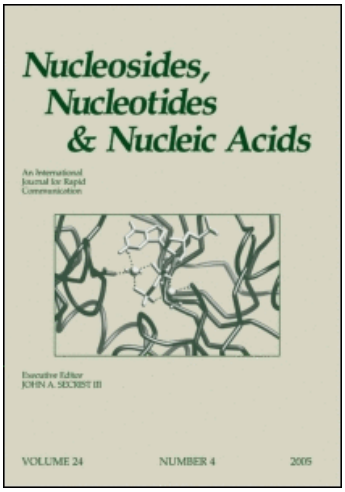

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SYNTHESIS AND BIOLOGICAL EVALUATION OF SOME D-ARABINO- AND D-LYXOFURANOSYL-PYRIDINE C-NUCLEOSIDES

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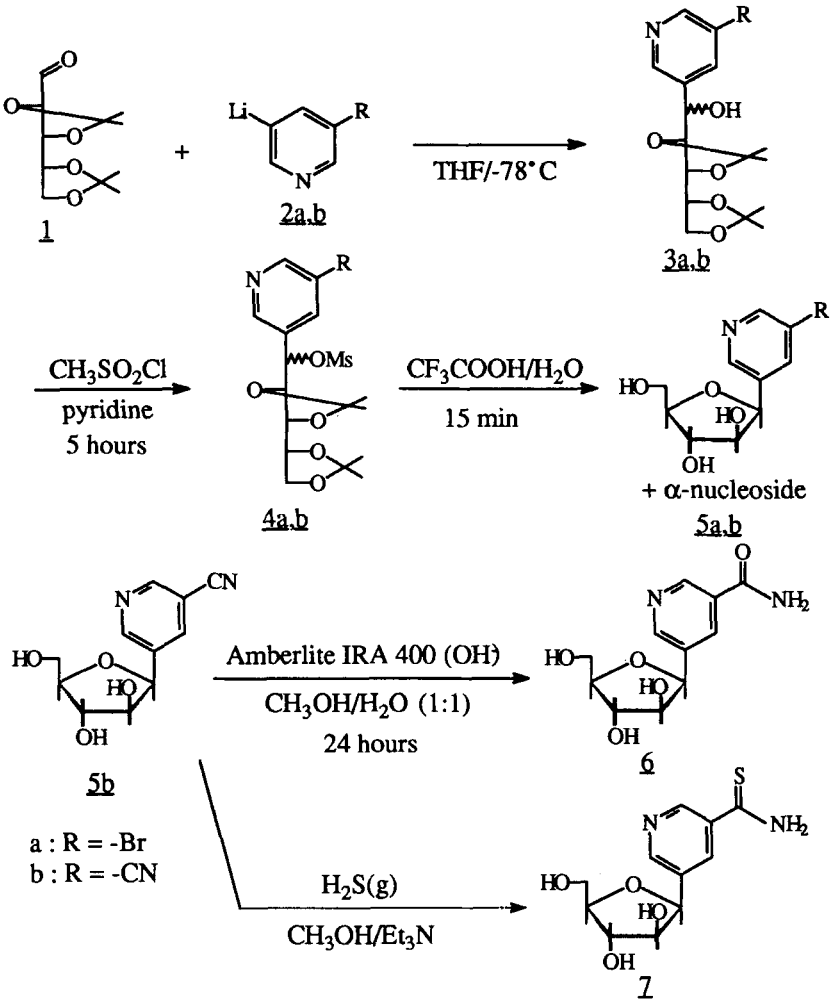
ABSTRACT.

The addition reaction of either 3-bromo-5-lithiopyridine (2a) or 3-cyano-5-lithiopyridine (2b) to 2,3:4,5-di-O-isopropylidene-aldehydo-D-arabinose (1) or 2,4:3,5-di-O-benzylidene-aldehydo-D-lyxose (8) gave respectively a D-gluco/D-manno mixture of 3-bromo- and 3-cyano-5-(2,3:4,5-di-O-isopropylidene-pentitol-1-yl)pyridine (3a,b) or a D-galacto/D-talo mixture of respectively 3-bromo- and 3-cyano-5-(2,4:3,5-di-O-benzylidene-pentitol-1-yl)pyridine (9a,b). Mesylation of C-1' followed by reaction with CF_3COOH/H_2O resulted in the formation of the corresponding D-arabino- or D-lyxofuranosyl pyridine C-nucleosides. The cyano group of (5b) and (11b) was converted into a carbamoyl group using Amberlite IRA 400 (OH^-). 3-Cyano-5-D-arabinofuranosylpyridine (5b) was converted into 3-thiocarbamoyl-5-D-arabinofuranosyl-pyridine (7) using H_2S and triethylamine.
None of the test compounds showed a marked cytostatic or antiviral activity *in vitro*.

INTRODUCTION.

Since the discovery that 3-carbamoyl-5-β-D-ribofuranosylpyridine[1] showed mild *in vitro* cytostatic activity when evaluated against P-815, CCRF-CEM, F-MOLT-3 and HL-60 tumor cells, we initiated a programme aiming at the synthesis of a series of 3-substituted pyridine-C-nucleosides with a D-arabino-, D-lyxo- or D-xylo[2]-sugar moiety in order to study the structure-activity relationship. In this paper, we present the results obtained for some D-arabino- and D-lyxofuranosyl compounds.

Dedicated to the memory of Dr. R.K. Robins.



SCHEME 1 : general reaction scheme for the synthesis of D-arabinofuranosyl nucleosides.

RESULTS AND DISCUSSION.

As already discussed in a previous paper[2], pyridine-C-nucleosides can be obtained in an elegant way using lithiopyridines and an appropriate protected sugar derivative.

In the past we obtained good results using 2,4:3,5-di-O-benzylidene-aldehydo-D-ribose[6,7] or 2,4:3,5-di-O-benzylidene-aldehydo-D-xylose[2] in order to synthesize D-ribo- or D-xylo-furanosyl-pyridine-C-nucleosides respectively. Therefore we decided to synthesize the D-lyxofuranosyl compounds using 2,4:3,5-di-O-benzylidene-aldehydo-D-lyxose (8),

obtained according to the methods described by Zinner et al.[3,4,5], as the protected sugar derivative.

A few remarks should be made however. The protected aldehydo sugar (8) was synthesized starting from D-lyxose which was then converted into its dipropyldithioacetal analog[3] using n-propanethiol. This derivative was treated with benzaldehyde and gaseous HCl in order to obtain 2,4:3,5-di-O-benzylidene-D-lyxose-dipropyldithioacetal[4]. Sometimes the latter compound spontaneously crystallized from the reaction mixture[8], giving a yield of 71%. However, in most of the cases this protected sugar derivative was isolated with a 50% yield by means of evaporation of the solvent followed by recrystallization in methanol/ether. The conversion into 2,4:3,5-di-O-benzylidene-aldehydo-D-lyxose (8) could be improved significantly from 65% to 85% by changing the reaction time for the removal of the thioalkylgroups from 5 hours to 1 hour.

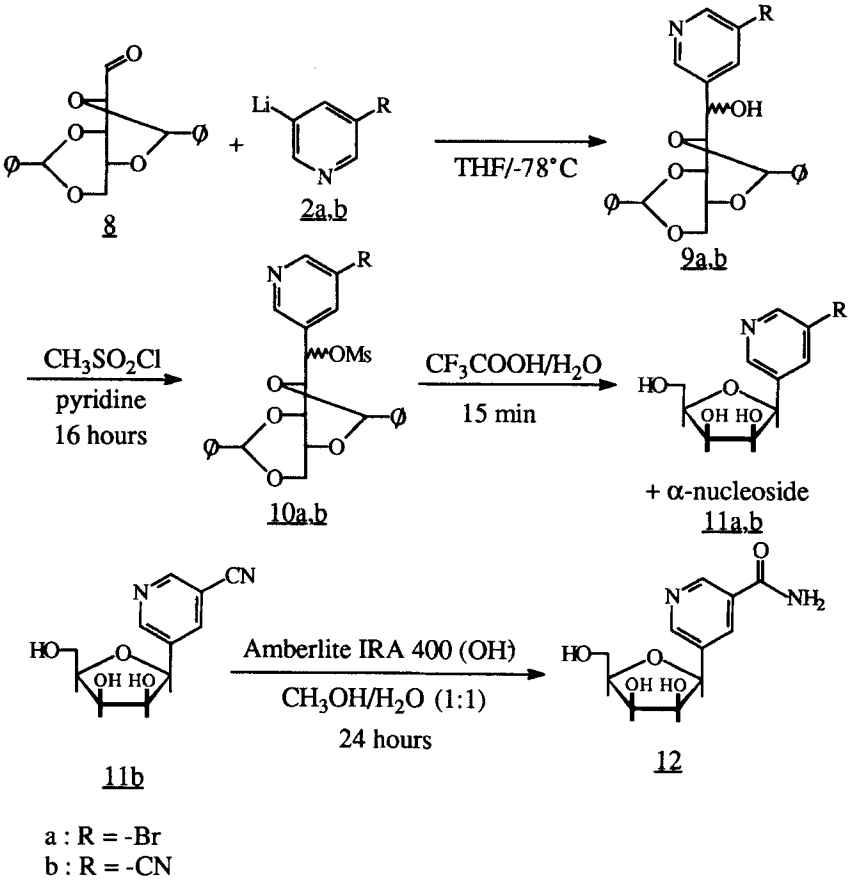
In order to synthesize D-arabino-C-nucleosides, a different protected aldehydo-D-arabinose sugar derivative was chosen. Two protected aldehydo sugars were considered : 2,3:4,5-di-O-benzylidene-aldehydo-D-arabinose[9,10] and 2,3:4,5-di-O-isopropylidene-aldehydo-D-arabinose[3,11]. The latter was selected on the basis of a better overall yield (52% vs. 16%) and the possibility of purifying the compound by vacuum distillation. 2,3:4,5-Di-O-isopropylidene-aldehydo-D-arabinose (1) was synthesized according to the procedures described by Zinner et al.[3,11]. It should be noted that (1) cannot be stored for a long time due to an irreversible polymerisation reaction.

The synthesis of the D-arabino- and D-lyxofuranosyl nucleosides was performed according to SCHEME 1 and 2, respectively. A crucial step in the total synthesis is the *in situ* formation of the lithio pyridine (2a,b) and the addition reaction to the protected aldehydo sugar derivatives (1) and (8). Details of the lithiation procedures of 3,5-dibromopyridine and 3-bromo-5-cyanopyridine have been discussed previously[2].

The addition products (3a,b) and (9a,b) were isolated in good to moderate yields. The D-gluco/D-manno adducts (3a,b) could be separated by preparative centrifugal circular thin layer chromatography (CCTLC) on a Chromatotron®.

The D-gluco/D-manno assignment of the separated epimers was based on their conversion after mesylation into nucleosides. In an earlier study by De Vos et al.[12] , it was proven that analogous compounds, namely D-allo/D-altro configurated 2-(2,4:3,4-di-O-benzylidene-1-O-mesyl-1-C-pyridinyl)pentitols cyclized according to an S_N2 mechanism. In view of these data, it seemed reasonable to assume that the D-gluco/D-manno mesylates cyclized according to the same mechanism, which means that D-gluco adducts yield α-nucleosides and D-manno adducts β-nucleosides.

Conversion of the slowest eluting adducts on TLC gave α-nucleosides, so these adducts were assigned the D-gluco configuration. Accordingly, the fastest eluting adducts gave β-nucleosides, hence they were assigned the D-manno configuration. No mixture of α/β-anomers was isolated when cyclizing an epimer pure mesylate, thereby supporting the hypothesis that these mesylates cyclize according to a S_N2 mechanism.



SCHEME 2 : general reaction scheme for the synthesis of D-lyxofuranosyl nucleosides.

The D-gluco/D-manno ratio was 79/21 for (3a) and 76/24 for (3b), as determined by the weight of the isolated epimers after separation.

Since the D-galacto/D-talo adducts (9a,b) could not be separated after several attempts by chromatography or fractional crystallization, reactions were carried out on the epimeric mixture.

Treatment of the addition products (3a,b) and (9a,b) with methanesulphonyl chloride in dry pyridine, resulted in the formation of the mesylates (4a,b) and (10a,b), which were converted into the corresponding nucleosides (5a,b) and (11a,b) using a mixture of CF_3COOH/H_2O (4:1).

After purification by preparative CCTLC, 3-cyano-5-β-D-arabinofuranosylpyridine (5bβ) or the α-anomer (5bα) was dissolved in CH_3OH/Et_3N, saturated with H_2S, and stirred

TABLE 1 : ^{1}H-NMR data of (5a), (5b), (6), (7), (11a), (11b) and (12). : δ-values in ppm.

	5aα	5aβ	5bα	5bβ	6α	6β	7α	7β	11aα	11aβ	11bα	11bβ	12α	12β
H-2	8.562	8.528	8.837	8.811	8.934	8.916	8.933	8.933	8.457	8.523	8.836	6.847	8.673	8.689
H-4	8.078	8.091	8.228	8.242	8.351	8.317	8.321	8.266	8.206	8.128	8.232	8.240	8.284	8.152
H-6	8.547	8.516	8.821	8.795	8.725	8.718	8.658	8.658	8.419	8.512	8.825	8.829	8.891	8.947
H-1'	4.788	5.144	4.860	5.217	4.863	5.224	4.849	5.204	4.763	4.958	4.847	4.981	4.748	5.033
H-2'	3.924	4.049	3.932	4.081	3.962	4.085	3.969	4.089	3.932	4.256	3.969	4.262	3.902	4.283
H-3'	4.129	4.139	4.144	4.145	4.153	4.152	4.148	4.148	4.224	4.572	4.248	4.568	4.261	4.578
H-4'	4.044	3.984	4.703	4.004	4.080	4.007	4.075	3.999	4.321	4.150	4.342	4.155	4.364	4.162
H-5'	3.802	3.835	3.812	3.835	3.820	3.857	3.819	3.854	3.873	3.870	3.870	3.885	3.862	3.870
H-5"	3.716	3.790	3.726	3.807	3.734	3.815	3.732	3.810	3.823	3.830	3.835	3.835	3.812	3.830

for 2 hours yielding 3-thiocarbamoyl-5-β-D-arabinofuranosylpyridine (7β) or the α-anomer (7α).

The amide analogs (6α), (6β) and (12) were obtained after treatment of (5α), (5β) and the α/β-mixture of 3-cyano-5-D-lyxofuranosylpyridine (11) with Amberlite IRA 400 (OH^-) in a mixture of CH_3OH/H_2OH (1:1) during 24 hours.

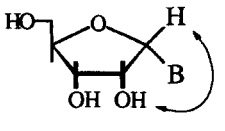
Purification and α/β-separation of the D-lyxofuranosyl nucleosides was performed by preparative CCTLC. The α/β ratio was 72/28 as determined by HPLC on the crude nucleoside mixture.

Structure identification by NMR.

Structure identification and α/β-assignment was done by 400 or 500 MHz ^{1}H-NMR and 25 or 100 MHz ^{13}C-NMR spectroscopy. All spectra were recorded in CD_3OD solutions, using the residual solvent signal as internal reference, and are summarized in TABLES 1, 2 and 3.

The assignment of the anomeric configuration in D-arabino- and D-lyxofuranosyl-C-nucleosides (5a), (5b) and (6) was achieved using several criteria.

A method which is generally used for D-ribofuranosyl compounds[6,7] is based upon the syn-upfield rule which states that δH-1'(α) > δH-1'(β). This empirical rule is a result from the different spacial interaction between H-1' and the hydroxyl function at C-2' in each anomer :



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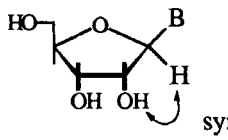


syn

Since the 2'-OH-group in D-arabinofuranosyl and D-lyxofuranosyl nucleosides is standing

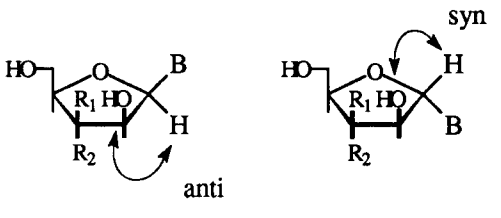
TABLE 2 : ^{1}H-NMR data of (5a), (5b), (6), (7), (11a), (11b) and (12) : coupling constants in Hz.

J	5aα	5aβ	5bα	5bβ	6α	6β	7α	7β	11aα	11aβ	11bα	11bβ	12α	12β
2,4	2.3	2.3	2.1	1.8	2.1	2.1	2.1	2.3	2.2	2.2	2.0	2.0	1.6	1.7
4,6	1.8	1.7	2.0	2.0	2.0	2.0	2.0	2.0	1.7	1.6	2.0	1.9	1.5	1.6
1',2'	7.2	3.4	6.9	3.5	7.2	3.4	7.3	3.4	8.3	4.4	8.5	4.3	8.2	4.4
2',3'	6.0	1.4	5.8	1.4	6.0	1.4	6.0	1.4	4.2	5.1	4.3	5.2	4.3	5.1
3',4'	6.3	2.1	6.1	2.3	6.3	2.3	6.4	2.4	3.8	6.8	3.6	6.9	3.5	6.5
4',5'	3.3	4.1	3.4	4.0	3.3	4.1	3.3	4.0	4.7	3.6	4.8	3.8	4.6	3.5
4',5"	5.1	4.9	5.0	5.0	5.1	5.0	5.1	5.1	6.2	4.5	6.5	4.2	6.6	4.6
5',5"	-12.0	-11.6	-12.1	-11.6	-12.0	-11.6	-12.0	-11.6	-11.7	-11.9	-11.6	-11.9	-11.7	-11.7

TABLE 3 : ^{13}C-NMR data of (5a), (5b) and (6) : δ-values in ppm.

	5aα	5aβ	5bα	5bβ	6α	6β	7α	7β	11aα	11aβ	11bα	11bβ	12α	12β
C-2	150.3	150.0	152.1	152.9	150.7	151.9	150.0	151.2	149.7	150.0	152.4	152.2	150.9	150.3
C-3	121.8	121.4	111.1	110.8	130.9	130.6	133.8	134.9	121.6	121.8	110.7	110.9	130.2	130.8
C-4	137.9	139.8	138.5	140.2	134.6	136.3	138.3	135.2	140.2	140.0	140.1	139.7	135.7	134.6
C-5	140.8	137.5	139.5	136.4	138.8	135.6	137.2	136.8	137.9	137.5	138.1	138.0	136.8	135.9
C-6	146.6	147.6	151.7	151.8	148.5	148.2	147.7	147.7	147.8	147.9	151.4	151.6	148.9	149.4
C-1'	82.6	82.0	82.5	82.0	82.8	82.5	83.0	82.5	80.8	80.7	80.6	80.9	80.5	80.6
C-2'	84.8	79.9	84.5	80.4	84.7	80.0	84.8	80.0	79.4	74.4	80.1	74.3	79.8	74.5
C-3'	78.7	80.4	78.3	79.9	78.4	80.5	78.8	80.5	73.1	74.0	73.4	73.8	73.2	73.9
C-4'	85.8	88.0	85.8	88.2	85.6	88.1	85.8	88.1	83.5	81.8	83.2	81.6	83.4	81.5
C-5'	63.3	63.5	63.1	63.5	63.3	63.6	63.4	63.6	62.1	61.8	62.3	62.0	62.2	61.7
-CN	-	-	117.5	117.6	-	-	-	-	-	-	117.8	117.6	-	-
-CO	-	-	-	-	169.7	170.0	-	-	-	-	-	-	169.1	169.2
-CS	-	-	-	-	-	-	200.9	200.9	-	-	-	-	-	-

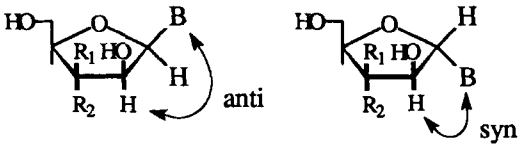
in "β-position", as can be seen below, the sequence of the syn-upfield rule has to be inverted : δH-1'(β) > δH-1'(α).



D-arabinose
R_1 : -H
R_2 : -OH

D-lyxose
R_1 : -OH
R_2 : -H

A second criterium is based on a syn-upfield effect for the H-2' proton. This effect has been reported by De Vos et al.[13] and probably originates from interactions of H-2' with the pyridine moiety. For D-arabino- and D-lyxofuranosyl nucleosides we obtain the following sequence : δH-2'(β) > δH-2'(α).



D-arabinose
R_1 : -H
R_2 : -OH

D-lyxose
R_1 : -OH
R_2 : -H

Comparison of a number of α/β-anomers of D-arabinofuranosyl nucleosides[14,15] showed that the H-1' proton of the α-anomers resonates upfield with respect to the H-1' proton of its β-anomer. Saturating H-1' of a α-D-arabinofuranosyl nucleoside in a NOE-DIFF[16] experiment should give an enhancement on H-3' and not on H-4' while these effects are reversed in the case of the β-anomers. Another difference between α- and β-anomers can be seen by saturating H-2' : enhancement of H-4 and H-6 of the heterocyclic base is typical for an α–nucleoside. 400 MHz NOE-DIFF spectra of (5aα) and (5bβ) are in agreement with the expected NOE enhancements. The α/β-assignment of the D-arabinofuranosyl nucleosides was confirmed independently by X-ray diffraction analysis[17] of (5aα) and (6β).

Data published for a series of α- and β-D-lyxofuranosyl analogues of the naturally occurring nucleosides[18] showed that the H-1' proton of each α-analogue resonates upfield with respect to the H-1' proton of its β-anomer. The α/β-assignment, based upon the above stated syn-upfield rules, was confirmed using NOE-DIFF spectra (500 MHz) of compounds (11aβ) and (11bα). Saturation of H-1' of (11aβ) resulted in NOE factors of 9.7% for H-2', 1.2% for H-3' and 2.9% for H-4', thereby confirming the β-configuration. Irradiation of H-1' of (11bα) only gave a NOE factor of 1.9% for H-2', no effect could be observed for H-3' and H-4', which is in agreement with the proposed α-configuration.

The carbon atoms of the D-arabinofuranosyl nucleosides were assigned using HETCOR spectra of (5aα) and (5aβ). The other spectra were assigned accordingly.

The assignment of the carbon atoms of the D-lyxofuranosylnucleosides was accomplished using HETCOR spectra of (11aβ) and (11bα). The sequence of the sugar carbon atoms, obtained from these spectra, is C-4', C-1', C-2', C-3' and C-5' when going upfield. This sequence was used to assign the other nucleosides.

Biological evaluation.

The compounds listed in TABLE 4 were evaluated for their cytostatic activity against several murine and human tumor cell lines. None of the D-lyxofuranosyl derivatives (i.e. compounds 11aα, 11aβ, 11bα, 11bβ, 12α, 12β) showed any marked cytostatic activity at 200 μg/ml.

Most of the D-arabinofuranosyl derivatives were slightly inhibitory to tumor cell proliferation at a 50% inhibitory concentration (IC_{50}) that ranged between 110 and 450 μg/ml (TABLE 4). None of the test compounds listed in TABLE 4 were inhibitory to

TABLE 4 : Cytostatic effects of test compounds on murine leukemia cells (L1210), murine mammary carcinoma FM3A and human T-lymphocyte Molt4/C8 and CEM cells.

Compound	IC_{50}[a] (µg/ml)				
	L1210	FM3A	Molt4/C8	CEM	MT-4
5aα	> 200	-	> 200	> 200	> 100
5aβ	231 ± 12	> 500	202 ± 9	190 ± 3	> 100
5bα	232 ± 1	450 ± 54	218 ± 4	208 ± 10	> 100
5bβ	> 200	> 200	> 200	> 200	> 100
6α	228 ± 14	372 ± 56	240 ± 3	206 ± 19	> 100
6β	126 ± 16	110 ± 7	121 ± 54	152 ± 31	> 100
7α	220 ± 28	346 ± 64	220 ± 13	209 ± 9	> 100
7β	> 200	> 200	> 200	> 200	> 100
11aα	> 200	-	> 200	> 200	> 100
11aβ	> 200	-	> 200	> 200	> 100
11bα	> 200	-	> 200	> 200	> 100
11bβ	> 200	-	> 200	> 200	> 100
12α	> 200	-	> 200	> 200	> 100
12β	> 200	-	> 200	> 200	> 100

a: 50% inhibitory concentration

HIV-1 and HIV-2 at 100 µg/ml. Nor was any activity found with the D-lyxofuranosyl derivatives against HSV-1, HSV-2, VV, VSV, Coxsackie B4 virus, polio-1 virus, Sindbis virus, reovirus-1 or Semliki forest virus.

EXPERIMENTAL.

General methods.

^{1}H-NMR spectra were recorded on a 100 MHz Jeol FX-100, a Varian Unity 400 or a Bruker-500 spectrometer (R.U.Ghent). ^{13}C-NMR spectra were recorded on a Jeol FX-100 connected to a TI-980B computer system or a Varian Unity 400 spectrometer. The CD_3OD solutions were degassed by bubbling N_2 through it prior to the NOE-DIFF experiment. DCI-mass spectra were run on a Ribermag 10-10B (Nermag SA) quadrupole mass spectrometer, equipped with a Sidar data system. Primary ionization was performed by 70 eV electrons using an emission current of 0.08 mA, the pressure in the ion source was around 0.3 Torr. Separations on silica gel were performed by preparative centrifugal circular thin layer chromatography (CCTLC) on a Chromatotron® (Kieselgel 60 PF_{254} gipshaltig, purchased from Merck), layer thickness was 2 mm.

Elemental analyses were recorded at Janssen Pharmaceutica (Beerse, Belgium).
Reactions involving organometallic reagents were performed in oven-dried glassware under a dry N_2 atmosphere. THF was distilled from $LiAlH_4$, and pyridine from CaH_2, prior to use.
D-arabinose, D-lyxose and BuLi (1.6 M in hexane) were purchased from Janssen Chimica (Beerse, Belgium), 3,5-dibromopyridine from Lancaster Synthesis Ltd. (Mundolsheim, France).

Cytostatic assays.

The cytostatic assays were performed as previously described[19]. Briefly, 100 µL aliquots of the cell suspensions [5 10^5 murine leukemia L1210 or murine mammary carcinoma FM3A cells/mL, or 7.5 10^5 human T-lymphocyte Molt4 (clone 8) or CEM cells/mL] were added to the wells of a microtiter plate containing 100 µL of varying concentrations of the test compounds. After a 2-day (L1210 and FM3A) or 3-day [Molt4 (clone 8) and CEM] incubation period at 37°C in a humidified CO_2-controlled incubator, the number of viable cells was determined using a Coulter Counter. Cytostatic activity is expressed as the compound concentration that reduces the number of viable cells by 50% (IC_{50}).

Inhibition of MT-4 cell proliferation.

All assays were performed in flat-bottomed microtest III Plates (96 wells) as previously described[19]. Briefly, the cells were suspended in growth medium and added to the microplate wells at a density of 6.25 10^4 MT-4 cells/well in the presence of varying concentrations of the test compounds. The cells were then allowed to proliferate for 120h at 37°C in a humidified CO_2-controlled atmosphere. At the end of the incubation period, the cells were counted in a blood cell counting chamber by trypan blue dye exclusion. The CC_{50} was defined as the concentration of compound that reduced the number of viable cells by 50%.

Antiviral assays.

The antiviral assays, other than the anti-HIV-1 assays, were based on inhibition of virus-induced cytopathicity in either E_6SM, HeLa or Vero cell cultures, following previously established procedures[20,21]. Following viruses were included in the study : herpes simplex virus type 1 (HSV-1) (strain KOS), HSV-2 (strain G), vaccinia virus (VV) and vesicular stomatitis virus (VSV) in E_6SM cells; Coxsackie virus B4 and poliovirus-1 in HeLa cells; and parainfluenza-3 virus, reovirus-1, Sindbis virus, Coxsackie virus B4 and Semliki forest virus in Vero cells. Briefly, confluent cell cultures in microtiter trays were inoculated with 100 $CCID_{50}$ of virus, 1 $CCID_{50}$ being the virus dose required to infect 50% of the cell cultures. After a 1h virus adsorption period, residual virus was removed, and the cell cultures were incubated in the presence of varying concentrations (400, 200, 100, ... µg/mL) of the test compounds. Viral cytopathicity was recorded as soon as it reached completion in the control virus-infected cell cultures.

Inhibition of HIV-1 induced cytopathicity in MT-4 cells.

Human 5 10^5 MT-4 cells were infected with 100 $CCID_{50}$ of HIV-1 (strain $HTLV\text{-}III_B$) per mL and seeded in 200 µL wells of a microtiter plate, containing appropriate dilutions of the test

compounds[22]. After 5 days of incubation at 37°C, the number of viable cells was determined in a blood cell counting chamber by trypan blue exclusion.

SYNTHESIS.

a) D-gluco/D-manno 3-bromo-5-(2,3:4,5-di-O-isopropylidene-pentitol-1-yl)pyridine (3a) and D-gluco/D-manno 3-cyano-5-(2,3:4,5-di-O-isopropylidene-pentitol-1-yl)pyridine (3b).
b) D-galacto/D-talo 3-bromo-5-(2,4:3,5-di-O-benzylidene-pentitol-1-yl)pyridine (9a) and D-galacto/D-talo 3-cyano-5-(2,4:3,5-di-O-benzylidene-pentitol-1-yl)pyridine (9b).

a) A three necked flask of 250 ml, equipped with a dropping funnel, $CaCl_2$ tube and dry N_2 inlet system, was filled with 3,5-dibromopyridine (1.597 g, 6.74 mmol) or 3-bromo-5-cyanopyridine (1.234 g, 6.74 mmol) dissolved in 140 ml dry THF. The solution was cooled to -78°C in a CO_2/acetone bath, and 4.2 ml of BuLi (1.6 M in hexane, 6.74 mmol) was added while stirring. After 3 min., a solution of 2,3:4,5-di-O-isopropylidene-aldehydo-D-arabinose (1.41 g, 6.13 mmol) in 20 ml dry THF, precooled to -78°C, was added over a period of 8 to 10 min. After 2 hours at -78°C, the solution was allowed to warm up, overnight, to room temperature.
The solvent was removed under reduced pressure, and the residue was partitioned between CH_2Cl_2 (200 ml) and H_2O (200 ml). The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (3x50 ml). The combined CH_2Cl_2 layers were dried over $MgSO_4$. After evaporation of the solvent, a brown syrup was obtained, which was purified by preparative CCTLC (CH_2Cl_2/CH_3OH (98:2), flow-rate 5 ml/min.), yielding compound (3a) (1.968 g, 78%) or compound (3b) (1.425 g, 66%).
The D-gluco/D-manno epimers of (3a) and (3b) were separated by preparative CCTLC (CH_2Cl_2/THF/CH_3OH (93/7/0.5), flow-rate = 4 ml/min).
Compound (D-gluco 3a) (R_f=0.44) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.532 (1H, d, J=2.2 Hz, H-2), 8.509 (1H, d, J=2.0 Hz, H-6), 7.849 (1H, t, H-4), 4.687 (1H, q, J=3.2 Hz, H-1'), 4.161 (1H, dd, J=7.4, H-2'), 3.615 (1H, dd, J=8.9, H-3'), 3.972 (1H, m, J=6.2, H-4'), 4.094 (1H, dd, J=5.1, H-5'), 3.844 (1H, dd, J=-8.9, H-5"), 3.407 (1H, s, J=8.4, -OH, disappears when CD_3OD is added), 1.280, 1.286, 1.313, 1.330 (4*3H, 4s, $-CH_3$).
100 MHz ^{13}C-NMR ($CDCl_3$) : δ 149.6 (C-2), 120.3 (C-3), 137.3 (C-4), 138.5 (C-5), 146.4 (C-6), 109.8/110.0 (C-6'/C-6"), 69.6 (C-1'), 82.7 (C-2'), 77.4 (C-3'), 76.7 (C-4'), 67.6 (C-5'), 25.0, 26.3, 26.8, 27.0 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 388 ($[MH]^+$(^{79}Br), 100%).
Compound (D-manno 3a) (R_f=0.53) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.602 (1H, d, J=2.3 Hz, H-2), 8.554 (1H, d, J=1.8 Hz, H-6), 7.974 (1H, t, H-4), 4.678 (1H, d, J=7.6 Hz, H-1'), 3.874 (1H, dd, J=7.5, H-2'), 3.806 (1H, dd, J=8.5, H-3'), 4.098 (1H, m, J=5.9, H-4'), 4.242 (1H, dd, J=5.2, H-5'), 4.045 (1H, dd, J=-8.5, H-5"), 2.575 (1H, s, -OH, disappears when CD_3OD is added), 1.311, 1.397, 1.406, 1.491 (4*3H, 4s, $-CH_3$).
100 MHz ^{13}C-NMR ($CDCl_3$) : δ 150.0 (C-2), 120.5 (C-3), 137.3 (C-4), 138.4 (C-5), 147.3 (C-6), 110.0/110.5 (C-6'/C-6"), 72.3 (C-1'), 83.7 (C-2'), 81.2 (C-3'), 76.5 (C-4'), 68.0 (C-5'), 25.1, 26.3, 26.8 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 388 ($[MH]^+$(^{79}Br), 100%).
Compound (D-gluco 3b) (R_f=0.33) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.862 (1H, d, J=2.1 Hz, H-2), 8.812 (1H, d, J=2.0 Hz, H-6), 8.052 (1H, t, H-4), 5.011 (1H, q, J=3.2 Hz, H-1'), 4.239 (1H, dd, J=7.6, H-2'), 3.671 (1H, dd, J=8.9, H-3'), 4.052 (1H, m, J=6.3, H-4'), 4.176 (1H, dd, J=5.0, H-5'), 3.926 (1H, dd, J=-8.9, H-5"), 3.519 (1H, d, J=8.7, -OH, disappears when CD_3OD is added), 1.344, 1.361, 1.382, 1.420 (4*3H, 4s, $-CH_3$).
25 MHz ^{13}C-NMR ($CDCl_3$) : δ 151.9 (C-2), 109.6 (C-3), 137.9 (C-4), 137.4 (C-5), 151.3 (C-6),

110.1/110.4 (C-6'/C-6"), 116.5 (-CN), 69.4 (C-1'), 82.6 (C-2'), 77.6 (C-3'), 76.9 (C-4'), 67.9 (C-5'), 25.0, 26.5, 26.9, 27.1 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 335 ($[MH]^+$, 100%).
Compound (D-manno 3b) (R_f=0.41) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.852 (1H, d, J=2.0 Hz, H-2), 8.803 (1H, d, J=2.1 Hz, H-6), 8.086 (1H, t, H-4), 4.712 (1H, d, J=7.2 Hz, H-1'), 3.828 (1H, dd, J=7.3a, H-2'), 3.793 (1H, dd, J=8.4a, H-3'), 4.106 (1H, m, J=5.8, H-4'), 4.251 (1H, dd, J=5.2, H-5'), 4.063 (1H, dd, J=-8.5, H-5"), 2.167 (1H, s, -OH, disappears when CD_3OD is added), 1.293, 1.411, 1.501 (2*3H, 1*6H, 3s, $-CH_3$).
a : approximative due to signal overlap.
25 MHz ^{13}C-NMR ($CDCl_3$) : δ 152.2 (C-2), 109.3 (C-3), 137.7 (C-4), 137.2 (C-5), 151.1 (C-6), 116.5 (-CN), 109.9/110.3 (C-6'/C-6"), 71.8 (C-1'), 83.3 (C-2'), 81.0 (C-3'), 76.0 (C-4'), 67.7 (C-5'), 24.8, 26.1, 26.6 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 335 ($[MH]^+$, 100%).
b) A three necked flask of 100 ml, equipped with a dropping funnel, $CaCl_2$ tube and dry N_2 inlet system, was filled with 3,5-dibromopyridine (400 mg, 1.69 mmol) or 3-bromo-5-cyanopyridine (310 mg, 1.69 mmol) dissolved in 60 ml dry THF. The solution was cooled to -78°C in a CO_2/acetone bath, and 1.05 ml of BuLi (1.6 M in hexane, 1.69 mmol) was added while stirring. After 3 min., a solution of 2,4:3,5-di-O-benzylidene-aldehydo-D-lyxose (8) (500 mg, 1.53 mmol) in 20 ml dry THF was added over a period of 10 min. After 2 hours at -78°C, the solution was allowed to warm up, overnight, to room temperature.
The solvent was removed under reduced pressure, and the residue was partitioned between CH_2Cl_2 (100 ml) and H_2O (100 ml). The layers were separated, and the aqueous layer was extracted with CH_2Cl_2 (2x50 ml). The combined CH_2Cl_2 layers were dried over $MgSO_4$. After evaporation of the solvent, a brown solid was obtained, which was purified by preparative CCTLC (CH_2Cl_2/CH_3OH (98:2), flow-rate 5 ml/min.), yielding compound (9a) (600 mg, 81%) or compound (9b) (430 mg, 65%).
Compound (9a) : 100 MHz ^{1}H-NMR (DMSO-d_6) : δ 8.61 (1H, d, J=2.3 Hz, H-2), 8.69 (1H, d, J=1.8 Hz, H-6), 8.17 (1H, t, H-4), 7.2 - 7.6 (10H, m, aromatic protons), 6.19 (1H, d, J=5.1, -OH, disappears when CD_3OD is added), 6.09 (1H, s, H-6'), 5.77 (1H, s, H-6"), 5.36 (1H, q, J=10.0 Hz, H-1'), 4.0 - 4.5 (5H, m, H-2', H-3', H-4', H-5', H-5"). All signals mentioned are present in pairs due to the presence of the D-galacto and D-talo isomers.
25 MHz ^{13}C-NMR (DMSO-d_6) : δ 148.9/149.4 (C-2), 146.7/147.4 (C-6), 136.9/137.4 (C-4), 140.3/140.7 (C-5), 138.3 - 138.7 and 125.1 -128.8 (aromatic C-atoms), 119.9/120.2 (C-3), 94.8 - 99.9 (C-6', C-6"), 79.0/80.0 and 66.1 - 71.2 (C-1', C-2', C-3', C-4', C-5').
DCI-mass spectrometry (NH_3) : m/z 484 ($[MH]^+$(^{79}Br), 100%).
Compound (9b) : 100 MHz ^{1}H-NMR (DMSO-d_6) : δ 8.98 (1H, d, J=2.0 Hz, H-2), 8.94 (1H, d, J=2.0 Hz, H-6), 8.43 (1H, t, H-4), 7.2 - 7.6 (10H, m, aromatic protons), 6.28 (1H, d, J=5.0 Hz, -OH, disappears when CD_3OD is added), 6.10 (1H, s, H-6'), 5.77 (1H, s, H-6"), 5.42 (1H, q, J=10.0 Hz, H-1'), 4.0 - 4.5 (5H, m, H-2', H-3', H-4', H-5', H-5"). All signals mentioned are present in pairs due to the presence of the D-galacto and D-talo isomers.
25 MHz ^{13}C-NMR (DMSO-d_6) : δ 151.9/152.4 (C-2), 151.0/151.5 (C-6), 138.1/138.4 (C-4), 138.6/138.9 (C-5), 138.1 - 138.7 and 125.3 -128.8 (aromatic C-atoms), 117.0 (-CN), 108.3/108.9 (C-3), 94.9 - 99.9 (C-6', C-6"), 79.8/80.2 and 66.2 - 69.2 (C-1', C-2', C-3', C-4', C-5').
DCI-mass spectrometry (NH_3) : m/z 431 ($[MH]^+$, 100%).

a) D-gluco/D-manno 3-bromo-5-(1-O-mesyl-2,3:4,5-di-O-isopropylidene-pentitol-1-yl)pyridine (4a) D-gluco/D-manno 3-cyano-5-(1-O-mesyl-2,3:4,5-di-O-isopropylidene-pentitol-1-yl)pyridine (4b).
b) D-galacto/D-talo 3-bromo-5-(1-O-mesyl-2,4:3,5-di-O-benzylidene-pentitol-1-yl)pyridine (10a) and D-galacto/D-talo 3-cyano-5-(1-O-mesyl-2,4:3,5-di-O-benzylidene-pentitol-1-yl)pyridine (10b).

a) To a solution of 500 mg D-gluco or D-manno addition products (3a,b) in dry pyridine (50 ml), 5 eq. CH_3SO_2Cl were added at room temperature. The reaction mixture was stirred for 5 hours and quenched by pouring the mixture in a saturated $NaHCO_3$-solution (300 ml). The aqueous layer was extracted with CH_2Cl_2 (1x100 ml, 2x50 ml) and the combined CH_2Cl_2 layers were dried over $MgSO_4$. Evaporation of the solvent yielded a yellow foam, which was purified by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (98:2), flow-rate 5 ml/min.). Yields : (D-gluco 4a) : 94%, (D-manno 4b) : 90%, (D-gluco 4b) : 96%, (D-manno 4b) : 87%.
Compound (D-gluco 4a) (R_f=0.29) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.623 (1H, d, J=2.2 Hz, H-2), 8.558 (1H, d, J=1.8 Hz, H-6), 7.905 (1H, t, H-4), 5.587 (1H, d, J=3.5 Hz, H-1'), 4.172 (1H, dd, J=6.5, H-2'), 3.850 (1H, dd, J=8.3, H-3'), 3.952 (1H, m, J=6.2, H-4'), 4.087 (1H, dd, J=5.5, H-5'), 3.850 (1H, dd, J=-8.8, H-5"), 2.894 (3H, s, $-OSO_2CH_3$), 1.241, 1.309, 1.310, 1.409 (4*3H, 4s, $-CH_3$).
100 MHz ^{13}C-NMR ($CDCl_3$) : δ 151.5 (C-2), 120.7 (C-3), 138.1 (C-4), 133.6 (C-5), 147.2 (C-6), 110.0/111.0 (C-6'/C-6"), 78.3 (C-1'), 82.1 (C-2'), 78.1 (C-3'), 77.0 (C-4'), 67.7 (C-5'), 39.2 ($-OSO_2CH_3$), 25.1, 26.2, 26.8, 27.5 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 466 ($[MH]^+(^{79}Br)$, 100%).
Compound (D-manno 4a) (R_f=0.32) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.634 (1H, d, J=2.1 Hz, H-2), 8.514 (1H, d, J=2.0 Hz, H-6), 7.966 (1H, t, H-4), 5.718 (1H, d, J=3.4 Hz, H-1'), 4.361 (1H, dd, J=7.6, H-2'), 3.333 (1H, dd, J=8.4, H-3'), 3.998 (1H, m, J=6.4, H-4'), 4.074 (1H, dd, J=5.6, H-5'), 3.758 (1H, dd, J=-8.4, H-5"), 2.874 (3H, s, $-OSO_2CH_3$), 1.093, 1.291, 1.324, 1.392 (4*3H, 4s, $-CH_3$).
100 MHz ^{13}C-NMR ($CDCl_3$) : δ 151.7 (C-2), 120.5 (C-3), 139.2 (C-4), 132.1 (C-5), 148.0 (C-6), 110.3/111.1 (C-6'/C-6"), 78.6 (C-1'), 82.0 (C-2'), 78.8 (C-3'), 76.7 (C-4'), 68.0 (C-5'), 36.9 ($-OSO_2CH_3$), 25.2, 26.7, 26.9, 27.3 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 466 ($[MH]^+(^{79}Br)$, 100%).
Compound (D-gluco 4b) (R_f=0.44) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.872 (1H, d, J=2.0a Hz, H-2), 8.865 (1H, d, J=2.1a Hz, H-6), 8.114 (1H, t, H-4), 5.718 (1H, d, J=2.9 Hz, H-1'), 4.179 (1H, dd, J=6.9, H-2'), 3.916 (1H, dd, J=8.6, H-3'), 4.015 (1H, m, J=6.1, H-4'), 4.156 (1H, dd, J=5.4, H-5'), 3.917 (1H, dd, J=-8.7, H-5"), 2.984 (3H, s, $-OSO_2CH_3$), 1.310, 1.349, 1.350, 1.457 (4*3H, 4s, $-CH_3$).
a: approximative due to signal overlap.
25 MHz ^{13}C-NMR ($CDCl_3$) : δ 152.7 (C-2), 110.1 (C-3), 138.9 (C-4), 132.9 (C-5), 152.2 (C-6), 110.1/110.4 (C-6'/C-6"), 116.2 (-CN), 77.0 (C-1'), 82.0 (C-2'), 77.9 (C-3'), 77.2 (C-4'), 67.9 (C-5'), 39.2 ($-OSO_2CH_3$), 25.0, 26.3, 26.7, 27.4 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 413 ($[MH]^+$, 100%)
Compound (D-manno 3b) (R_f=0.46) : 400 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.823 (1H, d, J=2.0 Hz, H-2), 8.781 (1H, d, J=2.1 Hz, H-6), 8.065 (1H, t, H-4), 5.779 (1H, d, J=3.4 Hz, H-1'), 4.352 (1H, dd, J=7.5, H-2'), 3.346 (1H, dd, J=8.4, H-3'), 3.994 (1H, m, J=6.4, H-4'), 4.074 (1H, dd, J=5.7, H-5'), 3.757 (1H, dd, J=-8.7, H-5"), 2.964 (3H, s, $-OSO_2CH_3$), 1.275, 1.318, 1.380 (2*3H, 1*6H, 3s, $-CH_3$).
25 MHz ^{13}C-NMR ($CDCl_3$) : δ 152.4 (C-2), 110.9 (C-3), 139.4 (C-4), 130.9 (C-5), 152.4 (C-6), 115.8 (-CN), 109.9/110.9 (C-6'/C-6"), 77.5 (C-1'), 81.4 (C-2'), /8.3 (C-3'), 76.1 (C-4'), 67.5 (C-5'), 38.8 ($-OSO_2CH_3$), 24.8, 26.1, 26.6 ($-CH_3$).
DCI-mass spectrometry (NH_3) : m/z 413 ($[MH]^+$, 100%).

b) To a solution of the D-galacto/D-talo addition products (9a,b) (1 mmol) in dry pyridine (50 ml), CH_3SO_2Cl (1 ml) was added at room temperature. The reaction mixture was stirred for 16 hours and quenched by pouring the mixture in a saturated $NaHCO_3$-solution (300 ml). The aqueous layer was extracted with CH_2Cl_2 (1x100 ml, 2x50 ml) and the combined CH_2Cl_2 layers were

dried over $MgSO_4$. Evaporation of the solvent yielded a yellow foam, which was purified by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (98:2), flow-rate 5 ml/min.). Yields : compound (10a) : 92%, compound (10b) : 88%.

Compound (10a) : 100 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.73 (1H, d, J=2.2 Hz, H-2), 8.58 (1H, d, J=1.9 Hz, H-6), 7.9 (1H, t, H-4), 7.3 - 7.6 (10H, m, aromatic protons), 6.2 (1H, s, H-6'), 5.5 (1H, s, H-6''), 5.9 (1H, d, J=6.6 Hz, H-1'), 3.9 - 4.4 (5H, m, H-2', H-3', H-4', H-5', H-5''), 2.9 (3H, s, $-OSO_2CH_3$). All signals are present in pairs due to the presence of the D-galacto and D-talo isomers.

25 MHz ^{13}C-NMR ($CDCl_3$) : δ 152.0/152.2 (C-2), 146.6/148.2 (C-6), 137.4/138.6 (C-4), 132.5/134.8 (C-5), 136.9 - 139.9 and 125.9 -129.6 (aromatic C-atoms), 121.0/121.4 (C-3), 96.4 - 101.2 (C-6', C-6''), 78.7/79.1 and 66.7 - 76.2 (C-1', C-2', C-3', C-4', C-5'), 39.1/39.2 ($-OSO_2CH_3$).

DCI-mass spectrometry (NH_3) : m/z 562 ($[MH]^+$(^{79}Br), 100%).

Compound (10b) : 100 MHz ^{1}H-NMR ($CDCl_3$) : δ 8.88 (1H, d, J=2.0 Hz, H-2), 8.84 (1H, d, J=2.2 Hz, H-6), 8.0 (1H, t, H-4), 7.3 - 7.6 (10H, m, aromatic protons), 6.2 (1H, s, H-6'), 5.5 (1H, s, H-6''), 6.0 (1H, d, J=5.7 Hz, H-1'), 4.0 - 4.5 (5H, m, H-2', H-3', H-4', H-5', H-5''), 3.0 (3H, s, $-OSO_2CH_3$). All signals mentioned are present in pairs due to the presence of the D-galacto and D-talo isomers.

25 MHz ^{13}C-NMR ($CDCl_3$) : δ 152.1/152.8 (C-2), 151.2/151.8 (C-6), 137.6/138.0 (C-4), 130.2/131.7 (C-5), 136.5 - 137.3 and 125.8 -129.2 (aromatic C-atoms), 115.6 (-CN), 110.1/110.9 (C-3), 96.5 -101.2 (C-6', C-6''), 75.8/77.9 and 66.3 - 74.0 (C-1', C-2', C-3', C-4', C-5'), 38.7/38.9 ($-OSO_2CH_3$).

DCI-mass spectrometry (NH_3) : m/z 509 ($[MH]^+$, 100%).

α- and β-3-bromo-5-D-arabinofuranosylpyridine (5a) and α- and β-3-cyano-5-D-lyxofuranosylpyridine (5b), α- and β-3-bromo-5-D-lyxofuranosylpyridine (11a) and α- and β-3-cyano-5-D-lyxofuranosylpyridine (11b).

The mesylates (4a,b) and (10a,b) (1 mmol) were dissolved in 25 ml of a mixture of CF_3COOH/H_2O (4:1), and the reaction mixture was stirred for 15 min. at room temperature. The reaction mixture was poured into 200 ml H_2O and washed with CH_2Cl_2 (3x40 ml). After evaporation of the aqueous solution, the residue was redissolved in water, neutralised to pH=7 with NH_3 and again evaporated to dryness, yielding (5aα) : (252 mg, 87%), (5aβ) : (244 mg, 84%), (5bα) : (198 mg, 84%), (5bβ) : (196 mg, 83%), (11α) : (252 mg, 87%) and (11b) : (200 mg, 85%).

3-Bromo-5-α-D-arabinofuranosylpyridine (5aα) and 3-bromo-5-β-D-arabinofuranosylpyridine (5aβ) were purified by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (85:15), flow-rate 6 ml/min). R_f value α-anomer : 0.41, R_f value β-anomer :0.53.

DCI-mass spectrometry (NH_3): m/z 290 ($[MH]^+$(^{79}Br), 100%), m/z 200 ($[B+44]^+$ (^{79}Br), 4.1%), m/z 186 ($[B+30]^+$(^{79}Br), 3.6%), (B = heterocyclic moiety).

Anal. calcd. for $C_{10}H_{12}BrNO_4$: C, 41.40%; H, 4.17%; Br, 27.54%; N, 4.83%. Found : C, 41.14%; H, 4.21%; Br, 27.36%; N, 4.80%.

3-Cyano-5-α-D-arabinofuranosylpyridine (5bα) and 3-cyano-5-β-D-arabinofuranosylpyridine (5bβ) were purified by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (85:15), flow-rate 6 ml/min). R_f value α-anomer : 0.24, R_f value β-anomer :0.43.

DCI-mass spectrometry (NH_3) : m/z 254 ($[MNH_4]^+$, 74.3%), m/z 237 ($[MH]^+$, 100%), m/z 147 ($[B+44]^+$, 2.8%), (B = heterocyclic moiety).

Anal. calcd. for $C_{11}H_{12}N_2O_4$: C, 55.93%; H, 5.12%; N, 11.86%. Found : C, 55.96%; H, 5.15%; N, 11.81%.

The α/β-mixture of 3-bromo-5-D-lyxofuranosylpyridine (11a) was purified and α/β separated by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (85:15), flow-rate 6 ml/min). R_f value α-anomer : 0.61, R_f value β-anomer : 0.47.
DCI-mass spectrometry (NH_3): m/z 290 ($[MH]^+(^{79}Br)$, 100%), m/z 200 ($[B+44]^+$ (^{79}Br), 13.6%), m/z 186 ($[B+30]^+(^{79}Br)$, 9.0%), (B = heterocyclic moiety).
Anal. calcd. for $C_{10}H_{12}BrNO_4$: C, 41.40%; H, 4.17%; Br, 27.54%; N, 4.83%. Found : C, 41.16%; H, 4.20%; Br, 27.34%; N, 4.79%.
The α/β-mixture of 3-cyano-5-D-lyxofuranosylpyridine (11b) was purified and α/β-separated by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (85:15), flow-rate 6 ml/min). R_f value α-anomer : 0.58, R_f value β-anomer : 0.48.
DCI-mass spectrometry (NH_3) : m/z 237 ($[MH]^+$, 100%), m/z 147 ($[B+44]^+$, 3.8%), (B = heterocyclic moiety).
Anal. calcd. for $C_{11}H_{12}N_2O_4$: C, 55.93%; H, 5.12%; N, 11.86%. Found : C, 55.88%; H, 5.17%; N, 11.79%.

α- and β- 3-carbamoyl-5-D-arabinofuranosylpyridine (6) and α- and β- 3-carbamoyl-5-D-lyxofuranosylpyridine (12).
In a mixture of CH_3OH/H_2O (1:1) (20 ml) (5bα), (5bβ) or (11b) (200 mg, 0.85 mmol) was dissolved and stirred for 24 hours in the presence of Amberlite IRA-400 (OH^-) (800 mg). The resin was filtered and washed with CH_3OH (4x10 ml). The combined filtrate and washings were concentrated in vacuo to give crude 3-carbamoyl-5-α-D-arabinofuranosyl-pyridine (6α) (203 mg, 94%), 3-carbamoyl-5-β-D-arabinofuranosylpyridine (6β) (196 mg, 91%) or a α/β-mixture of 3-carbamoyl-5-D-lyxo-furanosylpyridine (12) (180 mg, 84%).
3-Carbamoyl-5-α-D-arabinofuranosylpyridine (6α) and 3-carbamoyl-5-β-D-arabinofuranosyl-pyridine (6β) were purified by preparative CCTLC (eluant : CH_2Cl_2/CH_3OH (70:30), flow-rate 6 ml/min). R_f value α-anomer : 0.36, R_f value β-anomer :0.42.
DCI-mass spectrometry (NH_3) : m/z 255 ($[MH]^+$, 100%), m/z 165 ($[B+44]^+$, 8.2%), m/z 151 ($[B+30]^+$, 16.7%), (B = heterocyclic moiety).
Anal. calcd. for $C_{11}H_{14}N_2O_5$: C, 51.97%; H, 5.55%; N, 11.02%. Found : C, 51.85%; H, 5.58%; N, 10.94%.
Purification and α/β-separation of (12) was performed by preparative CCTLC (eluant: CH_2Cl_2/CH_3OH (80:20), flow-rate 6 ml/min). R_f value α-anomer : 0.44, R_f value β-anomer : 0.35.
DCI-mass spectrometry (NH_3) : m/z 255 ($[MH]^+$, 100%), m/z 165 ($[B+44]^+$, 10.4%), m/z 151 ($[B+30]^+$, 21.6%), (B = heterocyclic moiety).
Anal. calcd. for $C_{11}H_{14}N_2O_5$: C, 51.97%; H, 5.55%; N, 11.02%. Found : C, 51.87%; H, 5.59%; N, 10.96%.

α- and β- 3-thiocarbamoyl-5-D-arabinofuranosylpyridine (7).
In a 25 ml flask, 30 mg 3-cyano-5-D-arabinofuranosylpyridine (6) was stirred for 2 hours in a solution of 1 ml Et_3N in 10 ml dry methanol, saturated with H_2S. After evaporation of the solvent and purification by preparative CCTLC (eluant: CH_2Cl_2/CH_3OH (80:20), flow-rate 6 ml/min), 3-thiocarbamoyl-5-D-arabinofuranosylpyridine was isolated as a yellow oil.
3-Thiocarbamoyl-5-α-D-arabinofuranosylpyridine (7α) was isolated with a 89% yield (30.5 mg) (R_f : 0.28) and (7β) with a 87% yield (28.5 mg) (R_f :0.37).
DCI-mass spectrometry (NH_3) : m/z 271 ($[MH]^+$, 6.8%), m/z 137 ($[MH-H_2S]^+$, 100%).
Anal. calcd. for $C_{11}H_{14}N_2O_4S$: C, 48.88%; H, 5.22%; N, 10.36%; S, 11.86%. Found : C, 48.54%; H, 5.17%; N, 10.28%; S, 11.80%.

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