4), 4.59 (1H, dd, J = 10.2 and 9.6 Hz, H-2), 4.32 (1H, dd, J = 12.5 and 4.6 Hz, H-6), 4.20 (1H, dd, J = 12.5 and 2.3 Hz, H-6'), 3.95 (1H, ddd, J = 10.2, 4.6, and 2.3 Hz, H-5), 2.13, 2.05, and 1.88 (3H × 3, s, $COCH_3$). *Anal.* Calcd. for $C_{20}H_{18}NO_9BrCl_2$: C, 42.35; H, 3.20; N, 2.47%. Found: C, 42.64; H, 3.29; N, 2.30%. **3α**: ^{1}H-NMR ($CDCl_3$) δ: 6.60 (1H, dd, J = 11.4 and 8.9 Hz, H-3), 6.54 (1H, d, J = 5.2 Hz, H-1), 5.15 (1H, dd, J = 11.4 and 8.9 Hz, H-4), 4.65 (1H, dd, J = 11.4 and 5.2 Hz, H-2), 2.11, 2.07, and 1.89 (3H × 3, s, $COCH_3$).

*Methyl 3,4,6-tri-O-acetyl-2-deoxy-2-(4,5-dichlorophthalimido)-1-thio-β-*D*-glucopyranoside* (**4**). To a stirred solution of compound **1** (15.0 g, 27.5 mmol) and *n*-Bu_3SnSMe (18.0 g, 53.4 mmol) in 1,2-dichloroethane (150 ml) was added $SnCl_4$ (11.5 ml, 98.2 mmol) at 0 C. The mixture was gradually warmed to ambient temperature, stirred overnight and diluted with AcOEt. An aq. KF solution and aq. $NaHCO_3$ solution were added, and the mixture was stirred for 2 h. The precipitate was filtered off, and the filtrate was extracted with AcOEt. The organic layer was washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was crystallized from ether to afford compound **3** (11.9 g, 83%); mp 179–180 C; $[\alpha]_D$ +54.7 (*c* 1.2, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.95 and 7.94 (1H × 2, s, aromatic), 5.79 (1H, dd, J = 10.2 and 9.3 Hz, H-3), 5.34 (1H, d, J = 10.2 Hz, H-1), 5.18 (1H, dd, J = 10.2 and 9.3 Hz, H-4), 4.38 (1H, t, J = 10.2 Hz, H-2), 4.32 (1H, dd, J = 12.2 and 4.6 Hz, H-6), 4.19 (1H, dd, J = 12.2 and 2.3 Hz, H-6'), 3.90 (1H, ddd, J = 10.2, 4.6, and 2.3 Hz, H-5), 2.16, 2.11, 2.04, and 1.88 (3H × 4, s, 3 × $COCH_3$ and SCH_3); ^{13}C-NMR ($CDCl_3$) δ: 80.27 (C-1), 75.90, 71.32, 68.48, 62.01, 53.29, 20.61 ($COCH_3$), 20.47 ($COCH_3$), 20.38 ($COCH_3$), 11.27 (SCH_3). *Anal.* Calcd. for $C_{21}H_{21}NO_9Cl_2S$: C, 47.20; H, 3.96; N, 2.62%. Found: C, 47.44; H, 3.98;

N, 2.62%.

Methyl 2-deoxy-2-(4,5-dichlorophthalimido)-1-thio-β-D-glucopyranoside (**5**). A solution of compound **4** (306 mg, 0.573 mmol) in MeOH (5 ml) containing 0.60 ml of conc. HCl was stirred at 70 C for 3.5 h. The mixture was evaporated *in vacuo*, and the residue was subjected to silica gel column chromatography (hexane–AcOEt = 1 : 4) to afford 222 mg (95%) of compound **5**; mp 147–149 C; $[\alpha]_D$ +24.7 (*c* 1.0, MeOH); ^{1}H-NMR (CD_3OD) δ: 8.07 and 8.05 (1H × 2, s, aromatic), 5.16 (1H, d, J = 10.2 Hz, H-1), 4.25 (1H, dd, J = 10.2 and 8.3 Hz, H-3), 4.08 (1H, t, J = 10.2 Hz, H-2), 3.92 (1H, dd, J = 11.9 and 1.7 Hz, H-6), 3.73 (1H, dd, J = 11.9 and 5.3 Hz, H-6'), 2.14 (3H, s, SCH_3). *Anal.* Calcd. for $C_{15}H_{15}NO_6Cl_2S$: C, 44.13; H, 3.70; N, 3.43%. Found: C, 43.97; H, 4.01; N, 3.23%.

Methyl 4,6-O-benzylidene-2-deoxy-2-(4,5-dichlorophthalimido)-1-thio-β-D-glucopyranoside (**6**). A solution of compound **5** (1.96 g, 4.80 mmol) and benzaldehyde dimethylacetal (2.0 ml, 13 mmol) in acetonitrile (20 ml) containing camphorsulphonic acid (0.20 g, 0.80 mmol) was stirred at room temperature for 24 h. The mixture was diluted with AcOEt and quenched with ice-aq. $NaHCO_3$. The aq. layer was back-extracted with AcOEt, and the combined organic layers were washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (toluene–AcOEt = 19 : 1) to afford 1.74 g (73%) of compound **6**; $[\alpha]_D$ +8.9 (*c* 1.2, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.94 and 7.92 (1H × 2, s, aromatic), 7.5–7.3 (5H, m, aromatic), 5.56 (1H, s, benzylidene CH), 5.25 (1H, d, J = 10.6 Hz, H-1), 4.65 (1H, ddd, J = 9.9, 8.9, and 3.3 Hz, H-3), 4.41 (1H, dd, J = 9.9 and 4.3 Hz, H-6), 4.31 (1H, dd, J = 10.6 and 9.9 Hz, H-2), 3.80 (1H, t, J = 9.9 Hz, H-6'), 3.70 (1H, ddd, J = 9.9, 8.9 and 4.3 Hz, H-5), 3.58 (1H, t, J = 8.9 Hz, H-4), 2.70 (1H, d, J = 3.3 Hz, OH), 2.16 (3H, s, SCH_3). *Anal.* Calcd. for $C_{22}H_{19}NO_6Cl_2S$: 54.24; H, 3.86; N, 2.82%. Found: C, 53.99; H, 3.98; N, 2.60%.

Methyl 3-O-benzyl-4,6-O-benzylidene-2-deoxy-2-(4,5-dichlorophthalimido)-1-thio-β-D-glucopyranoside (**8**). To a stirred solution of compound **6** (70 mg, 0.14 mmol) and benzyl bromide (0.12 ml, 1.0 mmol) in DMF (3 ml) was added NaH (oil free; 15 mg, 0.63 mmol) at 0 C. The mixture was gradually warmed to room temperature and stirred for 4 h. After being diluted with AcOEt, the mixture was quenched with MeOH and washed with water. The aq. layer was back-extracted with AcOEt, and the combined organic layers were washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (toluene–AcOEt = 20 : 1) to afford 69 mg (84%) of compound **8**; mp 118–120 C (from ether); $[\alpha]_D$ +48.6 (*c* 0.3, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.89 and 7.68 (1H × 2, s, aromatic), 7.6–6.8 (10H, m, aromatic), 5.63 (1H, s, benzylidene CH), 5.18 (1H, d, J = 10.6 Hz, H-1), 4.27 (1H, t, J = 10.6 H, H-2), 3.80 (1H, dd, J = 9.4 and 8.6 Hz, H-4), 2.13 (3H, s, SCH_3). *Anal.* Calcd. for $C_{29}H_{25}NO_6Cl_2S$: C, 59.39; H, 4.30; N, 2.39%. Found: C, 59.36; H, 4.29; N, 2.37%.

Methyl 3,6-di-O-benzyl-2-deoxy-2-(4,5-dichlorophthalimido)-1-thio-β-D-glucopyranoside (**7**). Compound **8** (635 mg, 1.08 mmol), $NaCNBH_3$ (570 mg, 9.07 mmol) and 4A molecular sieves (0.15 g) were mixed in THF (15 ml) containing *ca.* 1 mg of methyl orange as an indicator. A saturated HCl solution in ether was added dropwise until the mixture became acidic. After being stirred at room temperature for 3 h, the mixture was diluted with AcOEt and washed with an ice-cooled $NaHCO_3$ solution. The aq. layer was back-extracted with AcOEt, and the combined organic layers were washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (toluene–AcOEt = 20 : 1) to afford 429 mg (68%) of compound **7**; $[\alpha]_D$ +33.2 (*c* 1.1, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.85 and 7.69 (1H × 2, s, aromatic), 7.4–6.9 (10H, m, aromatic), 5.10 (1H, d, J = 8.6 Hz, H-1), 4.18–4.28 (2H, m, H-2 and H-3), 3.02 (1H, d, J = 2.6 Hz, OH), 2.08 (3H, s, SCH_3). *Anal.* Calcd. for $C_{29}H_{27}NO_6Cl_2S$: C, 59.19; H, 4.62; N, 2.38%. Found: C, 59.68; H, 4.72; N, 2.36%.

Methyl 4,6-O-benzylidene-2-deoxy-2-(4,5-dichlorophthalimido)-3-O-levulinoyl-1-thio-β-D-glucopyranoside (**9**). To a solution of compound **6** (100 mg, 0.201 mmol) in CH_2Cl_2–pyridine (2 : 1; 1.5 ml) was added levulinic anhydride (500 mg, 2.0 mmol). The solution was stirred at room temperature overnight, diluted with AcOEt, and washed with ice-cooled aq. $NaHCO_3$. The aq. layer was back-extracted with AcOEt, and the combined organic layers were washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (toluene–AcOEt = 10 : 1) to afford 114 mg (95%) of compound **9**; $[\alpha]_D$ −6.8 (*c* 1.0, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 7.98 and 7.68 (1H × 2, s, aromatic), 7.5–7.3 (10H, m, aromatic), 5.95 (1H, dd, J = 9.6 and 9.2 Hz, H-3), 5.54 (1H, s, benzylidene CH), 5.39 (1H, d, J = 10.6 Hz, H-1), 4.39 (1H, dd, J = 10.6 and 9.2 Hz, H-2), 2.69–2.32 (4H, m, $COCH_2CH_2CO$), 2.17 and 1.89 (3H × 2, s, CH_3CO and SCH_3). *Anal.* Calcd. for $C_{27}H_{25}NO_8Cl_2S$: C, 54.55; H, 4.23; N, 2.36%. Found: C, 54.38; H, 4.25; N, 2.30%.

Removal of the levulinoyl group. To a mixture of hydrazine hydrate (48.5 μl), pyridine (1.6 ml), and acetic acid (0.4 ml) was added compound **9** (52 mg, 0.0875 mmol). The solution was stirred at room temperature for 5 min, diluted with AcOEt, successively washed with aq. $NaHCO_3$ and brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (hexane–AcOEt = 3 : 1) to afford compound **6** (45 mg, quantitative).

Methyl O-[3,4,6-tri-O-acetyl-2-deoxy-2-(4,5-dichlorophthalimido)-β-D-glucopyranosyl]-(1→6)-2,3,4-tri-O-benzyl-α-D-glucopyranoside (**12**). A mixture of compounds **4** (84.2 mg, 0.158 mmol) and **10** (55.5 mg, 0.12 mmol), *N*-(phenylseleno)phthalimide (62.5 mg, 0.207 mmol), and AW-300 molecular sieves (0.13 g) in 1,2-dichloroethane (1 ml) was stirred at −40 C. Trimethylsilyl triflate (30 μl, 0.16 mmol) was added, and stirring was continued for 20 min. The mixture was quenched with aq. $NaHCO_3$, diluted with AcOEt and filtered through Celite. The filtrate was washed with water, and the aq. layer was back-extracted with AcOEt. The combined organic layers were washed with brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified in a column of Bio Beads S-X2 (Bio Rad) in toluene to afford 91.3 mg (80%) of compound **12**; $[\alpha]_D$ +39.1 (*c* 1.0, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 5.69 (1H, dd, J = 10.2 and 9.2 Hz, H-3^2), 5.42 (1H, d, J = 8.6 Hz, H-1^2), 4.46 (1H, d, J = 3.6 Hz, H-1^1), 3.85 (1H, dd, J = 9.6 and 9.2 Hz, H-3^1), 3.44 (1H, dd, J = 9.6 and 3.6 Hz, H-2^1), 3.32 (1H, t, J = 9.2 Hz, H-4^1), 3.26 (3H, s, OCH_3), 2.08, 2.03, and 1.84 (3H × 3, s, CH_3); ^{13}C-NMR ($CDCl_3$) δ: 98.06 (C-1^1), 97.79 (C-1^2), 81.83, 79.59, 77.54, 75.76, 74.77, 73.37, 71.90, 70.68, 69.00, 68.64, 68.56, 61.98, 55.08, 20.67 (CH_3), 20.54 (CH_3), 20.33 (CH_3). *Anal.* Calcd. for $C_{48}H_{49}NO_{15}Cl_2$: C, 60.64; H, 5.19; N, 1.47%. Found: C, 60.65; H, 5.13; N, 1.48%.

Benzyl O-[3,4,6-tri-O-acetyl-2-deoxy-2-(4,5-dichlorophthalimido)-β-D-glucopyranosyl]-(1→3)-2,4,6-tri-O-benzyl-β-D-galactopyranoside (**13**). Compounds **4** (70.0 mg, 0.131 mmol) and **11** (50.0 mg, 0.0925 mmol) were reacted in a similar manner to that described for the preparation of compound **12** to afford 73.6 mg (77%) of compound **13**; mp 147–149 C; $[\alpha]_D$ +3.2 (*c* 1.3, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 5.72 (1H, dd, J = 10.6 and 9.2 Hz, H-3^2), 5.62 (1H, d, J = 8.3 Hz, H-1^2), 5.13 (1H, dd, J = 10.2 and 9.2 Hz, H-4^2), 4.35 (1H, d, J = 7.3 Hz, H-1^1), 4.31 (1H, dd, J = 10.6 and 8.3 Hz, H-2^2), 2.03, 1.98, and 1.82 (3H × 3, s, CH_3); ^{13}C-NMR ($CDCl_3$) δ: 102.32 (C-1^1), 99.25 (C-1^2), 82.57, 78.08, 75.76, 74.61, 73.51, 73.46, 73.28, 71.59, 70.59, 70.50, 69.29, 68.69, 61.91, 55.40, 20.58 (CH_3), 20.36 (CH_3). *Anal.* Calcd. for $C_{54}H_{59}NO_{15}Cl_2$: C, 63.16; H, 5.20; N, 1.36%. Found: C, 63.31; H, 5.15; N, 1.12%.

Benzyl O-(2-acetamido-3,4,6-tri-O-acetyl-2-deoxy-β-D-glucopyranosyl)-(1→3)-2,4,6-tri-O-benzyl-β-D-galactopyranoside (**14**)

Method A. To a solution of compound **13** (100 mg, 0.097 mmol) in MeOH (1 ml) was added ethylenediamine (0.57 ml), the mixture then being stirred at room temperature for 2 h. The volatiles were removed by evaporation, and the residue was treated with acetic anhydride–pyridine (1 : 1; 2 ml). The solution was stirred at room temperature for 5 h and evaporated *in vacuo*. The residue was diluted with AcOEt, successively washed with aq. $NaHCO_3$ and brine, dried ($MgSO_4$) and evaporated *in vacuo*. The residue was purified by silica gel column chromatography (toluene–AcOEt = 2 : 1) to afford 93.0 mg (98%) of compound **14**; mp 112 C; $[\alpha]_D$ −40.2 (*c* 1.3, $CHCl_3$); ^{1}H-NMR ($CDCl_3$) δ: 4.81 (1H, d, J = 8.6 Hz, H-1^2), 4.43 (1H, d, J = 7.6 Hz, H-1^1), 2.02, 2.01, 1.98, and 1.54 (3H × 4, s, CH_3); ^{13}C-NMR ($CDCl_3$) δ: 102.41 (C-1^1), 101.73 (C-1^2), 80.88, 79.55, 75.40, 74.50, 74.36, 73.68, 73.48, 72.80, 71.72, 70.68, 68.97, 68.47, 62.03, 54.20, 22.81 (CH_3), 20.65 (CH_3), 20.60 (CH_3). *Anal.* Calcd. for $C_{48}H_{55}NO_{14}Cl_2$: C, 66.27; H, 6.37; N, 1.61%. Found: C, 66.47; H, 6.32; N, 1.67%.

Method B. A solution of compound **13** (36.0 mg, 0.0351 mmol) and hydrazine hydrate (0.15 ml) in MeOH (1 ml) was stirred at room temperature for 1 d. The volatiles were removed by evaporation, and the residue was treated with acetic anhydride-pyridine as described in **Method A** to afford 28.6 mg (94%) of compound **14**.

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