# Acyclic Stereocontrol in Additions of Grignard Reagents to α-Alkoxyiminium Ions. A Stereoselective Approach to *threo* Amino Ethers

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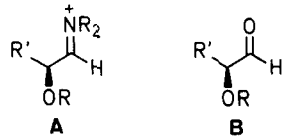
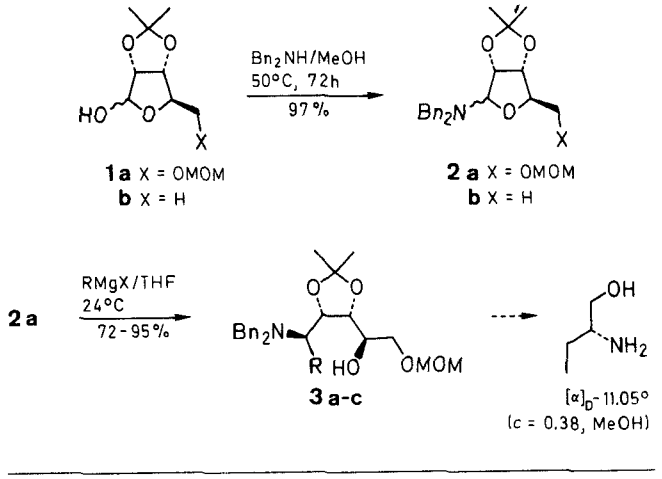
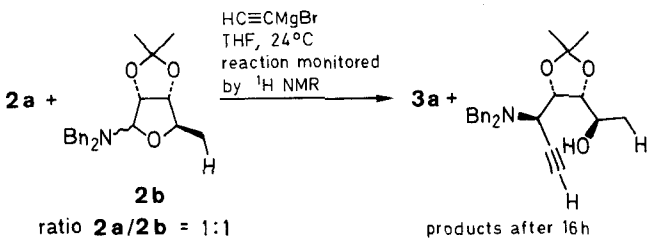
The data in this paper suggest that reactions of Grignard reagents with dialkylaminofuranosides derived from pentoses proceed via α-alkoxyiminium ions and that these α-alkoxyiminium ions react quite stereoselectively. The rate of this reaction is dependent on the substituent at the 5-position of the pentose. A 5-deoxy analog is shown to react very slowly compared with a 5-*O*-methoxymethyl derivative. Importantly, the face selectivity of iminium ions with nucleophiles is shown to be opposite that expected and observed for reactions of aldehydes. A predictive mechanistic model is presented.

The ability to predict the stereochemical outcome for additions of nucleophilic reagents to acyclic α-alkoxyaldehydes and ketones has had an enormous impact on the practice of chemical synthesis.[2] Iminium ions **A** and aldehydes **B** have some obvious similarities. The data in this paper suggest that reactions of dialkylaminoglycosides with Grignard reagents proceed via α-alkoxyiminium ions and that these α-alkoxyiminium ions react stereoselectively. Importantly, the face selectivity of iminium ions **A** with nucleophiles is shown to be opposite that expected for reactions of aldehydes **B**. A predictive model is presented.




| 3 | a | b | c |
|---|---|---|---|
| R | C≡CH | $CH=CH_2$ | Et |



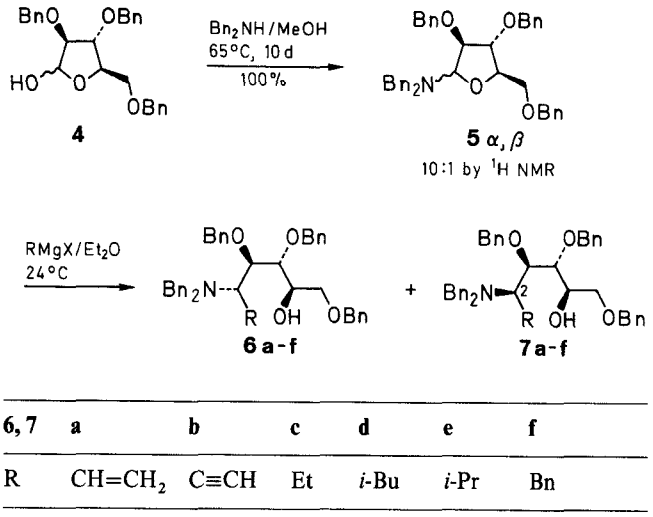

**Scheme 1**

In 1972 Couturier reported the reaction of dialkylaminotetrahydropyran with ethynylmagnesium bromide.[3] Our interest in analogs of nucleosides and aminosugars led us to test this reaction with dialkylaminoglycosides.[4-6] A protected ribose hemiacetal **1a** was converted to the dibenzylaminoglycoside **2a** (Scheme 1). Treatment of ribosylamine **2a** with ethynylmagnesium bromide at 24°C in THF for 15 minutes provided a 95% yield of a single diasteromer, the propargylic amine **3a**. Similar results were found for diethylamino- and diallylaminoglycosides. Stereoselectivity was equally good with ethyl, ethenyl, and ethynyl Grignard reagents. (The structures of the ethynyl, ethenyl, and ethyl Grignard products were established by converting them to (*R*)-(−)-2-amino-1-butanol by standard procedures.)

This reaction with **1a** is much faster than the analogous reaction reported by Couturier. Chelation by the 5-alkoxy substituent of **2a** could favor a mechanism that involved coordination of the leaving group with a magnesium ion. To evaluate this hypothetical effect, the 5-deoxyribosylamine **2b** was prepared[7] (Scheme 1). It was found that **2b** reacts much more slowly with ethynylmagnesium bromide than **2a**. In a competitive experiment, a 1:1 mixture of **2a** and **2b** was treated at 24°C in THF with ethynylmagnesium bromide. In 10 minutes, **2a** was completely consumed; after 3 hours, only 40% of **2b** had reacted.

Similar results were found in the arabinose series. Tribenzylarabinose **4** was converted to the arabinosylamines **5α** and **5β** (Scheme 2). Treatment of these amines with ethenylmagnesium bromide provided a single product, allylic amine **6a** in 80% yield. A 10:1 mixture of anomeric amines (**5α** and **5β**) gave the same stereochemical result as a 1:1 mixture of those amines. Ethynyl and ethyl Grignard reagents were less selective and provided 88:12 (**6b/7b**, 99% yield) and 79:21 (**6c/7c**, 77% yield) mixtures of products, respectively.

A mechanism consistent with these results begins with coordination-assisted heterolysis of the aminoglycoside **i** to provide iminium ion **ii** (Figure 1a). Reaction of this iminium ion with an external Grignard reagent would afford the product **iii**. The arabinose and ribose systems both give *threo* amino ether products: the ribose system reacts on the *re* face of the iminium ion while the




| 6,7 | a | b | c | d | e | f |
|---|---|---|---|---|---|---|
| R | $CH=CH_2$ | C≡CH | Et | *i*-Bu | *i*-Pr | Bn |

**Scheme 2**

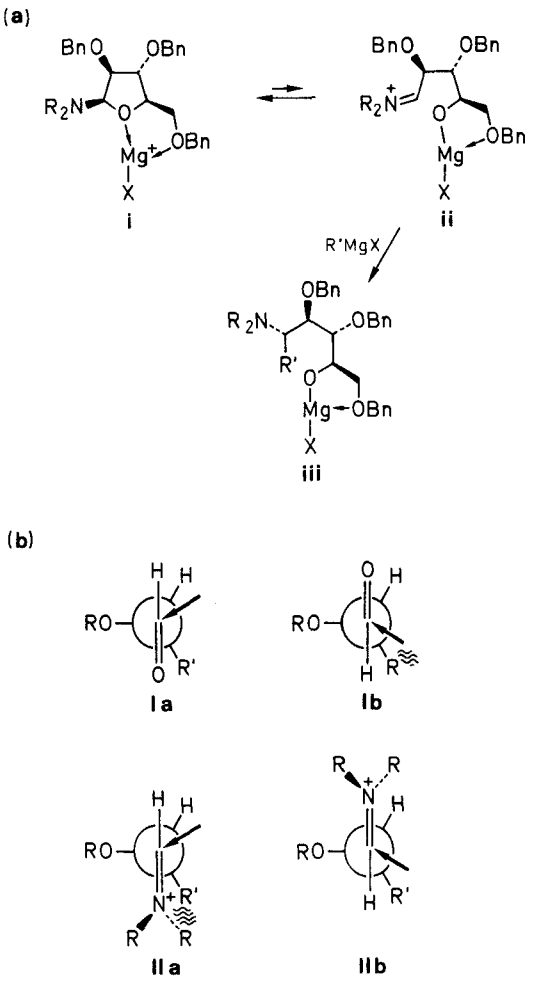



**Figure 1. (a)** A hypothetical reaction pathway consistent with the observed data. **(b)** Newman representations illustrating the potential steric interactions and electronic effects that could influence the stereochemical outcome in these reactions.[10] While **Ia** is more stable than **Ib**, the stereochemical outcome of additions to α-alkoxyiminium ions can be explained by the hypothesis that **IIa** is *less* stable than **IIb** because of $A_{1,3}$ steric interactions present in **IIa**.

arabinose system reacts preferentially on the *si* face of the iminium ion. The simplest explanation of this is that the stereocenter at C-2 is controlling the addition process and that the C-3 and C-4 stereocenters are not important factors. A more complicated mechanism that would invoke delivery of the nucleophile from some intramolecular coordination site was considered, but discarded. It is proposed that stereocontrol in this process is established during reaction of an external nucleophile with the α-alkoxyiminium ion.[8]

Model transition states for this key step and for the analogous reaction of α-alkoxyaldehydes have been considered. Newman projections **Ia** and **Ib** (Figure 1b) represent the canonical models for transition-state interactions during addition of nucleophiles to α-alkoxyaldehydes.[10] Both diastereomeric models provide for the incoming nucleophile to approach the side opposite the α-alkoxy substituent along an electronically favorable trajectory.[10a] Steric interactions between the incoming nucelophile and the α-alkyl substituent will favor **Ia** over **Ib**, and therefore *erythro* products are to be expected.

The situation for iminium ions is quite different. Transition state **IIa** is analogous to **Ia** but it is improbable. The $A_{1,3}$ steric interactions between the syn *N*-alkyl group and the α-substituents in **IIa** will greatly destabilize this activated complex. The diastereomeric transition state rotamer **IIb** does not have this unfavorable $A_{1,3}$ interaction. Both **IIa** and **IIb** still allow for approach of the nucleophile from the side opposite the electronegative α-substituent and along a favorable trajectory. The energetic advantage of *si* reactivity for **I** is not present for **II** due to $A_{1,3}$ strain and for this reason α-alkoxyiminium ions afford threo amino ethers but α-alkoxyaldehydes afford *erythro* hydroxy ethers.

In summary, the reactions of a dialkylribosylamine and a dialkylarabinosylamine with alkylmagnesium halides proceed efficiently and with excellent stereocontrol. The rate of the reaction is sensitive to the presence of an oxygen at C-5 and the reaction is stereoselective but not stereospecific. In both cases the reaction favors *threo* amino ether products and contrasts with reactions of α-alkoxyaldehydes, which afford *erythro* products. The stereochemical outcome is proposed to be dominated by an $A_{1,3}$ interaction present in the iminium ions and not present for the aldehydes. It is hoped that this work will encourage further experiments and calculations concerning acyclic stereocontrol in reactions of α-alkoxyiminium ions.

**N,N-Dibenzyl-5-*O*-methoxymethyl-2,3-*O*-(1-methylethylidene)-β-D-ribofuranosylamine and N,N-Dibenzyl-5-*O*-methoxymethyl-2,3-*O*-(1-methylethylidene)-α-D-ribofuranosylamine (2a):**

To a stirred solution of 5-*O*-methoxymethyl-2,3-*O*-(1-methylethylidene)-D-ribofuranose (66 mg, 2.82 mmol) in MeOH (0.6 mL) at r.t. under nitrogen was added dibenzylamine (556 mg, 2.82 mmol). The solution was then heated to 50 °C. After 72 h, the mixture was diluted to 5 mL with $CH_2Cl_2$ and then concentrated under reduced pressure to yield 1.13 g (97 %) of product which appeared to be a 20:1 ratio of anomers.

*β-Anomer* (**2a-β**): $R_f$ 0.34 (silica gel, 30 % EtOAc/hexane); $[\alpha]_D^{22}$ − 62.0° (*c* = 1.03, $CHCl_3$).

IR ($CHCl_2$): $\nu$ = 3027, 3022, 3013, 2998, 2939, 2907, 293, 1495, 454, 1384, 1376, 1227, 1215, 1212, 1154, 1154, 1104, 1076, 1036 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.42–7.20 (m, 10 H), 4.79 (d, 1 H, $J$ = 4.1 Hz), 4.70 (d, 1 H, $J$ = 7.4 Hz), 4.68 (d, 1 H, $J$ = 6.7 Hz), 4.59 (dd, 1 H, $J$ = 6., 4.3 Hz), 4.46 (dd, 1 H, $J$ = 6.6, 4.2 Hz), 4.00 (dd, 1 H, $J$ = 9.1, 4.6 Hz), 3.87 (d, 2 H, $J$ = 14.5 Hz), 3.74 (d, 2 H, $J$ = 14.5 Hz), 3.72 (m, 1 H), 3.39 (s, 3 H), 1.38 (s, 3 H), 1.30 (s, 3 H).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 139.2, 128.6, 127.0, 113.8, 97.0, 96.8, 82.1, 80.8, 80.6, 68.0, 55.3, 53.5, 27.4, 25.6.

HRMS: $m/z$ ($M^+$) calcd for $C_{24}H_{31}NO_5$ 413.22033, found 413.22084.

**N,N-Dibenzyl-5-deoxy-2,3-O-(1-methylethylidene)-β-D-ribofuranosylamine (2b):**

To a stirred solution of 5-deoxy-2,3-(1-methylethylidene)-D-ribofuranose (75 mg, 0.43 mmol)[7] in MeOH (0.1 mL) at r.t. under nitrogen was added dibenzylamine (89 mg, 0.43 mmol). The solution was then heated to 50 °C. After 72 h, the mixture was diluted to 5 mL with $CH_2Cl_2$, concentrated under reduced pressure, and flash chromatographed (6″ × 10 mm column, silica gel, 30% EtOAc/hexane) to yield 60 mg (39%) of **2b**; $R_f$ 0.50 (silica gel, 30%) EtOAc in hexane); $[\alpha]_D^{22}$ – 67.1° ($c$ = 1.00, $CHCl_3$).

IR ($CHCl_3$): $\nu$ = 3028, 3023, 3014, 2992, 2936, 1495, 1454, 1384, 1376, 1264, 1229, 1222, 1203, 1159, 1141, 1114, 1077, 967, 930 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.40–7.20 (m, 10 H), 4.72 (d, 1 H, $J$ = 3.8 Hz), 4.59 (dd, 1 H, $J$ = 6.8, 3.8 Hz), 4.12 (dd, 1 H, $J$ = 12.2, 6.6 Hz), 3.86 (dd, 1 H, $J$ = 11.0, 6.1 Hz), 3.83 (d, 2 H, $J$ = 13.8 Hz), 3.72 (d, 2 H, $J$ = 14.4 Hz), 1.40 (s, 3), 1.35 (d, 3 H, $J$ = 6.4 Hz), 1.28 (s, 3 H).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 139.2, 128.7, 127.1, 114.2, 96.5, 84.8, 83.0, 78.2, 53.7, 27.4, 25.7, 19.1.

HRMS: $m/z$ ($M^+$) calcd for $C_{22}H_{27}NO_3$ 353.19921, found 353.19858.

**3-Amino-N,N-dibenzyl-1,2,3-trideoxy-7-O-methoxymethyl-4,5-O-(1-methylethylidene)-D-*altro*-hept-1-ynitol (3a):**

To rapidly stirred THF (6 mL) at – 78 °C under nitrogen was added acetylene gas (719 mg, 27.6 mmol) over 15 min. The solution was then warmed to 0 °C and treated carefully with a solution of EtMgBr (1.14 g, 8.28 mmol) in $Et_2O$ (1.7 mL). After vigorous ethane evolution had ceased, the white slurry was warmed to r.t. and treated with a solution of ribosyl amine anomers **2a** (1.14 g, 2.76 mmol) by cannulation. After 30 min, the orange mixture was cooled to 0 °C and quenched with sat. aq $K_2CO_3$ (1 mL). The mixture was then diluted to 60 mL with $CH_2Cl_2$ and washed with sat. aq $K_2CO_3$ (50 mL). The organic phase was dried ($MgSO_4$), filtered, and concentrated under reduced pressure to yield a yellow oil which appeared to be purely one diastereomer by $^1H$ NMR. Flash chromatography (6″ × 30 mm column, silica gel, 40% EtOAc in hexane) yielded, after removal of volatile components under reduced pressure, 1.26 g (95%) of the desired propargylic amine **3a**; $R_f$ 0.29 (silica gel, 40% EtOAc/hexane); $[\alpha]_D^{22}$ – 69.4° ($c$ = 1.03, $CHCl_3$).

IR ($CHCl_3$): $\nu$ = 3569, 3303, 3065, 3028, 3021, 3011, 2992, 2939, 2889, 2839, 2835, 2829, 1495, 1454, 1383, 1373, 1242, 1227, 1215, 1151, 1115, 1072, 1060, 1038, 911 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.43–7.21 (m, 10 H), 4.62 (s, 2 H), 4.45 (dd, 1 H, $J$ = 7.8, 5. Hz), 4.08 (dd, 1 H, $J$ = 9.1, 5.2 Hz), 4.02 (d, 2 H, $J$ = 13.5 Hz), 3.96 (, 1 H), 3.84 (dd, 1 H, $J$ = 7.9, 2.2 Hz), 3.69 (dd, 1 H, $J$ = 10.6, 2.6 Hz), 3.60 (dd, 1 H, $J$ = 10.6, 5.9 Hz), 3.47 (d, 2 H, $J$ = 13.5 Hz), 3.34 (s, 3 H), 2.54 (d, 1 H, $J$ = 2.2 Hz), 1.32 (s, 3 H), 1.31 (s, 3 H).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 138.7, 129.3, 128.3, 127.2, 108.6, 96.9, 79.7, 77.4, 75.0, 69.9, 68.0, 55.3, 53.1, 50.8, 27.5, 25.3.

HRMS: $m/z$ ($M^+$) calcd for $C_{26}H_{33}NO_5$ 439.23600, found 439.23590.

**Competition Experiment. 3-Amino-N,N-dibenzyl-1,2,3,7-tetradeoxy-4,5-O-(1-methylethylidene)-D-*altro*-hept-1-ynitol and 3-Amino-N,N-dibenzyl-1,2,3-trideoxy-7-O-methoxymethyl-4,5-O-(1-methylethylidene)-D-*altro*-hept-7-ynitol (3a):**

To a rapidly stirred THF (2 mL) at – 78 °C under nitrogen was added acetylene gas (64.0 mg, 2.46 mmol) over 1.5 min. The solution was then warmed to 0 °C and treated carefully with a solution of EtMgBr (110 mg, 0.82 mmol) in $Et_2O$ (0.17 mL). After vigorous ethane gas evolution had ceased, the solution was warmed to r.t. and treated with a solution of ribosyl amine anomers **2a** (170 mg, 0.41 mmol) and (0.4 mL) 5-deoxy ribosyl amine derivative **2b** (145 mg, 0.41 mmol) in THF by cannulation. Progress of the reaction was followed by withdrawing 50 μL aliquots from the mixture periodically and monitoring product formation by $^1H$ NMR. The ribosyl amine derivatives **2a** appeared to be completely converted to propargylic amine **3a** after only 10 min while the 5-deoxy derivative **2b** was less than half converted to propargylic amine derivative after 3 h. After 16 h, the orange mixture was cooled to 0 °C and quenched with sat. aq $K_2CO_3$ (0.2 mL). The mixture was then diluted to 30 mL with $CH_2Cl_2$ and washed with sat. aq $K_2CO_3$ (30 mL). The organic phase was dried ($MgSO_4$), filtered, and concentrated under reduced pressure to yield a yellow oil. Flash chromatography (6″ × 10 mm column, silica gel, 30% EtOAc/hexane) yielded the 7-methoxymethyl material **3a** as well as a pure sample of the 7-deoxypropargylic amine.

*3-Amino-N,N-dibenzyl-1,2,3,7-tetradeoxy-4,5-O-(1-methylethylidene)-D-altro-hept-1-ynitol:*

$R_f$ 0.29 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ – 112.2° ($c$ = 0.99, $CHCl_3$).

IR ($CHCl_3$): $\nu$ = 3548, 3301, 3087, 3066, 3058, 3030, 3020, 3011, 2993, 2936, 2889, 2874, 2857, 2838, 1495, 1454, 1383, 1373, 1243, 1164, 1118, 1106, 1074 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.41–7.23 (m, 10 H), 4.42 (dd, 1 H, $J$ = 7.2, 5.4 Hz), 4.06 (d, 2 H, $J$ = 13.3 Hz), 3.94 (m, 1 H), 3.83 (dd, 1 H, $J$ = 8.6, 5.3 Hz), 3.77 (dd, 1 H, $J$ = 7.3, 2.2 Hz), 3.65 (m, 1 H), 3.45 (d, 2 H, $J$ = 13.4 Hz), 2.61 (d, 1 H, $J$ = 2.2 Hz), 1.33 (s, 3 H), 1.18 (d, 3 H, $J$ = 6.1 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 138.3, 129.5, 128.5, 127.5, 108.5, 127.5, 108.5, 82.2, 79.7, 77.6, 75.7, 64.7, 55.6, 50.9, 27.7, 25.5, 20.1.

HRMS: $m/z$ ($M^+$) calcd for $C_{24}H_{29}NO_3$ 379.2149, found 379.2147.

**3-Amino-N,N-dibenzyl-1,2,3-trideoxy-4,5-O-(1-methylethylidene)-7-O-methoxymethyl-D-*altro*-hept-1-enitol (3b):**

To a stirred solution of amine **2a** (38 mg, 0.092 mmol) in THF (0.2 mL) at r.t. under nitrogen was added, dropwise, vinylmagnesium bromide (36 mg, 0.276 mmol) in $Et_2O$ (0.276 mL). After 30 min, the reaction was cooled to 0 °C and quenched with 50 μL of $H_2O$. The mixture was then diluted with $CH_2Cl_2$ (15 mL) and washed with sat. aq $K_2CO_3$ (15 mL). The organic phase was dried ($MgSO_4$), filtered, and concentrated under reduced pressure to afford a crude product that appeared to be only one diastereomer by $^1H$ NMR. Flash chromatography with 30% EtOAc in hexane afforded 29 mg (72%) of pure **3b**; $R_f$ 0.21 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ + 19.5° ($c$ = 1.03, $CHCl_3$);

IR ($CHCl_3$): $\nu$ = 3570, 3085, 2882, 2855, 1495, 1454, 1382, 1373, 1201, 1133, 929 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.43–7.21 (m, 10 H), 6.01 (ddd, 1 H, $J$ = 18, 8, 11 Hz), 5.34 (dd, 1 H, $J$ = 11, 1 Hz), 5.25 (dd, 1 H, $J$ = 18, 1 Hz), 4.54 (s, 2 H), 4.37 (dd, 1 H, $J$ = 7, 5 Hz), 4.1–3.4 (m, 8 H), 3.27 (s, 3 H), 1.39 (s, 3 H), 1.30 (s, 3 H).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 139.5, 1345.5, 129.3, 128.4, 127.1, 119.0, 107.7, 97.0, 79.4, 77.7, 70.12, 68.5, 58.8, 55.3, 54.9, 27.8, 25.2.

HRMS: $m/z$ calcd for $C_{26}H_{35}NO_5$ ($M^+$) 441.2515, found 441.2515.

**3-Amino-N,N-dibenzyl-1,2,3-trideoxy-4,5-O-(1-methylethylidene)-7-O-methoxymethyl-D-*altro*-heptitol (3c):**

To a stirred solution of amine **2a** (37 mg, 0.09 mmol) in THF (0.2 mL) at r.t. under nitrogen was added, dropwise, ethylmagnesium bromide (37 mg, 0.276 mmol) in $Et_2O$ (0.094 mL). After 30 min, the reaction was cooled to 0 °C and quenched with 50 μL of $H_2O$. The mixture was then diluted with $CH_2Cl_2$ (15 mL) and washed with sat. aq $K_2CO_3$ (15 mL). The organic phase was dried ($MgSO_4$), filtered, and concentrated under reduced pressure to afford a crude product that appeared to be only one diastereomer by $^1H$ NMR. Flash chromatography with 30% EtOAc in hexane afforded 28 mg

(72%) of pure **3c**; $R_f$ 0.30 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ + 78.6° (*c* = 1.01, $CHCl_3$).

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.43–7.21 (m, 10 H), 4.57 (s, 2 H), 4.26 (dd, 1 H, *J* = 9, 4 Hz), 3.9–3.5 (m, 8 H), 3.30 (s, 3 H), 2.9 (m, 1 H), 1.45 (s, 3 H), 1.36 (s, 3 H), 1.35 (dq, 2 h, *J* = 7, 4 Hz) 0.82 (t, 3 H, *J* = 7 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 140.8, 129.5, 128.1, 126.8, 107.7, 97.2, 81.0, 78.0, 71.0, 68.6, 56.21, 55.5, 54.6, 28.4, 25.6, 22.5, 11.5.

HRMS: *m/z* calcd for $C_{26}H_{36}NO_5$ ($M^+ - H$) 442.2593, found 442.2593.

**N,N-Dibenzyl-2,3,5-O-tribenzyl-α-D-arabinofuranosylamine (5α) and N,N-Dibenzyl-2,3,5-O-tribenzyl-β-D-arabinofuranosylamine (5β):**

To a stirred suspension of 2,3,5-tri-*O*-benzyl-D-arabinofuranose (500 mg, 1.19 mmol) in MeOH (0.5 mL) at r.t. under nitrogen was added dibenzylamine (315 mg, 1.78 mmol). The mixture was then heated to 65 °C. After 10 d, the solution was diluted to 5 mL with $CH_2Cl_2$ and then concentrated under reduced pressure to a yellow oil. $^1H$ NMR indicated that the reaction had produced a 10 : 1 mixture of **5α/5β**. Flash chromatography (150 × 40 mm column, silica gel 10% EtOAc/hexane) yielded 417 mg (58%) of pure major diastereomer **5α**, 205 mg (29%) of mixture of diastereomers, 91 mg (13%) of pure minor diastereomer **5β** (100% overall yield).

*Major diastereomer* **5α**: $R_f$ 0.59 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ + 24.0° (*c* = 0.93, $CHCl_3$).

IR ($CHCl_3$): ν = 3319, 3066, 3033, 3010, 2862, 1604, 1496, 1454, 1364, 1265, 1096, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.42 7.16 (m, 25 H), 4.85 (d, 1 H, *J* = 5.4 Hz), 4.56 (s, 2 H), 4.52 (s, 1 H), 4.51 (s, 1 H), 4.73 (d, 1 H, *J* = 11.5 Hz), 4.41 (d, 1 H, *J* = 11.5 Hz), 4.24 (dd, 1 H, *J* = .3, 10.5 Hz), 4.17 (dd, 1 H, *J* = 4.7, 4.7 Hz), 4.01 (d, 2 H, *J* = 14.2 Hz), 3.95 (dd, 1 H, *J* = 5.2, 5.2 Hz), 3.74 (d, 2 H, *J* = 14.2 Hz), 3.52 (dd, 2 H, *J* = 1.1, 4.8 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 139.5, 138.3, 138.0, 137.9, 128.9, 128.4, 128.3, 128.2, 128.0, 127.9, 127.8, 127.6, 127.0, 95.9, 85.4, 83.8, 80.7, 73.4, 72.0, 71.9, 70.5, 53.6.

HRMS: *m/z* calcd for $C_{33}H_{34}NO_4$ ($M^+ - CH_2C_6H_5$) 508.2488, found 508.2488.

*Anal.* Calcd. for $C_{40}H_{41}NO_4$: C, 80.10; H, 6.89; N, 2.33. Found: C, 80.05; H, 6.94; N, 2.30.

*Minor diastereomer* (**5β**): $R_f$ 0.54 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ + 11.8° (*c* = 1.06, $CHCl_3$).

IR ($CHCl_3$): ν = 3010, 2862, 1495, 1454, 1363, 1265, 1121, 1028, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.41–7.16 (m, 25 H), 4.94 (d, 1 H, *J* = 4.2 Hz), 4.58 (d, 1 H, *J* = 11.5 Hz), 4.54 (d, 1 H, *J* = 11.5 Hz), 4.52 (d, 1 H, *J* = 11.5 Hz), 4.42 (d, 1 H, *J* = 11.5 Hz), 4.38 (d, 1 H, *J* = 11.5 Hz), 4.33 (d, 1 H, *J* = 11.5 Hz), 4.10–4.03 (m, 1 H), 3.87 (d, 2 H, *J* = 14.4 Hz), 3.82–3.75 (m, 2 H), 3.74 (d, 2 H, *J* = 14.4 Hz), 3.64 (dd, 1 H, *J* = 3.0, 10.6 Hz), 3.55 (d, 1 H, *J* = 3.8, 10.6 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 139.6, 138.1, 137.9, 128.5, 128.2, 128.1, 128.0, 127.8, 127.5, 126.7, 96.2, 78.8, 76.5, 73.3, 71.8, 71.4, 70.2, 53.6.

HRMS: *m/z* calcd for $C_{33}H_{34}NO_4$ ($M^+ - CH_2C_6H_5$) 508.2488, found 508.2488.

*Anal.* Calcd for $C_{40}H_{41}NO_4$: C, 80.10; H, 6.89; N, 2.33. Found: C, 80.03; H, 6.93; N, 2.37.

**General Procedure of Grignard Reaction used with the Arabinose Substrates:**

To a stirred solution of the amine (0.86 mmol) in THF (4 mL) at r.t. under nitrogen was added Grignard reagent (2.59 mmol) in THF (2.59 mL). After stirring for 3 h at the same temperature, the mixture was cooled to 0 °C and quenched with sat. aq $NH_4Cl$ (1 mL). The mixture was then diluted to 100 mL with $CH_2Cl_2$ and washed with brine (20 mL), dried ($MgSO_4$), filtered, and concentrated under reduced pressure to a yellow oil.

*4,5,7-Tri-O-benzyl-3-dibenzylamino-1,2,3-trideoxy-D-glucohept-1-enitol* (**6a**):

The crude product was prepared by the general procedure and purified by flash chromatography (150 × 40 mm column, silica gel 12% EtOAc/hexane) yielded 80% of alcohol **6a**: $R_f$ 0.44 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ −12.5° (*c* = 0.84, $CHCl_3$).

IR ($CHCl_3$): ν = 3556, 3011, 2862, 1496, 1454, 1361, 1265, 1211, 1099, 1002 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.44–7.17 (m, 23 H), 7.05–6.98 (m, 2 H), 6.03 (ddd, 1 H, *J* = 9.4, 9.4, 17.3 Hz), 5.36 (dd, 1 H, *J* = 2.0, 10.3 Hz), 5.03 (dd, 1 H, *J* = 2.0, 17.3 Hz), 4.75 (d, 1 H, *J* = 11.4 Hz), 4.67 (d, 1 H, *J* = 11.4 Hz), 4.57 (d, 1 H, *J* = 11.5 Hz), 4.54 (d, 1 H, *J* = 11.5 Hz), 4.45 (d, 1 H, *J* = 11.4 Hz), 4.38 (d, 1 H, *J* = 11.4 Hz), 4.14 (d, 1 H, *J* = 13.7 Hz), 3.97 (dd, 1 H, *J* = 5.7, 5.7 Hz), 3.83 (dd, 1 H, *J* = 6.3, 6.3 Hz), 3.72–3.65 (m, 1 H), 3.55 (m, 2 H), 3.35 (d, 2 H, *J* = 13.7 Hz), 2.56 (d, 1 H, *J* = 6.3 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 139.8, 139.0, 138.6, 138.1, 132.9, 129.2, 128.4, 128.3, 128.2, 127.8, 127.7, 127.5, 127.4, 127.3, 126.9, 120.2, 81.5, 80.4, 74.1, 73.1, 70.1, 62.2, 54.7, 53.5.

HRMS: *m/z* calcd for $C_{35}H_{38}NO_4$ ($M^+ - CH_2C_6H_5$) 536.2801, 536.2801.

*Anal.* Calcd for $C_{42}H_{45}NO_4.0.25H_2O$: C, 79.77; H, 7.25; N, 2.21. Found: C, 79.63; H, 7.16; N, 2.19.

*4,5,7-Tri-O-benzyl-3-dibenzylamino-1,2,3-trideoxy-D-glucohept-1-ynitol* (**6b**) *and 4,5,7-Tri-O-benzyl-3-dibenzylamino-1,2,3-trideoxy-D-mannohept-1-ynitol* (**7b**):

The crude product was prepared by the general procedure and purified by flash chromatography (150 × 40 mm column, silica gel 30% EtOAc/hexane) The experiment afforded in 99% yield a mixture of **6b** and **7b** (ratio 1 : 12) The mixture was separated with HPLC using the same solvent system.

*Major diastereomer* **6b**: $R_f$ 0.40 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ + 52.5° (*c* = 1.68, $CHCl_3$).

IR ($CHCl_3$): ν = 3567, 3304, 3010, 2924, 2866, 1496, 1454, 1265, 1072, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.45–7.14 (m, 23 H), 7.00–6.96 (m, 2 H), 4.93 (d, 1 H, *J* = 11.2 Hz), 4.64 (d, 1 H, *J* = 11.2 Hz), 4.60 (d, 1 H, *J* = 11.2 Hz), 4.46–4.39 (m, 3 H), 4.18–3.78 (m, 5 H), 3.60–3.44 (m, 4 H), 2.48 (br s, 1 H), 2.43 (d, 1 H, *J* = 6.7 Hz),

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 138.8, 138.3, 137.9, 129.0, 128.4, 128.3, 128.2, 128.1, 127.8, 127.7, 127.6, 127.4, 127.3, 127.0, 79.8, 79.0, 78.5, 77.3, 75.8, 74.4, 73.7, 73.3, 71.0, 69.9, 55.5, 53.9.

HRMS: *m/z* ($M^+$) calcd for $C_{42}H_{43}NO_4$ 625.3192, found 625.3192.

*Anal.* Calcd for $C_{42}H_{43}NO_4$: C, 80.61; H, 6.93; N, 2.24. Found: C, 80.54, H, 6.99; N, 2.20.

*Minor diastereomer* **7b**: $R_f$ 0.45 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ −22.1° (*c* = 1.02, $CHCl_3$).

IR ($CHCl_3$): ν = 3557, 3305, 3010, 2926, 2866, 1496, 1454, 1265, 1097, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.42–7.15 (m, 23 H), 7.02–6.5 (m, 2 H), 4.90 (d, 1 H, *J* = 10.8 Hz), 4.65 (d, 1 H, *J* = 10.8 Hz), 4.48 (d, 1 H, *J* = 11.8 Hz), 4.42 (d, 1 H, *J* = 11.8 Hz), 4.35–3.82 (m, 7 H), 3.54–3.46 (m, 4 H), 2.45 (d, 1 H, *J* = 1.7 Hz), 2.35 (d, 1 H, *J* = 4.9 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$) δ = 139.0, 138.7, 138.3, 138.2, 129.5, 129.2, 129.0, 128.5, 128.4, 128.3, 128.2, 128.0, 127.7, 127.6, 127.4, 127.3, 127.2, 80.2, 78.6, 77.3, 74.7, 74.4 73.3, 71.1, 70.0, 65.9, 55.9, 54.3.

HRMS: *m/z* ($M^+$) calcd for $C_{42}H_{43}NO_4$ 625.3192, found 625.3192.

*Anal.* Calcd for $C_{42}H_{43}NO_4$: C, 80.61; H, 6.93; N, 2.24. Found: C, 80.50; H, 6.96; N, 2.21.

*4,5,7-Tri-O-benzyl-3-dibenzylamino-1,2,3-trideoxy-D-glucoheptitol* (**6c**) *and 4,5,7-Tri-O-benzyl-dibenzylamino-1,2,3-trideoxy-D-mannoheptitol* (**7c**):

The crude product was prepared by the general procedure and purification by flash chromatography (150 × 40 mm column, silica gel 30% EtOAc/hexane) yielded 75% of the mixture of **6c** and **7c** (ratio 79:21) The mixture was separated with HPLC using 30% EtOAc/hexane.

*Major diastereomer* **6c**: $R_f$ 0.49 (silica gel, 30% EtOAc/hexane); $[\alpha]_D^{22}$ −23.7° (*c* = 0.68, $CHCl_3$).

IR ($CHCl_3$): *v* = 3556, 3011, 2930, 2871, 1496, 1454, 1364, 1208, 1067 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.40–7.14 (m, 25 H), 4.85 (d, 1 H, *J* = 11.6 Hz), 4.70 (d, 1 H, *J* = 11.3 Hz), 4.59 (d, 1 H, *J* = 11.3 Hz), 4.45 (d, 1 H, *J* = 11.6 Hz), 4.42 (d, 1 H, *J* = 11.4 Hz), 4.35 (d, 1 H, *J* = 11.4 Hz), 4.19–4.12 (m, 3 H), 3.63 (dd, 1 H, *J* = 3.4, 7.6 Hz), 3.45–3.36 (m, 4 H), 3.28–3.22 (m, 1 H), 2.72 (d, 1 H, *J* = 5.7 Hz), 2.64–2.57 (m, 1 H), 1.78–1.59 (m, 2 H), 0.74 (t, 3 H, *J* = 7.4 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 140.2, 139.0, 138.9, 138.4, 129.6, 128.3, 127.9, 127.8, 127.6, 127.4, 127.0, 81.0, 80.8, 77.3, 75.1, 74.6, 72.9, 70.6, 70.4, 59.7, 55.5, 16.4, 11.9.

HRMS: *m/z* calcd for $C_{42}H_{46}NO_4$ ($M^+$ −H) 628.3427, found 628.3427.

*Anal.* Calcd for $C_{42}H_{47}NO_4$: C, 80.09; H, 7.52; N, 2.22. Found: C, 79.95; H, 7.53; N, 2.26.

*Minor diastereomer* **7c**: $R_f$ 0.49 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ +54.0° (*c* = 0.25, $CHCl_3$).

IR ($CHCl_3$): *v* = 3557, 2928, 2859, 1465, 1453, 1363, 1097, 1027 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.39–7.13 (m, 25 H), 4.81 (d, 1 H, *J* = 11.2 Hz), 4.61 (d, 1 H, *J* = 11.2 Hz), 4.56 (d, 1 H, *J* = 11.8 Hz), 4.52 (d, 1 H, *J* = 11.8 Hz), 4.35 (d, 1 H, *J* = 11.3[6]), 4.28 (d, 1 H, *J* = 11.3 Hz), 3.906 (dd, 1 H, *J* = 4.0 Hz), 3.82–3.75 (m, 3 H), 3.68 (dd, 1 H, *J* = 4.8, 6.9 Hz), 3.62 (d, 2 H, *J* = 4. Hz), 3.47 (d, 2 H, *J* = 13.9 Hz), 2.77 (dt, 1 H, *J* = 3.4, 7.6 Hz), 2.67 (br s, 1 H), 1.90–1.79 (m, 1 H), 1.64–1.52 (m, 1 H), 1.01 (t, 3 H, *J* = 7.3 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 140.4, 138.9, 138.6, 128.2, 129.6, 129.1, 128.5, 128.3, 128.2, 127.9, 127.8, 127.6, 127.4, 127.0, 126.8, 79.4, 78.5, 77.3, 74.2, 71.3, 71.1, 60.7, 54.3, 19.4, 12.9.

HRMS: *m/z* calcd for $C_{42}H_{46}NO_4$ ($M^+$ −H) 628.3427, found 628.3427.

*Anal.* Calcd for $C_{42}H_{47}NO_4$: C, 80.09; H, 7.52; N, 2.22. Found: C, 79.99; H, 7.53; N, 2.27.

*5,6,8-Tri-O-benzyl-1,2,3,4-tetradeoxy-4-dibenzylamino-2-methyl-*D*-glucooctitol* **(6d)** *and 5,6,8-Tri-O-benzyl-1,2,3,4-tetradeoxy-4-dibenzylamino-2-methyl-*D*-mannooctitol* **(7d)**:

These products could be obtained in good yields by the general procedure, but could not be separated by chromatography on silica gel. The acetates of these products [7-*O*-acetyl-5,6,8-tri-*O*-benzyl-1,2,3,4-tetradeoxy-4-dibenzylamino-2-methyl-D-glucooctidol **(6d–Ac)** and 7-*O*-acetyl-5,6,8-tri-*O*-benzyl-1,2,3,4-tetradeoxy-4-dibenzylamino-2-methyl-D-*manno*octitol **(7d–Ac)**] were prepared as follows: Crude product prepared by the general procedure was treated with $Ac_2O$ (3 mol equiv) and DMAP (catalytic amount) in pyridine (2 mL). After 16 h at r. t., the mixture was poured into water (3 mL). The mixture was then diluted to 50 mL with $CH_2Cl_2$ and washed with 10% HCl (2 × 5 mL), sat. aq $KHSO_3$ (5 mL) and with brine (5 mL). The organic layer was dried ($MgSO_4$), filtered and concentrated under reduced pressure. Flash chromatography (150 × 25 mm column, silica gel 16% EtOAc/hexane) afforded 83% of mixture of **6d–Ac** and **7d–Ac** (ratio 80:20). The mixture was separated by HPLC using the same solvent system.

*Major diastereomer* **6d–Ac**: $R_f$ 0.58 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ −3.4° (*c* = 1.17, $CHCl_3$).

IR ($CHCl_3$): *v* = 3011, 2957, 2868, 1733, 1454, 1371, 1246, 1098, 1028 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.40–7.18 (m, 25 H), 4.98–4.90 (m, 1 H), 4.83 (d, 1 H, *J* = 11.5 Hz), 4.74 (d, 1 H, *J* = 11.4 Hz), 4.66 (d, 1 H, *J* = 11.4 Hz), 4.39 (d, 1 H, *J* = 11.5 Hz), 4.35 (d, 1 H, *J* = 11.4 Hz), 4.28 (d, 1 H, *J* = 11.4 Hz), 4.20–4.12 (m, 3 H), 3.68–3.59 (m, 3 H), 3.48 (dd, 1 H, *J* = 6.0, 10.3 Hz), 3.41 (d, 2 H, *J* = 13.7 Hz), 2.76–2.68 (m, 1 H), 1.906 (s, 3 H), 1.74–1.61 (m, 1 H), 1.45–1.23 (m, 2 H), 0.71 (d, 6 H, *J* = 5.8 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 169.9, 140.5, 139.2, 139.1, 138.2, 129.3, 128.3, 128.2, 128.2, 127.7, 127.6, 127.3, 126.8, 80.9, 80.5, 77.2, 75.6, 74.9, 73.3, 72.8, 67.9, 56.5, 55.7, 2.8, 25.1, 24.0, 22.2, 21.3.

*Anal.* Calcd for $C_{46}H_{53}NO_5$: C, 78.94; H, 7.63; N, 2.00. Found: C, 78.81; H, 7.64; N, 2.08.

*Minor diastereomer* **7d–Ac**: $R_f$ 0.58 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ +55.0° (*c* = 0.38, $CHCl_3$).

IR ($CHCl_3$): *v* = 3014, 2956, 2868, 1735, 1454, 1370, 1244, 1219, 1099, 1028 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.42–7.18 (m, 25 H), 5.06–4.98 (m, 1 H), 4.79 (d, 1 H, *J* = 11.0 Hz), 4.58 (d, 1 H, *J* = 11.0 Hz), 4.52 (d,1 H, *J* = 11.8 Hz), 4.44 (d, 1 H, *J* = 11.8 Hz), 4.35 (d, 1 H, *J* = 11.5 Hz), 4.15 (d, 1 H, *J* = 11.5 Hz), 3.88–3.72 (m, 6 H), 3.48 (d, 2 H, *J* = 13.7 Hz), 2.90–2.82 (m, 1 H), 1.95 (s, 3 H), 1.95 (s, 3 H), 1.80–1.67 (m, 1 H), 1.33–1.18 (m, 2 H), 0.90 (d, 3 H, *J* = 6.8 Hz), 0.63 (d, 3 H, *J* = 6.8 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 170.1, 140.5, 138.8, 138.3, 129.2, 128.4, 128.3, 128.2, 127.8, 127.4, 127.0, 80.3, 78.7, 77.3, 74.5, 74.1, 73.6, 73.2, 68.5, 56.6, 54.3, 35.3, 24.8, 23.8, 22.8, 22.2.

HRMS: *m/z* calcd for $C_{39}H_{46}NO_5$ ($M^+ - CH_2C_6H_5$) 608.3376, 608.3376.

*4,5,7-Tri-O-benzyl-1,2,3-trideoxy-3-dibenzylamino-2-methyl-*D*-glucoheptinitol* **(6e)** *and 4,5,7-Tri-O-benzyl-1,2,3-trideoxy-3-dibenzylamino-2-methyl-*D*-mannoheptinitol* **(7e)**:

These products could be obtained in good yield by the general procedure, but could not be separated by chromatography on silica gel. The acetates of these products [6-*O*-acetyl-4,5,5-tri-*O*-benzyl-1,2,3-trideoxy-3-dibenzylamino-2-methyl-D-*gluco*heptinitol **(6e–Ac)** and 6-*O*-acetyl-4,5,7-tri-*O*-benzyl-1,2,3-trideoxy-3-dibenzylamino-2-methyl-D-*manno*heptinitol **(7e–Ac)**] were prepared as follows. Crude product prepared by the general procedure was treated with $Ac_2O$ (3 mol equiv) and DMAP (catalytic amount) in pyridine (2 mL). After 16 h at r. t., the mixture was poured into 3 mL of water. The mixture was then diluted to 50 mL with $CH_2Cl_2$ and washed 10% HCl (2 × mL), sat. aq $KHSO_3$ (5 mL) and brine (5 mL). The organic layer was dried ($MgSO_4$), filtered and concentrated under reduced pressure. Flash chromatography (150 × 25 mm column, silica gel, 16% EtOAc/hexane) afforded a mixture of **6e–Ac** and **7e–Ac** (ratio 78:22, 90% yield). The mixture was separated by HPLC using the same solvent system.

*Major diastereomer* **6e–Ac**: $R_f$ 0.56 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ −35.2° (*c* = 0.89, $CHCl_3$).

IR ($CHCl_3$): *v* = 3013, 2930, 2872, 1735, 1496, 1454, 1370, 1244, 1095, 1028 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.33–7.12 (m, 25 H), 4.98–4.92 (m, 1 H), 4.88 (d, 1 H, *J* = 11.4 Hz), 4.75 (d, 1 H, *J* = 11.6 Hz), 4.65 (d, 1 H, *J* = 11.6 Hz), 4.50–4.37 (m, 3 H), 4.20 (d, 2 H, *J* = 13.6 Hz), 3.92 (dd, 1 H, *J* = 3.5, 7.7 Hz), 3.83 (dd, 1 H, *J* = 2.8, 7.7 Hz), 3.74 (d, 2 H, *J* = 13.6 Hz), 3.45 (dd, 1 H, *J* = 6.2, 10.4 Hz), 2.47 (dd, 1 H, *J* = 2.8, 7.0 Hz), 2.31–2.19 (m, 1 H, *J* = 4.5, 10.5 Hz), 3.45 (dd, 1 H, *J* = 6.2, 10.4 Hz), 2.47 (dd, 1 H, *J* = 2.8, 7.0 Hz), 2.31–2.19 (m, 1 H), 1.93 (s, 3 H), 0.99 (d, 3 H, *J* = 6.8 Hz), 0.83 (d, 3 H, *J* = 6.6 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 169.9, 141.1, 139.2, 139.0, 138.1, 129.6, 128.4, 128.2, 128.0, 127.8, 127.6, 127.2, 126.6, 80.1, 80.0, 77.1, 74.7, 74.4, 73.2, 72.9, 66.4, 65.0, 57.3, 28.3, 22.3, 21.7, 21.4.

HRMS: *m/z* calcd for $C_{43}H_{48}NO_4$ ($M^+ - COCH_3$) 642.3219, found 642.3219.

*Anal.* Calcd for $C_{45}H_{51}NO_5$: C, 78.80; H, 7.49; N, 2.04. Found: C, 78.70; H, 7.49; N, 2.05.

*Minor diastereomer* **7e–Ac**: $R_f$ 0.56 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ +27.2° (*c* = 1.02, $CHCl_3$).

IR ($CHCl_3$): *v* = 3013, 2929, 1732, 1454, 1373, 1244, 1098 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): δ = 7.46–7.12 (m, 25 H), 5.06–5.00 (M, 1 H), 4.91 (d, 1 H, *J* = 11.0 Hz), 4.60 (br s, 2 H), 4.54 (d, 1 H, *J* = 11.0 Hz), 4.35 (d, 1 H, *J* = 11.5 Hz), 4.25 (d, 1 H, *J* = 11.5 Hz), 4.07–3.89 (m, 3 H), 3.89–3.77 (m, 3 H), 3.43 (d, 1 H, *J* = 13.8 Hz), 2.63 (dd, 1 H, *J* = 3.0, 6.8 Hz), 2.36–2.21 (m, 1 H), 1.87 (s, 3 H), 1.13 (d, 3 H, *J* = 6.8 Hz), 1.01 (d, 3 H, *J* = 6.5 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): δ = 170.2, 140.1, 139.2, 138.8, 138.3,

129.3, 128.5, 128.2, 127.8, 127.3, 127.2, 126.9, 80.4, 77.3, 74.4, 74.2, 73.5, 73.4, 68.6, 63.8, 54.5, 27.5, 22.8, 21.2, 21.1.

HRMS: *m/z* calcd for $C_{43}H_{48}NO_4$ ($M^+ - COCH_3$) 642.3219, found 642.3219.

*1-Benzyl-3,4,6-tri-O-benzyl-1,2-deoxy-2-dibenzylamino-*D*-glucitol* (**6f**) *and 1-Benzyl-3,4,6-tri-O-benzyl-1,2-deoxy-2-dibenzylamino-*D*-mannitol* (**7f**).

The crude product was prepared by the general procedure and purified by flash chromatography (150 × 25 mm column, silica gel 20% EtOAc/hexane) yielded 92% of the mixture of **6f** and **7f** (ratio 63:37) The mixture was then further separated by HPLC using the same solvent system.

*Major diastereomer* **6f**: $R_f$ 0.51 (silica gel, 50% EtOAc/hexane, $[\alpha]_D^{22}$ + 19.3° (*c* = 0.72, $CHCl_3$).

IR ($CHCl_3$): *v* = 3564, 2926, 2860, 1496, 1454, 1364, 1219, 1099, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.50–6.92 (m, 30 H), 4.82 (d, 1 H, *J* = 11.9 Hz), 4.52 (s, 2 H), 4.43–4.28 (m, 1 H), 4.29 (d, 1 H, *J* = 11.9 Hz), 4.14 (dd, 1 H, *J* = 4.7, 7.7 Hz), 3.51 (d, 2 H, *J* = 13.4 Hz), 3.34 (dd, 1 H, *J* = 2.2, 7.8 Hz), 3.32–3.04 (m, 6 H), 2.94 (dd, 1 H, *J* = 10.3, 12.3 Hz), 2.67 (d, 1 H, *J* = 5.3 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 140.2, 140.0, 139.3, 138.7, 138.5, 129.6, 129.2, 128.5, 128.4, 128.3, 127.8, 127.6, 127.4, 127.3, 126.1, 80.7, 80.5, 77.2, 74.7, 74.4, 72.8, 70.5, 70.4, 59.7, 55.9, 29.9.

HRMS: *m/z* calcd for $C_{40}H_{42}NO_4$ ($M^+ - CH_2C_6H_5$) 600.3114, found 600.3114.

*Anal.* Calcd for $C_{47}H_{49}NO_4$: C, 81.59; H, 7.14; N, 2.02. Found: C, 81.54; H, 7.14; N, 2.09.

*Minor diastereomer* **7f**: $R_f$ 0.51 (silica gel, 50% EtOAc/hexane); $[\alpha]_D^{22}$ + 30.4° (*c* = 0.58, $CHCl_3$).

IR ($CHCl_3$): *v* = 3564, 3018, 2860, 2928, 1496, 1454, 1265, 1211, 1098, 1028, 909 $cm^{-1}$.

$^1H$ NMR (300 MHz, $CDCl_3$): $\delta$ = 7.42–7.02 (m, 30 H), 4.87 (d, 1 H, *J* = 11.1 Hz), 4.66 (d, 1 H, *J* = 11.7 Hz), 4.48 (d, 1 H, *J* = 11.9 Hz), 4.29 (d, 1 H, *J* = 11.4 Hz), 4.21 (d, 1 H, *J* = 11.4 Hz), 4.03 (dd, 1 H, *J* = 4.5, 4.5 Hz), 3.86–3.77 (m, 1 H), 3.74 (d, 2 H, *J* = 14.0 Hz), 3.66 (dd, 1 H, *J* = 5.7, 5.7 Hz), 3.61 (d, 2 H, *J* = 4.4 Hz), 3.53 (d, 2 H, *J* = 14.0 Hz), 3.38–3.26 (m, 1 H), 3.06 (d, 2 H, *J* = 6.8 Hz), 2.49 (d, 1 H, *J* = 5.3 Hz).

$^{13}C$ NMR (75 MHz, $CDCl_3$): $\delta$ = 141.4, 140.0, 138.6, 138.1, 129.9, 129.6, 129.2, 128.8, 128.5, 128.4, 128.3, 128.1, 127.9, 127.6, 127.5, 127.3, 126.8, 125.8, 79.9, 78.9, 77.3, 74.2, 73.8, 73.4, 69.6, 60.9, 54.3, 32.7.

HRMS: *m/z* calcd for $C_{40}H_{42}NO_4$ ($M^+ - CH_2C_6H_5$) 600.3114, found 600.3114.

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