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Note

Synthesis of 2-acylamino-2-deoxy-D-glucofuranoses and their transformation into hex-2-enofuranoses

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Abstract

The preparation of 2-deoxy-2-hexanamido (octanamido, decanamido, dodecanamido)-5,6-isopropylidene-D-glucofuranoses (**9**–**12**) from the corresponding O-unprotected 2-acylamino-2-deoxy-D-glucopyranoses through the bicyclic glucofurano[2,1-*d*]oxazolines is reported. Compounds **9**–**12** are transformed into 2-acylamino-2-deoxy-2-enofuranoses by treatment with Amberlite IRA-400 (OH^-) resin. © 1999 Elsevier Science Ltd. All rights reserved.

Keywords: Hex-2-enofuranoses; 2-Acylamino-2-deoxy-glucofuranoses; *N*-Acylglucosamines; Oxazolines

2-Acetamido-2-deoxy-D-glycopyranoses represent an important class of compounds widely used in organic synthesis. Thus, 2-acetamido-2-deoxy-D-gluco- (and D-manno)-pyranoses have been employed in the chemical [1] and chemoenzymatic [2,3] synthesis of neuraminic acid derivatives. Different types of isopropylidene derivatives of 2-acylamino-2-deoxy-D-glucoses [4] have been prepared, and the 5,6-*O*-isopropylidenefuranose derivatives have been used to prepare 2-acetamido-2-deoxy-D-mannose [5] and 5,6-*O*-isopropylidene-hex-2-enofuranoses [6,7]. These hex-2-enofuranoses are related to Kuhn's chromogen I [8,9].

At the same time, glycolipids are described as immunomodulators [10]. Recently, vaccines have been developed that frequently need the simultaneous use of adjuvants to increase the immune response to the antigen [11]. Among these adjuvants are several types of glycolipids, which have an amino sugar as glycosyl moiety and one or several fatty acyl chains, frequently on the amino group. Long-chain *N*-acyl-glycosylamines and -amino sugars have been prepared to study their biological properties and their activity as carbohydrate-based detergents [12–15]. In addition, amido sugar derivatives containing two sugar units (amino sugars [16], aminopolyols [17] and glycosylamines [18,19]) joined by a polymethylenic chain are being studied as sugar-based bola amphiphiles in water.

In this paper, we report the preparation of the 2-acylamino-2-deoxy-D-glucofuranoses **9**–**12** with long *N*-acyl chains from the easily available D-glucosamine derivatives **1**–**4**, through the sugar-oxazolines **5**–**8**. Compounds **9**–**12** have been transformed into the *N*-fatty acylamino-enofuranoses **13**–**16**, of in-

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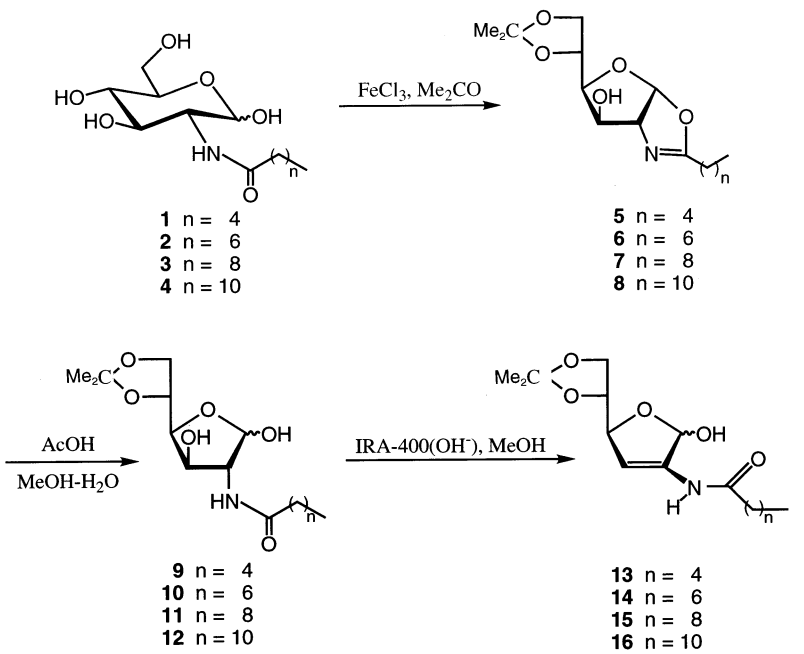
terest because they are suitable substrates for the preparation of 3-*C*-glucofuranose sulfonates by addition of potassium sulfite [20].

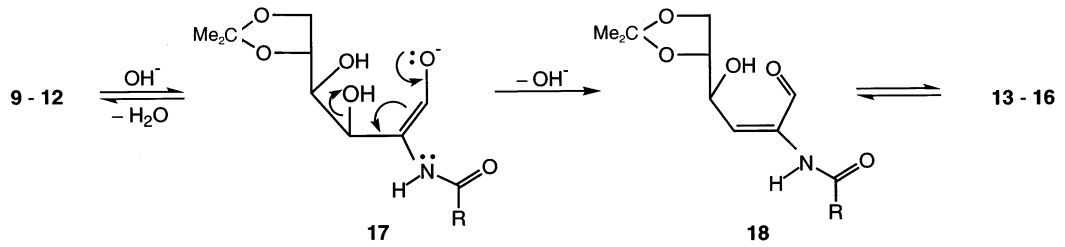
Treatment of 2-acylamino-2-deoxy-D-glucopyranoses **1**–**4** [21] with anhydrous ferric chloride in boiling acetone [5] gave the 2-alkylglucofurano[2,1-*d*]2-oxazolines **5**–**8** in moderate yields. Studies on the action of strong Lewis acids on 2-acetamido-2-deoxy-D-glucopyranose [5] in dry acetone at different temperatures showed that the 2-acetamido-5,6-isopropylidene-furanosidic derivative is formed first, and then it is transformed into the furanosidic oxazoline. This oxazoline has also been prepared by treating chitin with dry HF at 0 °C, followed by acetone at 100 °C [22]. The ^{1}H NMR spectra (see Section 1) for **5**–**8** showed a characteristic doublet at 4.47 ppm for H-2 with $J_{1,2}$ 5.1 Hz. The $J_{2,3}$ coupling was $\approx$0.0 Hz, in agreement with reported data for related cis-fused five-membered bicyclic systems [5,23,24] (Scheme 1).

The selective hydrolysis of the oxazoline ring of **5**–**8** with acetic acid in methanol–water produced, in moderate to high yields, 2-acylamino-D-glucofuranoses **9**–**12** as pairs of anomers. Integration of the corresponding ^{1}H NMR signals showed that the α/β ratio was 1.6:1 in methanol solution for the four acyl derivatives. Compounds **9**–**12** showed ^{1}H NMR signals in agreement with reported data for analogue compounds [5]. We have not found ^{13}C NMR data on 2-acylaminofuranoses, but the chemical shifts for C-2 (61.7 ppm for the α anomers and 64.7 ppm for the β anomers) are close to those for the corresponding resonances in 2-acylaminothiofuranose derivatives [25].

Basic treatment of compounds **9**–**12** with Amberlite IRA-400 (OH^-) [6] for 48 h yielded, after purification by preparative thin-layer chromatography (TLC), the crystalline 2-enofuranoses **13**–**16**, which are fatty analogues of Kuhn's chromogen I [8,9]. The ^{1}H and ^{13}C NMR data of **13**–**16** in methanol indicated the presence of pairs of anomers in 1.3:1 ratio for the four acyl derivatives. The presence of the double bond in **13**–**16** was supported by the chemical shifts for the resonances of H-3 ($\approx$6.25 ppm), C-2 ($\approx$136.5 ppm) and C-3 ($\approx$110.4 ppm). It is noteworthy that the homoallylic coupling constant $^5J_{1,4}$ value is large ($\approx$4.1 Hz) in α anomers, in agreement [26] with protons that are trans-related, and small ($\approx$1.0 Hz) when the relationship is cis. The β-elimination of water in **9**–**12** probably takes place through the enolate **17** (Scheme 2), which is stabilized by the acylamino group [6].



Scheme 1.



Scheme 2.

1. Experimental

General methods.—Melting points were determined in an electrothermal apparatus and are uncorrected. Optical rotations were measured at 20 °C with a Perkin–Elmer 241 polarimeter, and IR spectra (KBr disks) with an FTIR Bomen MB-120 spectrophotometer. ^{1}H (300 and 500 MHz) and ^{13}C (75.5 and 125.7 MHz) spectra were recorded with a Bruker AMX-300 and AMX-500 for solutions in $CDCl_3$ and CD_3OD, using Me_4Si as internal standard. The assignments of ^{1}H signals were confirmed by COSY experiments. Heteronuclear 2D correlated spectra were used for ^{13}C signal assignments. FAB mass spectra were taken on a Kratos MS-80 RFA instrument. The samples were dissolved in thioglycerol, and NaI was added as cationising agent. Ions were produced by a beam of Xe atoms with a maximum energy of 8 keV, and the positive ions were separated and accelerated over a potential of 7 kV. All reactions were monitored by TLC on aluminium sheets coated with Silica Gel 60 F_{254} (E. Merck) with visualisation by UV light and by charring with 10% H_2SO_4 in EtOH. Preparative TLC was carried out using Silica Gel 60 HF_{254} (E. Merck). Microanalyses were performed at 'Instituto Químico de Sarriá', Barcelona, Spain.

*2-Alkyl-(2-deoxy-5,6-*O*-isopropylidene-α-*D*-glucofurano)[2,1-*d*]2-oxazolines* (**5**–**8**)*: general procedure.*—To a suspension of 2-acylamino-2-deoxy-D-glucopyranose (**1**–**4**) (1.22 mmol) in dry acetone (7 mL), anhyd $FeCl_3$ (2.50 mmol) was added. The mixture was stirred under reflux for 20 min and then cooled to 0 °C. Diethylamine (1.2 mL) and acetone (4.5 mL) were added and the solution was dropwise neutralised with aq Na_2CO_3 (4.5 mL, 1.5 M). The reaction mixture was evaporated and the residue extracted with Et_2O (7 × 20 mL). The organic layer was dried ($MgSO_4$) and evaporated to give the crude products as brownish syrups (55–67%) that were used without purification in the preparation of compounds **9**–**12**. The following compounds were prepared in this manner.

*2-Pentyl-(2-deoxy-5,6-*O*-isopropylidene-α-*D*-glucofurano)[2,1-*d*]2-oxazoline* (**5**). Yield: 202 mg (55%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.44 (20:1 CH_2Cl_2–MeOH); $[\alpha]_D$ −20° (*c* 1.2, $CHCl_3$); ν_{max} 3185 (OH), 1655 (C=N). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 6.16 (d, 1 H, $J_{1,2}$ 5.1 Hz, H-1), 4.47 (d, 1 H, $J_{2,3} \approx 0$ Hz, H-2), 4.42 (d, 1 H, $J_{3,4}$ 2.8 Hz, H-3), 4.32 (ddd, 1 H, $J_{4,5}$ 7.8 Hz, $J_{5,6}$ 6.1 Hz, $J_{5,6'}$ 4.8 Hz, H-5), 4.16 (dd, 1 H, $J_{6,6'}$ 8.7 Hz, H-6), 4.00 (dd, 1 H, H-6′), 3.72 (dd, 1 H, H-4), 2.31 (t, 2 H, *J* 7.6 Hz, CH_2 alkyl chain), 1.63 (m, 2 H, CH_2 alkyl chain), 1.27 (m, 4 H, 2 CH_2 alkyl chain), 1.36, 1.42 (2 s, 3 H each, Me_2C), 0.90 (m, 3 H, Me alkyl chain); ^{13}C NMR ($CDCl_3$, 75.5 MHz): δ 170.07 (C=N), 109.37 (Me_2C), 106.73 (C-1), 81.65 (C-4), 77.83 (C-2), 74.71 (C-3), 72.85 (C-5), 67.32 (C-6), 31.14 (C-3′), 27.99 (C-1′), 26.67, 25.02 (Me_2C), 25.19 (C-2)′, 22.10 (C-4′), 13.77 (C-5′). FABMS: 322 (54, $[M + Na]^+$), 300 (100, $[M + H]^+$), 284 (9, $[M - Me]^+$). Anal. Calcd. for $C_{15}H_{25}NO_5$: C, 60.18; H, 8.42; N, 4.68. Found: C, 60.49; H, 8.60; N, 4.64.

*2-Heptyl-(2-deoxy-5,6-*O*-isopropylidene-α-*D*-glucofurano)[2,1-*d*]2-oxazoline* (**6**). Yield: 268 mg (67%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.36 (20:1 CH_2Cl_2–MeOH); $[\alpha]_D$ −19° (*c* 1.1, $CHCl_3$); ν_{max} 3157 (OH), 1664 (C=N). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 6.16 (d, 1 H, $J_{1,2}$ 5.1 Hz, H-1), 4.46 (d, 1 H, $J_{2,3} \approx 0$ Hz, H-2), 4.39 (dd, 1 H, $J_{3,4}$ 2.8 Hz, H-3), 4.32 (ddd, 1 H, $J_{4,5}$ 7.7 Hz, $J_{5,6}$ 6.2 Hz, $J_{5,6'}$ 4.9 Hz, H-5), 4.14 (dd, 1 H, $J_{6,6'}$ 8.7 Hz, H-6), 4.00

(dd, 1 H, H-6′), 3.72 (dd, 1 H, H-4), 2.31 (t, 2 H, 7.6 Hz, CH_2 alkyl chain), 1.62 (t, 2 H, CH_2 alkyl chain), 1.27 (m, 8 H, 4 CH_2 alkyl chain), 1.36, 1.42 (2 s, 3 H each, Me_2C), 0.89 (m, 3 H, Me alkyl chain); ^{13}C NMR ($CDCl_3$, 75.5 MHz): δ 169.94 (C=N), 109.41 (Me_2C), 106.69 (C-1), 81.68 (C-4), 77.87 (C-2), 74.85 (C-3), 72.94 (C-5), 67.39 (C-6), 31.50 (C-5′), 28.94, 28.70 (C-3′, C-4′), 28.04 (C-1′), 26.67, 25.02 (Me_2C), 25.52 (C-2′), 22.44 (C-6′), 13.91 (C-7′). FABMS: 350 (8, $[M + Na]^+$), 328 (100, $[M + H]^+$), 312 (6, $[M - Me]^+$). HRFABMS: Calcd. for $C_{17}H_{30}NO_5$ $[M + H]^+$ 328.2124. Found 328.2139. Anal. Calcd. for $C_{17}H_{29}NO_5$: C, 62.36; H, 8.93; N, 4.28. Found: C, 62.08; H, 8.50; N, 4.28.

*2-Nonyl-(2-deoxy-5,6-*O*-isopropylidene-α-*D*-glucofurano)[2,1-*d*]2-oxazoline* (**7**). Yield: 260 mg (60%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.48 TLC (20:1 CH_2Cl_2–MeOH); $[\alpha]_D$ −20° (*c* 1.0, $CHCl_3$); ν_{max} 3179 (OH), 1658 (C=N). ^1H NMR ($CDCl_3$, 300 MHz): δ 6.16 (d, 1 H, $J_{1,2}$ 5.1 Hz, H-1), 4.46 (d, 1 H, $J_{2,3} \approx 0$ Hz, H-2), 4.41 (dd, 1 H, $J_{3,4}$ 2.8 Hz, H-3), 4.33 (ddd, 1 H, $J_{4,5}$ 7.8 Hz, $J_{5,6}$ 6.1 Hz, $J_{5,6'}$ 4.9 Hz, H-5), 4.15 (dd, 1 H, $J_{6,6'}$ 8.7 Hz, H-6), 4.00 (dd, 1 H, H-6′), 3.72 (dd, 1 H, H-4), 2.31 (t, 2 H, 7.6 Hz, CH_2 alkyl chain), 1.62 (m, 2 H, CH_2 alkyl chain), 1.27 (m, 12 H, 6 CH_2 alkyl chain), 1.36, 1.42 (2 s, 3 H each, Me_2C), 0.88 (m, 3 H, Me alkyl chain); ^{13}C NMR ($CDCl_3$, 75.5 MHz): δ 170.04 (C=N), 109.38 (Me_2C), 106.72 (C-1), 81.69 (C-4), 77.89 (C-2), 74.74 (C-3), 72.89 (C-5), 67.36 (C-6), 31.71 (C-7′), 29.28, 29.11, 29.06, 29.01 (C-3′-C-6′), 28.05 (C-1′), 26.68, 25.04 (Me_2C), 25.52 (C-2′), 22.52 (C-8′), 13.96 (C-9′). FABMS: 378 (32, $[M + Na]^+$), 356 (100, $[M + H]^+$), 340 (6, $[M - Me]^+$). Anal. Calcd. for $C_{19}H_{33}NO_5$: C, 64.19; H, 9.36; N, 3.94. Found: C, 64.13; H, 9.36; N, 3.85.

*2-Undecyl-(2-deoxy-5,6-*O*-isopropylidene-α-*D*-glucofurano)[2,1-*d*]2-oxazoline* (**8**). Yield: 272 mg (58%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.39 (20:1 CH_2Cl_2–MeOH); $[\alpha]_D$ −20° (*c* 1.0, $CHCl_3$); ν_{max} 3244 (OH), 1657 (C=N). ^1H NMR ($CDCl_3$, 300 MHz): δ 6.16 (d, 1 H, $J_{1,2}$ 5.1 Hz, H-1), 4.47 (d, 1 H, $J_{2,3} \approx 0$ Hz, H-2), 4.42 (dd, 1 H, $J_{3,4}$ 2.8 Hz, H-3), 4.32 (ddd, 1 H, $J_{4,5}$ 7.9 Hz, $J_{5,6}$ 6.2 Hz, $J_{5,6'}$ 4.8 Hz, H-5), 4.15 (dd, 1 H, $J_{6,6'}$ 8.7 Hz, H-6), 3.99 (dd, 1 H, H-6′), 3.72 (dd, 1 H, H-4), 2.31 (t, 2 H, 7.6 Hz, 7.6 Hz, CH_2 alkyl chain), 1.62 (m, 2 H, CH_2 alkyl chain), 1.28 (m, 16 H, 8 CH_2 alkyl chain), 1.36, 1.42 (2 s, 3 H each, Me_2C), 0.88 (m, 3 H, Me alkyl chain); ^{13}C NMR ($CDCl_3$, 75.5 MHz): δ 169.89 (C=N), 109.47 (Me_2C), 106.69 (C-1), 81.70 (C-4), 77.86 (C-2), 75.00 (C-3), 73.03 (C-5), 67.46 (C-6), 31.79 (C-9′), 29.48(2C), 29.35, 29.21, 29.08, 29.04 (C-3′-C-8′), 28.07 (C-1′), 26.70, 25.03 (Me_2C), 25.56 (C-2′), 22.56 (C-10′), 14.00 (C-11′). FABMS: 406 (64, $M + Na]^+$), 384 (100, $[M + H]^+$), 368 (10, $[M - Me]^+$). Anal. Calcd. for $C_{21}H_{37}NO_5$: C, 65.76; H, 9.72; N, 3.65. Found: C, 65.90; H, 9.88; N, 3.60.

*2-Acylamino-2-deoxy-5,6-*O*-isopropylidene-*D*-glucofuranoses* (**9**–**12**)*: general procedure.*— To a solution of 2-alkyl-(2-deoxy-5,6-*O*-isopropylidene - α - D - glucofurano)[2,1 - *d*]2-oxazoline (**5**–**8**) (0.76 mmol) in MeOH (14 mL), 2% aq HOAc (7 mL) was added. The solution was left at 40 °C for 24 h. Total consumption of starting material was observed by TLC (20:1 CH_2Cl_2–MeOH). The reaction mixture was then concentrated to dryness by coevaporating with H_2O. The residue was washed with acetone (20 mL) and filtered. The solid residue was extracted with EtOAc (2 × 10 mL). The filtrates were concentrated to give **9**–**12** as white solids (61–86%) that were used without purification in the preparation of compounds **13**–**16**. The following compounds were prepared in this manner.

*2-Deoxy-2-hexanoylamino-5,6-*O*-isopropylidene-*D*-glucofuranose* (**9**). Yield: 199 mg (82%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.39 (20:1 CH_2Cl_2–MeOH); mp 132–134 °C; $[\alpha]_D$ +38° (*c* 1.0, pyridine); ν_{max} 3338 (OH and NH), 1628 (CO). ^1H NMR (CD_3OD, 500 MHz): δ 5.42 (d, 0.62 H, $J_{1,2}$ 4.9 Hz, H-1α), 5.13 (d, 0.38 H, $J_{1,2}$ 1.1 Hz, H-1β), 4.41 (q, 0.38 H, *J* 6.3 Hz, H-5β), 4.30 (q, 0.62 H, *J* 6.3 Hz, H-5α), 4.25 (dd, 0.62 H, $J_{2,3}$ 4.4 Hz, $J_{3,4}$ 5.3 Hz, H-3α), 4.17 (dd, 0.62 H, $J_{4,5}$ 6.3 Hz, H-4α), 3.92 (dd, 1 H, $J_{5,6'}$ 6.3 Hz, $J_{6,6'}$ 8.4 Hz, H-6′α), 2.24 (t, 1.22 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, α anomer), 2.19 (t, 0.76 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, β anomer), 1.61 (m, 2 H, 1

CH_2 alkyl chain), 1.32 (m, 4 H, 2 CH_2 alkyl chain), 1.37, 1.32 (2 s, 1.86 H each, $Me_2C\alpha$), 1.38, 1.33 (2 s, 1.14 H each, $Me_2C\beta$), 0.91 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 125.7 MHz): δ 176.67 (COα), 176.32 (COβ), 110.03 ($Me_2C\beta$), 109.99 ($Me_2C\alpha$), 102.85 (C-1β), 96.22 (C-1α), 83.80 (C-4β), 80.01 (C-4α), 76.05 (C-3α), 75.66 (C-3β), 75.38 (C-5β), 75.31 (C-5α), 67.93 (C-6β), 67.46 (C-6α), 64.79 (C-2β), 61.75 (C-2α), 36.88 (C-1α), 36.76 (C-1′β), 32.48 (C-3′), 26.98, 26.86, 26.67, 25.57 (C-2′, Me_2C), 23.44 (C-4′), 14.26 (C-5′). FABMS: 340 (100, $[M+Na]^+$). Anal. Calcd. for $C_{15}H_{27}NO_6$: C, 56.76; H, 8.57; N, 4.41. Found: C, 56.43; H, 8.57; N, 4.39.

*2-Deoxy-5,6-*O*-isopropylidene-2-octanoylamino-*D*-glucofuranose* (**10**). Yield: 160 mg (61%). Analytical samples were obtained by preparative TLC (20:1 CH_2Cl_2–MeOH). R_f 0.41 (20:1 CH_2Cl_2–MeOH); mp 130–132 °C; $[\alpha]_D$ +39° (*c* 1.0, pyridine); ν_{max} 3343 (NH), 3279 (OH), 1636 (CO). ^1H NMR (CD_3OD, 500 MHz): δ 5.42 (d, 0.62 H, $J_{1,2}$ 4.9 Hz, H-1α), 5.13 (d, 0.38 H, $J_{1,2}$ 1.0 Hz, H-1β), 4.41 (q, 0.38 H, *J* 6.3 Hz, H-5β), 4.30 (q, 0.62 H, *J* 6.3 Hz, H-5α), 4.25 (dd, 0.62 H, $J_{2,3}$ 4.4, $J_{3,4}$ 5.3 Hz, H-3α), 4.17 (dd, 0.62 H, $J_{4,5}$ 6.3 Hz, H-4α), 3.92 (dd, 0.62 H, $J_{5,6'}$ 6.3 Hz, $J_{6,6'}$ 8.4 Hz, H-6′α), 2.24 (t, 1.24 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, α anomer), 2.19 (t, 0.76 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, β anomer), 1.61 (m, 2 H, 1 CH_2 alkyl chain), 1.31 (m, 8 H, 4 CH_2 alkyl chain), 1.37, 1.32 (2 s, 1.86 each H, $Me_2C\alpha$), 1.38, 1.33 (2 s, 1.14 H each, $Me_2C\beta$), 0.89 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 125.7 MHz): δ 176.61 (COα), 176.26 (COβ), 109.95 ($Me_2C\beta$), 109.91 ($Me_2C\alpha$), 102.77 (C-1β), 96.15 (C-1α), 83.75 (C-4β), 79.93 (C-4α), 75.96 (C-3α), 75.57 (C-3β), 75.30 (C-5α), 75.24 (C-5β), 67.86 (C-6β), 67.38 (C-6α), 64.71 (C-2β), 61.66 (C-2α), 36.84 (C-1′α), 36.71 (C-1′β), 32.84 (C-3′), 30.17, 30.13, 30.09, 30.04 (C-4′, C-5′), 26.92, 26.79, 25.49 (C-2′, Me_2C), 23.60 (C-6′), 14.33 (C-7′). FABMS: 368 (100, $[M+Na]^+$). Anal. Calcd. for $C_{17}H_{31}NO_6$: C, 59.11; H, 9.05; N, 4.06. Found: C, 58.87; H, 9.06; N, 3.99.

*2-Decanoylamino-2-deoxy-5,6-*O*-isopropylidene-*D*-glucofuranose* (**11**). Yield: 244 mg (86%). R_f 0.40 (20:1 CH_2Cl_2–MeOH); mp 132–134 °C; $[\alpha]_D$ +27° (*c* 0.9, pyridine); ν_{max} 3350 (NH), 3129 (OH), 1614 (CO). ^1H NMR (CD_3OD, 500 MHz): δ 5.42 (d, 0.62 H, $J_{1,2}$ 4.9 Hz, H-1α), 5.13 (d, 0.38 H, $J_{1,2}$ 1.2 Hz, H-1β), 4.42 (q, 0.38 H, *J* 6.3 Hz, H-5β), 4.29 (q, 0.62 H, *J* 6.3 Hz, H-5α), 4.25 (dd, 0.62 H, $J_{2,3}$ 4.4, $J_{3,4}$ 5.3 Hz, H-3α), 4.17 (dd, 0.62 H, $J_{4,5}$ 6.3 Hz, H-4α), 3.92 (dd, 1 H, $J_{5,6'}$ 6.3 Hz, $J_{6,6'}$ 8.3 Hz, H-6′α), 2.24 (t, 1.24 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, α anomer), 2.19 (t, 0.76 H, *J* 7,4 Hz, 1 CH_2 alkyl chain, β anomer), 1.60 (m, 2 H, 1 CH_2 alkyl chain), 1.29 (m, 12 H, 6 CH_2 alkyl chain), 1.37, 1.32 (s, 61.86 each H, $Me_2C\alpha$), 1.38, 1.33 (s, 1.14 each H, $Me_2C\beta$), 0.89 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 125.7 MHz): δ 176.69 (COα), 176.34 (COβ), 109.98 (Me_2C), 102.83 (C-1β), 96.21 (C-1α), 83.81 (C-4β), 79.99 (C-4α), 76.02 (C-3α), 75.63 (C-3β), 75.37 (C-5β), 75.30 (C-5α), 67.92 (C-6β), 67.44 (C-6α), 64.77 (C-2β), 61.72 (C-2α), 36.91 (C-1′α), 36.78 (C-1′β), 33.04, 30.60, 30.49, 30.42, 30.28, 30.23 (C-3′-C-7′), 26.99, 26.86, 25.56 (C-2′, Me_2C), 23.71 (C-8′), 14.43 (C-9′). FABMS: 396 (100, $[M+Na]^+$). Anal. Calcd. for $C_{19}H_{31}NO_6$: C, 61.10; H, 9.45; N, 3.75. Found: C, 61.18; H, 9.25; N, 3.65.

*2-Deoxy-2-dodecanoylamino-5,6-*O*-isopropylidene-*D*-glucofuranose* (**12**). Yield: 226 mg (74%); R_f 0.36 (20:1 CH_2Cl_2–MeOH); mp 109–111 °C; $[\alpha]_D$ +37° (*c* 1.0, pyridine); ν_{max} 3420 (NH), 3294 (OH), 1648 (CO). ^1H NMR (CD_3OD, 300 MHz): δ 5.42 (d, 0.62 H, $J_{1,2}$ 4.9 Hz, H-1α), 5.13 (d, 0.38 H, $J_{1,2}$ 1.1 Hz, H-1β), 4.42 (q, 0.38 H, *J* 6.3 Hz, H-5β), 4.29 (q, 0.62 H, *J* 6.3 Hz, H-5α), 4.25 (dd, 0.62 H, $J_{2,3}$ 4.4, $J_{3,4}$ 5.3 Hz, H-3α), 4.18 (dd, 0.62 H, $J_{4,5}$ 6.3 Hz, H-4α), 3.92 (dd, 0.62 H, $J_{5,6'}$ 6.3 Hz, $J_{6,6'}$ 8.3 Hz, H-6′α), 2.24 (t, 1.24 H, *J* 7.4 Hz, 1 CH_2 alkyl chain, α anomer), 2.19 (t, 0.76 H, *J* 4,7 Hz, 1 CH_2 alkyl chain, β anomer), 1.59 (m, 2 H, 1 CH_2 alkyl chain), 1.28 (m, 16 H, 8 CH_2 alkyl chain), 1.37, 1.32 (2 s, 1.86 H each, $Me_2C\alpha$), 1.38, 1.33 (2 s, 1.14 H each, $Me_2C\beta$), 0.89 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 75.5 MHz): δ 176.67 (COα), 176.30 (COβ), 110.02 ($Me_2C\beta$), 109.59 ($Me_2C\alpha$), 102.82 (C-1β), 96.20 (C-1α), 83.81 (C-4β), 79.96 (C-4α), 75.99 (C-3α), 75.59 (C-3β), 75.36 (C-5β), 75.30 (C-5α), 67.91 (C-6β), 67.43 (C-6α), 64.75 (C-2β), 61.70 (C-2α), 36.90 (C-1′α), 36.75 (C-1′β), 33.07, 30.74,

30.64, 30.47, 30.24 (C-3′-C-9′), 26.99, 26.87, 25.56 (C-2′, *Me*$_2$C), 23.74 (C-10′), 14.45 (C-11′). FABMS: 424 (100, $[M+Na]^+$). Anal. Calcd. for $C_{21}H_{39}NO_6$: C, 62.82; H, 9.79; N, 3.49. Found: C, 63.00; H, 9.59; N, 3.45.

*2-Acylamino-2,3-dideoxy-5,6-*O*-isopropylidene-*D*-erythro-hex-2-enofuranoses* (**13**–**16**)*: general procedure.*—To a solution of 2-acylamino-2-deoxy-5,6-*O*-isopropylidene-D-glucofuranose (0.6 mmol) in MeOH (11 mL) Amberlite IRA-400(OH^-) (9.5 mL) was added. The mixture was left at rt for 48 h, then filtered, and the resin repeatedly washed with hot MeOH. The resulting solution was concentrated and the residue was purified by preparative TLC (2:1 EtOAc–hexane) giving **13**–**16** as white solids that were recrystallised from EtOH. The following compounds were prepared in this manner.

*2,3-Dideoxy-2-hexanoylamino-5,6-*O*-isopropylidene-*D*-erythro-hex-2-enofuranose* (**13**). Yield: 65 mg (36%); R_f 0.57 (2:1 EtOAc–hexane); mp 109–110 °C; $[\alpha]_D$ −29° (*c* 1.0, pyridine); ν_{max} 3213 (NH), 3163 (OH), 1655 (C=C and CO). ^{1}H NMR (CD_3OD, 300 MHz): δ 6.29 (dd, 0.56 H, $J_{1,3}$ 1.0 Hz, $J_{3,4}$ 1.5 Hz, H-3α), 6.25 (dd, 0.44 H, $J_{1,3}$ 1.0 Hz, $J_{3,4}$ 1.8 Hz, H-3β), 5.68 (dd, 0.56 H, $J_{1,4}$ 4.1 Hz, H-1α), 5.56 (t, 0.44 H, $J_{1,4}$ 1.0 Hz, H-1β), 4.80 (ddd, 0.56 H, $J_{4,5}$ 6.1 Hz, H-4α), 4.67 (m, 0.44 H, H-4β), 4.04 (m, 0.44 H, H-6β), 4.04 (dd, 0.56 H, $J_{5,6}$ 6.3 Hz, $J_{6,6'}$ 8.1 Hz, H-6α), 3.98 (m, 0.44 H, H-5β), 3.96 (m, 0.44 H, H-6′β), 3.94 (ddd, 0.56 H, $J_{5,6'}$ 5.0 Hz, H-5α), 3.84 (dd, 0.56 H, H-6′α), 2.29 (t, 2 H, 1 CH_2 alkyl chain), 1.63 (m, 2 H, 1 CH_2 alkyl chain), 1.38 (s, 1.32 H, $Me_2C\beta$), 1.37 (s, 1.68 H, $Me_2C\alpha$), 1.32 (s, 3 H, Me_2C), 1.30 (m, 4 H, 2 CH_2 alkyl chain), 0.91 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 75.5 MHz): δ 175.27 (CO), 136.64 (C-2α), 136.41 (C-2β), 110.72 (Me_2C), 110.53 (C-3β), 110.36 (C-3α), 101.63 (C-1α), 101.49 (C-1β), 85.91 (C-4β), 85.77 (C-4α), 80.14 (C-5β), 79.94 (C-5α), 67.67 (C-6β), 67.31 (C-6α), 37.23 (C-1′), 32.50 (C-3′), 26.46 (C-2′), 26.94, 25.52 (*Me*$_2$Cβ), 26.84, 25.45 (*Me*$_2$Cα), 23.46 (C-4′), 14.28 (C-5′). FABMS: 322 (100, $[M+Na]^+$). Anal. Calcd. for $C_{15}H_{25}NO_5$: C, 60.18; H, 8.42; N, 4.68. Found: C, 60.29; H, 8.45; N, 4.65.

*2,3-Dideoxy-5,6-*O*-isopropylidene-2-octanoylamino-*D*-erythro-hex-2-enofuranose* (**14**). Yield: 69 mg (35%); R_f 0.54 (2:1 EtOAc–hexane); mp 116–118 °C; $[\alpha]_D$ −28° (*c* 1.0, pyridine); ν_{max} 3252 (NH), 3171 (OH), 1657 (C=C and CO). ^{1}H NMR (CD_3OD, 500 MHz): δ 6.25 (dd, 0.44 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.7 Hz, H-3β), 6.23 (dd, 0.56 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.5 Hz, H-3α), 5.85 (dd, 0.56 H, $J_{1,4}$ 4.1 Hz, H-1α), 5.82 (t, 0.44 H, $J_{1,4}$ 1.1 Hz, H-1β), 4.82 (ddd, 0.56 H, $J_{4,5}$ 6.2 Hz, H-4α), 4.59 (ddd, 0.44 H, $J_{4,5}$ 6.6 Hz, H-4β), 4.04 (dd, 0.44 H, $J_{5,6}$ 6.0 Hz, $J_{6,6'}$ 7.7 Hz, H-6β), 4.03 (dd, 0.56 H, $J_{5,6}$ 6.3 Hz, $J_{6,6'}$ 8.4 Hz, H-6α), 4.00 (ddd, 0.44 H, $J_{5,6'}$ 5.0 Hz, H-5β), 3.95 (dd, 0.44 H, H-6′β), 3.92 (ddd, 0.56 H, $J_{5,6'}$ 5.2 Hz, H-5α), 3.83 (dd, 0.56 H, H-6′α), 2.30 (t, 2 H, 1 CH_2 alkyl chain), 1.63 (m, 2 H, 1 CH_2 alkyl chain), 1.38 (s, 1.32 H, $Me_2C\beta$), 1.37 (s, 1.68 H, $Me_2C\alpha$), 1.32 (s, 3 H, Me_2C), 1.30 (m, 8 H, 4 CH_2 alkyl chain), 0.92 (m, 3 H, Me alkyl chain). ^{13}C NMR (CD_3OD, 75.5 MHz): δ 175.28 (CO), 136.63 (C-2α), 136.41 (C-2β), 110.72 (Me_2C), 110.53 (C-3β), 110.36 (C-3α), 101.62 (C-1α), 101.48 (C-1β), 85.90 (C-4β), 85.77 (C-4α), 80.13 (C-5β), 79.93 (C-5α), 67.66 (C-6β), 67.30 (C-6α), 37.26 (C-1′), 32.88 (C-5′), 30.25, 30.15 (C-3′, C-4′), 26.77 (C-2′), 26.94, 25.51 (*Me*$_2$Cβ), 26.83, 25.44 (*Me*$_2$Cα), 23.67 (C-6′), 14.41 (C-7′). FABMS: 350 (100, $[M+Na]^+$). Anal. Calcd. for $C_{17}H_{29}NO_5$: C, 62.36; H, 8.93; N, 4.28. Found: C, 62.30; H, 8.94; N, 4.20.

*2-Decanoylamino-2,3-dideoxy-5,6-*O*-isopropylidene-*D*-erythro-hex-2-enofuranose* (**15**). Yield: 72 mg (34%); R_f 0.58 (2:1, EtOAc–hexane); mp 118–120 °C; $[\alpha]_D$ −25° (*c* 1.0, pyridine); ν_{max} 3247 (NH), 3162 (OH), 1643 (CO). ^{1}H NMR (CD_3OD, 300 MHz): δ 6.25 (dd, 0.44 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.7 Hz, H-3β), 6.23 (dd, 0.56 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.6 Hz, H-3α), 5.85 (dd, 0.56 H, $J_{1,4}$ 4.0 Hz, H-1α), 5.82 (t, 0.44 H, $J_{1,4}$ 1.1 Hz, H-1β), 4.82 (ddd, 0.56 H, $J_{4,5}$ 6.3 Hz, H-4α), 4.59 (ddd, 0.44 H, $J_{4,5}$ 6.5 Hz, H-4β), 4.04 (dd, 0.44 H, $J_{5,6}$ 6.0 Hz, $J_{6,6'}$ 7.6 Hz, H-6β), 4.03 (dd, 0.56 H, $J_{5,6}$ 6.4 Hz, $J_{6,6'}$ 8.4 Hz, H-6α), 4.00 (ddd, 0.44 H, $J_{5,6'}$ 5.0 Hz, H-5β), 3.95 (dd, 0.44 H, H-6′β), 3.92 (ddd, 0.56 H, $J_{5,6'}$ 5.2 Hz, H-5α), 3.83 (dd, 0.56 H, H-6′α), 2.30 (t, 2 H, 1 CH_2 alkyl chain), 1.62 (m, 2 H, 1 CH_2 alkyl chain), 1.38 (s, 1.32 H, $Me_2C\beta$), 1.37 (s, 1.68 H, $Me_2C\alpha$), 1.32 (s, 3 H, Me_2C), 1.30 (m, 12 H, 6 CH_2 alkyl chain), 0.89 (m, 3 H, Me alkyl chain).^{13}C

NMR (CD_3OD, 75.5 MHz): δ 175.28 (CO), 136.62 (C-2α), 136.40 (C-2β), 110.72 (Me_2C), 110.52 (C-3β), 110.36 (C-3α), 101.62 (C-1α), 101.48 (C-1β), 85.90 (C-4β), 85.77 (C-4α), 80.12 (C-5β), 79.93 (C-5α), 67.66 (C-6β), 67.30 (C-6α), 37.26 (C-1′), 33.04 (C-7′), 30.59, 30.48, 30.41, 30.28 (C-3′-C-6′), 26.76 (C-2′), 26.94, 25.52 ($Me_2C\beta$), 26.84, 25.54 ($Me_2C\alpha$), 23.73 (C-8′), 14.44 (C-9′). FABMS: 378 (100, $[M + Na]^+$). Anal. Calcd. for $C_{19}H_{33}NO_5$: C, 64.19; H, 9.36; N, 3.94. Found: C, 64.16; H, 9.33; N, 3.78.

*2,3-Dideoxy-2-dodecanoylamino-5,6-*O*-isopropylidene-*D*-erythro-hex-2-enofuranose* (**16**). Yield: 83 mg (36%); R_f 0.78 (2:1 EtOAc–hexane); mp 116–118 °C; $[\alpha]_D$ −21° (*c* 1.0, pyridine); ν_{max} 3220 (NH), 3148 (OH), 1650 (C=C and CO). ^1H NMR (CD_3OD, 300 MHz): δ 6.25 (dd, 0.44 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.7 Hz, H-3β), 6.23 (dd, 0.56 H, $J_{1,3}$ 0.9 Hz, $J_{3,4}$ 1.6 Hz, H-3α), 5.85 (dd, 0.56 H, $J_{1,4}$ 4.0 Hz, H-1α), 5.82 (t, 0.44 H, $J_{1,4}$ 1.1 Hz, H-1β), 4.82 (ddd, 0.56 H, $J_{4,5}$ 6.2 Hz, H-4α), 4.59 (m, 0.44 H, H-4β), 4.04 (m, 0.44 H, H-6β), 4.03 (dd, 0.56 H, $J_{5,6}$ 6.3 Hz, $J_{6,6'}$ 8.1 Hz, H-6α), 3.99 (m, 0.44 H, H-5β), 3.96 (m, 0.44 H, H-6′β), 3.92 (ddd, 0.56 H, $J_{5,6'}$ 5.1 Hz, H-5α), 3.83 (dd, 0.56 H, H-6′α), 2.30 (t, 4 H, 2 CH_2 alkyl chain), 1.62 (m, 4 H, 2 CH_2 alkyl chain), 1.38 (s, 1.32 H, $Me_2C\beta$), 1.37 (s, 1.68 H, $Me_2C\alpha$), 1.32 (s, 3 H, Me_2C), 1.30 (m, 8 H, 4 CH_2 alkyl chain), 0.89 (m, 6 H, CH_3 alkyl chain).^{13}C NMR (CD_3OD, 75.5 MHz): δ 175.28 (CO), 136.64 (C-2α), 136.42 (C-2β), 110.72 (Me_2C), 110.53 (C-3β), 110.39 (C-3α), 101.63 (C-1α), 101.49 (C-1β), 85.91 (C-4β), 85.78 (C-4α), 80.14 (C-5β), 79.95 (C-5α), 67.68 (C-6β), 67.31 (C-6α), 37.27 (C-1′), 33.07 (C-9′), 30.74, 30.62, 30.47, 30.28 (C-3′-C-8′), 26.76 (C-2′), 26.95, 25.52 ($Me_2C\beta$), 26.84, 25.54 ($Me_2C\alpha$), 23.74 (C-10′), 14.44 (C-11′). FABMS: 406 (100, $[M + Na]^+$). Anal. Calcd. for $C_{21}H_{39}NO_6$: C, 65.76; H, 9.72; N, 3.65. Found: C, 65.73; H, 9.75; N, 3.84.

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