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Glucosylenamines as glycosyl acceptors: synthesis of gentiobiosylenamines *

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ABSTRACT

The preparation of 2,3,4-tri-*O*-benzyl- (**3**), 2,3,4-tri-*O*-acetyl- (**4**), and 2,3,4-tri-*O*-benzoyl-*N*-(2,2-diethoxycarbonylvinyl)-6-*O*-trityl-β-D-glucopyranosylamine (**5**) is described. The reaction of **3–5** with 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide yields 2,3,4-tri-*O*-benzyl- (**9**), 2,3,4-tri-*O*-acetyl- (**10**), and 2,3,4-tri-*O*-benzoyl-*N*-(2,2-diethoxycarbonylvinyl)-6-*O*-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-β-D-glucopyranosylamine (**11**), respectively. 2,3,4-Tri-*O*-benzyl- (**6**), 2,3,4-tri-*O*-acetyl- (**7**), and 2,3,4-tri-*O*-benzoyl-*N*-(2,2-diethoxycarbonylvinyl)-β-D-glucopyranosylamine (**8**) are also described.

INTRODUCTION

Amino sugars are valuable intermediates in the syntheses of *neo*-glycoconjugates [1–3] and frequently are components of complex natural and synthetic oligosaccharides [2,4–7]. Carbohydrate structures are important in biological recognition processes and much effort has been devoted to the development of methods [2,3,8] for attaching oligosaccharides to larger molecules, such as proteins, to give multivalent conjugates, which can be used as immunising antigens or as antigens in immunoassays. Glycosylamines can be used to form covalent bonds between the protein and the carbohydrate parts of *N*-glycoproteins [2,5,8] and have been widely used in syntheses of *N*-nucleosides, glycosyl isothiocyanates, and glycosylureas [9–11].

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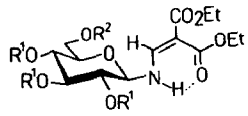
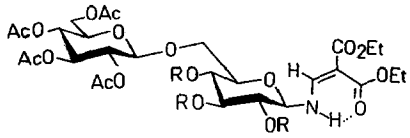


	1	2	3	4	5	6	7	8
R^1	H	H	Bn	Ac	Bz	Bn	Ac	Bz
R^2	H	Tr	Tr	Tr	Tr	H	H	H



9 R = Bn **10** R = Ac **11** R = Bz

Scheme 1.

There are many data [12] on syntheses of (1 → 6)-linked disaccharide derivatives, but glycosylamines appear not to have been used as glycosyl acceptors. We now describe the syntheses of the gentiobiosylenamines **9–11**, the acylvinyl groups of which are easy to remove [13,14]. These compounds were obtained by glycosylation of the glucosylamine derivatives **3–5**.

Partially protected sugar derivatives are useful precursors for specific functionalisation and for oligosaccharide syntheses [14–16], and we now report the preparation of the glucopyranosylenamines **6–8**.

RESULTS AND DISCUSSION

The reaction of *N*-(2,2-diethoxycarbonylvinyl)-β-D-glucopyranosylamine [17] (**1**) with trityl chloride yielded the 6-*O*-trityl derivative **2**. Treatment of **2** with benzyl chloride under the conditions of phase-transfer catalysis, or acetylation, or benzoylation gave the 2,3,4-trisubstituted derivatives **3–5**, respectively. The structures **3–5** were assigned on the basis of analytical, IR, ^{1}H- and ^{13}C-NMR, and MS data (see Experimental). The $^3J_{H,H}$ values shown that the $^4C_1$ (D) conformation preponderated in solutions in chloroform. Compounds **2** and **5** had two ^{13}C signals at 168.8 (C=O chelated) and 165.4 ppm (C=O free). The former is indicative of the hydrogen bond shown in the structure [18]. The mass spectrum of **4** showed the losses of EtO· and the enamino group, as described for glycosylenamines [19], and also peaks corresponding to losses of acetic acid and acetoxyl radical characteristic of acetylated sugar derivatives [20].

The glucosylenamine derivatives **6–8** with HO-6 unsubstituted were prepared from **3–5**, respectively, by treatment with aqueous 90% trifluoroacetic acid (**6** and **8**) or hydrogen bromide–acetic acid (**7**). Compounds **6–8** showed an IR absorption at 3500 cm^{-1} and a ^{1}H-NMR resonance at 2.73–2.89 ppm for hydroxyl.

Attempted glycosylation of **6–8**, using 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (acetobromoglucose) with silver triflate as the promotor and tetramethylurea as the acid acceptor [21,22], was unsuccessful. However, acetobromoglucose reacted with the 6-*O*-trityl derivatives **3–5** in the presence of silver perchlorate [23] to yield the crystalline gentiobiosylenamines **9–11** together with **6–8** as by-products. The structures of **9–11** were assigned on the basis of analytical, IR, ^{1}H-NMR (Table I), and ^{13}C-NMR (Table II) data. Thus, **9–11** had no IR or NMR signals for OH or trityl groups, and the signals for the enamino group were similar to those for **2–8**. Assignments of the ^{1}H and ^{13}C signals were based on homonuclear and heteronuclear 2D correlated experiments performed on **10**. The assignment of ^{13}C resonances was also supported by APT [24] spectra and bibliographic data on glucodisaccharides [25] and glucosylenamines [14]. The $J_{1,2}$ values (7.8–8.0 Hz) were in the range for antiperiplanar protons and indicated that the glucosyloxy moieties of **9–11** were β. This configuration was also confirmed by the chemical shift of the C-1′ resonance (100.5 ppm) [25]. The $^4C_1$(D) conformation for each sugar ring of **9–11** was evident from the $^3J_{H,H}$ values (7.8–9.5 Hz, Table I).

The mass spectrum of **10** contained a peak for M^+ and Scheme 1 summarises the primary fragments and pathways of fragmentation. The structures assigned to fragments with *m/z* 619 and 331 are similar to those reported for acylated glycosylamines [19,20,26]. The peaks at *m/z* 760, 216, 187, and 142, described[19] for glycosylenamines, were also observed.

EXPERIMENTAL

General methods.—Melting points are uncorrected. Optical rotations were measured at 20° ± 2°. FT-IR spectra were recorded for KBr discs. ^{1}H-NMR spectra (200, 250, and 400 MHz) were obtained for solutions in $CDCl_3$. Assignments were confirmed by decoupling, H–D exchange, and homonuclear 2D correlated experiments. ^{13}C-NMR spectra were recorded at 50.3 and 62.9 MHz for solutions in $CDCl_3$. Proton-decoupled APT [24] and heteronuclear 2D correlated spectra were obtained in order to assist in signal assignments. EI-mass spectra (70 eV) were measured with a Kratos MS-80RFA instrument, with an ionising current of 100 μA, an accelerating voltage of 4 kV, and a resolution of 1000 (10% valley definition). The elemental composition of the ions was determined with a resolution of 10000 (10% valley definition). TLC was performed on Silica Gel HF_{254} (Merck), with detection by UV light or charring with H_2SO_4. Silica Gel 60 (Merck, 230 mesh) was used for preparative chromatography.

N-(2,2-Diethoxycarbonylvinyl)-6-O-trityl-β-D-glucopyranosylamine (**2**).—To a stirred solution of **1** [17] (5.0 g, 14.3 mmol) in dry pyridine (25 mL) was added trityl chloride (4.4 g, 15.8 mmol). The mixture was heated for 24 h at 50°, then poured into ice–water (300 mL), and extracted with CH_2Cl_2 (2 × 30 mL). The combined extracts were washed with M H_2SO_4 (3 × 20 mL), satd aq $NaHCO_3$ (2 × 20 mL), and water (2 × 20 mL), then dried ($MgSO_4$), and the solvent evaporated. Column

TABLE I

^{1}H-NMR data (δ in ppm, J in Hz) for solutions of **9–11** in $CDCl_3$

	H-1	H-2	H-3	H-4	H-5	H-6a	H-6b	H-1′	H-2′	H-3′	H-4′	H-5′	H-6′a	H-6′b
9	4.36t	3.42t	⟵ 3.71–3.62m ⟶			4.08d	3.71–3.62m	4.54d	5.02dd	5.16t	5.11t	3.71–3.62m	4.21dd	4.11dd
10	4.52t	5.02dd	5.27t	4.95dd	3.76ddd	3.93dd	3.54dd	4.51d	4.98dd	5.19t	5.06t	3.68ddd	4.27dd	4.12dd
11	4.80t	5.49t	5.91t	5.43t	⟵ 4.08–4.02m ⟶		3.67dd	4.51d	4.96dd	5.16t	5.01t	3.63ddd	4.18dd	4.02dd

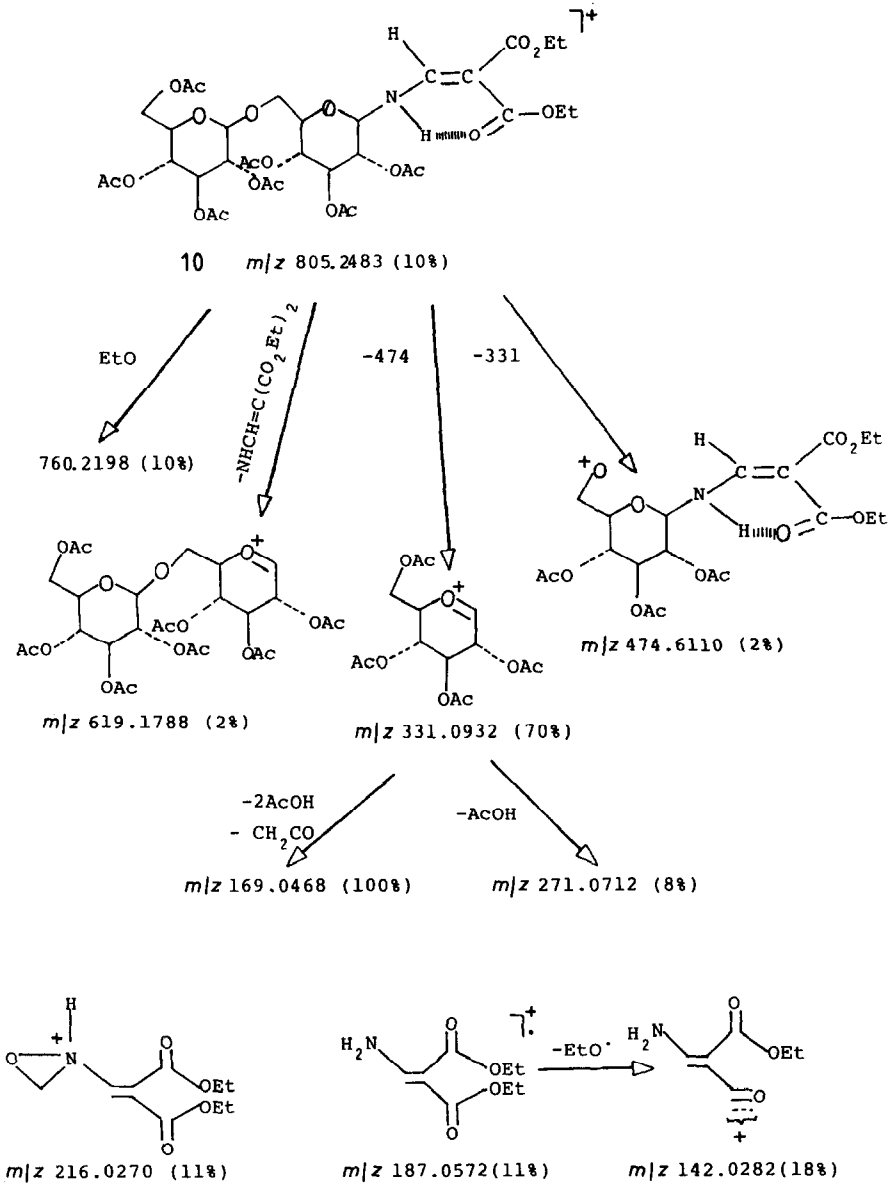
	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6a}$	$J_{5,6b}$	$J_{6a,6b}$	$J_{1',2'}$	$J_{2',3'}$	$J_{3',4'}$	$J_{4',5'}$	$J_{5',6'a}$	$J_{5',6'b}$	$J_{6'a,6'b}$
9	8.9	8.9	–	–	0.0	–	10.5	7.8	9.1	9.1	9.2	4.7	2.3	12.2
10	8.9	9.1	9.1	9.3	2.3	6.1	11.0	8.0	9.1	9.1	9.1	4.5	2.5	12.5
11	9.5	9.5	9.5	9.5	–	6.6	11.1	7.9	9.5	9.5	9.5	4.9	2.3	12.4

TABLE II

^{13}C-NMR data (δ in ppm) for solutions of **9–11** in $CDCl_3$

	C-1	C-2	C-3	C-4	C-5	C-6	C-1′	C-2′	C-3′	C-4′	C-5′	C6′
9	88.8	81.6	85.0	77.2 [a]	77.1 [a]	67.3	100.4	70.9	72.8	68.1	71.7	61.8
10	86.9	70.4	72.3 [a]	68.5	74.6	68.4	100.6	70.7	72.5 [a]	68.0	71.8	61.6
11	87.2	71.0	72.4	68.8	75.1	68.1	100.7	70.7	72.6	68.0	71.6	61.6

[a] Assignments may be interchanged.



Scheme 1.

chromatography (EtOAc–hexane, 4:1) of a small portion of the crude amorphous product (6.8 g, 79%) gave colourless amorphous **2**, $[\alpha]_D^{21}$ +15° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 277 and 231 nm (ϵ_{mM} 25.4 and 14.3); ν_{max} 3430 (OH), 3310 (NH), 1730 (C=O free), 1640 (C=O chelated, 1620 (C=C and NH)[27], 1606, 1491, 1450 (C=C aromatic), 1231 (C–O–C), 704, and 690 cm^{-1} (CH aromatic). NMR data: ^1H (200 MHz), δ 9.35 (dd, 1 H, $J_{NH,=CH}$ 13.6, $J_{1,NH}$ 8.0 Hz, NH), 8.10 (d, 1 H, =CH), 7.45–7.22 (m, 15 H, 3 Ph), 4.35 (t, 1 H, $J_{1,2}$ 8.0 Hz, H-1), 4.22, 4.15 (2 q, each 2 H,

J 7.0 Hz, 2 CH_3CH_2), 3.60–3.30 (m, 9 H, H-2,3,4,5,6a,6b and 3 OH), 1.31 and 1.22 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (50 MHz), δ 168.8 (C=O chelated), 165.7 (C=O free), 158.2 (=CH), 143.2 (3 C, 3 C-1 of Ph), 128.5, 127.9 (each 6 C, 3 C-2,3,5,6 of Ph), 127.2 (3 C, 3 C-4 of Ph), 93.9 (=C), 87.3 (Ph_3C), 88.1 (C-1), 76.6 (C-5), 75.7 (C-3), 73.0 (C-2), 71.4 (C-4), 63.7 (C-6), 60.4, 59.8 (2 C, 2 CH_2), 16.2, and 16.1 (2 CH_3).

Anal. Calcd for $C_{33}H_{37}NO_9$: C, 66.99; H, 6.30; N, 2.37. Found: C, 67.38; H, 6.46; N, 2.25.

*2,3,4-Tri-*O*-benzyl-*N*-(2,2-diethoxycarbonylvinyl)-6-*O*-trityl-β-*D*-glucopyranosylamine* (**3**).—To a solution of crude **2** (6.1 g, 10.4 mmol) in CH_2Cl_2 (15 mL) were added aq 50% NaOH (15 mL) and a catalytic amount of tetrabutylammonium hydrogensulphate. After 5 min, freshly distilled benzyl bromide (15 mL, 120 mmol) was added dropwise with vigorous stirring. After 7 h, the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL), the combined organic layers were washed with satd aq NaCl (2 × 20 mL) and water (20 mL), then dried (Na_2SO_4), and the solvent was evaporated under diminished pressure. Column chromatography (gradient, 1:8 → 1:4 EtOAc–hexane) of the residue and crystallisation of the product (5.4 g, 60%) from EtOH gave **3**, mp 64–65°C, $[\alpha]_D^{21}$ −6° (*c* 0.5, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 276.5 and 229.5 nm (ϵ_{mM} 5.5 and 10.5); ν_{max} 3260 (NH), 1730 (C=O free), 1660 (C=O chelated), 1620 (C=C and NH), 1605, 1494, 1451 (C=C aromatic), 1242 (C–O–C), and 698 cm^{-1} (CH aromatic). NMR data: ^1H (200 MHz), δ 9.69 (dd, 1 H, $J_{NH,=CH}$ 13.7, $J_{1,NH}$ 7.1 Hz, NH), 8.20 (d, 1 H, =CH), 7.80–6.84 (m, 3 OH and 6 Ph), 4.88 (s, 2 H, CH_2Ph), 4.83, 4.69 (2 d, 2 H, *J* 10.5 Hz, CH_2Ph), 4.71, 4.41 (2 d, 2 H, *J* 10.5 Hz, CH_2Ph), 4.45 (t, 1 H, $J_{1,2}$ 8.1 Hz, H-1), 4.30 (2 q, each 2 H, *J* 7.0 Hz, 2 CH_3CH_2), 3.93 (t, 1 H, $J_{2,3}$ 8.1, $J_{3,4}$ 8.1 Hz, H-3), 3.68 (t, 1 H, $J_{4,5}$ 8.1 Hz, H-4), 3.58 (dd, 1 H, $J_{5,6a}$ 2.8, $J_{6a,6b}$ 10.5 Hz, H-6a), 3.56 (t, 1 H, H-2), 3.49 (m, 1 H, H-5), 3.23 (dd, 1 H, $J_{5,6b}$ 3.2 Hz, H-6b), 1.38 and 1.19 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (50.3 MHz), δ 168.7 (C=O chelated), 165.6 (C=O free), 157.6 (HC=), 143.5 (3 C, 3 C-1 Ph of Tr), 138.0, 137.4, 137.0 (3 C, 3 C-1 Ph of Bn), 128.8–127.7 (27 C, aromatic), 126.9 (3 C, 3 C-4 Ph of Tr), 92.4 (=C), 88.1 (C-1), 86.4 (Ph_3C), 85.1 (C-3), 82.1 (C-2), 77.4 (C-4), 76.8 (C-5), 75.9, 75.4, 75.0 (3 C, 3 CH_2Ph), 62.0 (C-6), 60.2, 59.7 (2 CH_3CH_2), 14.3 and 14.0 (2 CH_3CH_2). Mass spectrum: *m/z* 618.2761 (2%, $M^+ - Tr$), 260 (12, $TrOH^+$), 244 (50, TrH^+), 243 (90, Tr^+), 165 (68, fluorenyl$^+$), 108 (51, $PhCH_2OH^+$), 91 (100, Bn^+), and 77 (68, Ph^+).

Anal. Calcd for $C_{54}H_{55}NO_9$: C, 75.24; H, 6.43; N, 1.62. Found: C, 75.35; H, 6.38; N, 1.47.

*2,3,4-Tri-*O*-acetyl-* (**4**) *and 2,3,4-tri-*O*-benzoyl-*N*-(2,2-diethoxycarbonylvinyl)-6-*O*-trityl-β-*D*-glucopyranosylamine* (**5**).—Conventional treatment of **2** (5.0 g, 8.46 mmol) with pyridine (25 mL) and acetic anhydride (25 mL, 267 mmol) or pyridine (15 mL) and benzoyl chloride (3.93 mL, 33.9 mmol) gave **4** or **5**, respectively.

Compound **4** (4.25 g, 70%) had mp 96–98° (from EtOH), $[\alpha]_D^{18}$ +46°, $[\alpha]_{546}^{18}$ +56° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 275 and 228 nm (ϵ_{mM} 33.9 and 15.9); ν_{max} 3270 (NH), 1750 (C=O, acetate), 1730 (C=O free), 1660 (C=O, chelated), 1615 (C=C and NH),

1600, 1490, 1448 (C=C aromatic), 1240, 1215 (C–O–C), 710 and 690 cm^{-1} (CH aromatic). NMR data: ^1H (200 MHz), δ 9.32 (dd, 1 H, $J_{NH,=CH}$ 13.3, $J_{1,NH}$ 8.5 Hz, NH), 8.03 (d, 1 H, NH), 7.57–7.33 (m, 15 H, 3 Ph), 5.30–5.03 (m, 3 H, H-2,3,4), 4.54 (t, 1 H, $J_{1,2}$ 8.5 Hz, H-1), 4.30, 4.20 (2 q, each 2 H, J 7.0 Hz, 2 CH_3CH_2), 3.64 (ddd, 1 H, $J_{4,5}$ 8.8, $J_{5,6a}$ 2.4, $J_{5,6b}$ 4.3 Hz, H-5), 3.37 (dd, 1 H, $J_{6a,6b}$ 10.8 Hz, H-6a), 3.09 (dd, 1 H, H-6b), 2.04, 2.01, 1.80 (3 s, each 3 H, 3 Ac), 1.35 and 1.26 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (50.3 MHz), δ 170.1, 169.5 (2 $COCH_3$), 168.7 (C=O chelated), 167.7 ($COCH_3$), 165.3 (C=O free), 157.1 (HC=), 143.2 (3 C, 3 C-1 of Ph), 128.3, 127.4 (each 6 C, 3 C-2,3,5,6 of Ph), 126.3 (3 C, 3 C-4 of Ph), 94.3 (=C), 86.8 (Ph_3C), 75.2 (C-3), 72.7 (C-5), 70.7 (C-2), 68.2 (C-4), 61.6 (C-6), 60.2, 60.0 (2 C, 2 CH_2), 20.5, 20.4, 20.3 (3 $COCH_3$), 14.2 and 14.1 (2 C, 2 CH_3). Mass spectrum: m/z 672.2564 (1%, M^+ – EtO), 657.2705 (1, M^+ – AcOH), 612.2223 (1, 672 – AcOH), 598.2525 (1, 657 – AcO), 531.1977 [1, M^+ – $NHCH{=}C(CO_2Et)_2$], 474.1764 (2, M^+ – Tr), 471.1674 (1, 531 – AcOH), 260 (1, $TrOH^+$), 244 (40, TrH^+), 243 (100, Tr^+), 165 (60, fluorenyl$^+$), 77 (10, Ph^+), 60 (25, $AcOH^+$), and 43 (40, Ac^+).

Anal. Calcd for $C_{39}H_{43}NO_{12}$: C, 65.26; H, 6.04; N, 1.95. Found: C, 65.44; H, 6.17; N, 1.88.

Compound **5** (5.0 g, 67%) had mp 151–153° (from EtOH), $[\alpha]_D^{22}$ −11°, $[\alpha]_{546}^{23}$ −14° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 275.3 and 235.4 nm (ϵ_{mM} 34.5 and 48.3); ν_{max} 3300 (NH), 1736 (C=O free), 1665 (C=O chelated), 1615 (C=C and NH), 1490, 1451 (C=C aromatic), 1263 (C–O–C), 708 and 690 cm^{-1} (CH aromatic). NMR data: ^1H (200 MHz), δ 9.44 (dd, 1 H, $J_{NH,=CH}$ 13.0, $J_{1,NH}$ 9.2 Hz, NH), 8.06 (d, 1 H, =CH), 7.95–7.09 (m, 30 H, 6 Ph), 5.87 (t, 1 H, $J_{2,3}$ 9.2, $J_{3,4}$ 9.2 Hz, H-3), 5.73 (t, 1 H, $J_{4,5}$ 9.2 Hz, H-4), 5.57 (t, 1 H, $J_{1,2}$ 9.2 Hz, H-2), 4.32, 4.17 (2 q, each 2 H, J 7.3 Hz, 2 CH_3CH_2), 3.90 (ddd, 1 H, $J_{5,6a}$ 2.3, $J_{5,6b}$ 4.6 Hz, H-5), 3.43 (dd, 1 H, $J_{6a,6b}$ 10.8 Hz, H-6a), 3.28 (dd, 1 H, H-6b), 1.34 and 1.23 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (50.3 MHz), δ 168.7 (C=O chelated), 166.4, 166.0, 165.9 (3 C, 3 COPh), 165.2 (C=O free), 157.8 (=CH), 143.8 (3 C, 3 C-1 of Ph of Tr), 134.1–126.7 (33 C, aromatic), 95.1 (=C), 87.8, 87.4 (2 C, C-1 and Ph_3C), 76.3 (C-3), 73.5 (C-5), 72.1 (C-2), 69.4 (C-4), 62.8 (C-6), 60.8, 60.6 (2 C, 2 CH_2), 14.8 and 14.7 (2 C, 2 CH_3). Mass spectrum: m/z 260 (10%, $TrOH^+$), 244 (50, TrH^+), 243 (45, Tr^+), 183 (19, 260 – Ph$^\cdot$), 165 (35, fluorenyl$^+$), 122 (80, $BzOH^+$), 105 (100, Bz^+), and 77 (38, Ph^+).

Anal. Calcd for $C_{54}H_{49}NO_{12}$: C, 71.75; H, 5.46; N, 1.55. Found: C, 72.10; H, 5.71; N, 1.51.

2,3,4-Tri-O-benzyl-N-(2,2-diethoxycarbonylvinyl-β-D-glucopyranosylamine (**6**).—A solution of **3** (0.2 g, 0.23 mmol) in aq 90% trifluoroacetic acid (0.6 mL) was kept at room temperature for 10 min, CH_2Cl_2 (10 mL) was added, the mixture was neutralised with satd aq $NaHCO_3$, and the organic layer was washed with water, dried ($MgSO_4$), and concentrated. Column chromatography (ether–hexane, 5 : 1) of the residue gave **6** (0.128 g, 90%), isolated as an amorphous and hygroscopic solid, $[\alpha]_D^{21}$ −41°, $[\alpha]_{546}^{21}$ −56° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 276.8 nm (ϵ_{mM} 27.8); ν_{max} 3500 (OH), 3270 (NH), 1730 (C=O free), 1665 (C=O chelated), 1607 (C=C and NH), 1600, 1487, 1452 (C=C aromatic), 1236 (C–O–C), and 700 cm^{-1} (CH aromatic).

NMR data: ^{1}H (200 MHz), δ 9.46 (dd, 1 H, $J_{NH,=CH}$ 12.5, $J_{1,NH}$ 8.8 Hz, NH), 8.06 (d, 1 H, HC=), 7.34–7.20 (m, 15 H, 3 Ph), 4.91 (s, 2 H, CH_2Ph), 4.86, 4.68 (2 d, 2 H, J 10.3 Hz, CH_2Ph), 4.77, 4.65 (2 d, 2 H, J 10.3 Hz, CH_2Ph), 4.44 (t, 1 H, $J_{1,2}$ 8.8 Hz, H-1), 4.26, 4.18 (2 q, each 2 H, J 7.4 Hz, 2 CH_3CH_2), 3.87 (dd, 1 H, $J_{6a,6b}$ 11.5, $J_{5,6a}$ 2.7 Hz, H-6a), 3.73 (t, 1 H, $J_{2,3}$ 8.8, $J_{3,4}$ 8.8 Hz, H-3), 3.67 (dd, 1 H, $J_{5,6b}$ 2.7 Hz, H-6b), 3.61 (t, 1 H, $J_{4,5}$ 8.8 Hz, H-4), 3.46 (m, 1 H, H-5), 3.43 (t, 1 H, H-2), 2.73 (s, 1 H, OH), 1.34 and 1.28 (2 t, each 3 H, 2 CH_3CH$_2$); ^{13}C (50.3 MHz), δ 168.6 (C=O chelated), 165.2 (C=O free), 157.9 (=CH), 137.9, 137.5, 136.8 (3 C, 3 C-1 of Ph), 128.4–127.6 (15 C, 3 C-2,3,4,5,6 of Ph), 92.6 (=C), 88.5 (C-1), 84.9 (C-3), 81.6 (C-2), 77.3 (C-4), 76.9 (C-5), 75.5, 75.5, 75.0 (3 CH_2Ph), 61.3 (C-6), 60.1, 59.8 (2 CH_3CH_2), 14.2 and 14.1 (2 CH_3CH_2). Mass spectrum: m/z 619.2827 (2%, M^+; calc. for $C_{35}H_{41}NO_9$ 619.2781), 601 (1, $M^+ - H_2O$), 574 (3, $M^+ -$ EtO), 510 (5, 601 − Bn), 433 [1, $M^+ -$ NHCH=C$(CO_2Et)_2$], 108 (30, BnOH$^+$), 91 (100, Bn$^+$), and 77 (20, Ph$^+$).

*2,3,4-Tri-*O*acetyl-*N*-(2,2-diethoxycarbonylvinyl)-β-*D*-glucopyranosylamine* (**7**).—A solution of **4** in acetic acid (10 mL) was cooled in an ice bath and treated with precooled 33% HBr in acetic acid (0.85 mL). The mixture was shaken vigorously for 60 s, then filtered quickly at ~ 0°. The insoluble material was washed with ice–water and the combined filtrate and washings were extracted with CH_2Cl_2 (3 × 20 mL). The combined extracts were dried ($MgSO_4$) and concentrated, and residual acetic acid was removed by evaporation with toluene from the residue (0.27 g, 41%). Column chromatography (ether–hexane, 5:1) then gave **7**, isolated as an amorphous solid, $[\alpha]_D^{20}$ −49°, $[\alpha]_{546}^{20}$ −54° (c 0.4, $CHCl_3$); $\lambda_{max}^{CH_2Cl_2}$ 274 nm (ϵ_{mM} 11.5); ν_{max} 3500 (OH), 3290 (NH), 1760 (C=O of acetate), 1720 (C=O free), 1670 (C=O chelated), 1615 (C=C and NH), 1240 and 1220 cm^{-1} (C–O–C). NMR data: ^{1}H (200 MHz), δ 9.25 (dd, 1 H, $J_{NH,=CH}$ 12.7, $J_{1,NH}$ 9.8 Hz, NH), 7.96 (d, 1 H, =CH), 5.35 (t, 1 H, $J_{2,3}$ 9.8 Hz, $J_{3,4}$ 9.8 Hz, H-3), 5.07, 5.05 (2 t, 2 H, $J_{1,2}$ 9.8, $J_{4,5}$ 9.8 Hz, H-2,4), 4.59 (t, 1 H, H-1), 4.27, 4.22 (2 q, each 2 H, J 6.9 Hz, 2 CH_3CH_2), 3.80–3.50 (m, 3 H, H-5,6a,6b), 2.71 (bt, 1 H, OH), 2.09, 2.05, 2.04 (3 s, each 3 H, 3 Ac), 1.33 and 1.31 (2 t, each 3 H, 2 CH_3CH$_2$); ^{13}C (50.3 MHz): δ 171.8, 171.0, 169.6, 167.7, 165.5 (5 C=O), 157.4 (=CH), 94.4 (=C), 87.1 (C-1), 76.0 (C-5), 74.5 (C-3), 70.4 (C-2), 68.3 (C-4), 62.4 (C-6), 60.3, 60.1 (2 CH_2), 20.8, 20.7, 20.4 (3 $COCH_3$), 14.3 and 14.1 (2 CH_3). Mass spectrum: m/z 475.1684 (7%, M^+), 458.1744 (1, $M^+ -$ HO), 457.1560 (1, $M^+ - H_2O$), 430.1225 (9, $M^+ -$ EtO), 412.1118 (1, 457 − EtO), 398.1347 (9, 458 − AcOH), 397.1382 (7, 457 − AcOH), 289.0786 [7, $M^+ -$ NHCH=C$(CO_2Et)_2$], 169.0400 (100, $C_8H_9O_4^+$), 109.0261 (80, $C_6H_5O_2^+$), and 43 (78, Ac$^+$).

Anal. Calcd for $C_{20}H_{29}NO_{12}$: C, 50.52; H, 6.11; N, 2.95. Found: C, 50.31; H, 6.01; N, 2.77.

*2,3,4-Tri-*O*-benzoyl-*N*-(2,2-diethoxycarbonylvinyl)-β-*D*-glucopyranosylamine* (**8**). —A solution of **5** (0.3 g, 0.46 mmol) in aq 90% trifluoroacetic acid (1 mL) was kept at room temperature for 10 min, then neutralised with Amberlite IR-45(HO$^-$) resin, filtered, and concentrated. A solution of the residue in CH_2Cl_2 (15 mL) was

washed with water (2 × 15 mL), dried ($MgSO_4$), then concentrated. Column chromatography (hexane–ethyl ether gradient) of the residue gave **8** (150 mg, 70%), isolated as an amorphous solid, $[\alpha]_D^{22}$ −37°, $[\alpha]_{546}^{22}$ −43° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 232.8 and 274.4 nm (ϵ_{mM} 39.5 and 25.8); ν_{max} 3500 (OH), 3281 (NH), 1728 (C=O free), 1667 (C=O chelated), 1609 (C=C and NH), 1580, 1450 (C=C aromatic), 1263 (C–O–C), 712 and 690 cm^{-1} (CH aromatic). NMR data: ^1H (200 MHz), δ 9.40 (dd, 1 H, $J_{NH,=CH}$ 13.1, $J_{1,NH}$ 9.4 Hz, NH), 7.99 (d, 1 H, =CH), 7.96–7.22 (m, 15 H, 3 Ph), 6.04 (t, 1 H, $J_{2,3}$ 9.4, $J_{3,4}$ 9.4 Hz, H-3), 5.56, 5.56 (2 t, each 1 H, $J_{1,2}$ 9.4, $J_{4,5}$ 9.4 Hz, H-2,4), 4.89 (t, 1 H, H-1), 4.27, 4.16 (2 q, each 2 H, *J* 7.1 Hz, 2 CH_3CH_2), 3.90–3.70 (m, 3 H, H-5,6a,6b), 2.89 (bt, 1 H, OH), 1.33 and 1.26 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (50.3 MHz), δ 167.0 (C=O chelated), 165.7, 165.5, 165.4, 165.2 (4 C=O), 157.2 (=CH), 133.6, 133.4, 133.2 (3 C, 3 C-4 of Ph), 129.7–128.1 (15 C, 3 C-1,2,3,5,6 of Ph), 94.7 (=C), 87.3 (C-1), 76.5 (C-5), 72.4 (C-3), 71.0 (C-2), 68.8 (C-4), 60.8 (C-6), 60.2, 59.9 (2 CH_2), 14.1 and 14.0 (2 CH_3). Mass spectrum: *m/z* 661 (2%, M^+), 643 (1, $M^+ - H_2O$), 616 (1, $M^+ - EtO$), 538 (1, 643 − Bz), 475 [1, $M^+ - NHCH{=}C(CO_2Et)_2$], 122 (80, $BzOH^+$), 105 (100, Bz^+), and 77 (50, Ph^+).

Anal. Calcd for $C_{35}H_{35}NO_{12}$: C, 63.53; H, 5.28; N, 2.12. Found: C, 63.35; H, 5.15; N, 1.98.

2,3,4-Tri-O-benzyl- (**9**), *2,3,4-tri-O-acetyl-* (**10**), *and 2,3,4-tri-O-benzoyl-N-(2,2-diethoxycarbonylvinyl)-6-O-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)-β-D-glucopyranosylamine* (**11**).—To a stirred solution of **3**, **4**, or **5** (1.11 mmol) in dry nitromethane (4 mL) containing molecular sieves 3A (0.13 g) and silver perchlorate (0.458 g, 2.22 mmol) was added, at room temperature under N_2, acetobromoglucose (0.90 g, 2.22 mmol). The mixture was stirred for 30 min at room temperature under N_2, then filtered through Celite. The insoluble material was washed with CH_2Cl_2 (20 mL), and the combined filtrate and washings were washed with satd aq $NaHCO_3$ (2 × 20 mL) and water (2 × 20 mL), dried ($MgSO_4$), and concentrated. Column chromatography (hexane–ethyl ether gradient for **9**, 1:1 → 6:1 ether–hexane then 2:1 → 4:1 ethyl acetate–hexane for **10**, and 5:1 ether–hexane for **11**) of the residue gave **9–11** together with **6** (2%), **7** (10%), and **8** (26%), respectively.

Compound **9** (189 mg, 33%) had mp 112–114° (from EtOH), $[\alpha]_D^{18}$ −10°, $[\alpha]_{546}^{18}$ +23° (*c* 0.8, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 276.0 and 229.6 nm (ϵ_{mM} 37.2 and 23.0); ν_{max} 3248 (NH), 1753 (C=O acetate), 1717 (C=O free), 1665 (C=O chelated), 1609 (C=C and NH), 1600, 1490, 1450 (C=C aromatic), 1240, 1227 (C–O–C), and 702 cm^{-1} (CH aromatic). NMR data: ^1H (400 MHz), Table I and also δ 9.50 (dd, 1 H, $J_{NH,=CH}$ 13.2, $J_{1,NH}$ 8.9 Hz, NH), 8.05 (d, 1 H, =CH), 7.20–7.17 (m, 15 H, 3 Ph), 4.90, 4.83 (2 d, each 2 H, *J* 11.1 Hz, CH_2Ph), 4.82, 4.56 (2 d, each 2 H, *J* 10.8 Hz, CH_2Ph), 4.73, 4.62 (2 d, each 2 H, *J* 10.4 Hz, CH_2Ph), 4.24, 4.16 (2 m, each 2 H, 2 CH_3CH_2), 2.05, 2.03, 2.00, 1.96 (4 s, each 3 H, 4 Ac), 1.35 and 1.28 (2 t, each 3 H, *J* 7.1 Hz, 2 CH_3CH_2); ^{13}C (50.3 MHz), Table II and also δ 170.6, 170.2, 169.3, 169.1 (4 $COCH_3$), 168.6 (C=O chelated), 165.1 (C=O free), 157.9 (=CH), 137.9,

137.5, 136.9 (3 C-1 of Ph), 128.4–127.6 (15 C, 3 C-2,3,4,5,6 of Ph), 92.5 (=C), 75.6, 75.5, 74.9 (3 CH_2Ph), 60.1, 59.7 (2 CH_3CH_2), 20.6 ($COCH_3$), 20.5 (3 C, 3 $COCH_3$), 14.3 and 14.2 (2 CH_2CH_3).

Anal. Calcd for $C_{49}H_{59}NO_{18}$: C, 61.96; H, 6.22; N, 1.47. Found: C, 61.57; H, 6.36; N, 1.57.

Compound **10** (320 mg, 36.6%) had mp 173–175° (from EtOH), $[\alpha]_D^{20}$ −6°, $[\alpha]_{546}^{20}$ −4° (*c* 0.8, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 274.0 and 226.4 nm (ϵ_{mM} 18.8 and 8.8); ν_{max} 3275 (NH), 1753 (C=O acetate), 1720 (C=O free), 1667 (C=O chelated), 1611 (C=C and NH), and 1246 cm^{-1} (C–O–C). NMR data: ^1H (250 MHz), Table I and also δ 9.20 (dd, 1 H, $J_{NH,=CH}$ 13.6 Hz, $J_{1,NH}$ 8.9 Hz, NH), 7.91 (d, 1 H, =CH), 4.25, 4.20 (2 q, each 2 H, *J* 7.2 Hz, 2 CH_3CH_2), 2.09, 2.05, 2.03, 2.02, 2.01, 2.00, 1.99 (7 s, each 3 H, 7 Ac), 1.33 and 1.30 (2 t, each 3 H, 2 CH_3CH_2); ^{13}C (62.9 MHz), Table II and also δ 170.5, 170.1, 169.9, 169.4, 169.3, 169.2, 169.1 (7 $COCH_3$), 167.5 (C=O chelated), 165.2 (C=O free), 157.1 (=CH), 60.3, 60.1 (2 CH_2), 20.6 ($COCH_3$), 20.5 (4 $COCH_3$), 20.4 (3 $COCH_3$), 14.3 and 14.1 (2 CH_3). Mass spectrum (see Scheme 1): *m/z* 805.2483 (10%, M^+), 760.2198 (10, M^+ − EtO), 619.1788 [2, M^+ − $NHCH{=}C(CO_2Et)_2$], 474.1610 (2, Scheme 1), 331.0932 (70, Scheme 1), 217.0712 (8, 331 − AcOH), 216.0720 (11, Scheme 1), 187.0572 [11, $H_2NCH{=}C(CO_2Et)_2^+$], 169.0468 (100, 331 − 2 AcOH − CH_2CO), 142.0282 (18, Scheme 1), 60 (40, $AcOH^+$), and 43 (58, Ac^+).

Anal. Calcd for $C_{34}H_{47}NO_{21}$: C, 50.68; H, 5.87; N, 1.74. Found: C, 50.24; H, 5.94; N, 1.75.

Compound **11** (324 mg, 30%) had mp 201–202° (from EtOH), $[\alpha]_D^{22}$ −36°, $[\alpha]_{546}^{22}$ −41° (*c* 1, CH_2Cl_2); $\lambda_{max}^{CH_2Cl_2}$ 274.4 and 232.0 nm (ϵ_{mM} 23.4 and 35.5); ν_{max} 3280 (NH), 1750 (C=O acetate), 1730 (C=O free), 1667 (C=O chelated), 1607 (C=C and NH), 1580, 1450 (C=C aromatic), 1254, 1230 (C–O–C), 712 and 690 cm^{-1} (CH aromatic). NMR data: ^1H (400 MHz), Table I and also δ 8.63 (dd, 1 H, $J_{NH,=CH}$ 12.3, $J_{1,NH}$ 9.5 Hz, NH), 7.98 (d, 1 H, =CH), 7.92–7.20 (m, 15 H, 3 Ph), 4.24, 4.13 (2 m, each 2 H, 2 CH_3CH_2), 1.99, 1.98, 1.97, 1.96 (4 s, each 3 H, 4 Ac), 1.29 and 1.23 (2 t, each 3 H, *J* 7.2 Hz, 2 CH_3CH_2); ^{13}C (50.3 MHz), Table II and also δ 170.9, 170.0, 169.2, 169.1 (4 $COCH_3$), 167.2 (C=O chelated), 165.5, 165.2, 165.1, 164.9 (3 PhCO and C=O free), 157.1 (=CH), 133.5, 133.3, 133.2 (3 C-4 of Ph), 129.7–128.1 (15 C, 3 C-1,2,3,5,6 of Ph), 94.7 (=C), 60.2, 59.9 (2 CH_2), 14.2 and 14.1 (2 CH_3).

Anal. Calcd for $C_{49}H_{53}NO_{21}$: C, 59.33; H, 5.38; N, 1.41. Found: C, 59.47; H, 5.69; N, 1.17.

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