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Stereoselective Catalytic Double Osmylation of 1,2-Dihydropyridines leading to Amino-Arabinose and to Amino-Altrose Derivatives and to potential Glycosidase Inhibitors.

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Dedicated to Prof. Christoph Tamm on the occasion of his 70th birthday.

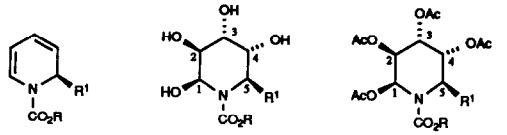
Summary. - Catalytic double osmylation of 1,2-dihydropyridines **1b** and **1c** proceeded stereospecifically and in good yields to the corresponding aminoarabinose **2b**, and aminoaltrose **2c** derivatives, respectively. In basic medium these piperidinoses equilibrated with their furanose isomers **6b** and **6c** (both α- and β-anomers). Hydrogenolysis of their urethane moieties led to the corresponding piperidine triols **7a** and **7b**.

Introduction. - In a preliminary communication we reported a catalytic double osmylation of 1,2-dihydropyridines **1a-1c** which led with complete stereoselectivity to (±)aminoarabinoses **2a** and **2b** and to (±)aminoaltrose **2c**, respectively [1]. In the meantime, *Sharpless, Park*, and *Moon Kim* reported a similar catalytic double osmylation of open-chain conjugated (E,E)-dienes. They found stereoselectivities which were strongly in favour of "cis/trans/cis" stereoisomeric tetrols [2a]. In Schröder's extensive review article [2b], catalytic as well as non catalytic osmylation reactions were described for a large series of monoolefins. Only two conjugated dienes were described to give the corresponding tetrols, *i.e.* anthracene, which led to the 1,2,3,4-tetrol derivative, and E,E-muconic acid. The stereochemistry of these two tetrols had not been ascertained [2b]. In an attempt to generalize this type of one-pot double osmylation a series of cyclohexadiene substrates were studied. It was found that dihydroxylation proceeded with complete stereoselectivity, affording the expected polyol derivatives when cyclohexa-1,3-diene, cyclohexa-1,4-diene, as well as *cis* cyclohexa-3,5-diene-1,2-diol were used as starting material. No stereoselectivity could be observed with the *trans* isomer of the latter diene, since three stereoisomeric inositols were isolated [3].

We describe herein in detail the double catalytic osmylation of a series of 1,2-dihydropyridines which occurs stereospecifically in all instances. This simple preparation of aminosugars permits the synthesis of piperidinose derivatives whose anomeric hydroxyl function can easily be removed, leading thereby to 1-desoxy aminosugars. Many 1-desoxypiperidinoses have been found in nature, *e.g.* desoxynojirimycine (DNJ), desoxy-mannojirimycine (DMJ), and castanospermine (CAST, bicyclic), to cite but a few. They are well known for their biological effects, particularly with respect to chemotherapy of AIDS, cancer, and diabetes [4]. Because of their potential biological effects, stereoisomers as well as analogues of such naturally occurring 1-desoxyaminosugars are worthwhile synthetic targets.

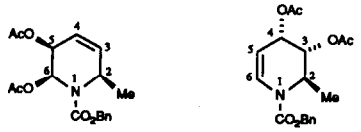
Catalytic osmylation. - Catalytic double osmylation of 1,2-dihydropyridines **1a-1c**, in the presence of N-methylmorpholine N-oxide (NMO ; slightly more than 2 equiv.) in acetone/water solution, gave directly and with high stereoselectivity the piperidinoses **2a-2c** in good yield. Aminoaltrose **2c** was obtained pure after standard work-up and column chromatography. In the other instances, solvents were evaporated and the crude mixtures were treated with Ac_2O in pyridine. The resulting tetraacetate derivatives **3a**, **3b** and **3c** were purified and crystallized.

Catalytic osmylation of **1c** in the presence of only 1 equiv. of NMO, followed by acetylation, gave a mixture of three products : tetraacetate **3c** (3 %), and diacetates **4** and **5** in a 55:45 ratio (74 % overall yield). Since **3c** was obtained in only trace amounts, one reaches the conclusion that any one of the two double bonds of **1c** is more reactive than either the Δ^3 double bond of **4**, or the Δ^5 double bond of **5**. Catalytic osmylation of **4** or of **5**, followed by peracetylation, gave the tetraacetate **3c** in both instances.



1 2 3

a) R = Me ; R¹ = H ; b) R = Bn ; R¹ = H ; c) R = Bn ; R¹ = Me

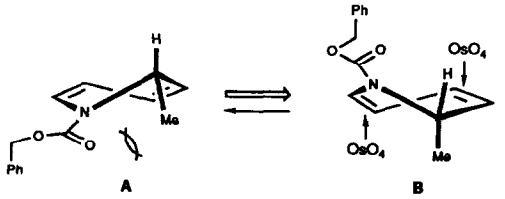


4 5

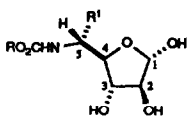
The high stereoselective outcome of these two consecutive osmylation steps is reminiscent of those observed with cyclohexa-1,3-diene or with *cis* cyclohexa-3,5-diene-1,2-diol [3], *i.e.* the second osmylation step occurs *anti* with respect to the first one. As a matter of fact no other tetrol(s) could be isolated in this reaction. The formation of non acetylated **5** occurs by osmylation of **1c** which is *anti* with respect to the methyl substituent, whereas the competitive osmylation which leads to **4** is *syn* with respect to that methyl group. This

somewhat surprising stereospecific *syn* osmylation is best accounted for by postulating a steric repulsion between the benzyloxycarbonyl substituent on nitrogen and the vicinal methyl group as follows (**Scheme 1**) : the dihydropyridine **1c** may occur in two conformations, **A** and **B**. In conformation **A** the pseudo-equatorial CH_3-group is quasi eclipsed by the benzyloxycarbonyl moiety [5], whereas in conformation **B** the benzyloxycarbonyl moiety is pointing away from the pseudo-axial CH_3-group and is shielding the vicinal double bond from a top-side attack by OsO_4. Conformation **B** is obviously favoured [5]. In our opinion, conformer **B** is a good example where the so-called "steric relay" plays the dominant role and orients the attack of OsO_4 as indicated. Such steric relay mechanisms have been well documented with some oxazolidines [6].

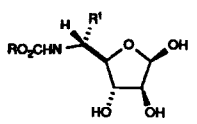
Scheme 1



Deprotection of the tetraacetates. - Deacetylation of compounds **3a-3c** was performed with Amberlyst A-26 (OH^- - form) in MeOH/H_2O solution. In all instances the resulting free aminosugar occurs as a mixture of the corresponding piperidinose **2** (β-anomer only) and furanose **6** (α and β anomers) (**Table 1**). Acetylation of any one of these mixtures leads to the formation of the peracetylated piperidinose and furanose forms, the ratios being identical with those indicated in **Table 1** for the free aminosugars. The piperidinose form appears always to be the major product, the ratio of piperidinose/furanose anomers decreasing when $R^1 = CH_3$, most probably as a consequence of a steric effect. Furthermore, the furanose α-anomers prevail over their β anomers which may also be due to a steric effect, the bulky CHR^1NHCO_2R group being *trans* with respect to HO-C(1) in the α anomer, and *cis* in the β anomer (steric crowding). Furthermore, the piperidinose/furanose equilibrium is temperature dependent : at r.t. the base induced deprotection of **3c** leads to a **2c/6c** ratio of 73:27, whereas at -20° the ratio increases to 90:10 (at -30° deprotection no longer occurs). Separation of **2c** from **6c** could be performed by flash-chromatography (see *Experimental*). Eventually, it could be shown that treatment of pure **2c** with Amberlyst A-26 (OH^- form) led to an equilibrium with the furanose anomers **6c**, and vice versa.



6α



6β

a) R = Me ; R^1 = H ; b) R = Bn ; R^1 = H ; c) R = Bn ; R^1 = Me

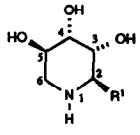
Table 1 : Piperidinose forms **2** and furanose α- and β-anomers in equilibrium as determined by ^{1}H-NMR in CD3OD after deacetylation at r.t. (see *Text*)

	Piperidinose form (%)	Furanose anomers Yield (%)	α/β ratio
a	86	14	60:40
b	92	8	54:46
c	65	35	73:27

It is known that 5-acetamido-5-desoxyaldohexoses occur preferentially in their furanose form, whereas 5-benzyloxy-carbonylamino-5-desoxyaldoses occur mostly in their piperidinose form [5].

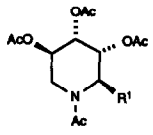
Hydrogenolysis of the N-benzyloxycarbonyl derivatives 2b and 2c. - Hydrogenolysis over 5 % Pd/C of the aminoarabinose derivative **2b** and of the aminoaltrose compound **2c** led in excellent yields to the corresponding piperidine-triols **7a** and **7b**, respectively, both of which gave the tetraacetyl derivatives, *i.e.* **8a** and **8b**.

Hydrogenolysis of the aminoaltrose in its furanose α- and β-forms **6c** led to piperidinetriol **7b** as the only reaction product[1]. This was expected since the intermediate primary amine is a good nucleophile.



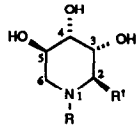
7

a) R^1 = H
b) R^1 = Me



8

a) R^1 = H
b) R^1 = Me



9

a) R^1 = H ; R = Me
b) R^1 = H ; R = n-Pr
c) R^1 = H ; R = n-Bu
d) R^1 = Me ; R = n-Pr
e) R^1 = Me ; R = n-Bu

N-Alkylation of the piperidine-triols 7a and 7b. - G.W.J. Fleet and his coworkers observed a marked enhancement of the glycosidase inhibitory effect when DNJ and similar piperidinose desoxyamino sugars were N-alkylated [2]. Therefore we undertook N-alkylation of **7a** (methylation, n-propylation, n-butylation) and of **7b** (n-propylation, n-butylation) according to a methodology similar to the one described by Paulsen [7] : the aminoarabinose **2b** and the aminoaltrose **2c** derivatives were submitted to hydrogenolysis/hydrogenation (Pd/C) in the presence of an aldehyde (formaldehyde, n-propanal, n-butanal) and of trace amounts of an acid. This

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1) Hydrogenolysis of the peracetylated aminosugar should be avoided since the acetyl groups are prone to undergo O- to N- migration.

one-pot procedure led to the piperidine-triol intermediates **7a** and **7b** which reacted at once with the aldehydes to the corresponding iminium ions which were hydrogenated to the tertiary amines **9**. Yields were close to quantitative for **9a-9c** and fair to good for **9d** and **9e** (see *Experimental*).

Structural analyses. - The N-acyl piperidinoses **2a-2c** and **3a-3c**, all of which are urethane derivatives, occur entirely in their chair conformation **C**, *i.e.* as axial β-anomers (see **Table 3**) as corroborated by the magnitude of the $^3J_{2,3}$ coupling constant (J *ca* 11 Hz characteristic for two vicinal *trans* diaxial H-atoms). This conformation was expected since it is well known that N-acyl piperidinose derivatives exhibit a very pronounced anomeric effect and occur only in their β-anomer form [5,8]. Furthermore the Me- substituent at C(5) of **2c** or **3c** is also oriented axially since in the other chair conformation it would undergo a strong steric (ecliptic) interaction with the urethane moiety. Both the (axial) anomeric effect and the steric effect (CH_3-C(5) axial) favour the chair conformation as indicated in the perspective view **C**.

In their furanose forms **6** these aminosugar derivatives always occur as both the **6α**- and **6β**-anomers. NMR parameters of the triacetate derivatives of **6α**- and of **6β** are indicated in **Table 4** : chemical shifts and coupling constants of the various pairs of anomers are in good agreement with those reported in the literature [9]. Due to several steric intramolecular interactions, the furanose rings are twisted and simultaneously highly flexible so that a fast equilibrium occurs between the twist conformations [10]. Both α- and β-anomers are easily recognised by considering the $J_{1,2}$ coupling constants (see **Table 4**), and by comparison with the corresponding $J_{1,2}$ values of some well-known pentafuranoses [9].

The piperidinetriols **7** occur as an equilibrium between both chair conformations (**Table 5**) : the magnitude of the $J_{4,5}$ coupling constants vary between 6.7 and 7.5 Hz with the piperidine-triol derivatives **7a**, **8a**, and **9a-9e** (**Table 5**) which is good evidence in favour of an equilibrium between the **D** and **E** chair conformations (**Scheme 2**). Consider now compound **7b** (**Table 5**) : from the $^3J_{2,3}$ (9.2 Hz) and the $^4J_{4,6}$ (1.1 Hz) coupling constants one infers that this compound occurs mostly in its chair conformation **E**.

Four conclusions emerge from the spectroscopic investigations of the various piperidine derivatives (c.f. **Scheme 2**) :

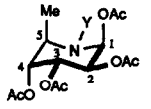
a) - N-acylated piperidinoses occur exclusively as β-anomers *i.e.* in conformation **C**.

b) - The CH_3-C(5) substituent of N-acylated piperidinoses is axial too (conformation **C**)

c) - N-alkyl-, or N-acylpiperidine-triols, *i.e.* piperidines which are lacking the anomeric hydroxyl, occur as an equilibrium between the **D** and **E** chair conformations

d) - the CH_3-C(5) substituent of NOR-piperidine-triols is equatorial.

Scheme 2



C

D E

7a , 8a , 9a - 9e

7a R^1 = H ; X = H ; Y = H
8a R^1 = H ; X = Ac ; Y = Ac

9a R^1 = H ; X = Me ; Y = H
9b R^1 = H ; X = iPr ; Y = H
9c R^1 = H ; X = n-Bu ; Y = H

9d R^1 = Me ; X = n-Pr ; Y = H
9e R^1 = Me ; X = n-Bu ; Y = H

X-Ray structure determination for 2c (Figure 1). -

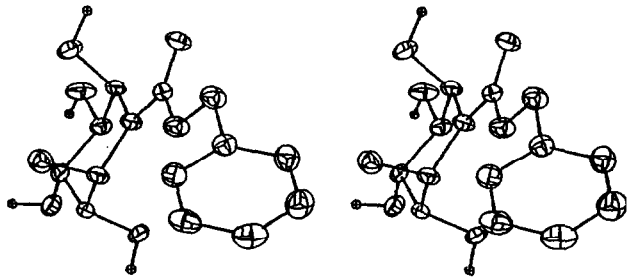


Figure 1: Stereopair view of **2c**
(C-H bonds are not represented)

In theory, the bonds of two *cis*-standing, 1,3-substituents to the ring atoms in a cyclohexane ring should be parallel. The X-ray structure shows an angle of 29.6° between the lines defined by the HO-C(1) bond and the Me-C(5) bond. Besides the steric 1,3-diaxial repulsion, this is essentially due to the quasi-planar ring N -atom and, in particular, to the C(1)-N-C(5) angle of 120.9(1)°. The intracyclic angles around the C(1) and C(5)

carbon atoms which are α to the N-atom are 110.1(1)° and 110.7(1)°, respectively ; around C(2) and C(4) they are 111.5(1)° and 113.1(1)°, respectively. The angle around the C(3) carbon atom in *para* position is 108.5(1)° which comes very near to the theoretical angle of about 109°. The extracyclic carbonyl is, as expected, completely planar. Its best plane and the best plane of the phenyl ring enclose an angle of 56.1°. Crystallographic data are deposited at the *Cambridge Crystallographic Data Centre*, University Chemical Laboratory, Lensfield Road, Cambridge CB2 1EW, England.

In vitro anti-HIV tests of piperidinetriols 9. - These compounds were evaluated for their antiviral activity in CEM-T4 cells infected with HIV 1 (strain GB 8). Their activity was assessed by light microscopic measurement of inhibition of syncytium formation. In this assay, all of the piperidine-triols **9** tested showed an antiviral activity less than that of castanospermine which was used as the reference substance.

We wish to thank the *Ministère de la Recherche et de la Technologie* for a research grant (to F.B.) and the *Roche-Welwyn Research Centre (U.K.)* for the *in vitro* anti-HIV inhibition assays.

Experimental Part

General. Flash chromatography(FC): silica gel (*Merck 60*, 230-400 mesh). TLC: Al roll silica gel (*Merck 60, F_{254}*). M.p.: *Kofler* hot bench or *Büchi-SMP-20* apparatus; corrected. IR Spectra (cm^{-1}): *Perkin-Elmer 157-G and 580 B*. ^1H- and ^{13}C-NMR Spectra: *Bruker WP-80 DS, AC-F-250* and *AM-400* using double-irradiation techniques; tetramethylsilane (TMS; ^1H) and $CDCl_3$ ($\delta(CDCl_3)$=77.0 ppm rel. to TMS; ^{13}C) as internal reference; δ in ppm and *J* in Hz. High-resolution (HR) MS were measured on a MAT-311 spectrometer at the University of Rennes. Microanalyses were carried out by the "Service Central de Microanalyses" of the CNRS, at Vernaison.

Reagents. The catalyst was prepared according to [13] from OsO_4 (1 g) and 1 ml of 70 % *t*-BuOOH in 200 ml of *t*-BuOH, a soln. which is *ca.* 0.02 mmol per ml. *Amberlyst A-26* (OH^- form) was prepared starting from its chloride precursor *A-26* (Cl^- form; 10 g) by adding 1N aq. NaOH and letting the ion exchange occur for 1 h. The *Amberlyst A-26* (OH^- form) beads were then rinsed several times with H_2O and MeOH and could be kept for several weeks in the cold.

1,2,3,4-Tetra-O-acetyl-5-deoxy-5-(methoxycarbonyl)amino-β-D,L-arabinopyranose **3a**. - To a stirred soln. of dihydropyridine **1a** [14] (168 mg; 1.2 mmol) in acetone/H_2O 9:1 (2 ml), were added NMO (535 mg; 3.95 mmol; 3.3 equiv.) and cat. OsO_4 soln. (1 ml). After 24 h at r.t., the soln. was evaporated and the crude residue taken up in Ac_2O (4 ml) and pyridine (8 ml) and left at r.t. for 15 h. Some Et_2O was added and the reaction mixture washed sequentially with 10 % aq. Na_2SO_3, 10 % aq. $NaHCO_3$ soln., and brine. The combined org. soln. was dried ($MgSO_4$), evaporated and the residue separated by column flash-chromatography

(AcOEt/cyclohexane 8:2): **3a** (327 mg; 72 %). Colourless crystals. M.p. 151-152° (AcOEt/n-hexane). IR(KBr): 1742, 1710, 1440, 1370, 1300, 1225. ^{1}H-NMR : *Table 2*. ^{13}C-NMR ($CDCl_3$; 20.1 MHz) : 169.9, 169.8, 169.6, 168.8 ($COCH_3$); 154.9 (NCO_2); 75.5 (Dd; 170 Hz), C(1)); 67.7 (Dm; 147 Hz; C(3)) ; 67.0 (Dm; 147 Hz ; C(2) or C(4)); 66.9 (Dm; 154 Hz; C(4) or C(2)); 53.5 (Qs; 147 Hz; CO_2CH_3); 42.2 (DDd; 139 and 147 Hz ; C(5)); 20.6, 20.5, 20.5, 20.3 ($COCH_3$). Anal. calc. for $C_{15}H_{21}O_{10}N$ (375.33): C 48.00, H 5.64, N 3.73; found: C 47.9, H 5.8, N 3.5.

1,2,3,4-Tetra-O-acetyl-5-deoxy-5(benzyloxycarbonyl)amino-β-D,L-arabinopyranose **3b**. - As described for **3a**, with **1b** [15] (1.09 g; 5.06 mmol), acetone/H_2O 9:1 (18 ml), NMO (2.12 g; 15.7 mmol), cat. OsO_4 soln. (10 ml), Ac_2O (8 ml), and NEt_3 (16 ml). FC of the crude (AcOEt/cyclohexane 1:1) gave **3b** as colourless crystals (1.50 g; 65 %). M.p. 127.5-128.5° (AcOEt/iPr_2O). IR(KBr): 1765, 1740, 1720, 1425, 1370, 1330, 1300. ^{1}H-NMR: *Table 2*. ^{13}C-NMR ($CDCl_3$, 20.1 MHz): 169.6, 169.5, 169.3, 168.5 ($COCH_3$); 153.9 (Sm; NCO_2); 135.4, 128.2, 127.9, 127.6 (C-arom); 75.2 (Dd; 169 Hz ; C(1)); 67.7 (Tm; 149 Hz; OCH_2) ; 67.5 (Dm; 151 Hz; C(3)); 66.8 (Dm; 147 Hz; C(2) or C(4)); 66.5 (Dm; 154 Hz; C(4) or C(2)); 41.9 (DDd; 139 and 147 Hz, C(5)); 20.2, 20.2, 20.2, 20.1 (Qs; $COCH_3$). Anal. Calc. for $C_{21}H_{25}O_{10}N$ (451.42): C 55.87, H 5.58, N 3.10; found: C 55.7, H 5.7, N 3.0.

1,2,3,4-Tetra-O-acetyl-5,6-dideoxy-5-(benzyloxycarbonyl)amino-β-D,L-altropyranose **3c**. - As described for **3a**, with **1c** [16] (3.02 g ; 13.2 mmol), acetone/H_2O 9:1 (14 ml), NMO (3.88 g; 28.7 mmol; 2.17 equiv.) cat. OsO_4 soln. (6.5 ml), Ac_2O (8 ml), NEt_3 (16 ml) at 55° for 7 h. FC (AcOEt/cyclohexane 3:7) gave **3c** (5.06 g; 82 %) as colourless crystals. M.p. 138-139° (AcOEt/n-hexane). IR(KBr): 1750, 1710, 1425, 1375, 1330, 1300, 1230, 1100, 1070, 1050. ^{1}H-NMR : *Table 2*. ^{13}C-NMR ($CDCl_3$, 20.1 MHz) : 170.0, 169.8, 169.6, 169.0 ($COCH_3$); 154.5 (Sm ; NCO_2); 135.6, 128.4, 128.2, 127.8 (C arom); 76.2 (Dd; 169 Hz; C(1)) ; 70.8 (Dm; 154 Hz; C(4)); 68.1 (Tm; 149 Hz; CH_2); 66.3 (Dq; 154; C(3)); 65.1 (D quint; 151 Hz; C(2)); 52.5 (D quint; 144 Hz; C(5)); 20.7, 20.5, 20.3 (Qs; $COCH_3$; 18.0 (Qm; 129 Hz; C(6)). Anal. calc. for $C_{22}H_{27}O_{10}N$ (465.44) : C 56.77, H 5.85, N 3.01; found: C 56.9, H 5.9, N 3.0.

5,6-Dideoxy-5-(benzyloxycarbonyl)-amino-β-D,L-altropyranose **2c**. - As described for **3a**, with **1c** (4.51 g ; 19.7 mmol), acetone/H_2O 9:1 (45 ml) NMO (6.67 g; 4.93 mmol; 2.5 equiv.), cat. OsO_4 soln. (16 ml). After 15 h at r.t. silica gel was added to this mixture and the organic solvents were evaporated. The crude residue was separated by FC (AcOEt/EtOH 9.5:0.5). Tetrol **2c** (4.18 g; 71 %) was eluted first. Colourless crystals. M.p. 134-136° (MeOH/iPr_2O). IR(KBr) : 3460-3320 ; 2830, 1695, 1675, 1405, 1355, 1315, 1285, 1255, 1220, 1110, 1075, 1040. ^{1}H-NMR : *Table 2*. Anal. calc. for $C_{14}H_{19}NO_6$ (297.30): C 56.56, H 6.44, N 4.71; found: C 56.3, H 6.7, N 4.7.

Table 2. - ^{1}H-NMR spectral data of piperidinose derivatives **2a-c** and **3a-c**. d in ppm ; J in Hz, internal standard TMS.

	H-C(1)	H-C(2)	H-C(3)	H-C(4)	Heq-C(5)	Hax-C(5)	Other data	
3a	7.49	5.53	5.71	5.49	4.20	3.00	3.28 (NCO_2CH_3); 1.72, 1.71, 1.63, 1.62 ($COCH_3$)	300 MHz C_6D_6 ; 65°
3b	7.16	5.35	5.30	5.40	4.23	3.38	7.36 (Ph); 5.26; 5.14 (2d; *J*=12.5,CH_2Ph); 2.09 ($COCH_3$); 2.02(3 peaks for $COCH_3$)	400 MHz $CDCl_3$; 40°
3c	7.18	5.39	5.49	5.29	4.40	-	7.37-7.31(m; Ph); 5.25, 5.12 (2d; *J*=12.6, CH_2Ph) 2.05, 2.02, 1.99, 1.98($COCH_3$);1.41(d,d=7.4; H-C(6))	250 MHz $CDCl_3$; 55°
2a	5.72	3.69	3.78	3.92	3.96	3.29	3.71(s, NCO_2CH_3)	250 MHz CD_3OD ; 45°
2b	5.77	3.71	3.79	3.93	4.02	3.32	7.39-7.28 (m; Ph); 5.16; 5.12(2d; *J*=12.4,CH_2Ph)	250 MHz CD_3OD ; 50°
2c	5.90	3.88	4.01	3.95	4.41	-	7.35-7.29 (m; Ph); 5.21 and 5.14(2d; *J*=12.5, CH_2Ph); 1.30 (d; *J*=7.2, H-C(6)).	250 MHz $CDCl_3$; 56°

	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5eq}$	$J_{4,5ax}$	$J_{5ax,5eq}$	$J_{1,5eq}$
3a	3.0	10.5	3.7	3.0	1.5	14.8	> 0
3b	3.6	11.0	3.0	3.0	1.5	14.8	1.3
3c	4.0	11.1	2.9	2.2	-	-	0.8
2a	3.6	9.8	3.0	3.0	1.4	13.8	1.2
2b	3.4	9.8	3.0	2.8	1.6	13.8	1.2
2c	4.2	10.2	3.0	2.0	-	-	-

Cristallographic data of **2c**. - Molecular formula $C_{14}H_{19}NO_6 \times H_2O$. Orthorhombic space group Pcab (nonstandard setting of Nr. 61). Unit cell dimensions a=10.437 (1), b=11.522(1), c=24.757(2) Å, $\alpha = 90°$, $\beta = 90°$, $\gamma = 90°$, V = 2977.1(6) $Å^3$, Z = 8, F(000) = 1344. Temperature = 298 K, θmax = 25°, radiation Mo$K\alpha$, $\lambda = 0.71069$ Å. Scan mode ω/2θ. Collected intensities -1 12, -1 13, -1 29. Absorption 1.06 cm^{-1}. No of ind. reflections 2615. No of refl. used in ref. 1848 ($F > 4\sigma F$). No of variables 222. Observations/parameters 8.3. Max and min. Δρ [e* $Å^{-3}$] 0.19, -0.20. Final R 0.036. Final Rw 0.041. Weighting scheme wght* $[1-(\Delta F/6*\sigma F)^2]^2$ using parameters 9.82 -8.61 10.4 -3.21 1.91.

Unit cell parameters have been refined by centering 25 independent, strong reflections. Data collection has been done using a four circle diffractometer CAD4. Four standard reflections monitored every h showed no significant intensity loss. The structure has been solved by direct methods using the program SIR88 [11] (**Figure 1**). Anisotropic refinements have been carried out on all non-hydrogen atoms. Hydrogen atoms bonded to oxygen atoms have been refined isotropically using restraints for the bond lengths. There is one water of crystallisation which is stabilized by hydrogen bonds. Refinement has been done using the program CRYSTALS [12].

Benzyl [2α,5α,6α]-(±)-5,6-bis(acetyloxy)-5,6-dihydro-2-methyl-(2H)-pyridine-1-carboxy- late **4** and benzyl [2α,3β,4β]-(±)-3,4-bis(acetyloxy)-3,4-dihydro-2-methyl-(2H)-pyridine-1- carboxylate **5**. - To a stirred soln. of **1c** (684 mg; 2.98 mmol) in acetone/H_2O 9:1 (4 ml) were added NMO (382 mg; 2.83 mmol; 1.0 equiv.) and cat. OsO_4 soln. (3 ml). After 18 h at r.t. the soln. was evaporated and the crude residue taken up in Ac_2O (6 ml) and NEt_3 (12 ml) to react at 40° overnight. Work-up as for **3a**. The residue was partly separated by FC(AcOEt/cyclohexane 3:7) leading sequentially to **1c** (60 mg), a **4-5** mixture (768 mg, 74 %) and some **3c** (47 mg). The **4+5** mixture was separated by medium pressure chromatography using a Jobin-Yvon apparatus (silica gel) Merck 25-40 m; cyclohexane/$CHCl_3$/iPrOH 80:18:2; 4 atm.).

Diol **4** was eluted first as colourless crystals. M.p. 84-86° (AcOEt/n-hexane). ^{1}H-NMR ($CDCl_3$, 250 MHz, 55°) : 7.37-7.31 (m ; arom), 7.20 (dd; 4.5 and 1.4 ; H-C(6)); 5.57 (ddd, 10.6, 3.6 and 2.4 ; H-C(3)); 5.55 (ddt; 10.6, 2.4, 1.4; H-C(5)); 5.23 and 5.18 (AB spectrum; 12; CH_2Ph); 4.45 (qddd; 6.8, 3.6, 3.2, 2.4; H-C(2)); 2.03 (Ac); 1.33 (d; 6.8; CH_3-C(2)). Anal. calc. for $C_{18}H_{21}NO_6$ (347.36): C 62.24, H 6.10, N 4.03; found: C 62.0, H 6.3, N 4.1.

Diol **5** was eluted as a viscous oil. ^{1}H-NMR ($CDCl_3$, 250 MHz; 55°): 7.36-7.35 (m; arom); 6.92 (ddd; 8.7, 2.1, 1.0; H-C(6)); 5.55 (ddd ; 4.2, 2.2, 2.1; H-C(4)); 5.27 (ddd; 4.2, 3.2, 2.; H-C(3)); 5.21 (s, CH_2Ph); 4.71 (dd ; 8.7, 2.2, 1.8; H-C(5)); 4.37 (qdd; 7.0, 3.2, 1.0; H-C(2)); 2.02, 2.01 (2s, Ac); 1.25 (d; 7.0; CH_3-C(2)).

Osmylation of diols **4** and **5** to the tetrol **3c**. - As described for **3a**, with the mixture of **4+5** (112 mg; 0.32 mmol), acetone/H_2O 9:1 (2 ml), NMO (70 mg), cat. OsO_4 soln. (1 ml) at r.t. overnight, then Ac_2O (4 ml) and

NEt_3 (8 ml) at 40° for 10 h. FC(AcOEt/cyclohexane 4:6) led to **3c** (112 mg; 75 %) as the only reaction product.

5-Deoxy-5-(methoxycarbonyl)amino-β-D,L-arabinopyranose **2a**. - To a stirred soln. of tetraacetate **3a** (1.17 g; 3.12 mmol) in MeOH (4 ml) and THF (10 ml) were added some Amberlyst A-26 (OH^-) beads. After 1 h at r.t. the starting material had disappeared (TLC). Amberlyst beads were removed by filtration and rinsed with hot MeOH. The combined soln. were evaporated and the residue crystallized in MeOH/iPr_2O wereby **2a** (356 mg; 55 %) was obtained as colourless crystals. M.p. 171.5-172.5°. IR(KBr): 3420, 3355, 3215, 2980, 1670, 1470, 1450, 1415. ^{1}H-NMR: see *Table 2*. Anal. calc. for $C_7H_{13}NO_6$ (207.18): C 40.58, H 6.32, N 6.76; found: C 40.8, H 6.4, N 6.7.

5-Deoxy-5-(methoxycarbonyl)amino-D,L-arabinofuranose **6a** triacetate, α- and β- anomers. - A stirred solution of **3a** (141 mg; 0.37 mmol) in MeOH/THF 1:1 (4 ml) was treated with some Amberlyst A-26 (OH^-) beads for 1 h at r.t. After filtration, the Amberlyst beads were rinsed with hot MeOH and the combined organic soln. were evaporated. The NMR of the crude showed it to be a mixture of **2a** and **6a** (66 mg; 86 %). This crude mixture was acetylated with Ac_2O (1 ml) in NEt_3 (2 ml) at r.t. overnight ; then treated with aq. of $NaHCO_3$ and extracted with AcOEt. After evaporation of the solution to dryness the crude was separated by FC (AcOEt/cyclohexane 5:5) : **3a** (88 mg; 62 %) and **6a**-triacetate (13 mg;11 %) as a 6:4 mixture of the a and the b anomers.

6a-triacetate. ^{1}H-NMR : see *Table 3*. ^{13}C-NMR ($CDCl_3$; 62.9 MHz): 170.4, 169.6, 169.2 (CH_3CO_2), 99.32 (C(1)-β); 93.8 (C(1)-α); 83.5 (C(4)-β); 80.9 (C(4)-α); 77.2 (C(2)-β); 75.5 (C(2)-α); 52.3 (CO_2CH_3); 43.9 (C(3)-α); 42.4 (C(3)-β); 29.7 (C(5)); 20.9, 20.6, 20.3 (CH_3CO). HR-MS: 274.0944 ($C_{11}H_{16}NO_7$, [M-OCOMe]$^+$, calc. 274.09267.

5-Deoxy-5-(benzyloxycarbonyl)amino-β-D,L-arabinopyranose **2b**. - A stirred solution of **3b** (3.45 g, 7.64 mmol) in THF (10 ml) and MeOH (4 ml) was treated with Amberlyst A-26 (OH^-) beads for 2 h at r.t. Work-up as for **2a** leads to a solid residue (1.94 g); 90 %) containing **2b** and **6b** (92:8 according to NMR). Recrystallisation in AcOEt/iPr_2O gave **2b** as colourless crystals. M.p. 168-170°. IR(KBr) : 3350, 3180, 1655, 1470, 1440, 1350, 1320, 1245. ^{1}H-NMR: *Table 2*.

5-Deoxy-5-(benzyloxycarbonyl)amino-D,L-arabinofuranose **6b**, α- and β-anomers. - As described for **6a** (triacetate) with **3b** (51 mg; 0.11 mmol), THF (2 ml), MeOH (2 ml), Amberlyst A-26 (OH^-). After reacetylation with Ac_2O (1 ml) and NEt_3 (2 ml) at r.t. overnight the crude was shown by NMR to be a mixture of **3b** (91 %) and **6b** (9 %; α/β 1:1). Separation by FC(AcOEt/cyclohexane 4:6) gave **3b** (32 mg; 63 %) and **6b** (triacetate) (3 mg; 6 %). ^{1}H-NMR: *Table 3*. HR-MS of **6b** (triacetate): 349.1175 ($C_{17}H_{19}NO_7$ [M-CH_3CO_2H]$^+$,

calc. 349.11614).

5,6-Dideoxy-5-(benzyloxycarbonyl)amino-β-D,L-altropyranose **2c**. - As described for **2b**, with **3c** (532 mg; 1.14 mmol), MeOH (15 ml), THF (10 ml), Amberlyst A-26 (OH^-) at 35° for 3 d. After evaporation of the solvents the remaining solid residue (299 mg; 88 %) was shown (NMR) to be a mixture of **2c** (92 %) and **6c** (8 %). Compound **2c** was obtained pure by recrystallisation ($MeOH/Et_2O$). At -18° the **2c/6c** ratio was 90:10; and at +20° 70:30.

5,6-Dideoxy-5-(benzyloxycarbonyl)amino-D,L-altrofuranose **6c**, α- and β-anomers and its triacetate. - a) As described for **6a**, with **3c** (169 mg; 0.36 mmol), THF (2 ml), MeOH (2 ml) Amberlyst A-26 (OH^-) for 1 h at r.t. After re-acetylation of the crude with Ac_2O (1 ml) and NEt_3 (2 ml) at r.t. overnight it was shown (^{1}H-NMR) to be a mixture of **3c** and **6c** (65:35) (acetate) ; **6c** (acetate) was a mixture of the α- and the β-anomers (73:27).

b) As for **2b**, with **2c** (25 mg), MeOH (2 ml), Amberlyst A-26 (OH^-) for 5 h at r.t. After filtration and evaporation to dryness the mixture was shown (NMR, CD_3OD) to be a 64:36 mixture of **2c** and **6c**.

c) As for **2b**, with **6c** (20 mg), MeOH (2 ml), Amberlyst A-26 (OH^-) for 5 h at r.t. After filtration and evaporation to dryness the mixture was shown (NMR, CD_3OD) to be a 58:42 mixture of **2c** and **6c**.

Separation of these mixtures by FC (AcOEt/EtOH 19:1) gave **6c** (α + β) and **2c**, in that order.

*Furanose **6c**, α- and β-anomers.* - ^{1}H-NMR (CD_3OD; 250 MHz; 30°): 7.34-7.27 (m, Ph-arom); 5.15 (d; 4.4; H-C(1), β); 5.11 (dd; 1.7, 0.5; H-C(1), α); 5.06 (s, CH_2Ph); 4.06-3.54 (m; H-C(2), H-C(3), H-C(4), H-C(5)); 1.19 (d; 6.6; H-C(6), β); 1.17 (d; 6.6; H-C(6), α). ^{13}C-NMR (CD_3OD; 62.9 MHz): 158.4 ($N-CO_2$); 138.4, 129.4, 128.9, 128.8, 128.7 (C-arom α and β); 103.6 (C(1)α); 97.3 (C(1)β) 87.6 (C(4)α); 85.5 (C(4)β); 83.6 (C(2)α); 79.3 (C(3)α); 79.0 (C(2)β); 77.7 (C(3)β); 67.4 (CH_2Ph); 50.8 (C(5)α); 50.0 (C(5)β); 17.1 (C(6)β); 17.0 (C(6)α). HR-MS: 279.1116 ($C_{14}H_{17}NO_5$ [$M-H_2O$]$^+$, calc. 279.11066).

5,6-Dideoxy-5-(benzyloxycarbonyl)amino-D,L-altrofuranose **6c** (triacetate), α- and β-anomers. - **6c** was acetylated with Ac_2O in NEt_3 as described above leading to **6c**-*triacetate*. IR(KBr): 1755, 1730, 1710, 1540, 1455, 1370. ^{1}H-NMR: *Table 3*.

(±)(3α,4α,5β)-Piperidine-3,4,5-triol **7a**. - A stirred soln. of **2b** (497 mg; 1.75 mmol) in EtOH (10 ml) was put under H_2 (1 atm.) in the presence of 5 % Pd/C catalyst at r.t. After 30 min the suspension was filtered over Celite and the soln. evaporated to dryness and led to **7a** (212 mg ; 91 %) as an oil. IR(film): 2960, 2920, 1645, 1590, 1570, 1480, 1440, 1425. ^{1}H-NMR: *Table 4*. HR-MS: 133.0735 ($C_5H_{11}NO_3$, [M$^+$], calc. 133.07389).

Table 3. - ^{1}H-NMR (250 MHz) spectral data of aminofuranose (triacetates) **6a-d**, α- and β-anomers. d in ppm ; J in Hz ; internal standard TMS.

	H-C(1)	H-C(2)	H-C(3)	H-C(4)	N-H	Other data	
6a-α-triacetate	6.15	5.20	4.96	4.25	5.0	3.68 (s, CO_2CH_3); 3.62 (ddd, 14.2, 6.0, 4.6, H-C(5);	
and	$J_{1,2}$=0.8 ;	$J_{2,3}$=2.0 ;	$J_{3,4}$=5.0			3.54 (ddd; 14.2, 4.6, 1.0; H-C(5); 3.51(ddd, 14.2,	CDCl$_3$; 30°
6a-β-triacetate	6.35	5.35	5.28	4.06	5.0	5.4, 2.0; H-C(5); 3.41 (ddd, 14.2, 6.8, 6.0, H-C(5);	
	$J_{1,2}$=4.3 ;	$J_{2,3}$=6.8 ;	$J_{3,4}$=5.3			2.10, 2.09, 2.06 ($COCH_3$)	
6b-α-triacetate	6.13	5.20	4.96	4.26		7.34-7.30 (m, Ph); 5.11 (s; CH_2Ph); 3.65 (ddd,	
and	$J_{1,2}$=0.8 ;	$J_{2,3}$=2.0 ;	$J_{3,4}$=5.0			14.2, 6.1, 4.4; H-C(5); 3.58 (ddd, 14.2, 4.6, 2.0	CDCl$_3$; 30°
6b-β-triacetate	6.34	5.32	5.28	4.08		H-C(5); 3.55 (ddd, 14.2, 5.4, 3.0, H-C(5); 3.44 (ddd,	
	$J_{1,2}$=4.3 ;	$J_{2,3}$=6.8 ;	$J_{3,4}$=5.3			14.2, 6.9, 5.9, H-C(5); 2.08, 2.06, 2.05 (s,Ac)	
6c-α-triacetate	6.16	5.16	5.07	4.15	4.86	7.32 (m, Ph); 5.09 (s,CH_2Ph); 4.05-3.92 (m, H-C(5),	CDCl$_3$; 56°
and	$J_{1,2}$=0 ;	$J_{2,3}$=1.8 ;	$J_{3,4}$=4.8			α andβ); 2.09-2.05 ($COCH_3$); 1.23(d, J=6.3,	
6c-β-triacetate	6.33	5.30	5.47	*Ca.*4.0	4.86	H-C(6)β); 1.22 (d, J=6,3, H-C(6)α)	
	$J_{1,2}$=4.6 ;	$J_{2,3}$=7.0 ;	$J_{3,4}$=5.7				

(±) N-Acetyl-(3α,4α,5β)-piperidine-3,4,5-triol triacetate **8a**. - To a soln. of **7a** (140 mg; 1.05 mmol) in pyridine (4 ml) was added Ac_2O (2 ml). After 16 h at r.t. the soln. was evaporated and the residue separated by FC (AcOEt) which led to **8a** (273 mg; 86 %) as colourless crystals. M.p. 102-103° (AcOEt/iPr_2O). IR(KBr): 1740, 1640, 1440, 1375, 1255, 1230. ^{1}H-NMR: *Table 4*. ^{13}C-NMR ($CDCl_3$; 20.1 MHz). *major rotamer* : 169.8, 169.7, 169.6, 169.5 (C=O); 69.8 (Dm; 154; C(4)); 67.6 (Dm; 154; C(5)); 66.6 (Dm; 154; C(3)); 46.7 (Tm; 142; C(2)); 41.8 (Tm; 142; C(6)); 21.0, 20.6, 20.5 (Qs; 130; CH_3) ; *minor rotamer* : 169.8, 169.7, 169.6, 169.5 (C=O); 70.2 (Dm; 154; C(4)); 67.1 (Dm; 148; C(3)); 66.6 (Dm; 148; C(5)); 46.5 (Tm; 142; C(6)); 41.9 (Tm; 142; C(2)); 21.0, 20.6, 20.5 (CH_3). Anal. calc. for $C_{13}H_{19}NO_7$ (301.29): C 51.82, H 6.36, N 4.65; found: C 51.6, H 6.4; N 4.5.

(±) (2α,3β,4β,5α)-2-Methylpiperidine-3,4,5-triol **7b**. - a) As described for **7a**, with **2c** (213 mg; 0.72 mmol), EtOH (10 ml), and 5 % Pd/C under H_2. After 30 min the suspension was filtered over Celite and the soln. evaporated to dryness: **7b** (quantitative) which was transformed into its chlorohydrine salt with anhydrous HCl in Et_2O. **7b,HCl**; m.p. 174-176° (rinsed with Et_2O). IR(KBr): 3430, 3360, 3060, 2960, 1555, 1445, 1280, 1245. ^{1}H-NMR (D_2O, 250 MHz): 4.43 (ddd; 4.8, 3.6, 2.3; H-C(5)); 4.29 (ddd; 4.8, 3.0, 0.9; H-C(4)); 4.15 (dd; 9.6, 3.0; H-C(3)); 3.71 (qd; 9.6, 6.7; H-C(2)); 3.64 (dd; 13.5, 2.3 ; H_{ax}-C(6)); 3.47 (ddd; 13.5, 3.6, 0.9; H_{eq}-C(6)); 1.69 (d; 6.7; CH_3) ; Anal. calc. for $C_6H_{14}ClNO_3$ (183.63): C 39.24, H 7.68, Cl 19.31, N 7.63; found: C 39.2, H 7.9, Cl 19.2, N 7.4.

b) As described for **7a**, with **6c** (10 mg), EtOH (2 ml) and 5 % Pd/C under H_2 for 3.5 h at r.t. After filtration over Celite the soln. was evaporated. The residue was almost pure piperidine **7b** (NMR).

(±) (3α,4α,5β)-1-Methylpiperidine-3,4,5-triol **9a**. - To a stirred soln. of **2b** (243 mg, 0.86 mmol) under H_2-atmosphere in MeOH (5 ml) were added AcOH (5 drops), 40 % formaldehyde (0.15 ml), and 10 % Pd/C. After 30 min at r.t. the suspension was filtered over Celite and the soln. evaporated to dryness. The residue was separated by FC ($CHCl_3$/MeOH/30 % NH_4OH 5:5:1): **9a** (125 mg; 100 %) as an oil.

^{1}H-NMR: *Table 4*. ^{13}C-NMR (CD_3OD; 62.9 MHz): 72.1 (Dm; 144; C(4)); 68.2 (Dm; 144; C(5)); 66.7 (Dm; 144; C(3)); 57.8 (Tm; 144; C(6)); 57.3 (Tm; 140; C(2)); 44.9 (Q; 140; CH_3). HR-MS: 147.0903 ($C_6H_{13}NO_3$ [M+], calc. 147.08954.

(±) (3α,4α,5β)-1-Propylpiperidine-3,4,5-triol **9b**. - To a stirred soln. of **2b** (94 mg; 0.33 mmol) under H_2-atmosphere in MeOH (4 ml), were added AcOH (5 drops), n-propanal (0.1 ml; 1.4 mmol), and 10 % Pd/C. After 30 min. at r.t. the suspension was filtered over Celite and the soln. evaporated. The residue was separated by FC (AcOEt/EtOH 4:6): **9b** (53 mg; 100 %) as an oil. ^{1}H-NM: *Table 4*. HR-MS: 175.1205 ($C_8H_{17}NO_3$

Table 4. - ^{1}H-NMR spectral data of piperidine derivatives **7, 8, 9.** d in ppm, J in Hz, internal standard TMS.

	H-C(2)	H-C(3)	H-C(4)	H-C(5)	Hax-C(6)	Heq-C(6)	Other data	
7a	Heq 2.87 Hax 2.61	3.86	3.46	3.73	2.33	3.02		80 MHz CD_3OD; 30°
8a major	Heq 3.75 Hax 3.55	5.23	5.16	4.99	3.31	3.95	2.13, 2.10, 2.08, 2.07, 2.05	400 MHz $CDCl_3$; 30°
8a minor	Heq 4.13 Hax 3.48	5.25	5.11	5.06	3.37	4.20	2.05 ($COCH_3$)	
7b	2.80	3.37	3.79	3.74	2.98	2.64	1.13 (d, 6.6 Hz, CH_3)	250 MHz CD_3OD; 30°
9a	Heq 2.93 Hax 2.71	4.00	3.56	3.90	2.55	3.03	2.55 (s; CH_3)	250 MHz CD_3OD; 30°
9b	Heq 2.80 Hax 2.39	3.91	3.42	3.79	2.21	2.87	2.43 (m; H-C(1'); 1.54 (m, H-C(2'); 0.91 (t, J=7.4; CH_3)	250 MHz CD_3OD; 40°
9c	Heq 2.76 Hax 2.27	3.88	3.38	3.78	2.09	2.79	2.37 (m; H-C(1'); 1.49 (m; H-C(2'); 1.35 (m; H-C(3'); 0.93 (t; J=7.4; CH3)	250 MHz CD_3OD; 27°
9d	2.86	3.57	3.61	3.77	*ca.* 2.50	2.75	2.51 (m; H-C(1'); 1.50 (m; H-C(2'); 1.07 (d; 6.6 Hz; Me-C(2); 0.89 (t; 7.4 Hz; H-C(3')	250 MHz CD_3OD
9e	2.84	3.56	3.60	3.75	2.49	2.73	2.50 (m; H-C(1'); 1.45 (m; H-C(2'); 1.32(m; H-C(3'); 1.06(d; 6.7 Hz; Me-C(6); 0.93(t; 7.2 Hz; H-C(4').	250 MHz CD_3OD

Table 4 bis. - ^{1}H-NMR spectral data of piperidine derivatives **7,8,9**. J in Hz, internal standard TMS.

	$J_{2',2}$	$J_{2,6}$	$J_{2,3}$	$J_{2',3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6}$	$J_{6',6}$	$J_{6',5}$	J_{2,CH_3}
7a	13.6	1.1	4.9	3.0	3.0	7.7	4.0	13.2	8	-
8a major	13.5	1.5	6.2	2.7	3.1	7.5	3.9	13.5	7.0	-
8a minor	13.5	1.5	6.2	2.7	3.1	7.5	4.0	13.5	7.0	-
7b	-	-	9.2	-	3.0	4.5	3.0	14.0	2.2	6.6
9a	11.8	1.2	7.0	3.2	3.2	6.7	3.4	11.8	6.7	-
9b	11.8	1.5	6.0	2.7	3.4	7.6	3.9	11.5	7.6	-
9c	11.7	1.6	5.4	2.5	3.5	7.8	4.0	11.3	7.8	-
9d	-	*ca.* 0	6.0	-	3.3	6.4	3.8	12.0	6.4	6.5
9e	-	*ca.* 0	5.7	-	3.3	6.5	3.9	11.9	6.5	6.5

[M+], calc. 175.12083).

(±) (3α,4α,5β)-1-Butylpiperidine-3,4,5-triol **9c**. - As above for **9b**, with **2b** (242 mg; 0.85 mmol), MeOH (4 ml), AcOH (1 drop), n-butanal (0.1 ml; 1.1 mmol), 10 % Pd/C under H_2-atmosphere for 1 h at r.t. FC (AcOEt/EtOH 8:2) of the crude residue gave **9c** (158 mg; 98 %) as an oil. ^{1}H-NMR: *Table 4*.

(±) (2α,3β,4β,5α)-1-Propyl-2-methylpiperidine-3,4,5-triol **9d**. - As for **9b**, with **2c** (300 mg; 1.01 mmol), MeOH (4 ml) AcOH (2 drops), n-propanal (0.15 ml; 2.0 mmol), 5 % Pd/C under H_2-atmosphere for 15 h at r.t. FC ($CHCl_3$/MeOH/30 % NH_4OH 8.5:1.5:0.15) gave **9d** (141 mg; 74 %) as a resin. ^{1}H-NMR: *Table 4*. HR-MS: 189.1369 ($C_9H_{19}NO_3$ [M+], calc. 189.13648.

(±) (2α,3β,4β,5α)-1-Butyl-2-methylpiperidine-3,4,5-triol **9e**. - As for **9b**, with **2c** (450 mg; 1.51 mmol), MeOH (7 ml), AcOH (3 drops), n-butanal (0.4 ml), 5 % Pd/C under H_2-atmosphere for 15 h at r.t. FC ($CHCl_3$/MeOH/30 % NH_4OH 8.5:1.5:0.15): **9e** (181 mg; 59 %). ^{1}H-NMR: *Table 4*. HR-MS: 203.1516 ($C_{10}H_{21}NO_3$ [M+], calc. 203.15213).

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