Diastereoselective conjugate additions of a D-glucose-derived δ-lactone

Marisa Ciampini[1], Patrick Perlmutter[1]* and Keith Watson[2]

[1]School of Chemistry, Monash University, PO Box 23, Victoria 3800 Australia; [2] Biota Chemistry Laboratory, Monash University, PO Box 23, Victoria 3800 Australia.
E-mail: Patrick.perlmutter@sci.monash.edu.au

Dedicated to Professor Sukh Dev on the occasion of his 80th birthday
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Abstract
Diastereoselective conjugate additions of a range of nucleophiles, some achieving excellent selectivity, to a D-glucose-derived δ-lactone are reported.

Keywords: Conjugate addition, Michael reaction, gluconolactone, diastereoselective

Introduction

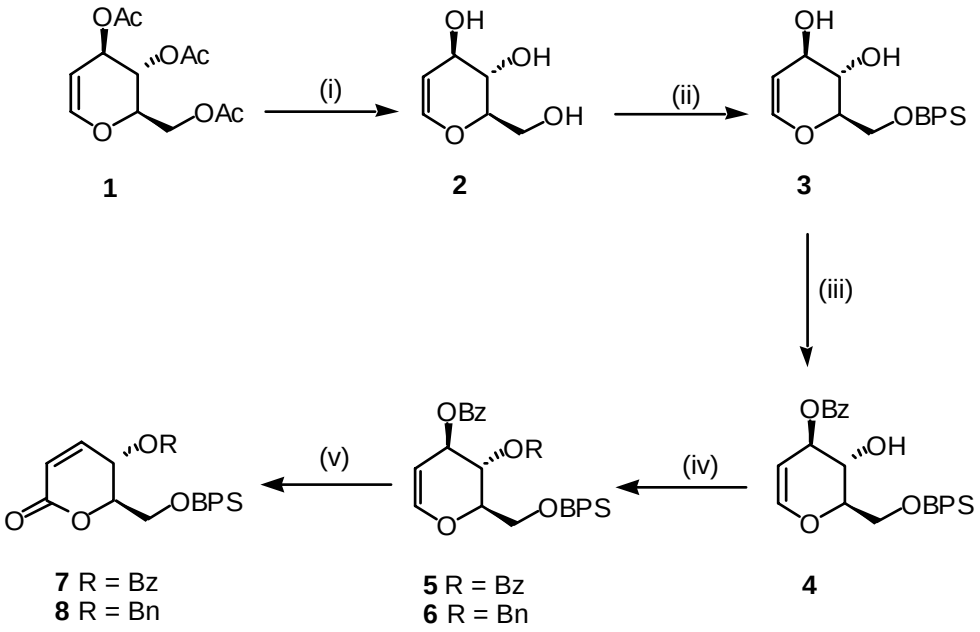
As part of a program directed towards the preparation of a variety of carbon- and heteroatom-linked disaccharides we had cause to investigate the conjugate addition of several nucleophiles to monosaccharide-derived δ-lactones. In this paper we report on additions of three different nucleophiles to a D-glucose-derived δ-lactone.

Results and Discussion

Preparation of new δ-lactones 7 and 8

The δ-lactone we chose to study was the differentially protected D-gluconolactone 8 (Scheme 1). This lactone has not been reported previously and so we first needed to develop an efficient synthesis of **8**. The approach we developed is outlined in Scheme 1. Most of the steps were straightforward providing lactone **8** in five steps and 18% overall yield from D-glucal triacetate. Differential protection of the three alcohols (at C3, C4 and C6) was required. Monosilylation[1,2] of the primary alcohol gave ether **3** in excellent yield. Differentiating the two secondary alcohols is less well precedented. Complete selectivity for and acceptable yields (~60%) of the monobenzoyl derivative **4** could be achieved by treatment of diol **3** with benzoyl chloride[1] and DMAP at room temperature in pyridine. Benzylation of **4**, using potassium hydride[2] and benzyl

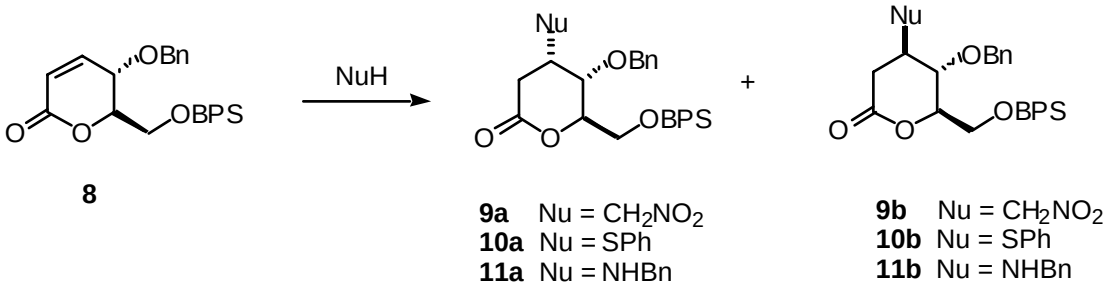
bromide led to poor yields (~20%) of tri-protected **6**. A significant improvement in the yield (70%) was obtained when the potassium hydride was replaced by silver oxide[3]. Lastly we were pleased to find that oxidative rearrangement[4] of benzoates **5** and **6** led smoothly to the new δ-lactones **7** and **8**, respectively.



Scheme 1. (i) NaOMe, MeOH; (ii) imidazole, BPSCl, DMF; (iii) BzCl, DMAP, Py; (iv) BnBr, Ag_2O, DMF; (v) MCPBA, $BF_3.Et_2O$.

Conjugate additions to 8

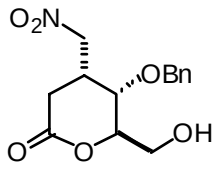
Conjugate additions[5] to **8** were then examined (Scheme 2). Three nucleophiles, nitromethane enolate, thiophenolate and benzylamine were chosen for this study as representative C-, S- and N-based nucleophiles.



Scheme 2

In all cases the diastereoselectivity was significantly influenced by reaction temperature (Table 1). Of the three nucleophiles examined nitromethane and benzylamine gave the most useful results. In both cases conditions were found which gave exclusively a single adduct in

good to excellent yields. In the former case where TBAF[6] was employed as base, the reaction was completely diastereoselective but the product was found to be **9c**.



9c

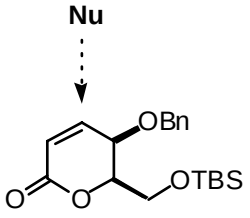
Presumably, although there is no proof at this stage, desilylation occurs after addition of the nitromethane anion. It is of course also possible that desilylated **8** may also undergo diastereoselective addition. In any case this is a rather interesting and potentially very useful one-pot conversion as the free alcohol is often required once the addition has been effected. At lower temperatures diastereomeric mixtures were obtained. Only the thiophenolate additions were somewhat disappointing. This is most likely due to the addition being reversible and incomplete at higher temperatures.

Table 1. Results of conjugate additions to δ-lactone 8

Entry	Nucleophile	Solvent	Temp (°C)	Time (h)	Yield (%)	Dr (**a** : **b**)
1	CH_3NO_2[a]	CH_3CN	Reflux	1	73	6.2[b] : 1
2	CH_3NO_2	CH_3CN	Rt	4d[c]	< 20	5 : 1
3	CH_3NO_2[d]	CH_3CN	Reflux	0.33	66[e]	100 : 0
4	PhSH[d]	THF	Rt	1	60[f]	3 : 1
5	PhSH[d]	THF	Reflux	1	60	3 : 1
6	PhSH[d]	THF	Reflux	1	80[g]	3 : 1
7	$BnNH_2$	MeOH	-78°C	18d[c]	41[h]	1 : 5
8	$BnNH_2$	MeOH	Rt	24	99	3 :2
9	$BnNH_2$	MeOH	Reflux	8	92	100 : 0

a. Base used was KF[7] in the presence of 18-crown-6[8]; b. 18% of **9a** obtained as desilylated product **9c**; c. Note the time is days not hours for this entry; d. TBAF was used as base in these experiments; e. Product obtained was exclusively **9c**; f. At 85% conversion; g. crude yield; h. At 70% conversion.

From these results each of the nucleophiles appear to prefer addition to the same face of **8** as shown in the Scheme below. This selectivity can be explained by assuming that the chair-like transition state is lower in energy than the boat-like transition state which would follow from addition to the opposite face of **8**. This outcome is similar to that reported by Herradon et al[9] in the conjugate addition of carbon nucleophiles to lactone **10**.



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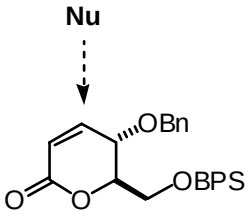

8

Conclusions

A concise and straightforward synthesis of the new δ-lactone **8** is reported. Conjugate additions of C-, N- and S-based nucleophiles were examined and conditions were found for the first two nucleophiles which led exclusively to the adducts **9a** and **11a**. In contrast addition of thiophenolate showed poorer selectivity.

Acknowledgements

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Experimental Section

General Procedures. Melting points were determined on a Kofler hotstage and are uncorrected. Elemental microanalyses were performed by the Australian Microanalytical Service, National Analytical Laboratories, Melbourne or the University of Otago, Dunedin, New Zealand. Optical rotations were recorded on a Perkin Elmer Model 141 Polarimeter. Infrared (IR) spectra were recorded on a Perkin-Elmer 1600 Series Fourier Transform spectrophotometer (cm^{-1} scale) and refer to thin films of liquids (neat) or paraffin (Nujol) mulls of solids between NaCl plates. High resolution hydrogen-1 nuclear magnetic resonance (^1H NMR) spectra were recorded at 300 MHz on a Bruker DPX-300 spectrometer or 400 MHz on a Bruker Avance DRX 400 spectrometer. The ^1H NMR spectral data refer to deuteriochloroform solutions ($CDCl_3$) using tetramethylsilane (TMS) as internal reference (δ 0.00 ppm). Carbon-13 nuclear magnetic resonance (^{13}C NMR) spectra were recorded at 75 MHz on a Bruker APX-300 spectrometer or 100 MHz on a Bruker Avance DRX 400 spectrometer. Mass spectrometry (ESI) was performed using samples in methanol on a Micromass Platform QMS Electrospray mass spectrometer. High resolution mass spectra (HRMS) for accurate mass determinations were recorded on a Bruker BioApex 47e FTMS fitted with an Analytica electrospray source using NaI for accurate mass calibration

(accuracy ± 3 ppm). Low resolution mass spectra were recorded on a VG micromass 70/70F or a VG TRIO-1 mass spectrometer with an ion source temperature of 200° and electron impact energy of 70 eV.

1,5-Anhydro-6-*O*-*t*-butyldiphenylsilyl-2-deoxy-D-*arabino*-hex-1-enitol (3). A solution of the triol **2**[1,2] (2.04 g, 14.0 mmol) dissolved in DMF (20.0 ml) was treated with imidazole (2.08 g, 30.59 mmol) followed by BPSCl (4.28 g, 4.05 ml, 15.6 mmol). The mixture was stirred at room temperature for 16 hr, diluted with Et_2O (100 ml) and the resulting solution washed with water (50.0 ml), saturated $CuSO_4$ solution (50 ml) and water (2 X 50 ml). The organic extracts were combined, dried ($MgSO_4$) and concentrated. The crude product was subjected to purification by flash column chromatography (SiO_2 3:2 light petroleum/ethyl acetate) to yield the title compound **3** as a clear oil (4.34 g, R_f 0.34, 81%). IR (CH_2Cl_2): 3421s, 3054s, 2931s, 2858s, 1718w, 1648s, 1472m, 1428s, 1391w, 1265s, 1112s, 926w, 896w, 877w, 823w, 739s, 703s cm^{-1}. ^1H n.m.r. δ1.07, s, 9H, 3(CH_3) -BPS; 3.93-3.78, m, 2H, 2(CH), H4, H5; 4.01, dq, *J* 10.1, 4.00, 2.80 Hz, 2H, CH_2, H6; 4.29, td, *J* 7.00, 4.00 Hz, 1H, CH, H3; 4.73, dd, *J* 6.1, 2.2 Hz, 1H, CH, H2; 6.32, dd, *J* 6.0, 1.7 Hz, 1H, CH, H1; 7.48-7.37, m, 6ArH -BPS; 7.67-7-71, m, 4ArH -BPS. ^{13}C n.m.r. δ 19.35, CH_2, C6; 26.87, 3(CH_3) -BPS; 63.77, $\underline{C}(CH_3)$ -BPS; 69.60, CH, C5; 71.57, CH, C3; 77.15, CH, C4; 102.40, CH, C2; 127.66, 127.71, ArCH, 2(C2', C6') -BPS; 129.76, 129.79, ArCH, 2(C4') -BPS; 132.63, 132.83, ArC, 2(C1') -BPS; 135.42, 135.52, ArCH, 2(C3', C6') -BPS; 144.11, CH, C1. MS: 407.2 ($[M + Na]^+$, 100%), 423.1, ($[M + K]^+$, 58), 791.3, ($[2M + Na]^+$, 90), 807.1, ($[2M + K]^+$, 32). HRMS calc'd for $C_{22}H_{28}O_4Si(Na^+)$ requires 407.165 found 407.165. Anal. Calc'd for $C_{22}H_{28}O_4Si$ (384.2): C, 68.72; H, 7.34. Found C, 68.96; H, 6.92. $[\alpha]_D^{24}$ +4.93 (c = 1.5, $CHCl_3$).

1,5-Anhydro-3-*O*-benzoyl-6-*O*-*t*-butyldiphenylsilyl-2-deoxy-D-*arabino*-hex-1-enitol (4). To a cool (-35°) solution of the monosilylated diol **3** (2.00 g, 5.20 mmol) in pyridine (9.0 ml) a solution of 4-(dimethylamino)pyridine (0.06 g, 0.52 mmol) in pyridine (10 ml) was added. Neat benzoyl chloride (800 mg, 0.67 ml, 5.70 mmol) was added and the reaction was stirred at -35° for 15 min. The reaction was warmed to 0° over a period of 3 hr and allowed to warm to room temperature overnight (16°). The reaction mixture was poured into Et_2O (50 ml), washed with water (50 ml), saturated $CuSO_4$ solution (50 ml), followed by water (50 ml) and the combined aqueous phases were reextracted with Et_2O (2 X 40 ml). The organic extracts were combined, dried ($MgSO_4$) and evaporated under reduced pressure. The residue was purified by flash column chromatography (SiO_2, 5:1, light petroleum/ethyl acetate) to give the product **4** as a colourless oil. Recrystallisation of the crude oil from light petroleum gave the desired di-protected sugar **4** (1.52 g, 60%, R_f 0.34), as colourless crystals (m.p. 78.5-80°). IR (CH_2Cl_2): 3448m, 3054m, 2933m, 2859w, 1718m, 1648w, 1602w, 1473w, 1452w, 1428m, 1309w, 1316m, 1285s, 1178w, 1113m, 1071w, 1060w, 1027w, 896w cm^{-1}. ^1H n.m.r. δ 1.06, s, 9H, 3(CH_3) -BPS; 3.25-3.40, bs, 1H, OH; 3.95-4.12, m, 3H, 1(CH_2), H6 and 1(CH), H4; 4.24, dd, *J* 3.00, 4.02 Hz, 1H, CH, H5; 4.83, dd, $J_{2a\text{-}3}$ 2.6 Hz, $J_{2e\text{-}3}$ 2.6 Hz, 1H, CH, H2; 5.53, dq, *J* 1.5, 2.6 Hz, 1H, CH, H3; 6.48, dd *J* 6.0, 1.4 Hz, 1H, CH, H1; 7.35-7.47, m, 8ArH; 7.53-7.59, m, 1ArH, (H4') -Bz; 7.68-7.73, m, 4ArH; 8.03-8.07, m, 2ArH, (H2', H6') -Bz. ^{13}C n.m.r. δ 19.40, CH_2, C6; 26.89, 3($\underline{C}H_3$) -BPS;

63.01, C(CH$_3$)$_3$ -BPS; 68.07, CH, C5; 73.44, CH, C3; 78.05, CH, C4; 98.59, CH, C2; 127.62, 127.65, ArCH, 2(C2', C6') -BPS; 128.28, ArCH, 2(C2', C6') -Bz; 129.70, ArCH, 2(C4') -BPS, -Bz; 132.95, 133.01, ArC, 2(C1') –BPS, -Bz; 133.15, ArCH, 2(C3', C5') -Bz; 135.48, 135.52, ArCH, (C3', C6') -BPS; 146.18, CH, C1; 167.31, CO. MS: 511.19 ([M + Na]$^+$, 29%), 999.41, ([2M + Na]$^+$, 72). HRMS calc'd for $C_{29}H_{32}O_5Si(Na^+)$ requires 511.192 found 511.192. Anal. Calc'd for $C_{29}H_{32}O_5Si$ (488.2): C,71.28; H, 6.60. Found C, 71.46; H, 6.41. $[\alpha]_D^{25}$ -57.5° (c = 1, $CHCl_3$).

1,5-Anhydro-3-*O*-benzoyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-2-deoxy-D-*arabino*-hex-1-enitol (5).

Method 1

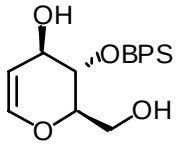
A solution of the alcohol **4** (500 mg, 1.02 mmol) in THF (5 ml) was added to a stirred slurry of KH (35% dispersion in oil, oil not removed) (0.07 g, 1.63 mmol) at 0°. The resulting solution was stirred for 15 min, neat benzyl bromide (0.28 g, 0.19 ml, 1.61 mmol) added and stirred for a further 2 hr at 0°. The contents were added to water (50 ml), and the aqueous phase extracted with Et_2O (3 X 40 ml). The organic extracts were combined, dried ($MgSO_4$) and evaporated under reduced pressure. Purification by flash column chromatography (SiO_2, 7% ethyl acetate in light petroleum) yielded two products **6** (100 mg, 17%, R_f 0.3), **5** (52 mg, 9%, Rf 0.26) both isolated as colourless oils, as well as recovered **4** (216 mg, R_f 0.09). **6** IR (CH_2Cl_2): 3053m, 2946s, 2930s, 2857s, 1740m, 1719s, 1649m, 1604w, 1560w, 1584w, 1494w, 1464w, 1452m, 1428m, 1390m, 1286s, 1243m, 1172w, 1107s, 1067m, 1026m, 941w, 821m, 792m, 738s, 702s cm^{-1}. ^{1}H n.m.r. δ1.02, s, 9H, 3(CH$_3$); 3.94-4.02, m, 2H, CH$_2$, H6; 4.04-4.13, dd, *J* 7.0, 5.4 Hz, 1H, CH, H4; 4.22, m, 1H, CH, H5; 4.75, 4.78, ABq, *J* 1.47 Hz, 2H, CH$_2$-Ph; 4.86, dd, *J* 3.09, 6.11 Hz, 1H, CH, H2; 5.62-5.65, m, 1H, CH, H3; 6.45, dd, *J* 1.31, 6.0 Hz, 1H, CH, H1; 7.21-7.23, m, 4ArH; 7.29-7.71, m, 8ArH; 7.51-7.57, m, 2ArH; 7.61-7.66, m, 4ArH; 7.96-7.99, m, 2ArH. ^{13}C n.m.r. δ19.34, CH$_2$, C6; 26.90, 3(CH$_3$) -BPS; 61.80, C(CH$_3$)$_3$ -BPS; 70.24, CH, C5; 72.90, CH, C3; 73.37, CH$_2$ -Bn; 77.57, CH, C4; 98.37, CH, C2; 127.52, 127.60, ArCH, 2(C2', C6') -BPS; 127.70, ArC, (C2', C6') -Bn; 128.26, ArC, 2(C2', C6') -Bz; 129.50, ArCH, (C4') -Bn, -Bz; 129.58, ArCH, 2(C4') -BPS; 130.00, ArC, (C1') -Bz; 132.90, ArCH, 2(C3, C5') -Bn, -Bz; 133.25, ArC, (C1') -BPS; 135.46, 135.59, ArCH, 2(C3', C5') -BPS; 137.70, ArC, (C1') -Bn; 145.90, CH, C1; 165.89, CO. MS: 601.24 [M + Na]$^+$, 72%), 617.21, ([M + K]$^+$, 10), 1179.51, ([2M + Na]$^+$, 52). HRMS calc'd for $C_{36}H_{38}O_5Si(Na^+)$ requires 601.239 found 601.238. $C_{36}H_{38}O_5Si(K^+)$ requires 617.213 found 617.211. Anal. Calc'd for $C_{36}H_{38}O_5Si$ (578.2): C, 74.71; H, 6.61. Found C, 75.00; H, 6.81. $[\alpha]_D^{23}$ -34.2° (c = 1.5, $CHCl_3$.

1,5-Anhydro-3,4-bis-*O*-benzoyl-6-*O*-*t*-butyldiphenylsilyl-2-deoxy-D-*arabino*-hex-1 enitol (5). (52 mg, 9%, R_f 0.26). IR (CH_2Cl_2): 3054m, 2960m, 2932m, 2891m, 2859m, 1968w, 1911w, 1720s, 1648s, 1602m, 1587m, 1490w, 1473m, 1452s, 1428s, 1391m, 1362m, 1316s, 1265s, 1178m, 1158m, 1108s, 1070m, 1027m, 998m, 941m, 896m, 879w, 850w, 824m cm^{-1}. ^{1}H n.m.r. δ1.02, s, 9H, 3(CH$_3$) -BPS; 3.96, d, *J* 4.6 Hz, CH$_2$, 2H, H6; 4.36, dq, *J* 4.70, 11.2 Hz, 1H, CH, H5; 4.99, dd, *J* 6.20, 3.40 Hz, 1H, CH, H2; 5.60, q, *J* 5.01, 3.90 Hz, 1H, H3; 5.82, t, *J* 6.6, 5.3

Hz, 1H, CH, H4; 6.51, dd, *J* 6.1, 1.0 Hz, 1H, CH, H1; 7.17-7.68, m, 16 ArH; 7.92-8.01, 4ArH, 2(H2', H6') -Bz. ^{13}C n.m.r. δ19.26, CH_2, C6; 26.76, 3(CH_3) -BPS; 61.72, C(CH_3) -BPS; 67.64, CH, C5; 67.91, CH, C3; 76.70, CH, C4; 98.16, CH, C2; 127.51, 127.59, ArCH, 2(C2', C6') -BPS; 128.25, 128.31, ArCH, 2(C2', C6') -Bz; 129.49, ArC, (C1') -Bz; 129.57, 129.63, ArCH, 2(C4') -Bz; 129.73, ArCH, 2(C4') -BPS, -Bz; 132.89, ArC, (C1') -BPS; 132.93, 132.13, ArCH, 2(C3', C5') -Bz; 135.45, 135.47, ArCH, 2(C3', C5') -BPS; 146.00, CH, C1; 164.74, 165.74, 2(CO). MS: 615.21 ($[M + Na]^+$, 45%), 1207.45 ($[2M + Na]^+$, 72). HRMS calc'd for $C_{36}H_{36}O_6Si(Na^+)$ requires 615.218 found 615.216. Anal. Calc'd for $C_{36}H_{36}O_6Si$ (592.2): C, 72.40; H, 6.44. Found C, 72.58; H, 6.21. $[\alpha]_D^{22}$ +15.5˚ (c = 2.7, $CHCl_3$.

Method 2

A solution of the alcohol **4** (200 mg, 0.41 mmol) in THF (30.0 ml) at 0° was added to a stirred slurry of KH (35% dispersion in oil, oil not removed) (0.03 g, 0.65 mmol) in THF (8.0 ml) also at 0°. The resulting solution was stirred for 15 min, neat benzyl bromide (0.11 g, 0.08 ml, 0.65 mmol) added and left overnight (15 hr) in the fridge (3°). The contents was added to water (50 ml), and the aqueous phase extracted with Et_2O (3 X 40 ml). The organic phases were combined, dried ($MgSO_4$) and evaporated under reduced pressure. Purification by flash column chromatography (SiO_2, 7% ethyl acetate in light petroleum) gave firstly the desired compound **6** as a colourless oil (63.0 mg, 27%). The column was flushed with ethyl acetate to obtain 140 mg of an unknown mixture. Purification of this material by flash column chromatography (SiO_2, 3:2, light petroleum/ethyl acetate) gave (2*R*,3*R*,4*R*)-4-((*tert*-butyldiphenylsilyl)oxy)-2-(hydroxymethyl)-3-(hydroxy)-3,4-dihydro-2*H*-pyran **12** (24.8 mg, 18%) and diol **3** (70.1 mg, 41%).



12

12 IR (CH_2Cl_2): 3385s, 3071m, 2931s, 2857s, 1708w, 1647s, 1590w, 1472m, 1428s, 1390w, 1362w, 1326w, 1235s, 1170w, 1113s, 1053s, 949w, 875w, 823m, 798m, 740s, 702s cm^{-1}. ^{1}H n.m.r. δ1.05, s, 9H, 3(CH_3) -BPS; 1.64, bs, OH; 2.91, bs, OH; 3.74-3.97, m, 4H, 2(CH), H4, H5, 1(CH_2), H6; 4.16-4.18, m, 1H, CH, H3; 4.71, dd, *J* 2.11, 6.03 Hz, 1H, CH, H2; 6.30, dd, *J* 1.56, 6.03 Hz, 1H, CH, H1; 7.38-7.47, m, 6ArH -BPS; 7.65-7-69, m, 4ArH -BPS. ^{13}C n.m.r. δ 26.90, 3(CH_3) -BPS; 29.78, CH_2, C6; 63.91, C(CH_3)$_3$ -BPS; 69.58, CH, C5; 71.90, CH, C3; 76.88, CH, C4; 102.27, CH, C2; 127.71, 127.78, ArCH, 2(C2', C6') -BPS; 129.84, 129.88, ArCH, 2(C4') -BPS; 132.62, 132.83, ArC, 2(C1') -BPS; 135.42, 135.52, ArCH, 2(C3', C6') -BPS; 144.11, CH, C1.

Method 3

Freshly prepared silver oxide[10] (1.02 g, 4.4 mmol) and benzyl bromide (0.36 g, 0.26 ml, 2.16 mmol) were added to a cool (0˚) solution of **4** (0.43 g, 0.879 mmol) in DMF (5 ml) under

nitrogen. The resulting mixture was stirred at 0˚ for 15 min, allowed to warm to room temperature and stirred for 2 days. It was diluted with CH_2Cl_2 (10.0 ml), filtered and the filtrate concentrated under reduced pressure. The resulting oil was dissolved in 10% aq. citric acid (10.0 ml) and extracted with Et_2O (2 X 15 ml). The organic phases was washed with 10 % aq. $NaHCO_3$ (10 ml) followed by water (10 ml). The organic phase were combined, dried ($MgSO_4$) and concentrated under reduced pressure to give an orange oil (1.91 g crude). Purification by flash column chromatography (SiO_2, 20:1 light petroleum/ethyl acetate) gave **6** as a light orange oil (R_f 0.81, 285 mg, 56%).

1,5-Anhydro-4-*O*-benzyl-6-*O*-*t*-butyldipnenylsilyl-2,3-deoxy-1-oxo-D-*arabino*-hex-2-enitol (8). A solution of MCPBA (85% anhydrous, 35.2 mg, 0.21 mmol) in CH_2Cl_2 (3 ml) was cooled to -20˚ and added to an equally cooled solution of **6** (100 mg, 0.17 mmol) in CH_2Cl_2 (3 ml). $BF_3.Et_2O$ (11.6 μL, 12.98 mg, 0.092 mmol) was then added dropwise. The reaction was stirred at -20˚ for 3.5 hr and quenched with saturated $NaHCO_3$ solution (10 ml). The aqueous phase was reextracted with CH_2Cl_2 (3 X 10 ml) and the organic phases were combined, dried ($MgSO_4$) and evaporated under reduced pressure to afford an orange solid (107 mg crude). Purification by column chromatography (SiO_2, CH_2Cl_2) gave the desired product **8** as an orange oil (52.0 mg, 64%). IR (CH_2Cl_2): 3071s, 2931s, 2858s, 1962w, 1895w, 1820w, 1738s, 1629w, 1589w, 1497w, 1472m, 1455m, 1428s, 1390s, 1307m, 1260m, 1228m, 1113s, 1029m, 961m, 857m, 823s, 740s cm^{-1}. ^1H n.m.r. δ (400 MHz) 1.06, s, 9H, 3(CH_3) -BPS; 3.92, dq, *J* 11.44, 3.45 Hz, 2H, CH_2, H6; 4.43, dt, *J* 3.64, 6.58 Hz, 1H, CH, H5; 4.54, dq, *J* 7.60, 2.80 Hz, $J_{4\text{-}2}$ 1.64 Hz, 1H, CH, H4; 4.64, q, *J* 11.53 Hz, 2H, CH_2-Ph; 5.99, dd, *J* 10.0, 1.60 Hz, 1H, CH, H2; 6.82, dd, *J* 10.0, 2.7 Hz, 1H, CH, H3; 7.25-7.27, m, 9ArH; 7.61-7.68, m, 6ArH. ^{13}C n.m.r. δ19.78, CH_2, C6; 27.31, 3(CH_3) -BPS; 62.67, $\underline{C}(CH_3)_3$ -BPS; 68.87, CH, C5; 72.50, $\underline{C}H_2$ -Bn; 81.42, CH, C4; 121.37, CH, C3; 128.14, ArCH, 2(C2', C6') -BPS; 128.17, ArCH, (C2', C6') -Bn; 128.54, ArCH, (C4') -Bn; 128.94, ArCH, (C4') -BPS; 130.21, 130.23, ArCH, (C3', C5') -Bn; 132.74, 133.23, ArC, 2(C1') -BPS; 135.84, 136.01, ArCH, 2(C3', C5') -BPS; 137.33, ArC, (C1') -Bn; 145.58, CH, C2; 162.83, CO, C1. MS: 473.1 ($[M + H]^+$, 10%), 495.1 ($[M + Na]^+$, 100), 967.2 ($[2M + Na]^+$, 15). HRMS calc'd for $C_{29}H_{32}O_4Si(Na^+)$ requires 495.197, found 495.196. Anal. Calc'd for $C_{29}H_{32}O_4Si$ (472.2): C, 73.69; H, 6.92. Found C, 73.33; H, 6.29. $[\alpha]_D^{22}$ +15.47˚ (c = 2.7, $CHCl_3$).

1,5-Anhydro-4-*O*-benzoyl-6-*O*-*t*-butyldiphenylsilyl-2,3-deoxy-1-oxo-D-*arabino*-hex-2-enitol (7). A solution of MCPBA (85% anhydrous, 0.04 g, 0.21 mmol) in CH_2Cl_2 (3 ml) was cooled to -20˚ and added to an equally cooled solution of **5** (0.10 g, 0.22 mmol) in CH_2Cl_2 (3 ml). $BF_3.Et_2O$ (0.012 ml, 0.013 g, 0.092 mmol) was added. The reaction was stirred at -20˚ for 3.5 hr and quenched with saturated $NaHCO_3$ solution (10 ml). The aqueous phase was reextracted with CH_2Cl_2 (3 X 10 ml), the organic phases were combined, dried ($MgSO_4$) and evaporated under reduced pressure to afford an orange solid (96 mg crude). Column chromatography (SiO_2, 3:2 light petroleum/ CH_2Cl_2) gave the desired product as a brown oil **7** (R_f 0.84 in 1:1, light petroleum/ ethyl acetate, 45.3 mg, 57%). IR (CH_2Cl_2): 3053s, 2931s, 2858s, 1965w, 1905w, 1820w, 1736s, 1649w, 1602m, 1588m, 1472m, 1452m, 1428s, 1390m, 1316m, 1266s, 1112s, 1070m, 1026m, 977m, 858w, 823m, 738s, 708s cm^{-1}. ^1H n.m.r. δ1.02, s, 9H, 3(CH_3) -BPS; 3.90,

d, *J* 4.0 Hz, 2H, (CH_2), H6; 4.7, q, *J* 4.0 Hz, 1H, H5; 5.93, t, *J* 4.8, 1H, H4; 6.14, d, *J* 10.9 Hz, 1H, H2; 6.89, dd, *J* 10.1, 3.7, 1H, H3; 7.17-7.66, m, 13 ArH; 8.01, d, *J* 6.7, 2ArH, (H2', H4') -Bz. ^{13}C n.m.r. δ19.22, CH_2, C6; 26.75, 3(CH_3) -BPS; 62.72, $\underline{C}(CH_3)_3$ -BPS; 63.92, CH, C5; 80.22, CH, C4; 123.02, CH, C3; 127.68, 127.75, ArCH, 2(C2', C6') -BPS; 128.47, ArCH, (C2', C6') -Bz; 128.77, ArC, (C1') -Bz; 129.74, ArCH, (C4') -Bz; 129.77, 129.83, ArCH, 2(C4') -BPS; 132.31, ArC, (C1') -BPS; 132.26, ArC, (C1') -BPS; 133.61, ArCH, (C3', C5') -Bz; 135.33, 135.47, ArCH, 2(C3', C5') -BPS; 141.93, CH, C2; 165.07, CO, C1. MS: 487.0 ($[M + H]^+$, 5%), 509.2 ($[M + Na]^+$, 100), 525.1 ($[M + K]^+$, 23), 995.2 ($[2M + Na]^+$, 23). HRMS calc'd for $C_{29}H_{30}O_5Si(Na^+)$ requires 509.176 found 509.175. Anal. Calc'd for $C_{29}H_{30}O_5Si$ (486.6): C, 71.58; H 6.21. Found C, 71.54; H, 6.28. $[\alpha]_D^{26}$ +106.9° (c = 3, $CHCl_3$).

2,3-Bis-deoxy-2H-3-nitromethyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-allonolactone (9a) and 2,3-bis-deoxy-2H-3-nitromethyl-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-gluconolactone (9b)

Method 1

A solution of the benzyl lactone **8** (50.0 mg, 0.11 mmol) in dry acetonitrile (2 ml) was added to a solution of 18-crown-6 (0.0014 g, 0.005 mmol) and KF (12 mg, 0.002 mmol) in dry acetonitrile (1 ml), followed by nitromethane (114 µL, 128.9 mg, 2.11 mmol). It was refluxed, and once the reaction was complete (1 hr) the solvent removed under vacuum, the residue dissolved in CH_2Cl_2 (3 ml) and washed with dil. HCl (1M, 2 X 3 ml). The organic extract was dried ($MgSO_4$) and reduced under pressure to afford an orange oil (56 mg). The crude product was purified using flash column chromatography (SiO_2, 3:1, light petroleum/ethyl acetate). The desired product in its isomer ratios of 9:2, **9a** (28 mg, 51%, R_f 0.59) to **9b** (6 mg, 11%, R_f 0.51) respectively were isolated, in addition to **9c** (6 mg, 11%, R_f 0.05).

Method 2

A solution of the benzyl lactone **8** (50.0 mg, 0.11 mmol) in dry THF (2 ml) was added to a solution of TBAF (62 µL, 0.002 mmol) in dry THF (1 ml), followed by nitromethane (114 µL, 128.9 mg, 2.11 mmol). It was refluxed, and once the reaction was complete (20 min) the solvent removed under vacuum, the residue dissolved in CH_2Cl_2 (3 ml) and washed with dil. HCl (1M, 2 X 3 ml). The organic extract was dried ($MgSO_4$) and reduced under pressure to afford an orange oil (40 mg). The crude product was purified using flash column chromatography (SiO_2, 10:1, light petroleum/ethyl acetate) to yield **9c** (20 mg, 66%). **9a** IR (CH_2Cl_2): 3055m, 2976w, 2956m, 2933m, 2860m, 1744s, 1557s, 1472w, 1428m, 1371w, 1286s, 1211w, 1182w, 1114m, 1088w, 1028m, 940w, 896w, 823w, 738s, 704s cm^{-1}. ^{1}H n.m.r. δ 1.06, s, 9H, 3(CH_3)- BPS; 2.55, 2.62, ABX, *J* 17.64, 10.05, 7.74 Hz, 2H, CH_2, H2; 3.16-3.25, m, 1H, CH, H3; 3.77, 3.81, ABX, *J* 11.19, 5.89, 4.41 Hz, 2H, CH_2, H6; 3.92, t, *J* 2.46 Hz, 1H, CH, H4; 4.27, 4,54, ABX, $J_{a\text{-}e}$ 13.20 Hz, $J_{a\text{-}3}$ 7.65 Hz, $J_{e\text{-}3}$ 6.41 Hz, 2H, CH_2, CH_2NO_2; 4.54, 4.56, ABq, *J* 11.20 Hz, 2H, O$\underline{CH_2}$Ph; 4.64-4.66, m, 1H, CH, H5; 7.28-7.99, m, 15ArH. Irradiations: H4, d, $J_{4,5}$ 1.90 Hz. H4, d, $J_{4,3}$ 2.90 Hz. H5, d, $J_{5,4}$ 1.90 Hz. ^{13}C n.m.r. δ 19.17, CH_2, C6; 26.82, 3($\underline{C}H_3$) -BPS; 29.84, CH_2, CH_2NO_2; 32.84, CH, C3; 63.36, $\underline{C}(CH_3)_3$ -BPS; 70.86, CH, C5; 71.72, CH_2, O$\underline{CH_2}$Ph; 75.30, CH_2, C2; 79.06, CH, C4; 127.90, 128.02, ArCH, 3(C2', C4') -Bn, BPS; 128.35, 128.63, ArCH, 2(C4') -

BPS; 130.05, ArCH, (C3', C5') -Bn; 131.73, ArC, (C1') -BPS; 132.14, ArC, (C1') -BPS; 135.38, 135.51, ArCH, 2(C3', C5') -BPS; 136.40, ArC, (C1') -Bn; 167.61, CO, C1. MS: 532.3 ($[M]^+$, 30%), 556.2 ($[M + Na]^+$, 60), ($[M + CH_3NO_2(H)]^+$, 100), 1089.3, ($[2M + Na]^+$, 20). HRMS calc'd for $C_{30}H_{35}NO_6Si(Na^+)$ requires 556.213, found 556.213. $C_{30}H_{35}NO_6Si(K^+)$ requires 572.187, found 572.187. Anal. Calc'd for $C_{30}H_{35}NO_6Si$ (533.7): C 67.52; H6.61. Found C 67.01, H 6.29. $[\alpha]_D^{23}$ +7.66˚ (c = 0.3, $CHCl_3$). **9b** This compound decomposed rapidly. IR (CH_2Cl_2): 3054m, 2986m, 2932m, 2860m, 1736s, 1557s, 1428s, 1379w, 1266s, 113m, 1028w, 896w, 823w, 739s, 704s cm^{-1}. ^1H n.m.r. δ 1.08, s, 9H, 3(CH_3)- BPS; 2.42-2.60, m, 2H, CH_2, H2; 2.89, td, $J_{3,4}$ 12.75 Hz, $J_{3\text{-}2a}$ 6.02 Hz, $J_{3\text{-}2e}$ 4.50 Hz, 1H, CH, H3; 3.84, dd (ABX), $J_{6a\text{-}e}$ 12.0 Hz, $J_{6a\text{-}5}$ 2.40 Hz, 1H, CH of CH_2, H6; 3.97, dd (ABX), $J_{6e\text{-}5}$ 1.80 Hz, 1H, CH of CH_2, H6; 3.92, t, *J* 7.80 Hz, 1H, CH, H4; 4.24, td, $J_{5\text{-}4}$ 7.80Hz, $J_{5\text{-}6a}$ 2.10 Hz, $J_{5\text{-}6e}$ 1.80 Hz, 1H, CH, H5; 4.35, 4,44, ABX, $J_{a\text{-}e}$ 12.60 Hz, $J_{a\text{-}3}$ 6.60 Hz, $J_{e\text{-}3}$ 4.80 Hz, 2H, CH_2, CH_2NO_2; 4.55, s, 2H, 0C$\underline{H_2}$Ph; 4.31-4.46, m, 9ArH; 7.64-7.85, m, 15ArH. ^{13}C n.m.r. δ 19.11, C6, (CH_2); 26.96, 3($\underline{C}H_3$) -BPS; 31.71, CH_2, (CH_2NO_2); 36.48, C3, (CH); 62.78, $\underline{C}(CH_3)_3$ -BPS; 72.42, C5, (CH); 73.57, C2, (CH_2); 76.13,CH_2, (OC$\underline{H_2}$Ph); 79.91, C4, (CH); 127.79, 127.84, ArCH, 2(C2', C6') -BPS; 127.95, ArCH (C2', C6') -Bn; 128.36, ArCH, (C4') -Bn; 128.63, ArCH, 2(C4') -BPS; 129.95, ArCH, (C3', C5') -Bn; 133.99, ArC, 2(C1') -BPS; 135.49, 135.67, ArCH, 2(C3', C5') -BPS; 136.55, ArC, (C1') -Bn; 155.27, C1, (CO). MS: 532.3 ($[M]^+$, 80%), 533.3 ($[M + H]^+$, 35), 556.2 ($[M + Na]^+$, 20). **9c** IR (CH_2Cl_2): 3678w, 3600w, 3448w, 3055m, 2987m, 2931m, 2360w, 2306w, 1740m, 1557s, 1498w, 1422m, 1383w, 1285s, 1071w, 1028w, 896w, 740s, 795 cm^{-1}. ^1H n.m.r. δ (400 MHz) 1.50-2.20, bs, OH; 2.57, 2.63, ABX, *J* 17.47, 9.44, 3.27 Hz, 2H, CH_2, H2; 3.14-3.22, m, 1H, CH, H3; 3.76, 3.91, ABX, $J_{6a\text{-}e}$ 12.10 Hz, $J_{6a\text{-}5}$ 4.56 Hz, $J_{6e\text{-}5}$ 3.72 Hz, 2H, CH_2, H6; 3.90, t, *J* 3.34, 3.27 Hz, 1H, CH, H4; 4.58, 4.62, ABX, $J_{e\text{-}a}$ 13.24 Hz, $J_{e\text{-}3}$ 6.61 Hz, $J_{a\text{-}3}$ 7.43 Hz, 2H, CH_2, CH_2NO_2; 4.58, 4.62, ABq, *J* 11.41 Hz, 2H, CH_2, OC$\underline{H_2}$Ph; 4.58-4.60, m, 1H, CH, H5; 7.27-7.65, m, 5ArH. ^{13}C n.m.r. δ 29.61, CH_2, C6; 33.17, CH, C3; 62.29, CH_2, CH_2NO_2; 70.95, CH, C5; 72.04, CH_2, O$\underline{C}H_2$Ph; 75.11, CH_2, C2; 79.79, CH, C4; 128.06, ArCH, 2(C2', C6'), 128.40, ArCH, (C4'); 128.64, ArCH, (C3', C5'); 136.35, ArC, (C1'); 163.66, CO, C1. MS: 318.1 ($[M + Na]^+$, 100%), 334.2 ($[M + K]^+$, 25), 629.3 ($[2M + K]^+$, 25).

2,3-Bis-deoxy-2H-3-phenylthio-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-allonolactone (10a) and 2,3-bis-deoxy-2H-3-phenylthio-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-gluconolactone (10b)

Method 1

To a solution of the benzyl lactone **8** (50.0 mg, 0.11 mmol) in anhydrous THF (2 ml), under a stream of nitrogen, TBAF (0.56 μL 0.002 mmol) was added whilst stirring at room temperature (18°), followed by thiophenol (9.85 μL, 0.10 mmol). After 1 hr the solvent was evaporated *in vacuo* to give a colourless oil. The crude product was purified *via* flash column chromatography (SiO_2, 5:1, light petroleum/ethyl acetate) to afford the desired product in its isomer ratios of 3:1, derivatives **10a** (25.2 mg, 45%, R_f 0.76) to **10b** (8.40 mg, 15%, R_f 0.65 (2:1, CH_2Cl_2/light petroleum), respectively. The lactone **8** (7.5 mg, 15%, R_f 0.54 in 2:1, CH_2Cl_2/light petroleum) was also isolated. **10a** IR (CH_2Cl_2): 3054m, 2955m, 2932m, 2860m, 1740s, 1589w, 1560w,

1543m, 1473m, 1439m, 1428m, 1379w, 1286s, 1215m, 1114s, 1026m, 942w, 896w, 823m, 739s, 704s cm^{-1}. ^1H n.m.r δ 0.98, s, 9H, 3(CH_3) -BPS; 2.75, (dd) ABX, $J_{2e\text{-}3e}$ 5.49 Hz, $J_{2a\text{-}3}$ 10.02 Hz, $J_{2e\text{-}a}$ 17.58 Hz, 1H, CH of CH_2, H2; 2.84, (dd), ABX, $J_{2a\text{-}3e}$ 10.02 Hz, $J_{2a\text{-}e}$ 17.58 Hz, 1H, CH of CH_2, H2; 3.76, 3.80, ABX, $J_{6e\text{-}5a}$ 11.33 Hz, $J_{6a\text{-}5}$ 17.24 Hz, $J_{6a\text{-}e}$ 20.46 Hz, 2H, CH_2, H6; 3.86-3.96, m, 1H, CH, H3; 4.14, t, $J_{4e\text{-}3e}$ 3.16 Hz, $J_{4e\text{-}5e}$ 3.57 Hz, 1H, H4; 4.58-4.62, m, 1H, CH, H5; 4.62, 4.71, ABq, *J* 11.53 Hz, 2H, O$\underline{C}H_2$Ph; 7.25-7.49, m, 12ArH; 7.56-7.59, m, 8ArH. Irradiations: H3, dd $J_{3\text{-}2}$ 5.49, 10.02 Hz. H5, q, $J_{5\text{-}6}$ 11.54, 8.93 Hz. H5 d, $J_{5\text{-}4}$ 3.6 Hz. ^{13}C n.m.r δ 19.22, CH_2, C6; 26.87, 3($\underline{C}H_3$) -BPS; 33.96, CH_2, C2; 44.13, CH, C3; 65.23 $\underline{C}(CH_3)_3$ -BPS; 72.41, CH_2, (O$\underline{C}H_2$Ph); 74.36, CH, C5; 80.15 CH, C4; 128.03, 128.06, ArCH, 2(C2', C6') -BPS; 128.19, ArCH, (C2', C6') -Bn; 128.32, ArCH, (C2', C6') -SPh; 128.62, 129.40, 130.14, ArCH, 4(C4'); 132.03, ArC, (C1'); 132.69, ArC, (C1'); 133.05, ArCH, 2(C3', C5') -Bn, SPh; 133.37, ArC, (C1'); 135.54, 135.88, ArCH, 2(C3', C5') -BPS; 137.27, ArC, C1'; 166.50, C1, CO. MS: 605.3 ($[M + Na]^+$ 100%), 621.2 ($[M + K]^+$ 28). HRMS calc'd for $C_{35}H_{38}O_4SSi(Na^+)$ requires 605.216, found 605.217. $C_{35}H_{38}O_4SSi(K^+)$ requires 621.190, found 621.189. $[\alpha]_D^{23}$ +29.6˚ (c = 0.25, $CHCl_3$). **10b** IR (CH_2Cl_2): 3645w, 3466w, 2985s, 2942s, 2909s, 2086w, 1890w, 1750s, 1448s, 1373s, 1301s, 1232s, 1160w, 1098s, 1047s, 938m, 918m, 847m, 787w, 743w, 705m cm^{-1}. ^1H n.m.r. δ 1.07, s, 9H, 3(CH_3) -BPS; 2.63, (dd)- ABX, $J_{2a\text{-}2e}$ 16.62 Hz, $J_{2e\text{-}3}$ 5.37 Hz, 1H, CH of CH_2, H2; 3.02 (dd)- ABX, $J_{2a\text{-}3}$ 6.73 Hz, 1H, CH of CH_2, H2; 3.66, bq, $J_{3\text{-}4}$ 5.63 Hz, $J_{3\text{-}5}$ 12.09 Hz, 1H, CH, H3; 3.91, qd, $J_{6a\text{-}e}$ 21.79, $J_{6e\text{-}5}$ 11.49 Hz, Hz, $J_{6a\text{-}5}$ 2.70 Hz, 2H, CH_2, H6; 4.04, dd, $J_{4e\text{-}5e}$ 7.97 Hz, $J_{4e\text{-}3a}$ 5.63 Hz, 1H, CH, H4; 4.21 td, $J_{5e\text{-}4e}$ 7.97 Hz, $J_{5e\text{-}6a}$ 5.63 Hz, $J_{5e\text{-}6e}$ 2.75 Hz, 1H, CH, H5; 4.59, 4.82, ABq, *J* 10.99 Hz, 2H, O$\underline{C}H_2$Ph; 7.28-7.69, m, 20ArH. ^{13}C n.m.r. δ19.37, CH_2, C6; 26.93, 3($\underline{C}H_3$) -BPS; 34.55, CH_2, C2; 45.49, CH, C3; 62.65 $\underline{C}(CH_3)_3$ -BPS; 73.39, CH_2, O$\underline{C}H_2$Ph; 75.06, CH, C5; 81.11, CH, C4; 127.70, 127.73, ArCH, 2(C2', C6')- BPS; 127.90, 128.01, 128.13, 128.30, ArCH, 2(C2', C6') -Bn, SPh; 128.40, 129.26, ArCH, 2(C4') -Bn, SPh; 129.77, 129.78, ArCH, (C4') -BPS; 132.24, 132.34, 132.94, 3ArC, 3(C1'); 133.44, ArCH, 2(C3', C5') -Bn, SPh; 135.51, 135.61, 135.68, ArCH, 2(C3', C5'); 137.00, ArC, C1'; 169.24, C1, (CO). MS: 605.4 ($[M + Na]^+$, 50%), 621.2 ($[M + K]^+$, 100). HRMS calc'd for $C_{35}H_{38}O_4SSi(Na^+)$ requires 605.216, found 605.214. $C_{35}H_{38}O_4SSi(K^+)$ requires 621.190, found 621.185. $[\alpha]_D^{23}$ +9.33˚ (c = 0.45, $CHCl_3$).

2,3-Bis-deoxy-2H-3-benzylamino-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-allonolactone (11a) and 2,3-bis-deoxy-2H-3-benzylamino-4-*O*-benzyl-6-*O*-*t*-butyldiphenylsilyl-D-gluconolactone (11b)

Method 1

A solution of the benzyl lactone **8** (100 mg, 0.21 mmol) in dry methanol (1 ml) was treated with freshly distilled benzylamine (22.6 mg, 23.0 μL, 0.21 mmol) and left stirring at room temperature. The reaction was monitored by t.l.c and once complete (24 hr), quenched with water (5 ml) and extracted with Et_2O (2 X 10 ml). The organic extracts were combined, dried ($MgSO_4$) and concentrated to give a colourless oil (112 mg). The crude product was purified by

flash column chromatography (SiO_2, 5:1, light petroleum/ethyl acetate) to yield the desired product in its isomer ratios of 2:3, compounds **11b** (49 mg, 40%, R_f 0.33) and **11a** (73 mg, 60%, R_f 0.28) respectively.

Method 2

A solution of the benzyl lactone **8** (52.0 mg, 0.11 mmol) in dry methanol (2 ml) was treated with freshly distilled benzylamine (33.0 mg, 36.0 μL, 0.33 mmol) and subjected to reflux. The reaction was monitored via t.l.c and once complete (8 hr), quenched with water (5 ml) and extracted with Et_2O (2 X 10 ml). The organic extracts were combined, dried ($MgSO_4$) and concentrated to give a colourless oil (78 mg). The crude product was purified by flash column chromatography (SiO_2, 3:1, light petroleum/ethyl acetate) to yield the desired product in one of its isomer forms **11a** (57 mg, 92%).

Method 3

A solution of the benzyl lactone **8** (73.0 mg, 0.15 mmol) in dry methanol (2 ml) was treated with freshly distilled benzylamine (16.5 mg, 16.8 μL, 0.15 mmol) and left stirring for 4 hr at 0° and then placed in the fridge for 18 hr. The reaction was quenched with water (5 ml) and extracted with Et_2O (2 X 5 ml). The organic extracts were combined, dried ($MgSO_4$) and concentrated to give a colourless oil (120 mg). The crude product was purified by flash column chromatography (SiO_2, 5:1, light petroleum/ethyl acetate) to yield the desired product in its isomer ratios of 2:1 **11b** (54.0 mg, 60%) and **11a** (27 mg, 30%).

Method 4

A solution of the benzyl lactone **8** (73.0 mg, 0.15 mmol) in dry methanol (2 ml) was treated with freshly distilled benzylamine (16.5 mg16.8 μL, 0.15 mmol) and left stirring for 6 hr at -78^o and left in the freezer for 18 days. The reaction was quenched with water (5 ml) and extracted with Et_2O (2 X 10 ml). The organic extracts were combined, dried ($MgSO_4$) and concentrated to give a colourless oil (90 mg). The crude product was purified by flash column chromatography (SiO_2, 5:1, light petroleum/ethyl acetate) to yield the desired product in its isomer ratios of 5:1, **11b** (30.0 mg, 34%) and **11a** (6.3 mg, 7%), in addition to recovered **8** (21.9 mg, 30%). **11a** IR (CH_2Cl_2): 3306m, 3052m, 2931s, 2858s, 1652m, 1588w, 1545m, 1496m, 1472m, 1455s, 1428s, 1391w, 1362w, 1266s, 1189w, 1113s, 1029m, 1008w, 911w, 824m, 738s, 701s cm^{-1}. ^{1}H n.m.r. δ 1.09, s, 9H, 3(CH_3) -BPS; 2.47, 2.56, ABX, $J_{2a\text{-}e}$ 15.52 Hz $J_{2a\text{-}3}$ 7.84 Hz, $J_{2e\text{-}3e}$ 4.16 Hz, 2H, CH_2, H2; 2.58-2.94, bs, NH; 3.34, bp, *J* 3.92, 7.79 Hz, 1H, CH, H3; 3.64-3.70, m, 1H, CH, H4; 3.73, s, 2H, CH_2, NHC$\underline{H_2}$Ph; 3.75- 3.90, m, 1H, CH, H5; 4.39, 4.41, ABq, *J* 6.20 Hz, 2H, OC$\underline{H_2}$Ph; 4.30-4.60, m, 2H, CH_2, H6; 7.05-7.70, m, 20H, 20ArH. Irradiations: H3, d, $J_{3\text{-}4}$ 3.0Hz. H4, t, $J_{4\text{-}5}$ 6.2 Hz. ^{13}C n.m.r. δ 19.39, CH_2, C6; 27.03, 3(C$\underline{H_3}$) -BPS; 36.30, CH_2, C2; 51.22, CH_2, (NH$\underline{C}H_2$Ph); 56.42, CH, C3; 65.33, $\underline{C}(CH_3)_3$ -BPS; 72.81, CH, C5; 73.64, O$\underline{C}H_2$Ph C6; 78.55, CH, C4; 127.24, 127.55, 127.70, 127.81, 128.17, 128.33, 128.36, 128.51, ArCH, 4(C2', C4'); 129.74, ArCH, 2(C3', C5') -Bn, NHPh; 132.81, ArC, (C1') -BPS; 133.04, ArC, (C1') -BPS; 135.47, 135.54, ArCH, 2(C3', C5') -BPS; 137.82, ArC, (C1'); 138.3, ArC, C1'; 171.91, CO, C1. MS: 580.29 ([M + H]$^+$, 5%), 687.36 ([M + $BnNH_3$]$^+$, 60). HRMS calc'd for $C_{36}H_{41}NO_4Si(H^+)$

requires 580.288 found 580.289, $C_{36}H_{41}NO_4Si(BnNH_3^+)$ requires 687.362 found 687.361. $[\alpha]_D^{22}$ -7.83° (c = 1, $CHCl_3$) **11b** IR (CH_2Cl_2): 3056m, 2933s, 2932s, 2845s, 1748s, 1472m, 1428m, 1263m, 1113s, 1030m, 823m, 740s, 782s cm^{-1}. ^1H n.m.r. δ 1.03, s, 9H, 3(CH_3) -BPS; 2.61, 2.69 ABX, $J_{2a\text{-}e}$ 15.87 Hz, $J_{2a\text{-}3}$ 6.04 Hz, $J_{2e\text{-}3}$ 5.36 Hz, 2H, CH_2, H2; 2.82-3.02, bs, NH; 3.29, bp, *J* 5.91 Hz, 11.40 Hz, 1H, CH, H3: 3.51-3.83, m, 4H, 2(CH) H4, H5 and 1(CH_2), H6; 3.56, s, 2H, CH_2, NHC$\underline{H_2}$Ph; 4.48, 4.52, ABq, *J* 11.06 Hz, 2H, OC$\underline{H_2}$Ph; 7.07-7.10, m, 2ArH; 7.12-7.38, m, 14ArH, 7.56-7.67, m, 4ArH. ^{13}C n.m.r. δ 19.45, CH_2, C6; 27.08, 3($\underline{C}H_3$) -BPS; 34.55, C2, (CH_2); 51.38, CH_2, (NH$\underline{C}H_2$Ph); 57.11, CH, C3; 65.19, $\underline{C}(CH_3)_3$ -BPS; 73.86, CH_2, OCH2Ph; 74.27, CH, C5; 78.72, CH, C4; 127.31, 127.83, 127.87, 127.91, 127.98, 128.41, 128.46, 128.59, ArCH, 4(C2', C6'); 129.84, ArCH, 2(C3', C5') -Bn; 133.21, ArC, (C1'); 133.50, ArC, (C1'); 135.34, 135.77, 135.81, 135.89, ArCH, 2(C3', C5') -Bn; 138.21, ArC, (C1'); 139.67, ArC, (C1'); 173.09, CO, C1. MS: 578.3 ($[M]^+$, 15%), 596.3 ($[M + NH_3]^+$, 47), 610.4 ($[M + MeOH]^+$, 100).

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