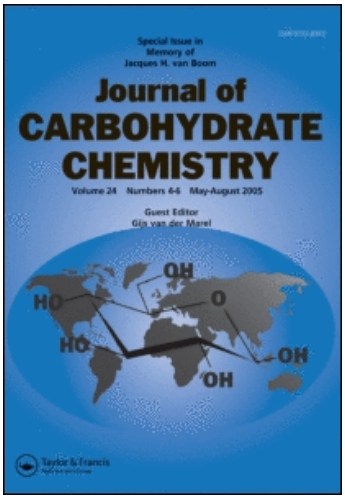

Journal of Carbohydrate Chemistry

Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713617200

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To cite this Article Tronchet, Jean M. J. , Zosimo-landolfo, Guido , Bizzozero, Nicoletta , Cabrini, Daniel , Habashi, Ford , Jean, Evelyne and Geoffroy, Michel(1988) 'Terminal Deoxy Hydroxyamino Sugars', Journal of Carbohydrate Chemistry, 7: 1, 169 — 186

To link to this Article: DOI: 10.1080/07328308808058912

URL: http://dx.doi.org/10.1080/07328308808058912

J. CARBOHYDRATE CHEMISTRY, 7(1), 169-186 (1988)

TERMINAL DEOXY HYDROXYAMINO SUGARS

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Received August 10, 1987 - Final Form January 19, 1988

ABSTRACT

Reduction of sugar aldoximes gave in good yield the corresponding terminal deoxy hydroxyamino sugars. These compounds were found to be reasonably stable (they could be kept for some weeks at 4° C). On standing in the air, these compounds in solution were spontaneously oxidized to the corresponding nitroxide free radicals whose ESR spectra gave useful structural information.

INTRODUCTION

Deoxyhydroxyamino sugars are smoothly oxidized to the corresponding nitroxide free radicals and constitute useful spin-labelled sugar analogs which can be introduced into larger molecules as oligosaccharides, nucleosides, glycopeptides or glycolipids analogs.[1] In a previous communication,[2] we described examples of compounds bearing their hydroxyamino group in a nonterminal position. This paper will report the preparation and properties of their more elusive terminal counterparts.

RESULTS AND DISCUSSION

Mono-*N*-alkylhydroxylamines are not very stable compounds[3] particularly when the first carbon atom of the chain bears two hydrogen atoms as in terminal deoxy hydroxyamino sugars where the accessibility of the reactive group is at a maximum. These compounds are best prepared by reduction of aldoximes with sodium cyanoborohydride[4] in acidic medium.

The acidic medium necessary to insure the protonation of the oximino nitrogen atom has two draw-backs :

it renders possible a nucleophile attack of a formed hydroxylamine onto the unreacted aldoxime leading to a symmetrically di-*N*-substituted hydroxylamine,[4]

$$\text{Glyc-CH}_2\text{NHOH} + \text{Glyc-CH=NOH} \longrightarrow (\text{Glyc-CH}_2)_2\text{NOH}$$

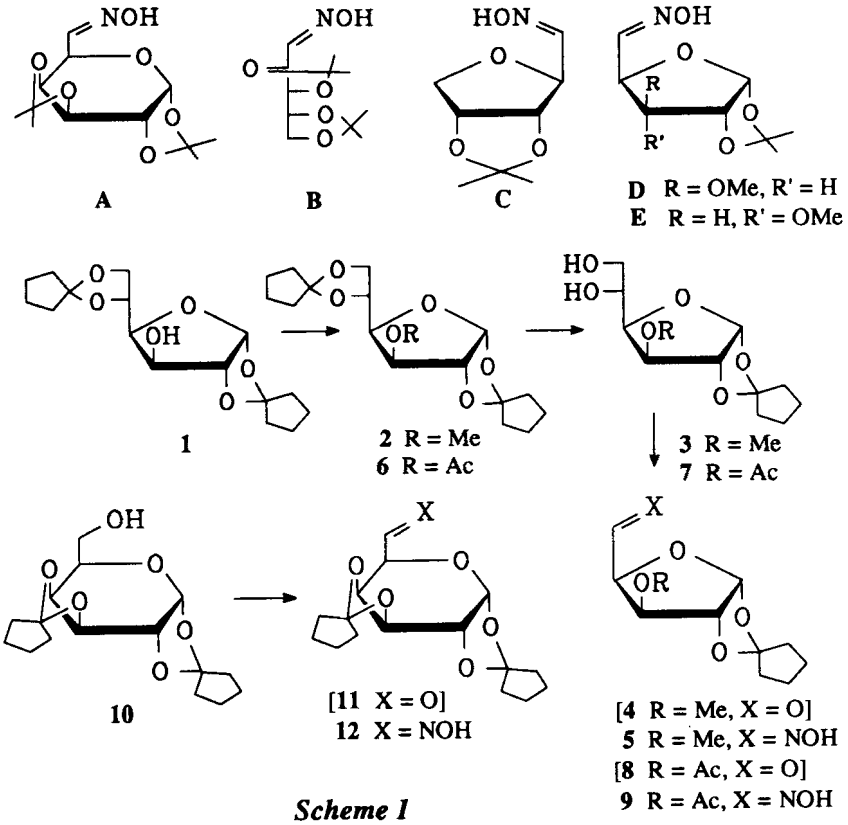
it catalyses the solvolysis of acetal blocking groups of the sugar and the formed carbonyl compounds react with the hydroxylamine to give nitrones which are reduced more rapidly than ketones leading to nonsymmetrically di-*N*- substituted hydroxylamines

$$\text{Glyc-CH}_2\text{NHOH} + \text{R}_2\text{CO} \longrightarrow \text{Glyc-CH}_2\text{-N}^+(\text{O}^-)\text{=CR}_2 \longrightarrow \text{Glyc-CH}_2\text{N(OH)CHR}_2$$

Amongst the oximes used, **A**,[5] **B**,[6] **C**[7] and **D**[6] were known and **E** was prepared from the corresponding dialdose derivative.[8] Some novel oximes bearing a cyclopentylidene group more acid-labile[9] than the classical isopropylidene group were also prepared. Methylation of **1**[2] to **2**, followed by a partial de-*O*-acetalation gave **3** whose periodate oxidation led to **4** which was oximated to **5**. The 3-*O*-acetyl derivative **6** was, in the same manner, converted to **9**, *via* **7** and **8** but in poorer yield. Di-*O*-cyclopentylidenation of D-galactose gave **10** which was oxidized to **11**, then oximated to **12** (*Scheme 1*).

Reduction ($NaBH_3CN$, acidic medium) of oximes **A**, **B**, **C**, **D**, **E**, **5** and **12** gave respectively deoxyhydroxyamino sugars **13**, **14**, **15**, **16**, **17**, **18** and **19** (*Scheme 2*). In our first reduction experiments of **D** at pH 4, we obtained mixtures of the mono- **16** and the diglycosylhydroxylamine **20** in variable amounts. Decreasing the pH to 3 reduced the formation of the diglycosylhydroxylamine but when these very acidic

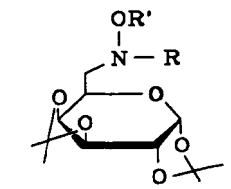
conditions were applied to substrates bearing one labile isopropylidene group as **A**, **B** or **C**, the corresponding *N*-isopropyl derivatives **21**, **22** and **23** were obtained (2-3%) even after total exclusion of acetone coming from the solvents or from the washing of the glassware. Owing to the α-effect,[10] these hydroxylamines are powerful nucleophiles and their reaction with acetone is instantaneous, for example in an NMR tube at room temperature. Also obtained, was about 2% of the *N*-methyl derivative **24**, the methyl group coming probably from the methanolic solvent. The structure of **24** was confirmed by its preparation by reduction of the known **F**.[11] As the formation of these different by-products rendered the isolation of the hydroxylamines difficult, we developed for the preparation of these compounds a general, fair-yielding (60-90%) procedure. Using a large excess of $NaBH_3CN$ (11 moles/mole, 33 equivalents) and keeping the pH carefully at 3 suppressed the formation of the diglycosylhydroxylamine. The formation of the *N*-glycosyl-*N*-isopropylhydroxylamines



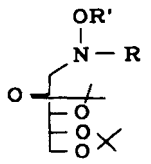
Scheme 1

was considerably reduced by decreasing the quantity of methanol, classically used as reaction solvent, to the minimum necessary to dissolve the starting oxime. The isolation procedure was also optimized : the aqueous reaction medium was extracted by dichloromethane and from this solution most of the *N*-glycosylhydroxylamine was obtained pure by extraction with an aqueous buffer solution (pH 3), the by-products remaining in the organic layer. Although less stable than their nonterminal counterparts, these deoxy hydroxyamino sugars could be kept for a few weeks at 4° C.

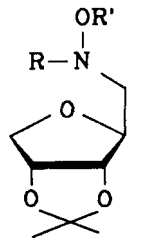
Upon acetylation (Ac_2O, pyridine), compounds **13**, **14**, **16**, **18** and **19** gave the di-*O*,*N*-acetyl derivatives **25**, **26**, **27**, **28** and **29** respectively. Under the same conditions, the di-*N*- substituted hydroxylamines **21** and **22** afforded the expected *O*-acylated compounds **30** and **31** respectively. Di-*O*,*N*-acetyl derivatives **25** and **26** were easily mono-de-*O*-acetylated to **32** and **33** respectively.



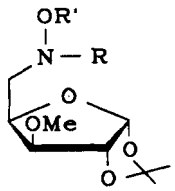
13 R=R'=H
21 R=Me_2CH, R'=H
24 R=Me, R'=H
25 R=R'=Ac
30 R=Me_2CH, R'=Ac
32 R=Ac, R'=H



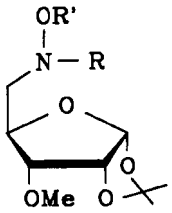
14 R=R'=H
22 R=Me_2CH, R'=H
26 R=R'=Ac
31 R=Me_2CH, R'=Ac
33 R=Ac, R'=H



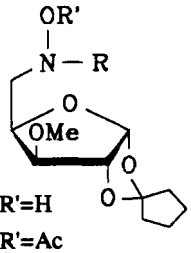
15 R=R'=H
23 R=Me_2CH, R'=H



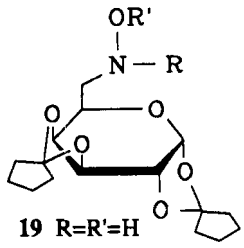
16 R=R'=H
27 R=R'=Ac



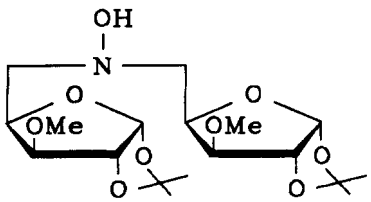
17 R=R'=H



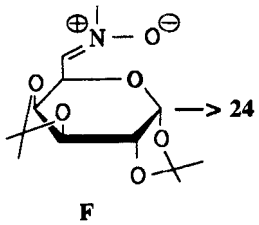
18 R=R'=H
28 R=R'=Ac



19 R=R'=H
29 R=R'=Ac



20



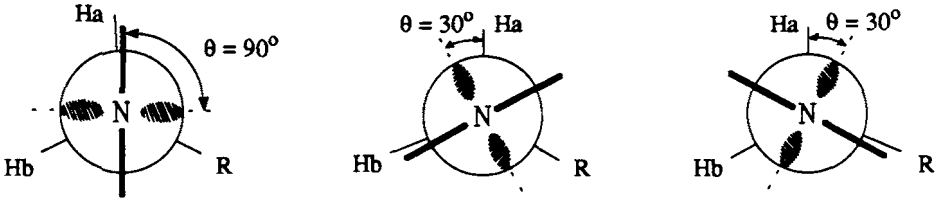
F —> **24**

Scheme 2

Deoxyhydroxyamino sugars in dilute solutions were oxidized in the air (in some cases addition of PbO_2 was necessary) to give the corresponding nitroxide free radicals (numbers primed, f. ex. **14** —> **14'**) some ESR data of which are collected in the *TABLE*. The values recorded for the hyperfine coupling constants of the methyl protons of **24'** (12.7 G) were in good accordance with the classical relationship[12] $a_H = 26\cos^2\theta$ and a strong preference for eclipsed conformers, the expected a_{Me} value for a 1:1:1 mixture of eclipsed conformers **G**, **H**, **I** (R = H *Scheme 3*) being 13 G (19.5 • 2/3). The fact that for radicals **14'**, **20'**, **21'-24'** the sum of the methylene hyperfine coupling constants was close to 19.5 G, a temperature variation affecting their individual values but not their sum, confirmed our previous observations[1,13] of a strong preference for conformations where a hydrogen atom of the methylene group lies in the plane of the almost sp^2 hybridized nitrogen atom (conformers **G** and **H**, R = sugar moiety, *Scheme 3*). For the *N*-acylnitroxides **32'** and **33'**, the same general rule applied but with a decrease in the hyperfine coupling constants due to the resonance with the carbonyl group.

EXPERIMENTAL

General methods. Melting points (uncorrected) were determined under microscope with a *Mettler* FP52 mp apparatus. TLC were performed on silica gel HF_{254} (*Merck*) with detection by UV light and phosphomolybdic-sulfuric acid.[14] Dry column chromatography[15] was conducted on silica gel $60F_{254}$ (0.063 - 0.200 mm). Silica gel 60 (0.040 - 0.200 mm) *Merck* was used for flash column chromatography.[16] IR spectra were recorded with a *Perkin-Elmer* Model 357 or a FT-IR *Nicolet* 20



G $a_{Ha} = 0$ G, $a_{Hb} = 19.5$ G

H $a_{Ha} = 19.5$ G, $a_{Hb} = 0$ G

I $a_{Ha} = 19.5$ G, $a_{Hb} = 19.5$ G

Scheme 3

TABLE. ESR Data of Some Representative Nitroxide Free Radicals.[a]

Compds	solvent	temp. (°C)	g	a_N	a_{H1}	a_{H2}	a_{H3}	a_{H4}	a_{H5}	a_{H6}	Γ
14'	diglyme	20	2.0064	12.3	11.6	12.3	7.7				0.6
20'	$CHCl_3$	25	2.0060	15.7	12.4	7.7	12.4	7.7			
	diglyme	90		14.6	11.8	8.3	11.8	8.3	0.7	0.7	
21'	diglyme	20	2.0060	15.0	11.25	7.	4.5	0.7			0.7
22'	diglyme	20	2.0061	14.7	10.9	6.3	4.6				0.8
24'	diglyme	20	2.0062	14.6	12.7	12.7	12.7	11.1	7.1	1.0	0.4
32'	diglyme	20	2.0068	7.3	10.2	2.8	0.4				0.6
	diglyme	100		7.6	8.8	3.7	0.4				
33'	diglyme	20	2.0070	7.3	7.3	4.2					0.8

a. Hyperfine couplings constants (in Gauss) of protons belonging to the same groups are included in a box : [ ] methyl, ▭ methylene of a N-glycosylnitroxide, ▭ methylene of a N-glycosyl-N-acylnitroxide.

SXB spectrometer. UV spectra were measured on a *Kontron* Uvicon 810 spectrophotometer. NMR spectra were recorded at 20°C on a *Brucker* WP 200 SY spectrometer (^{1}H 200 MHz; ^{13}C 50.4 MHz; chemical shifts in ppm from TMS; δ units; *b* : broad; *s* : singlet...). The MS were recorded on *Finningan* 4023 or *VG* 70-70E spectrometers. Optical rotations were measured with a *Schmidt-Haensch* polarimeter. ESR spectra were recorded on a *Varian* E-9 spectrometer (X band, 100 KHz modulation) equipped with a variable temp device. The g values were measured by using a DPPH sample and the magnetic field was calibrated with an NMR marker. All the hyperfine coupling constants were checked by simulating the corresponding ESR spectra with a 9830 *Hewlett-Packard* or *Victor* S1 desk computer, using a program developped in this Laboratory.

5-Deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-5-oximino-α-D-ribofuranose (E). To a soln of 1,2-*O*-isopropylidene-3-*O*-methyl-α-D-ribo-pentodialdo-1,4-furanose (540 mg, 2.7 mmol) in a mixture of pyridine (4.5 mL) and EtOH (4.5 mL), NH_2OH, HCl (990 mg, 14 mmol) was added and the mixture refluxed for 90 min. After removal of the solvents by a codistillation with toluene, the residue was extracted with Et_2O (50 mL), washed (water, 2x30 mL), dried (Na_2SO_4) and concd to a white solid which was washed (Et_2O/hexane) to give 510 mg (88%) of **E** as mixture of *Z* and *E* isomers (*Z*:*E* 93:7). UV ($CHCl_3$): 240 (163). IR (KBr): 3365 (OH), 2990 (CH), 1450, 1385, 1380 (CMe), 1250, 1235, 1170 and 1180 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$); *Z* isomer: 1.39 and 1.63 (*2s*, 2x3H, CMe_2), 3.52 (*s*, 3H, OMe), 3.66 (*dd*, $J_{2,3}$ 4.5 Hz, $J_{3,4}$ 9 Hz, 1H, H-3), 4.59 (*dd*, $J_{4,5}$ 6.5 Hz, 1H, H-4), 4.74 (*dd*, $J_{1,2}$ 3.5 Hz, 1H, H-2), 5.83 (*d*, 1H, H-1), 7.44 (*d*, 1H, H-5), 7.54 (*bs*, 1H, OH); *E* isomer: 1.47 and 1.70 (2s, 2x3H, CMe_2), 3.58 (s, 3H, OMe), 5.31 (dd, 1H, H-4), 6.78 (d, 1H, H-5). MS: *m/z* 217 (0.5, $M^{\cdot+}$), 202 (36, $M^{\cdot+}$ - Me·), 188(36), 143(21), 128(44), 115(46), 101(78), 85(100), 69(80), 59(92). *Anal* Calcd for $C_9H_{15}NO_5$ (217.22): C 49.76; H 6.96; N 6.45. Found: C 49.71; H 7.04; N 6.43.

1,2:5,6-Di-*O*-cyclopentylidene-3-*O*-methyl-α-D-glucofuranose (2). A soln of **1** (17 g, 54 mmol) in DMF (80 mL) was added at 15% to NaH (104 mmol corresponding to 4 g of a 60% suspension in mineral oil). After 1 hour at 20°, CH_3I (8 g, 60 mmol) was added drop-wise at 10-15° and the mixture kept at 20° for 14 h. After addition of MeOH (15 mL), then H_2O (80 mL), the reaction mixture was extracted ($CHCl_3$, 3x50 mL) and the organic phases washed (satd aq $NaHSO_3$, 30 mL), dried (Na_2SO_4), concd and submitted to column chromatography (AcOEt/hexane 1:1) to give 13 g (73%) of **2**. Syrup: R_F: 0.56 (AcOEt/hexane 1:1); $[\alpha]_D$ - 0.1° (25°C, 3); UV (EtOH): 202 (49); IR (KBr): 2980 (C-H), 1440, 1350 (cyclopent.), 1130, 1095 and 1040 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.60 and 1.90 (*m*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.00 (*dd*, 2H, $J_{5,6}$ 6 Hz, $J_{6a,6b}$ 8.5 Hz, H_2-6), 4.12 (*dd*, 1H, $J_{4,5}$ 8 Hz, H-2), 5.88 (*d*, 1H, H-1). MS: *m/z* 326 (20, $M^{\cdot+}$), 297 (73, $M^{\cdot+}$ - Et·), 242(35), 213(38), 141(20), 127(30), 85(25), 55(100). *Anal.* Calcd for $C_{17}H_{26}O_6$ (326.39): C 62.56; H 8.03. Found: C 62.58; H 8.09.

1,2-*O*-Cyclopentylidene-3-*O*-methyl-α-D-glucofuranose (3). To a soln of **2** (1 g, 3.1 mmol) in 0.5 N methanolic HCl (50 mL), H_2O (5 mL) was added. After 15 min stirring at 20°, the reaction mixture was extracted with hot (60°) AcOEt (50 mL) to give 680 mg (85%) of **3**. Syrup: R_F: 0.06 (AcOEt/hexane 1:1); $[\alpha]_D$ -24.2° (26°C, 1.24); UV (EtOH): 202 (49); IR (KBr): 3500 (OH), 2980 (C-H), 1425, 1330 (cyclopent.), 1120, 1075 and 1020 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.65 and 1.90 (*m*, 8H, cyclopent.), 2.50 (*bs*, 2H, 2xOH), 3.45 (*s*, 3H, Me - O), 3.70 (*dd*, 1H, $J_{5,6a}$ 5.8 Hz, $J_{6a,6b}$ 11 Hz, Ha-6), 3.85 (*dd*, 1H, $J_{5,6b}$ 3.8 Hz, Hb-6), 3.90 (*d*, $J_{3,4}$ 3 Hz, H-3), 4.00 (*dt*, 1H, $J_{4,5}$ 7.5 Hz, H-5), 4.15 (*dd*, 1H, H-4), 4.55 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.85 (*d*, 1H, H-1). MS: *m/z* 263 (3, M^{+} + 1), 232(13), 199(5), 139(30), 85(63), 55(100). *Anal.* Calcd for $C_{12}H_{20}O_6$ (260.29): C 55.37; H 7.74. Found: C 55.10; H 7.87.

1,2-*O*-Cyclopentylidene-5-deoxy-*O*-methyl-5-oximino-α-D-*xylo*-furanose (5). To a soln of **3** (1.5 g, 5.7 mmol) in H_2O (15 mL), $NaHCO_3$ (1 g, 11.9 mmol) and $NaIO_4$ (2 g, 9.3 mmol) were added. After 2 h stirring at 20°, the reaction mixture was extracted (CH_2Cl_2, 4x10 mL) and the organic phase dried (Na_2SO_4) gave **4** [1.15 g, 86%, ^{1}H NMR: δ 9.65 (*d*, $J_{4,5}$ = 2 Hz, H-5)] which was not further characterized. To a soln of **4** (1 g, 4.3 mmol) in pyridine (10 mL), NH_2OH, HCl (0.5 g, 7.2 mmol) was added. After 0.5 h at 60°, the pyridine was eliminated by co-evaporation with toluene, H_2O (50 mL) was added and the aqueous soln extracted with CH_2Cl_2 (3x20 mL). The organic phase dried (Na_2SO_4) and concd gave after column chromatography (AcOEt/hexane 1:1) 0.8 g (76%) of **5**. Syrup: R_F: 0.41 (AcOEt/hexane 1:1); UV (EtOH): 202 (3730); IR (KBr): 3400 (OH), 2980 (C-H), 1450 and 1350 (cyclopent.); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$); ***Z* isomer**: 1.65 and 1.90 (*m*, 8H, cyclopent.), 3.40 (*s*, 3H, Me - O), 4.15 (*d*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.58 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 4.78 (*dd*, 1H, $J_{4,5}$ 7 Hz, H-4), 5.96 (*d*, 1H, H-1), 7.48 (*d*, 1H, H-5), 8.30 (*bs*, 1H, OH); ***E* isomer**: 1.65 and 1.90 (*m*, 8H, cyclopent.), 3.40 (*s*, 3H, Me - O), 3.82 (*d*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.58 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.22 (*dd*, 1H, $J_{4,5}$ 4 Hz, H-4), 5.96 (*d*, 1H, H-1), 6.90 (*d*, 1H, H-5), 7.95 (*bs*, 1H, OH). MS: *m/z* 243 (4, M^{+}), 214 (32, M^{+} - Et·), 182(5), 142(7), 85(53), 55(100). *Anal.* Calcd for $C_{11}H_{17}NO_5$ (243.26): C 54.31; H 7.04; N 5.76. Found: C 54.39; H 7.33; N 6.00.

3-*O*-Acetyl-1,2:5,6-di-*O*-cyclopentylidene-α-D-glucofuranose (6). A soln of **1** (312 mg, 1mmol) in a mixture of pyridine (10 mL) and Ac_2O (10 mL) was kept 12 h at room temp, the reaction mixture coevaporated with toluene and the residue submitted to a chromatography (AcOEt/hexane 1:1) to give 200 mg (56%) of **6**. Mp 51.0 - 54.0°C. R_F: 0.54 (AcOEt/hexane 1:2); $[\alpha]_D$ - 17.7° (20°C, 1); UV (EtOH): 204 (206); IR (KBr): 1750 (C=O), 1345 (cyclopent.), 1245, 1110 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.55 and 2.00 (*m*, 16H, cyclopent.), 2.10 (*s*, 3H, Ac-O), 4.00 (*d*, 2H, $J_{5,6}$ 6 Hz, H_2-6), 4.20 (*dt*, 1H, $J_{4,5}$ 4.5 Hz, H-5), 4.25 (*dd*, 1H, $J_{3,4}$ 3.5 Hz, H-4), 4.45 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.25 (*d*, 1H, H-3), 5.85 (*d*, 1H, H-1). MS: *m/z* 354 (20, M^{+}), 325 (85, M^{+} - Et·), 241(30), 169(19),

127(79), 109(17), 85(29), 55(100). *Anal.* Calcd for $C_{18}H_{26}O_7$ (354.40): C 61.00; H 7.39. Found: C 60.98; H 7.44.

3-*O*-Acetyl-1,2-*O*-cyclopentylidene-α-D-glucofuranose (7). To a soln of **6** (5 g, 14.1 mmol) in MeOH (50 mL) 1*N* methanolic HCl (50 mL) was added. After 30 min under stirring at room temp, the reaction mixture was concd to dryness and the residue extracted by CH_2Cl_2 (50 mL). The organic soln washed (2x50 mL water), dried (Na_2SO_4) yielded after chromatography (AcOEt/hexane 1:1) 2 g (50%) of **7**. Mp 108.7 - 111.6°C. R_F: 0.15 (AcOEt/hexane 1:1); $[\alpha]_D$ + 7.35° (25°C, 1); UV (EtOH): 202 (134); IR (KBr): 3500 (OH), 2990 (C-H), 1780 (C=O), 1350 (cyclopent.), 1270, 1115 and 1060 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.65 and 1.90 (*m*, 8H, cyclopent.), 2.10 (*s*, 3H, Ac), 2.40 (*bs*, 2H, 2xOH), 3.65 (*ddd*, 1H, $J_{4,5}$ 8.8 Hz, $J_{5,6a}$ 3.5 Hz, $J_{5,6b}$ 6 Hz, H-5), 3.83 (*dd*, 1H, $J_{6a,6b}$ 11 Hz, Hb-6), 3.91 (*dd*, 1H, Ha-6), 4.15 (*dd*, 1H, $J_{3,4}$ 3 Hz, H-4), 4.55 (*d*, 1H, H-1). MS: *m/z* 288 (12, M^{+}), 259 (58, M^{+} - Et), 185(17), 127(31), 103(32), 85(63), 73(38), 55(100). Anal. Calcd for $C_{13}H_{20}O_7$ (288.30): C 54.16; H 6.99. Found: C 54.43; H 7.02.

3-*O*-Acetyl-1,2-*O*-cyclopentylidene-5-deoxy-5-oximino-α-D-xylofuranose (9). A soln of **7** (2 g, 6.9 mmol), $NaHCO_3$ (2 g, 23.8 mmol) and $NaIO_4$ (1.5 g, 7 mmol) in water (40 mL) was kept 1 h at room temp under stirring, concd to dryness and the residue extracted (CH_2Cl_2, 50 mL). The dried (Na_2SO_4) extract was filtered, concd and distillated (150°, 10^{-3} mm Hg) to give 770 mg (43%) of essentially pure **8** (^{1}H NMR, δ = 9.75, *d*, 1H, $J_{4,5}$ = 2 Hz, H-5) which was not further characterized. To a soln of **8** (500 mg, 1.95 mmol) in a 1:1 mixture (10 mL) of EtOH and pyridine, NH_2OH, HCl (500 mg, 7.3 mmol) was added and the soln kept at 80°C for 30 min. After coevaporation with toluene, a chromatography (AcOEt/hexane 1:1) of the residue gave 150 mg (18%) of **9**. Syrup: R_F: 0.28 (AcOEt/hexane 1:1); UV (EtOH): 201 (290), 257 (1139); IR (KBr): 3400 (OH). 2970 (C-H), 1750 (C=O), 1435 (cyclopent.), 1350, 1230, 1120 and 1040 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$); ***Z* isomer**: 1.70 and 1.90 (*m*, 8H, cyclopent.), 2.06 (*s*, 3H, Ac), 4.52 (*bdd*, 1H, $J_{1,2}$ 4 Hz, H-2), 4.90 (*dd*, 1H, $J_{3,4}$ 3 Hz, $J_{4,5}$ 6.8 Hz, H-4), 5.28 (*d*, 1H, H-3), 5.96 (*d*, 1H, H-1), 7.38 (*d*, 1H, H-5). 7.80 (*bs*, 1H, OH); ***E* isomer**: 1.70 and 1.90 (*m*, 8H, cyclopent.), 2.04 (*s*, 3H, Ac), 4.52 (*bdd*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.38 (*dd*, 1H, $J_{3,4}$ 3 Hz, $J_{4,5}$ 4 Hz, H-4), 5.62 (*d*, 1H, H-3), 5.96 (*d*, 1H, H-1), 6.85 (*d*, 1H, H-5), 8.00 (*bs*, 1H, OH). MS: *m/z* 271 (8, M^{+}), 242 (M^{+} - Et), 224(5), 170(9), 128(17), 85(36), 55(100). *Anal.* Calcd for $C_{12}H_{17}NO_6$ (271.27): C 53.13; H 6.32; N 5.16. Found: C 53.42; H 6.48; N 5.32.

1,2:3,4-Di-*O*-cyclopentylidene-α-D-galactopyranose (10). To a soln of galactose (5 g, 32 mmol) in freshly distillated cyclopentanone (75 mL), powdered fused $ZnCl_2$ (5.2 g, 36 mmol) and cryst H_3PO_4 (5-10 mg) were added. After 24 h at 40° in the dark in dry conditions, the unreacted galactose (2.5 g) was recovered by filtration and the soln neutralized ($NaHCO_3$, 3 g, 36.8 mmol) concd

to dryness. The residue was extracted (AcOEt, 100 mL) and the organic soln washed (5% NaOH, 30 mL, then water, 2x3 mL), dried (Na_2SO_4), concd and submitted to a chromatography (AcOEt/hexane 1:1) to give 3.2 g (64% from the reacted galactose) of **10**. Syrup: $[\alpha]_D$ - 32.8° (22°C, 1.22); UV (EtOH): 203 (80); IR (KBr): 3240 (OH), 2980 (C-H), 1430 (cyclopent.), 1330, 1200, 1110 and 1055 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.65 and 1.90 (*m*, 16H, cyclopent.), 2.35 (*bs*, 1H, OH), 3.75 (*m*, 3H, $J_{4,5}$ 2 Hz, H-5, H_2-6), 4.15 (*dd*, 1H, $J_{3,4}$ 8 Hz, H-4), 4.20 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.8 Hz, H-2), 4.50 (*dd*, 1H, H-3), 5.50 (*d*, 1H, H-1). MS: *m/z* 312 (4, $M^{\cdot+}$), 283 (15, $M^{\cdot+}$ - Et·), 199(14), 127(19), 99(25), 85(28), 81(55), 69(48), 55(100). *Anal.* Calcd for $C_{16}H_{24}O_6$ (312.37): C 61.52; H 7.74. Found: C 61.73; H 7.65.

6-Deoxy-1,2:3,4-di-*O*-cyclopentylidene-6-oximino-α-D-galactopyranose (12). To a mixture of pyridine (58 mL) and CH_2Cl_2 (700 mL), CrO_3 (24.9 g, 326 mmol) then, after 20 min at room temp, **10** (9 g, 28 mmol) were added. After 25 min under stirring, the reaction medium was brought to 10°, washed (satd aq $NaHCO_3$, 3x100 mL, satd aq NaCl 2x100 mL) and the organic layer dried (Na_2SO_4), concd to dryness and extracted by Et_2O (200 mL). The ether extract stirred 15 min with active charcoal (1 g), filtered yielded by evaporation of the solvent 5.6 g (70%) of **11** (^{1}H NMR δ 9.65, *d*, 1H, $J_{5,6}$ = 1 Hz, H-6) which was not further characterized. To a soln of **11** (1 g, 3.2 mmol) in a mixture of pyridine (3 mL) and MeOH (15 mL), NH_2OH, HCl (500 mg, 7.2 mmol) were added. After 1 h refluxing, the solvents were coevaporated with toluene and the residue extracted by CH_2Cl_2 (50 mL). The extracts washed (water 2x30 mL), dried (Na_2SO_4), concd gave after chromatography (AcOEt/hexane 1:1) 640 mg (63%) of **12**. Syrup: R_F: 0.51 (AcOEt/hexane 1:1); $[a]_D$ - 85.9° (22°C, 1.28); UV (EtOH): 203 (2390); IR (KBr): 3350 (OH), 2980 (C-H), 1740 (C=N), 1435, 1340 (cyclopent.), 1200, 1115, 1090 and 1060 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$); ***Z* isomer**: 1.65 and 1.95 (*m*, 16H, cyclopent.), 4.20 (*dd*, 1H, $J_{3,4}$ 8 Hz, $J_{4,5}$ 2 Hz, H-4), 4.23 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.42 (*dd*, 1H, $J_{5,6}$ 6.5 Hz, H-5), 4.47 (*dd*, 1H, H-3), 5.55 (*d*, 1H, H-1), 7.43 (*d*, 1H, H-6), 9.30 (*bs*, 1H, OH); ***E* isomer**: 1.65 and 1.95 (*m*, 16H, cyclopent.), 4.22 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.65 (*bs*, 1H, $J_{4,5}$ 1 Hz, H-4), 4.47 (*bd*, 1H, H-3), 5.05 (*bd*, 1H, $J_{5,6}$ 4.5 Hz, H-5), 5.55 (*d*, 1H, H-1), 6.80 (*d*, 1H, H-6), 9.80 (*bs*, 1H, OH). MS: *m/z* 325 (3, $M^{\cdot+}$), 296 (11, $M^{\cdot+}$ - Et·), 212(12), 167(13), 140(16), 85(26), 55(100). *Anal.* Calcd for $C_{16}H_{23}NO_6$ (325.36): C 59.07; H 7.13; N 4.30. Found: C 58.98; H 7.23; N 4.15.

Reduction of sugar aldoximes. - ***Method A*:** To a soln of $NaBH_3CN$ (7 g, 111 mmol) in MeOH (70 mL) a soln of oxime (10 mmol) in MeOH (10 mL) was added. The pH was kept at 3 (pH-meter) by addition of 3 *N* HCl (room temp). 2 h after the last addition of HCl, the solvent was evaporated (30°, 12 mm Hg) and the residue extracted (citrate-HCl buffer pH 3, Titrisol®*Merck*, 2x50 mL). The aqueous soln was washed (CH_2Cl_2, 30 mL) to remove the by-products, brought to pH 8 (10% NaOH)

and extracted with CH_2Cl_2 (5x30 mL). These last CH_2Cl_2 extracts after drying (Na_2SO_4) and evaporation of the solvent yielded the expected terminal hydroxylamine which was further purified by chromatography (AcOEt/hexane 1:1). ***Method B :*** To a soln of $NaBH_3CN$ (2.3 g, 37 mmol) in water (30 ml) a soln of oxime (3.7 mmol) in MeOH (10 mL) was added at 0-4° and the pH kept at 3 by addition of 3 *N* HCl, the reaction mixture was washed ($CHCl_3$, 30 mL), brought to pH 8 (10% of NaOH satd with NaCl) and extracted ($CHCl_3$, 3x30 mL). The chloroform extract, dried (Na_2SO_4) yielded after evaporation of $CHCl_3$ the expected hydroxylamine which was purified by chromatography (Et_2O/MeOH 97:3).

6-Deoxy-6-hydroxyamino-1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose (13). Application of method A to **A** (1.8 g) yielded 1.31 g (73%) fo **13**. Mp 52.5-53.3°C; $[\alpha]_D$ - 29.7° (26°C, 1); IR (KBr): 3580, 3280 (NHOH), 1390, 1370 (CMe_2), 1210 and 1080 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.35, 1.46 and 1.56 (*3s*, 12H, $2CMe_2$), 3.11 (*m*, 2H, H_2-6), 4.22 (*m*, 2H, H-4, H-5), 4.33 (*dd*, 1H, $J_{3,4}$ 8 Hz, H-3), 5.54 (*d*, 1H, H-1), 5.72 (*bs*, 2H, NH, OH). MS: *m/z* 275 (2, M^{+}), 260 (22, M^{+} - Me·), 217(14), 202(12), 188(6), 59(100). *Anal.* Calcd for $C_{12}H_{21}NO_6$ (275.30): C 52.35; H 7.69; N 5.09. Found C 52.31; H 7.74; N 5.02.

1-Deoxy-1-hydroxyamino-2,3:4,5-di-*O*-isopropylidene-D-arabinitol (14). Application of method A to **B** (1 g) yielded 730 mg (73%) of **14**. Syrup: $[\alpha]_D$ + 14.7° (22°C, 1.4); IR (KBr): 3600, 3300 (NHOH), 1380, 1370 (CMe_2), 1220 and 1080 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.33, 1.38, 1.40 and 1.42 (*4s*, 4x3H, $2CMe_2$), 3.11 (*dd*, 1H, $J_{1a,1b}$ 13.5 Hz, $J_{1a,2}$ 7.5 Hz, Ha-1), 3.29 (*dd*, 1H, $J_{1b,2}$ 4 Hz, Hb-1), 3.69 (*t*, 1H, $J_{2,3}$ 8 Hz, $J_{3,4}$ 8 Hz, H-3), 3.98 (*dd*, 1H, $J_{5a,5b}$ 7.5 Hz, $J_{4,5a}$ 4 Hz, Ha-5), 4.04 (*ddd*, 1H, $J_{4,5b}$ 6 Hz, H-4), 4.16 (*dd*, 1H, Hb-5), 4.22 (*dt*, 1H, H-2), 5.70 (*bs*, 2H, NH, OH). MS: *m/z* 214(2), 200(5), 184(5), 171(23), 157(36), 143(100). *Anal.* Calcd for $C_{11}H_{21}NO_5$ (247.29): C 53.43; H 8.56; N 5.67. Found: C 53.70; H 8.58; N 5.66.

2,5-Anhydro-1-deoxy-1-hydroxyamino-3,4-*O*-isopropylidene-D-ribitol (15). Application of method B to **C** (210 mg) yielded 150 mg (68%) of **15**. Mp 85.3-89.4°C. R_F: 0.43 ($CHCl_3$/MeOH, 9:1); $[\alpha]_D$ - 61° (24°C, 1); UV ($CHCl_3$): 241(127); IR (KBr): 3250 (NHOH), 1385, 1375 (CMe_2), 1275, 1215, 1085 and 1055 (C-O); ^{1}H NMR (200 MHz, 20°C, - $CDCl_3$): 1.33 and 1.51 (*2s*, 2x3H, CMe_2), 2.96 (*m*, 1H, $J_{1a,1b}$ 13.5 Hz, $J_{1a,2}$ 10.85 Hz, Ha-1), 2.98 (*m*, 1H, $J_{1b,2}$ 2.75 Hz, Hb-1), 3.87 (*dd*, 1H, $J_{5a,5b}$ 11 Hz, $J_{4,5a}$ 4.5 Hz, Ha-5), 3.98 (*dd*, 1H, $J_{4,5b}$ 2 Hz, Hb-5), 4.32 (*m*, 1H, $J_{2,3}$ 2 Hz, H-2), 4.56 (*dd*, 1H, $J_{3,4}$ 6.5 Hz, H-3), 4.79 (*ddd*, 1H, H-4), 5.40 (*bs*, 2H, NH, OH). MS: *m/z* 174 (3, M^{+} - Me·), 131(8), 104(3), 86(100), 85(17), 81(5), 69(40), 59(73), 57(54). *Anal.* Calcd for $C_8H_{15}NO_4$ (189.22): C 50.78; H 7.99; N 7.40. Found: C 50.76; H 8.07; N 7.43.

5-Deoxy-5-hydroxyamino-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose (16). Application of method A to **D** (1 g) yielded 650 mg (65%) of **16**. Syrup: R_F: 0.20 (AcOEt/hexane,

1:1); $[\alpha]_D$ - 38° (23°C, 1); UV (EtOH): 203(961), 235 (1032); IR (KBr): 3280 (NHOH), 1390, 1370 (CMe_2), 1220 and 1050 (C-O); ^1H NMR (200 MHz, 20°C, $CDCl_3$): 1.30 and 1.49 (*2s*, 2x3H, CMe_2), 3.20 (*d*, 2H, $J_{4,5}$ 6 Hz, H_2-5), 3.40 (*s*, 3H, OMe), 3.70 (*d*, 1H, $J_{3,4}$ 3.2 Hz, H-3), 4.50 (*dd*, 1H, H-4), 4.59 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.89 (*d*, 1H, H-1), 5.97 (*bs*, 2H, NH, OH). MS: *m/z* 219 (2, $M^{+\cdot}$), 204 (4, $M^{+\cdot}$ - Me·), 187(3), 161(5), 142(7), 78(100). *Anal.* Calcd for $C_9H_{17}NO_5$ (219.24): C 49.31; H 7.82; N 6.39. Found: C 49.48; H 7.94; N 6.45.

5-Deoxy-5-hydroxyamino-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-ribofuranose (17). Application of method B to **E** (800 mg) yielded 720 mg (90%) of **17**. Mp 78.7-79.4°C; R_F 0.21 (Et_2O/MeOH 97:3); $[\alpha]_D$ + 100° (26°C, 1.02); IR (KBr): 3260 (NHOH), 2980 (CH), 1460, 1385, 1375 (CMe_2), 1260, 1215, 1170 and 1050 (C-O). ^1H NMR (200 MHz, 20°C, $CDCl_3$): 1.37 and 1.59 (*2s*, 2x3H, CMe_2), 3.15 (*dd*, $J_{4,5a}$ 6 Hz, $J_{5a,5b}$ 13.5 Hz, 1H, Ha-5), 3.30 (*dd*, $J_{4,5b}$ 4 Hz, 1H, Hb-5), 3.52 (*s*, 3H, OMe), 3.56 (*dd*, $J_{2,3}$ 4 Hz, $J_{3,4}$ 9 Hz, 1H, H-3), 4.22 (*ddd*, 1H, H-4), 4.70 (*t*, $J_{1,2}$ 4 Hz, 1H, H-2), 5.00 (*bm*, 2H, NH,OH), 5.78 (*d*, 1H, H-1). MP: *m/z* 204 (3, $M^{+\cdot}$ - Me·), 161(10), 142(13), 132(12), 127(11), 116(14), 115(28), 100(14), 87(100), 85(46), 71(65), 59(58). *Anal.* Calcd for $C_9H_{17}NO_5$ (219.24): C 49.31; H 7.82; N 6.39. Found: C 49.32; H 7.86; N 6.35.

1,2-*O*-Cyclopentylidene-5-deoxy-5-hydroxyamino-3-*O*-methyl-α-D-xylofuranose (18). Application of method A to **5** (500 mg) yielded 300 mg (60%) of **18** which was fully characterized as its diacetate **28**. Syrup: R_F: 0.05 (AcOEt/hexane 1:1); $[\alpha]_D$ - 28.3° 25°C, 1); UV (EtOH): 202 (613), 235 (267); IR (KBr): 3150 (NHOH), 2970 (C-H), 1430, 1350 (cyclopent.), 1115 and 1085 (C-O); ^1H N.M.R. (200 MHz, 20°C, $CDCl_3$): 1.60 and 1.85 (*m*, 8H, cyclopent.), 3.12 (*m*, 2H, H_2-5), 3.32 (*s*, 3H, Me-O), 3.62 (*d*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.45 (*dt*, 1H, $J_{4,5}$ 6 Hz, H-4), 4.50 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 4.90 (*bs*, 2H, NHOH), 5.85 (*d*, 1H, H-1). MS: *m/z* 245 (2, $M^{+\cdot}$), 216 (34, $M^{+\cdot}$ - Et·), 214(35), 132(19), 87(61), 71(42), 55(100). *Anal.* Calcd for $C_{11}H_{19}NO_5$ (145.28): C 53.87; H 7.81; N 5.71. Found: C 53.66; H 7.78; N 5.64.

6-Deoxy-1,2:3,4-di-*O*-cyclopentylidene-6-hydroxyamino-α-D-galactopyranose (19). Application of method A to **12** (350 mg) yielded 270 mg (76%) of **19**. Syrup: $[\alpha]_D$ - 14.0° (21°C, 1.4); UV (EtOH): 202 (1340); IR (KBr): 3140 (NHOH), 2985 (C-H), 1340 (cyclopent.), 1200, 1120, 1090 and 1000 (C-O); ^1H NMR (200 MHz), 20°C, $CDCl_3$): 1.72 and 1.99 (*m*, 16H, cyclopent.), 3.12 (*m*, 2H, H_2-6), 4.10 (*dd*, 1H, $J_{3,4}$ 8 Hz, $J_{4,5}$ 2 Hz, H-4), 4.25 (*bm*, 1H, H-5), 4.26 (*dd*, 1H, $J_{2,3}$ 2.5 Hz, $J_{1,2}$ 5 Hz, H-2), 4.55 (*dd*, 1H, H-3), 5.50 (*d*, 1H, H-1), 5.60 (*bs*, 2H, NH, OH). MS: *m/z* 327 (3, $M^{+\cdot}$), 298 (2, $M^{+\cdot}$ - Et·), 214(25), 201(19), 159(18), 142(16), 126(28), 114(49), 97(59), 85(74), 67(68), 55(100). *Anal.* Calcd for $C_{16}H_{25}NO_6$ (327.38): C 58.70; H 7.70; N 4.28. Found: C 59.00; H 8.00; N 4.38.

Bis-(5-deoxy-1,2-O-isopropylidene-3-*O*-methyl-α-D-xylofuranos-5-yl)-hydroxylamine (20). To a soln of **D** (1.2 g, 5 mmol) in MeOH (50 mL) was added dropwise a soln of $NaBH_3CN$ (0.35

g, 5.5 mmol) in water (50 mL), the pH being kept between 4 and 5 by addition of 1 *N* HCl. After 2 h, the reaction mixture was extracted with Et_2O (2x50 mL) to remove the unreacted **D** (30 mg). A second extraction (CH_2Cl_2, 3x100 mL) yielded **20, HCl**, (300 mg, 24.8%). Alkalinization (10% NaOH) of the reaction mixture to pH 8 followed by extraction ($CHCl_3$, 3x100 mL) drying (Na_2SO_4) and evaporation of the solvent gave **16** (700 mg, 58%). A soln of **20**, HCl (300 mg) in CH_2Cl_2 (100 mL) was washed (satd aqueous $NaHCO_3$ 100 mL, water (2x50 mL)) dryied (Na_2SO_4) to give after recrystallization (hexane) 140 mg (15%) of **20**. Mp 174.3-175.6°C; R_F: 0.30 (AcOEt/hexane, 2:1); $[\alpha]_D$ + 66° (23°C, 1); UV (EtOH): 202(1168); IR (KBr): 3510 (OH), 2825 (CH), 1390 (CMe_2) 1080 and 1075 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.30 and 1.48 (*2s*, 2x6H, $2CMe_2$), 3.03 (*dd*, 4H, $J_{4,5}$ 4.2 Hz, $J_{5a,5b}$ 6 Hz, 2xH_2-5), 3.40 (*s*, 6H, 2xOMe), 3.69 (*d*, 2H, $J_{3,4}$ 3.3 Hz, 2xH-3), 4.46 (*dt*, 2H, 2xH-4), 4.53 (*d*, 2H, $J_{1,2}$ 4.2 Hz, 2xH-2), 5.40 (*bs*, 1H, OH), 5.90 (*d*, 2H, H-1). MS: *m/z* 405 (10, M^{+}), 390 (19, M^{+} - Me), 374(4), 347(5), 330(10), 232(100). *Anal.* Calcd for $C_{18}H_{31}NO_9$ (405.45): C 53.32; H 7.71; N 3.45. Found: C 53.61; H 7.84; N 3.57.

6-Deoxy-6-(*N*-hydroxy-*N*-isopropylamino)-1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose (21). The acid CH_2Cl_2 extracts from the preparation of **13** yielded 45 mg (3%) of **21**. Mp 99.88-101.4°C; $[\alpha]_D$ - 42.1° (24.1°C, 1.1); IR (KBr): 3580 (OH), 1380 (CMe_2), 1250, 1210, 1070 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.06 and 1.08 (*2d*, 2x3H, $J_{CH,Me}$ 6.5 Hz, $CH(Me)_2$), 1.28, 1 30, 1.41 and 1.59 (*4s*, 4x3H, $2Me_2C$), 2.80 (*dd*, 1H, $J_{5,6a}$ 4.5 Hz, $J_{6a,6b}$ 13.5 Hz, Ha-6), 2.90 (*sept*, 1H, $CH(Me)_2$), 2.95 (*dd*, 1H, $J_{5,6b}$ 8 Hz, Hb-6), 4.12 (*dt*, 1H, $J_{4,5}$ 1.5 Hz, H-5), 4.18 (*dd*, 1H, $J_{3,4}$ 5 Hz, H-4), 4.28 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.57 (*dd*, 1H, H-3), 5.10 (*bs*, 1H, OH), 5.54 (d, 1H, H-1). MS: *m/z* 317 (1, M^{+}), 302 (2, M^{+} - Me), 286(1), 259(1), 244(2), 88(100). *Anal.* Calcd for $C_{15}H_{27}NO_6$ (317.39): C 56.77; H 8.57; N 4.41. Found: C 56.71; H 8.60; N 4.70.

1-Deoxy-1-(*N*-hydroxy-*N*-isopropylamino)-2,3:4,5-di-*O*-isopropylidene-D-arabinitol (22). The acid CH_2Cl_2 extracts from the preparation of **14** yielded 25 mg (2%) of **22**. Syrup: $[\alpha]_D$ + 7.9° (26°C, 0.6); IR (KBr): 3460 (OH), 1380, 1370 (CMe_2), 1220, 1070 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.09 (*d*, 6H, $J_{CH,Me}$ 6.5 Hz, $CH(Me)_2$), 1.32, 1.36, 1.40 and 1.42 (*4s*, 4x3H, $2CMe_2$), 2.92 (*m*, 3H, $CH(Me)_2$, H_2-1), 3.80 (*t*, 1H, $J_{2,3}$ 7.5 Hz, $J_{3,4}$ 7.5 Hz, H-3), 4.08 (*m*, 3H, H_2-5, H-4), 4.28 (*q*, 1H, H-2), 5.77 (*bs*, 1H, OH). MS: *m/z* 256(1), 243(1), 215(1), 194(1), 183(2), 173(18), 55(100). *Anal.* Calcd for $C_{14}H_{27}NO_5$ (289.37); C 58.11; H 9.40; N 4.84. Found: C 57.91; H 9.30; N 4.64.

2,5-Anhydro-1-deoxy-1-(*N*-hydroxy-*N*-isopropylamino-3,4-*O*-isopropylidene-D-ribitol (23). The acid $CHCl_3$ extracts from the preparation of **15** yielded 6 mg (2%) of **23**. Syrup: R_F: 0.62 ($CHCl_3$/MeOH, 9:1); $[\alpha]_D$ - 43° (25°C, 0.90); UV ($CHCl_3$): 243(460); IR (KBr): 3420 (OH), 1385 (CMe_2), 1280, 1170, 1115, 1095 and 1060 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.07 (*d*, 6H, $J_{CH,Me}$ 6.5 Hz, $CH(CH_3)_2$), 1.32 and 1.49 (*2s*, 2x3H, CMe_2), 2.62 (*dd*, 1H, $J_{1a,1b}$ 13.5 Hz, $J_{1b,2}$ 6.5 Hz, Hb-1),

2.74 (*dd*, 1H, $J_{1a,2}$ 7.5 Hz, Ha-1), 2.93 (*sept*, 1H, $CH(Me)_2$), 3.85 (*dd*, 1H, $J_{5a,5b}$ 10.5 Hz, $J_{4,5b}$ 4 Hz, Hb-5), 3.95 (*dd*, 1H, $J_{4,5a}$ 1 Hz, Ha-5), 4.32 (*ddd*, 1H, $J_{2,3}$ 1.5 Hz, H-2), 4.61 (*dd*, 1H, $J_{3,4}$ 6 Hz, H-3), 4.78 (*ddd*, 1H, H-4), 5.70 (*bs*, 1H, OH). MS: *m/z* 231 (1, $M^{+\cdot}$), 216 (3, $M^{+\cdot}$ - $Me^{\cdot}$), 173(5), 158(12), 100(5), 99(5), 88(100), 85(15), 81(19), 72(47), 69(19), 59(35). *Anal.* Calcd for $C_{11}H_{21}NO_4$ (231.29): C 57.12; H 9.15; N 6.06. Found: C 56.98; H 9.02; N 6.17.

6-Deoxy-1,2:3,4-di-*O*-isopropylidene-6-(*N*-methylhydroxyamino)-α-D-galactopyranose (24). A soln of **F** (0.27 g, 0.94 mmol) and $NaBH_4$ (40 mg, 1.06 mmol) in MeOH (5 mL) was kept 15 min at room temp, evaporated to dryness and extracted with CH_2Cl_2 (10 mL). The CH_2Cl_2 extracts washed with water (10 mL), dried (Na_2SO_4) yielded after chromatography (AcOEt/hexane 3:1) 150 mg (56%) of **24** which was also obtained (2-3%) from the acid CH_2Cl_2 extracts from preparation of **13**. Syrup: $[\alpha]_D$ - 43.4° (24°C, 0.5); IR (CCl_4): 3400 (OH), 1390, 1380 (Me_2C), 1260, 1220 and 1080 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.30, 1.31, 1.42 and 1.52 (*4s*, 4x3H, $2Me_2C$), 2.67 (*s*, 3H, Me-N), 2.79 (*dd*, 1H, $J_{5,6a}$ 4 Hz, $J_{6a,6b}$ 13.5 Hz, Ha-6), 2.93 (*dd*, 1H, $J_{5,6b}$ 8 Hz, Hb-6), 4.10 (*ddd*, 1H, $J_{4,5}$ 2 Hz, H-5), 4.20 (*dd*, 1H, $J_{3,4}$ 7.8 Hz, H-4), 4.31 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.60 (*dd*, 1H, H-3), 5.52 (*d*, 1H, H-1), 5.70 (*bs*, 1H, OH). MS: *m/z* 289 (4, $M^{+\cdot}$), 274 (10, $M^{+\cdot}$ - $Me^{\cdot}$), 113(12), 100(20), 85 (16), 71(18), 60 (100). *Anal.* Calcd for $C_{13}H_{23}NO_6$ (289.33): C 53.97; H 8.01; N 4.84. Found: C 54.11; H 8.03; N 4.78.

Acetylation of deoxyhydroxyamino sugars. A soln of a sugar hydroxylamine (1 mmol) in a mixture of pyridine (10 mL) and Ac_2O (10 mL) was kept 12 h at room temp. After removal of the excess of reagents by coevaporation with toluene, the residue was purified by chromatography (AcOEt/hexane 1:1).

6-(*N*-Acetoxyacetamido)-6-deoxy-1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose (25). Acetylation (*see above*) of **13** (275 mg) yielded 330 mg (92%) of **25**. Syrup: $[\alpha]_D$ - 40.4° (24°C, 1.1); IR (KBr): 1790 (O-C=O), 1680 (N-C=O), 1380, 1370 (CMe_2), 1250, 1210, 1180, 1070, 1000 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.35, 1.47 and 1.53 (*3s*, 12H, $2Me_2C$), 2.07 (*bs*, 3H, N-Ac), 2.22 (*s*, 3H, OAc), 3.80 (*bdd*, 1H, $J_{5,6a}$ 8.5 Hz, $J_{6a,6b}$ 15 Hz, Ha-6), 4.02 (*bdd*, 1H, $J_{5,6b}$ 7 Hz, Hb-6), 4.05 (*bdt*, 1H, $J_{4,5}$ 1.5 Hz, H-5), 4.28 (*dd*, 1H, $J_{3,4}$ 8 Hz, H-4), 4.30 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.62 (*dd*, 1H, H-3), 4.51 (*d*, 1H, H-1). MS: *m/z* 359 (1, $M^{+\cdot}$), 344 (10, $M^{+\cdot}$ - $Me^{\cdot}$), 301(15), 286(1), 81(100). *Anal.* Calcd for $C_{16}H_{25}NO_8$ (359.38): C 53.48; H 7.01; N 3.90. Found: C 53.71; H 7.11; N 3.79.

1-(*N*-Acetoxyacetamido)-1-deoxy-2,3:4,5-di-*O*-isopropylidene-D-arabinitol (26). Acetylation (*see above*) of **14** (274 mg) yielded 305 mg (92%) of **26**. Syrup: $[\alpha]_D$ + 10.5° (20°C, 1.0); IR (KBr): 1800 (O-C=O), 1690 (N-C=O), 1380, 1370 (CMe_2), 1260, 1290 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.30, 1.37, 1.39 and 1.42 (*4s*, 4x3H, $2Me_2C$), 2.08 (*bs*, 3H, N-Ac), 2.20 (*s*, 3H, O-Ac),

3.62 (*t*, 1H, $J_{2,3}$ 7.5 Hz, $J_{3,4}$ 7.5 Hz, H-3), 3.79 (*dd*, 1H, $J_{1a,1b}$ 15 Hz, $J_{1a,2}$ 7.7 Hz, Ha-1), 3.96 (*dd*, 1H, $J_{4,5a}$ 5 Hz, $J_{5a,5b}$ 8 Hz, Ha-5), 4.03 (*m*, 1H, H-4), 4.17 (*m*, 3H, Hb-5, H-2, Hb-1). MS: *m/z* 331 (1, $M^{+\cdot}$), 316 (42, $M^{+\cdot}$ - Me·), 273(36), 258(20), 231(24), 101(100). *Anal.* Calcd for $C_{15}H_{25}NO_7$ (331.37): C 54.37; H 7.60; N 4.23. Found: C 54.63; H 7.77; N 4.11.

5-(*N*-Acetoxyacetamido)-5-deoxy-1,2-*O*-isopropylidene-3-*O*-methyl-α-D-xylofuranose (27). Acetylation (*see above*) of **16** (219 mg) yielded 230 mg (75%) of **27**. Syrup: $[\alpha]_D$ - 33.0° (23°C, 1); IR ($CHCl_3$): 1800 (O-C=O), 1680 (N-C=O), 1380 (CMe_2), 1180, 1080 and 1030 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.30 and 1.49 (*2s*, 2x3H, CMe_2), 2.03 (*bs*, 3H, N-Ac), 2.20 (*s*, 3H, O-Ac), 3.40 (*s*, 3H, OMe), 3.67 (*m*, 1H, $J_{5a,5b}$ 15 Hz, $J_{4,5a}$ 7 Hz, Ha-5), 3.81 (*d*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.28 (*m*, 1H, $J_{4,5b}$ 4.5 Hz, Hb-5), 4.35 (*ddd*, 1H, H-4), 4.58 (*d*, 1H, $J_{1,2}$ 3.8 Hz, H-2), 5.84 (*d*, 1H, H-1). MS: *m/z* 304 (1, $M^{+\cdot}$), 288 (2, $M^{+\cdot}$ - Me·), 261(1), 245(7), 87(100). *Anal.* Calcd for $C_{13}H_{21}NO_7$ (303.31): C 51.48; H 6.98; N 4.62. Found: C 51.20; H 7.15; N 4.75.

5-(*N*-Acetoxyacetamido)-1,2-*O*-cyclopentylidene-5-deoxy-3-*O*-methyl-α-D-xylofuranose (28). Acetylation (*see above*) of **18** (265 mg) yielded 265 mg (80%) of **28**. Syrup: R_F: 0.41 AcOEt/hexane 3:1); $[\alpha]_D$ - 18.7° (26°C, 0.6); UV (EtOH): 304 (5716); IR (KBr): 2990 (C-H), 1800 (O-C=O), 1675 (N-C=O), 1400 (cyclopent.), 1180, 1135 and 1090 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.68 and 1.90 (*m*, 8H, cyclopent.), 2.00 (*bs*, 3H, Ac-N), 2.20 (*s*, 3H, Ac-O), 3.40 (*s*, 3H, Me-O), 3.65 (*bs*, 1H, Ha-5), 3.70 (*d*, 1H, $J_{3,4}$ 3 Hz, H-3), 4.22 (*bs*, 1H, Hb-5), 4.35 (*bm*, 1H, H-4), 4.52 (*d*, 1H, $J_{1,2}$ 4 Hz, H-2), 5.85 (*d*, 1H, H-1). MS: *m/z* 329 (2, $M^{+\cdot}$), 300 (4, $M^{+\cdot}$ - Et·), 245(12), 196(28), 87(65), 55(100). *Anal.* Calcd for $C_{15}H_{23}NO_7$ (329.35): C 54.70; H 7.04; N 4.25. Found: C 54.61; H 7.09; N 4.29.

6-(*N*-Acetoxyacetamido)-1,2:3,4-di-*O*-cyclopentylidene-6-deoxy-α-D-galactopyranose (29). Acetylation (*see above*) of **19** (327 mg) yielded 330 mg (80%) of **29**. Syrup: R_F: 0.34 (AcOEt/hexane 1:1); $[\alpha]_D$ - 27° (22°C, 1); UV (EtOH): 204 (830); IR (CCl_4): 2290 (C-H), 1880 (O-C=O), 1690 (N-C=O), 1440, 1340 (cyclopent.), 1190 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.70 and 1.92 (*m*, 16H, cyclopent.), 2.05 (*s*, 3H, Ac-N), 2.20 (*s*, 3H, Ac-O), 3.75 (*dd*, 1H, $J_{5,6a}$ 8.8 Hz, $J_{6a,6b}$ 16 Hz, Ha-6), 4.05 (*bm*, 2H, H-5, Hb-6), 4.15 (*dd*, 1H, $J_{3,4}$ 8 Hz, $J_{4,5}$ 1.2 Hz, H-4), 4.20 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.8 Hz, H-2), 4.55 (*dd*, 1H, H-3), 5.48 (*d*, 1H, H-1). MS: *m/z* 411 (3, $M^{+\cdot}$), 382 (12, $M^{+\cdot}$ - Et·) 327(15), 285(12), 201(10), 127(21), 81(86), 55(100). *Anal.* Calcd for $C_{20}H_{29}NO_8$ (411.46): C 58.38; H 7.10; N 3.40. Found C 58.62; H 7.25; N 3.65.

6-(*N*-Acetoxy-*N*-isopropylamino)-6-deoxy-di-*O*-isopropylidene-α-D-galactopyranose (30). Acetylation (*see above*) of **21** (317 mg) yielded 265 mg (74%) of **30**. Syrup: $[\alpha]_D$ - 53.0° (21°C, 1.5); IR (KBr): 1770 (C=O), 1380, 1370 (CMe_2), 1260, 1210, 1070, 1010 (C-O); ^{1}H NMR (200 MHz,

20°C, $CDCl_3$): 1.06 (*d*, 6H, $J_{CH,Me}$ 6.5 Hz, CH(**Me**)$_2$), 1.26, 1.29, 1.39 and 1.43 (*4s*, 4x3H, 2Me$_2$C), 2.05 (*s*, 3H, AcO), 3.02 (*dd*, 1H, $J_{5,6a}$ 6 Hz, $J_{6a,6b}$ 14 Hz, Ha-6), 3.08 (*sept*, 1H, C**H**(Me)$_2$), 3.12 (*dd*, 1H, $J_{5,6b}$ 5.5 Hz, Hb-6), 3.86 (*dt*, 1H, $J_{4,5}$ 1.5 Hz, H-5), 4.25 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.27 (*dd*, 1H, $J_{3,4}$ 8.5 Hz, H-4), 4.54 (*dd*, 1H, H-3), 5.48 (*d*, 1H, H-1). MS: *m/z* 344 (5, M^{+} - Me$^{\cdot}$), 317(19), 302(3), 286(7), 259(5), 88(100). *Anal.* Calcd for $C_{17}H_{29}NO_7$ (359.42): C 56.81; H 8.13; N 3.90. Found: C 56.95; H 8.08; N 3.91.

1-(*N*-Acetoxy-*N*-isopropylamino)-1-deoxy-2,3:4,5-di-*O*-isopropylidene-D-arabinitol (31). Acetylation (*see above*) of **22** (289 mg) yielded 290 mg (88%) of **31**. Syrup: $[\alpha]_D$ +25.7° (26°C, 0.7); IR (KBr): 1770 (C=O), 1390, 1380 (CMe$_2$), 1220, 1080 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.11 (*d*, 6H, $J_{CH,Me}$ 6.5 Hz, CH(**Me**)$_2$), 1.30 and 1.37 (*2s*, 2x6H, 2Me$_2$C), 2.02 (*s*, 3H, OAc), 2.99 (*dd*, 1H, $J_{1a,1b}$ 14 Hz, $J_{1a,2}$ 8 Hz, Ha-1), 3.14 (*sept*, 1H, C**H**(Me)$_2$), 3.30 (*dd*, 1H, $J_{1b,2}$ 2 Hz, Hb-1), 3.53 (*t*, 1H, $J_{2,3}$ 8 Hz, $J_{3,4}$ 8 Hz, H-3), 3.90 (*dd*, 1H, $J_{5a,5b}$ 7.5 Hz, $J_{4,5a}$ 5 Hz, Ha-5), 4.10 (*m*, 3H, H-4, Hb-5, H-2). MS: *m/z* 316 (1, M^{+} - Me$^{\cdot}$), 273(1), 258(1), 231(1), 216(3), 200(1), 72(100). *Anal.* Calcd for $C_{16}H_{29}NO_6$ (331.41): C 57.99; H 8.82; N 4.23. Found: C 58.11; H 8.89; N 4.34.

Selective de-*O*-acetylation of *O,N*-diacetylhydroxylamines. To a soln of diacetyl compound (0.9 mmol) in MeOH (7 mL) MeONa (70 mg, 1.3 mmol) was added. After 15 min at room temp, the reaction mixture treated as usual was submitted to a chromatography (AcOEt/hexane 3:1).

6-(*N*-Acetylhydroxyamino)-6-deoxy-1,2:3,4-di-*O*-isopropylidene-α-D-galactopyranose (32). De-*O*-acetylation (*see above*) of **25** (323 mg) yielded 175 mg (61%) of **32**. Mp 34.6 - 36.0°C; $[\alpha]_D$ - 19.0° (21°C, 0.5); IR (CCl_4): 3160 (OH), 1640 (C=O), 1380, 1370 (Me$_2$C), 1260, 1210 and 1070 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.30, 1.32, 1.46 and 1.51 (*4s*, 4x3H, 2Me$_2$C), 2.12 (*s*, 3H, Ac-N), 3.73 (*bdd*, 1H, $J_{5,6a}$ 5 Hz, $J_{6a,6b}$ 15 Hz, Ha-6), 3.85 (*bdd*, 1H, $J_{5,6b}$ 7.5 Hz, Hb-6), 4.20 (*m*, 2H, H-4, H-5), 4.32 (*dd*, 1H, $J_{1,2}$ 5 Hz, $J_{2,3}$ 2.5 Hz, H-2), 4.66 (*bdd*, 1H, $J_{3,4}$ 7.5 Hz, H-3), 5.55 (*bd*, 1H, H-1), 7.33 and 8.52 (*2bs*, 1H, OH). MS: *m/z* 317 (1, M^{+}), 302 (3, M^{+} - Me$^{\cdot}$), 114(23), 100(32), 85(33), 81(41), 71(39), 59(100), 55(13). *Anal.* Calcd for $C_{14}H_{23}NO_7$ (317.34): C 52.99; H 7.31; N 4.41. Found C 52.70; H 7.42; N 4.27.

1-(*N*-Acetylhydroxyamino)-1-deoxy-2,3:4,5-di-*O*-isopropylidene-α-D-arabinitol (33). De-*O*-acetylation (see above) of **26** (298 mg) yielded 150 mg (58%) of **33**. Mp 57.2 - 59.1°C; $[\alpha]_D$ + 9.0° (28°C, 0.9); IR (CCl_4): 3340 (OH), 1680 (C=O), 1390, 1380 (Me$_2$C), 1220, 1160 and 1070 (C-O); ^{1}H NMR (200 MHz, 20°C, $CDCl_3$): 1.39, 1.42 and 1.47 (*3s*, 12H, 2Me$_2$C), 2.17 (*s*, 3H, Ac-N), 3.80 (*t*, 1H, $J_{2,3}$ 7.7 Hz, $J_{3,4}$ 7.7 Hz, H-3), 3.97 (*dd*, 1H, $J_{4,5a}$ 5 Hz, $J_{5a,5b}$ 8 Hz, Ha-5), 3.97 (*m*, 1H, Ha-1), 4.08 (*ddd*, 1H, $J_{4,5b}$ 6 Hz, H-4), 4.21 (*dd*, 1H, Hb-5), 4.20 (*m*, 1H, Hb-1), 4.25 (*m*, 1H, H-2), 7.57 (*bs*, 1H, OH). MS: *m/z* 289 (1, M^{+}), 274 (33, M^{+} - Me$^{\cdot}$), 231(40), 143(36), 130(47), 114(31), 101(71), 85(38),

72(36), 59(100). *Anal.* Calcd for $C_{13}H_{23}NO_6$ (289.33): C 53.97; H 8.01; N 4.84. Found: C 53.86; H 8.14; N 5.00.

ACKNOWLEGEMENTS

The authors thank M. G. Moret for the preparation of some starting material and the drawings, Dr F. Barbalat-Rey for the help with the NMR and ESR spectral interpretation, Prof. A. Buchs and Dr F. Gulaçar for the SM and Mrs C. Gratiot for the formatting of the document. The investigation was supported by the Swiss National Science Foundation, Grants 2.846-0.83 and 2.671-0.85.

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