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SYNTHESIS OF NEW *C*-NUCLEOSIDE ANALOGUES OF THE IMIDAZOLE FROM 1-ARYL-(1,2-DIDEOXY-β-D-*glycero*-L-*gluco*-HEPTOFURANO)[2,1-*d*]-IMIDAZOLIDINE-2-THIONES

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ABSTRACT

Treatment of 1-phenyl(and 1-*p*-tolyl)-(1,2-dideoxy-β-D-*glycero*-L-*gluco*-heptofurano)[2,1-*d*]imidazolidine-2-thiones (**1**) with trifluoroacetic acid caused isomerisation to 1-aryl-4-(D-*galacto*-pentitol-1-yl)-4-imidazoline-2-thiones (**2**) and subsequent dehydration of the sugar chain gave anomeric αβ-mixtures of 1-aryl-4-(D-lyxopyranosyl)-4-imidazoline-2-thiones (**3** and **5**). The *S*-benzylation and desulphuration of these compounds aromatised the imidazole ring to yield *C*-nucleoside analogues which could not be obtained by direct acid-catalysed dehydration from D-*galacto*-pentitol-1-yl derivatives of the imidazole.

INTRODUCTION

In previous papers on the preparation of *C*-nucleoside analogues, we described the acid-catalysed dehydration of some pentitol-1-yl derivatives of pyrrole and tetrahydroindol-4-one[1–3]. The mechanism proposed for the reaction involves an intermediate C-1′ carbocation. Furanosyl compounds were formed under kinetic control conditions, but pyranosyl compounds were the thermodynamically controlled products.

This reaction failed[4,5] when D-*galacto*-pentitol-1-yl derivatives of imidazole (**7** and **8**) were used, probably because the protonation of the basic imidazole precludes formation of the C-1′ carbocation. Similar behaviour has been observed with pentitol-1-yl derivatives of such other basic heterocycles as pyrazole[6], 6-azauracil[7], and pyridine[8].

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We now report an indirect route to 1,5-anhydro-D-*galacto*-pentitol-1-yl derivatives (**9, 11,** and **13**) of imidazole through the imidazolines **3** and **5** obtained by prolonged treatment of 1-aryl-(1,2-dideoxy-β-D-*glycero*-L-*gluco*-heptofurano)-[2,1-*d*]imidazolidine-2-thiones[9] (**1**) with acid.

RESULTS AND DISCUSSION

Prolonged treatment of **1** with acid gave a mixture of α- (**3**) and β-D-lyxopyranosyl-4-imidazolidine-2-thione (**5**). Monitoring of the reaction by chromatography showed the initial formation of the 4-(D-*galacto*-pentitol-1-yl)-4-imidazoline-2-thiones (**2**), which could be isolated if the reaction was stopped after an appropriate interval[10]. However, **2** was transformed slowly into three other products, two of which were identified as **3** and **5**. The third product could not be isolated, but it appeared to be converted into **3** and **5**, which were the only products present at the end of the reaction. This behaviour, together with the results of previous work[1–3,11], indicated that the third product could be an αβ-mixture of furanosyl compounds. Compounds **3** and **5** could be isolated by column chromatography and they were acetylated to give **4** and **6**, respectively. The structures of **3–6** were assigned on the basis of analytical and spectroscopic data. Thus, the ^{1}H-n.m.r. spectra of **3** (Table I) and **4** (Table II) showed $J_{1',2'}$ values (>9 Hz) that reflected a *trans*-diaxial arrangement of H-1′,2′, which is only possible for the α anomers in the $^1C_4$(D) conformation. The values of $J_{2',3'}$ and $J_{3',4'}$ (~3–4 Hz) obtained for **4** confirm this conformation. The ^{1}H-n.m.r. spectra of **5b, 6a,** and **6b** showed small values of $J_{1',2'}$ (~1 Hz), consistent with a *gauche* arrangement of H-1′,2′ in either the $^4C_1$ or $^1C_4$(D) conformation, and of the same magnitude as those for related β-D-lyxopyranosylheterocycles[1,2,12]. The $^4C_1$(D) conformation was assigned on the basis of the $J_{4',5'}$, $J_{4',5''}$, and $J_{5',5''}$ values for **6**, which indicated H-4′ to be axial[13]. The $J_{3',4'}$ value (10.1 Hz) for **6b** confirms this conformation.

The reaction of the mixture of **3** and **5** with benzyl chloride and an equivalent amount of sodium hydrogencarbonate yielded a mixture of 1-aryl-2-(benzylthio)-4-(α- and β-D-lyxopyranosyl)imidazole (**9** and **11**); **9a** and **11a** were isolated by fractional crystallisation and **9b** and **11b** by p.l.c. The ^{1}H-n.m.r. spectra (Table II) of the triacetates (**10a** and **12a**, respectively) of **9a** and **11a** confirm the proposed structures. The structures of **9b** and **11b** are also in agreement with their ^{1}H-n.m.r. spectra (Table I).

Desulphuration of the crude mixture of **3a** and **5a** with Raney nickel gave 4-(β-D-lyxopyranosyl)-1-phenylimidazole (**13a**); the α anomer was detected chromatographically but was not isolated. Compound **13a** had λ_{max} 239 nm, similar to that of related imidazoles[5]. The ^{13}C- and ^{1}H-n.m.r. spectra of **13a** contained signals for the imidazole and sugar moieties similar to those of **11** and **5b**, in agreement with the β configuration and $^4C_1$(D) conformation.

The ^{13}C-n.m.r. spectra of some selected compounds (Table III) are also in accord with the proposed structure.

TABLE I

^{1}H-N.M.R. DATA[a] FOR **3**, **5b**, **9b**, **11**, AND **13a** (δ IN P.P.M., J IN Hz)

Compound	*H-1'*	*H-2'*	*H-3'*	*H-4'*	*H-5'*	*H-5''*	*OH*	*H-2*	*H-5*	*-C_6H_5*	*-C_6H_4-*	*S-CH_2-*	*-CH_3*
3a[b]	4.27 d $J_{1',2'}$ 9.4			3.90–3.25 m			4.95–4.50 m		7.13 bs	7.70–7.30 m			
3b[b]	4.26 dd $J_{1',5}$ 0.3 $J_{1',2'}$ 9.4			3.90–3.25 m			4.97 d 4.71 d 4.75 d		7.14 bs		7.60–7.20 m		2.32 s
5b[b]	4.29 t $J_{1',5}$ 0.8 $J_{1',2'}$ 1.1			3.95–3.02 m			4.90–4.60 m		6.96 d		7.58–7.15 m		2.32 s
9b[c]	4.38 d $J_{1',2'}$ 9.1	4.03 m $J_{2',3'}$ 1.9		3.90–3.45 m			4.90 d (HO-4') 4.82 d (HO-3') 4.86 d (HO-2')		7.31 s	7.25 s	7.30–7.09 m	4.26 s	2.34 s
11a[c]	4.40 bs $J_{1',2'}$ 1.0	3.99 t $J_{2',3'}$ 3.4	3.46 dd $J_{3',4'}$ 9.0	3.71 m	3.83 dd $J_{4',5'}$ 5.3 $J_{4',5''}$ 10.0	3.13 t $J_{4',5''}$ 10.0	4.86 d (HO-4') 4.80 d (HO-3') 4.56 d (HO-2')		7.56–7.22 m			4.26 s	
11b[c]	4.37 s $J_{1',2'}$ 0.8	3.95 t $J_{2',3'}$ 3.2	3.40 t $J_{3',4'}$ 9.1	3.71 m	3.81 dd $J_{4',5'}$ 5.2 $J_{5',5''}$ 10.0	3.11 t $J_{4',5''}$ 10.0	4.82 d 4.77 d 4.53 d		7.21 s	7.25 s	7.30–7.09 m	4.25 s	2.34 s
13a[c]	4.39 bs $J_{1',2'}$ 1.0	3.95 bs $J_{2',3'}$ 2.8	3.42 dd $J_{3',4'}$ 8.8	3.71 m	3.84 dd $J_{4',5'}$ 5.6 $J_{5',5''}$ 9.9	3.12 t $J_{4',5''}$ 9.9	4.85 d 4.78 d 4.58 d	8.24 d	7.72–7.30 m				

[a]For solutions in $(CD_3)_2SO$ (J values were measured after exchanging with D_2O). [b]Recorded at 80.13 MHz. [c]Recorded at 200 MHz.

TABLE II

^{1}H-N.M.R. DATA[a] FOR **4, 6, 10a,** AND **12a** (δ IN P.P.M., J IN Hz)

Compound	*H-1'*	*H-2'*	*H-3'*	*H-4'*	*H-5'*	*H-5''*	*OAc*	*NH*	*H-5*	*-C_6H_5*	*S-CH_2-*	*-C_6H_4-*	*-CH_3*
4a[b]	4.71 d $J_{1',2'}$ 9.3	5.34 dd[c] $J_{2',3'}$ 3.0	5.42 dd[c] $J_{3',4'}$ 4.0	4.90 m	3.95 d		2.10 s (3 H) 2.06 s (3 H) 1.99 s (3 H)	12.52 bs	6.84 s	7.70–7.35 m			
4b[b]	4.70 d $J_{1',2'}$ 9.3	5.34 dd[c] $J_{2',3'}$ 3.0	5.42 dd[c] $J_{3',4'}$ 4.3	4.90 m	3.92 d		2.09 s (3 H) 2.04 s (3 H) 1.96 s (3 H)	12.53 bs	6.80 s			7.55–7.15 m	2.39 s
6a[b]	4.76 bs $J_{1',2'}$ 1.0	5.68 bd $J_{2',3'}$ 2.0			4.28 dd $J_{4',5'}$ 5.0 $J_{5',5''}$ 10.0	3.44 t $J_{4',5''}$ 10.0	2.15 s (3 H) 2.05 s (3 H) 2.02 s (3 H)		6.72 m	7.70–7.30 m			
6b[c]	4.67 bs $J_{1',2'}$ 1.3	5.61 dd $J_{2',3'}$ 3.0	5.14 dd $J_{3',4'}$ 10.1	5.29 m	4.28 dd $J_{4',5'}$ 5.4 $J_{5',5''}$ 11.2	3.41 t $J_{4',5''}$ 10.1	2.16 s (3 H) 2.07 s (3 H) 2.03 s (3 H)	10.56 s	6.67 s			7.43–7.26 m	2.40 s
10a[c]	4.86 d $J_{1',2'}$ 7.6	5.66–5.60 m		5.03 m $J_{3',4'}$ 4.9	4.07 dd $J_{4',5'}$ 2.7 $J_{5',5''}$ 12.8	3.98 dd $J_{4',5''}$ 3.4	2.16 s (6 H) 2.01 s (3 H)		7.22 s	7.38–7.15 m (10 H)	4.32 q		
12a[d]	4.79 bs $J_{1',2'}$ 1.1	5.82 dd $J_{2',3'}$ 3.2	5.24 dd $J_{3',4'}$ 10.2	5.36 m	4.31 dd $J_{4',5'}$ 5.6 $J_{5',5''}$ 11.0	3.48 t $J_{5',5''}$ 10.2	2.09 s (3 H) 2.08 s (3 H) 2.04 s (3 H)			7.39–7.02 m (11 H)	4.22 q		

[a]Recorded for solutions in $CDCl_3$. [b]Recorded at 90 MHz. [c]Recorded at 200 MHz. [d]Recorded at 360 MHz. [e]Obtained by the addition of $Eu(fod)_3$.

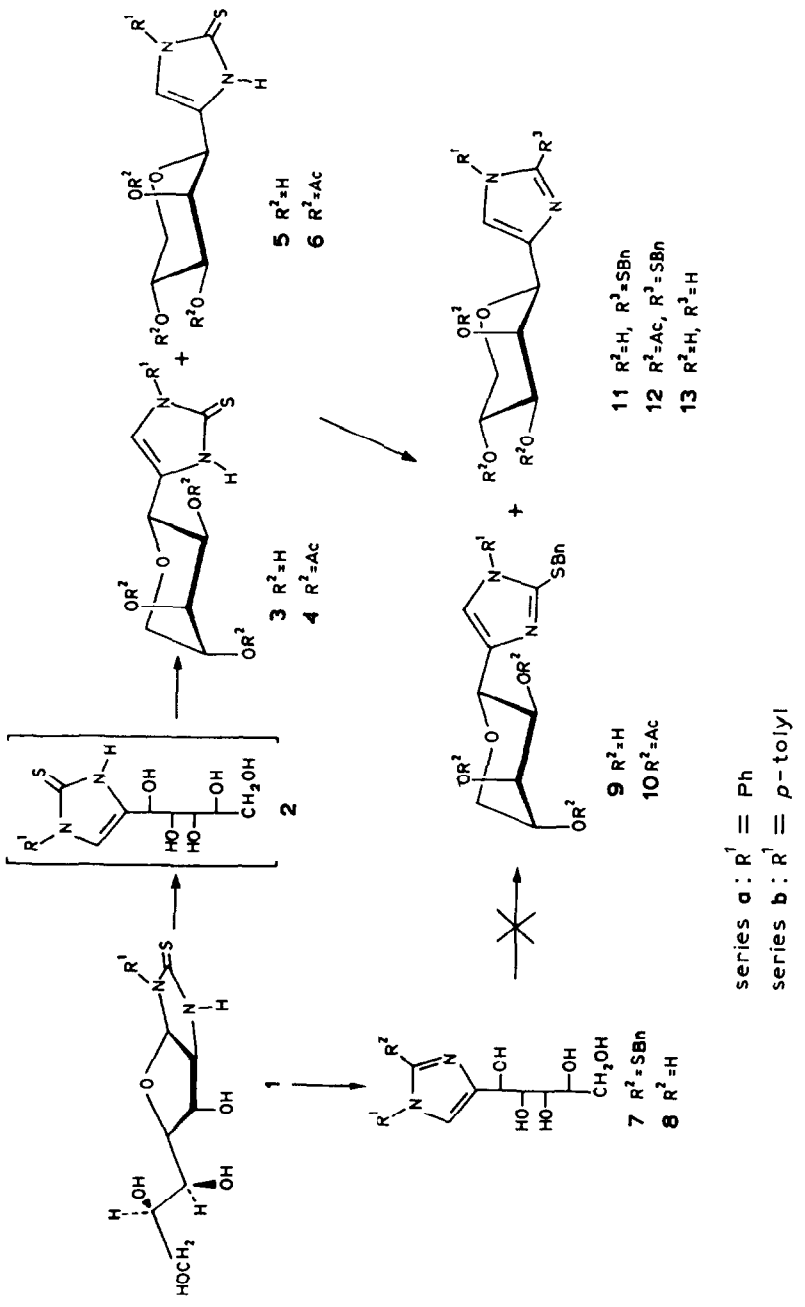
5 R²=H
6 R²=Ac
3 R²=H
4 R²=Ac
2
1
7 R²=SBn
8 R²=H
9 R²=H
10 R²=Ac
11 R²=H, R³=SBn
12 R²=Ac, R³=SBn
13 R²=H, R³=H
series a: R¹ = Ph
series b: R¹ = p-tolyl

TABLE III

^{13}C-N.M.R. DATA[a,b] FOR **3**, **5b**, **9b**, **11a**, AND **13a** (δ IN P.P.M.)

Compound	*C-1'*	*C-2'*	*C-3'*	*C-4'*	*C-5'*	*C-2*	*C-4*	*C-5*	*Aromatic*	*S-CH_2-*	*-CH_3*
3a	69.9*	69.5*	69.2*	66.2	66.6	161.6	128.0	117.0	137.8 (C-1″) 128.4 (C-3″) 127.2 (C-4″) 125.3 (C-2″)		
3b	69.9*	69.4*	69.2*	66.2	66.6	161.5	127.8	117.0	136.7 (C-1″) 135.3 (C-4″) 128.9 (C-3″) 125.1 (C-2″)		20.3
5b	74.3	69.8	72.8	66.0	69.8	161.1	126.8	116.5	136.7 (C-1″) 135.3 (C-4″) 128.9 (C-3″) 125.1 (C-2″)		20.3
9b	72.2	70.2*	69.3*	67.8	66.5	137.6**	137.3**	120.7	141.5 (C-1″) 139.3 (C-1″) 134.2 129.5 128.6 128.1 126.9 124.8	37.4	20.3
11a	76.3	70.8	74.9	66.6	70.1	137.4*	136.9*	121.0	140.9 (C-1″) 139.5 (C-1″) 129.5 128.9 128.5 127.4 125.4	37.9	
13a	76.3	70.7	74.8	66.5	70.0	134.3	136.9	115.8	141.3 (C-1″) 129.9 (C-3″) 126.9 (C-4″) 120.3 (C-2″)		

[a]Recorded at 20.15 MHz for solutions in $(CD_3)_2SO$. [b]Assignments marked * and ** may have to be interchanged.

EXPERIMENTAL

General methods. — Solutions were concentrated *in vacuo* at <40°. Melting points were determined with a Gallenkamp apparatus, and are uncorrected. Optical rotations were measured with a Perkin–Elmer 141 polarimeter (10-cm cell). I.r. spectra (KBr discs) were recorded with a Perkin–Elmer 399 spectrometer, and u.v. spectra with a Beckman 25 instrument. ^{1}H-N.m.r. spectra were recorded with Perkin–Elmer R-32 (90 MHz), Varian XL-200 (200 MHz), and Bruker WP-80-SY (80.13 MHz) spectrometers. ^{13}C-N.m.r. spectra (20.15 MHz) were recorded with a Bruker WP-80-SY spectrometer. T.l.c. was conducted on silica gel GF_{254} (Merck)

with *A*, ethyl acetate–ethanol (3:1); *B*, ethyl acetate–ethanol (8:1); *C*, ethyl acetate–chloroform–light petroleum–ethanol (3:3:3:1); and *D*, benzene–ether (3:2), and detection with u.v. light and iodine vapour, P.l.c. was conducted on 1-mm layers of silica gel 60 PF_{254} (Merck). Column chromatography was performed in the flash mode.

4-(α-D-Lyxopyranosyl and β-D-lyxopyranosyl)-1-phenyl-4-imidazoline-2-thione (**3a** *and* **5a**). — A solution of 1-phenyl-(1,2-dideoxy-β-D-*glycero*-L-*gluco*-hepto-furano)[2,1-*d*]imidazolidine-2-thione[9] (**1a**, 1 g, 3.06 mmol) in aqueous 50% ethanol (10 mL) was treated with trifluoroacetic acid (2 mL). The mixture was boiled for 7 h under reflux, then neutralised with sodium hydrogencarbonate, decolourised with charcoal, and concentrated to dryness. Column chromatography (solvent *B*) of the residue gave a fraction with R_F 0.35 that was crystallised from ethanol to yield **3a** (0.15 g, 13%), m.p. 120–122°, $[\alpha]_D^{18}$ +63°, $[\alpha]_{578}^{18}$ +66°, $[\alpha]_{546}^{18}$ +77°, $[\alpha]_{436}^{18}$ +161°, $[\alpha]_{365}^{18}$ +356° (*c* 0.5, pyridine); $\lambda_{max}^{H_2O}$ 265 and 243 nm (ε_{mM} 11.5 and 10.7); ν_{max} 3360, 3260 (OH, NH), 2960, 2920, 2880 (C–H), 1590, 1500, and 1480 cm^{-1} (C=C aromatic). The ^1H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{14}H_{16}N_2O_4S \cdot C_2H_5OH$: C, 54.22; H, 6.25; N, 7.90. Found: C, 53.97; H, 6.22; N, 7.77.

The fraction with R_F 0.27 was crystallised from water to yield **5a** (0.104 g, 10%), m.p. 192–194°, $[\alpha]_D^{18}$ +25°, $[\alpha]_{578}^{18}$ +27°, $[\alpha]_{546}^{18}$ +32°, $[\alpha]_{436}^{18}$ +71°, $[\alpha]_{365}^{18}$ +171° (*c* 0.5, pyridine); $\lambda_{max}^{H_2O}$ 265 and 243 nm (ε_{mM} 11.5 and 11.0); ν_{max} 3440, 3180 (OH, NH), 2940, 2890, 2860 (C–H), 1595, 1500, and 1470 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{14}H_{16}N_2O_4S \cdot 1.5\ H_2O$: C, 50.14; H, 5.70; N, 8.35. Found: C, 49.95; H, 5.55; N, 8.19.

*1-Phenyl-(2,3,4-tri-*O*-acetyl-α-D-lyxopyranosyl)-4-imidazoline-2-thione* (**4a**). — Conventional treatment of **3a** (0.1 g, 0.28 mmol) with pyridine (0.5 mL) and acetic anhydride (0.6 mL) gave **4a** (0.1 g, 82%), m.p. 123–125° (from ethanol), $[\alpha]_D^{16}$ +10°, $[\alpha]_{578}^{16}$ +8°, $[\alpha]_{546}^{16}$ +11°, $[\alpha]_{436}^{16}$ +20°, $[\alpha]_{365}^{16}$ +42° (*c* 0.55, pyridine); ν_{max} 2920, 2870 (C–H), 1755 (C=O), 1600, 1500 (C=C aromatic), and 1220 cm^{-1} (C–O–C). The ^1H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{20}H_{22}N_2O_7S$: C, 55.28; H, 5.10; N, 6.45. Found: C, 55.15; H, 5.15; N, 6.33.

*1-Phenyl-4-(2,3,4-tri-*O*-acetyl-β-D-lyxopyranosyl)-4-imidazoline-2-thione* (**6a**). — Conventional treatment of **5a** (0.1 g, 0.30 mmol) with pyridine (0.5 mL) and acetic anhydride (0.6 mL) gave **6a** (0.10 g, 78%). P.l.c. (solvent *D*) gave material with m.p. 126–128°, $[\alpha]_D^{16}$ −124°, $[\alpha]_{578}^{16}$ −131.5°, $[\alpha]_{546}^{16}$ −151.5°, $[\alpha]_{436}^{16}$ −312.5° (*c* 0.5, pyridine); ν_{max} 2920, 2860 (C–H), 1750 (C=O), 1600, 1500 (C=C aromatic), and 1225 cm^{-1} (C–O–C). The ^1H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{20}H_{22}N_2O_7S$: C, 55.28; H, 5.10; N, 6.45. Found: C, 55.43; H, 5.18; N, 6.24.

*4-(α-D-Lyxopyranosyl and β-D-*lyxopyranosyl)-1-p-*tolyl-4-imidazoline-2-thione* (**3b** *and* **5b**). — A solution of 1-*p*-tolyl-(1,2-dideoxy-β-D-*glycero*-L-*gluco*-hepto-furano)[2,1-*d*]imidazolidine-2-thione[9] (**1b**; 3.5 g, 10 mmol) in aqueous 50% ethanol

(35 mL) was treated with trifluoroacetic acid (7 mL). The mixture was boiled for 23 h under reflux and then processed as described above to yield **3b** (0.74 g, 20%), R_F 0.36, m.p. 132–134° (from ethanol), $[\alpha]_D^{16}$ +63°, $[\alpha]_{578}^{16}$ +65°, $[\alpha]_{546}^{16}$ +77°, $[\alpha]_{436}^{16}$ +159°, $[\alpha]_{365}^{16}$ +345° (*c* 0.57, pyridine); $\lambda_{max}^{H_2O}$ 262 nm (ε_{mM} 15.2); ν_{max} 3400–3100 (OH. NH), 2950, 2900, 2870 (C–H), 1575, 1505, and 1475 cm^{-1} (C=C aromatic). The ^1H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{15}H_{18}N_2O_4S \cdot C_2H_5OH$: C, 55.41; H, 6.56; N, 7.60. Found: C, 55.77; H, 6.87; N, 7.88.

Crystallisation from water of the product with R_F 0.25 gave **5b** (0.57 g, 16%), m.p. 214–216°, $[\alpha]_D^{16}$ +24°, $[\alpha]_{546}^{16}$ +29.5°, $[\alpha]_{436}^{16}$ +65°, $[\alpha]_{365}^{16}$ +154° (*c* 0.4, pyridine); $\lambda_{max}^{H_2O}$ 264 nm (ε_{mM} 12.5); ν_{max} 3400–3100 (OH, NH), 2890, 2870, 2840 (C–H), 1580, and 1510 cm^{-1} (C=C aromatic). The ^1H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{15}H_{18}N_2O_4S \cdot H_2O$: C, 52.93; H, 5.92; N, 8.23. Found: C, 53.09; H, 5.74; N, 8.18.

*1-*p*-Tolyl-4-(2,3,4-tri-*O*-acetyl-α-*D*-lyxopyranosyl)-4-imidazoline-2-thione* (**4b**). — Conventional treatment of **3b** (0.1 g, 0.27 mmol) with pyridine (0.5 mL) and acetic anhydride (0.6 mL) gave **4b** (0.04 g, 85%), m.p. 231–233° (from ethanol), $[\alpha]_D^{29}$ +1.4°, $[\alpha]_{578}^{29}$ +1°, $[\alpha]_{546}^{29}$ +0.8°, $[\alpha]_{436}^{29}$ +6°, $[\alpha]_{365}^{29}$ +5° (*c* 0.5, pyridine); ν_{max} 3450 (NH), 2910, 2860 (C–H), 1740 (C=O), 1580, 1510, 1485 (C=C aromatic), and 1210 cm^{-1} (C–O–C). The ^1H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{21}H_{24}N_2O_7S$: C, 56.24; H, 5.39; N, 6.24. Found: C, 56.29; H, 5.53; N, 6.19.

*1-*p*-Tolyl-4-(2,3,4-tri-*O*-acetyl-β-*D*-lyxopyranosyl)-4-imidazoline-2-thione* (**6b**). — Conventional treatment of **5b** (0.1 g, 0.29 mmol) with pyridine (0.5 mL) and acetic anhydride (0.6 mL) gave **6b** (0.120 g, 91%), m.p. 227–229° (from ethanol), $[\alpha]_D^{27}$ −105°, $[\alpha]_{578}^{27}$ −107°, $[\alpha]_{546}^{27}$ −124°, $[\alpha]_{436}^{27}$ −227°, $[\alpha]_{365}^{27}$ −403° (*c* 0.6, pyridine); ν_{max} 3280 (NH), 2915, 2870 (C–H), 1745, 1715 (C=O), 1580, 1515 (C=C aromatic), and 1230 cm^{-1} (C–O–C). The ^1H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{21}H_{24}N_2O_7S$: C, 56.24; H, 5.39; N, 6.24. Found: C, 56.51; H, 5.67; N, 6.20.

*2-(Benzylthio)-4-(α- and β-*D*-lyxopyranosyl)-1-phenylimidazole* (**9a** *and* **11a**). — To a solution of the crude mixture of **3a** and **5a** (1 g, 3.2 mmol) in aqueous 90% ethanol (10 mL) were added sodium hydrogencarbonate (0.28 g, 3.2 mmol) and benzyl chloride (0.42 mL, 3.2 mmol). The mixture was boiled for 2 h under reflux, and then concentrated to crystallisation of **11a** (0.13 g, 9%). Recrystallisation from ethanol gave material with m.p. 162–163°, $[\alpha]_D^{18}$ +7°, $[\alpha]_{578}^{18}$ +8°, $[\alpha]_{546}^{18}$ +9°, $[\alpha]_{436}^{18}$ +23°, $[\alpha]_{365}^{18}$ +56° (*c* 0.5, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 263 nm (ε_{mM} 6.6); ν_{max} 3400, 3260 (OH), 2915, 2900, 2850 (C–H), 1590, and 1495 cm^{-1} (C=C aromatic). The ^1H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{21}H_{22}N_2O_4S \cdot H_2O$: C, 60.56; H, 5.80; N, 6.72. Found: C, 60.60; H, 5.80; N, 6.65.

The mother liquors were concentrated to dryness, and ethanol and acetone were repeatedly evaporated from the syrupy residue to yield **9a** (0.07 g, 5%). Recrystallisation from 1:1 2-propanol–water gave material with m.p. 146–147°, $[\alpha]_D^{17}$ ~0°, $[\alpha]_{578}^{17}$ +3°, $[\alpha]_{546}^{17}$ ~0°, $[\alpha]_{436}^{17}$ +2°, $[\alpha]_{365}^{17}$ +9° (*c* 0.5, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 265 nm (ε_{mM} 5.5); ν_{max} 3400, 3150 (OH), 2910, 2900, 2850 (C–H), 1595, and 1500 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{21}H_{22}N_2O_4S$: C, 63.29; H, 5.56; N, 7.02. Found: C, 63.00; H, 5.51; N, 6.94.

*2-(Benzylthio)-1-phenyl-4-(2,3,4-tri-*O*-acetyl-α-*D*-lyxopyranosyl)imidazole* (**10a**). — Conventional treatment of **9a** (0.075 g, 0.19 mmol) with pyridine (0.4 mL) and acetic anhydride (0.45 mL) gave **10a** (0.083 g, 84%), m.p. 140–142° (from ethanol), $[\alpha]_D^{17}$ −6°, $[\alpha]_{578}^{17}$ −4°, $[\alpha]_{546}^{17}$ −7°, $[\alpha]_{436}^{17}$ −14.5°, $[\alpha]_{365}^{17}$ −27.5° (*c* 0.5, pyridine); ν_{max} 2880, 2840 (C–H), 1730 (C=O), 1590, 1490 (C=C aromatic), 1240, 1235, and 1205 cm^{-1} (C–O–C). The ^{1}H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{27}H_{28}N_2O_7S$: C, 61.81; H, 5.38; N, 5.34. Found: C, 61.45; H, 5.31; N, 5.38.

*2-(Benzylthio)-1-phenyl-4-(2,3,4-tri-*O*-acetyl-β-*D*-lyxopyranosyl)imidazole* (**12a**). — Conventional treatment of **11a** (0.075 g, 0.18 mmol) with pyridine (0.4 mL) and acetic anhydride (0.45 mL) gave **12a** (0.081 g, 86%). P.l.c. (solvent *D*) gave material with m.p. 96–98°, $[\alpha]_D^{27}$ −84°, $[\alpha]_{578}^{27}$ −89.5°, $[\alpha]_{546}^{27}$ −104°, $[\alpha]_{436}^{27}$ −185.5°, $[\alpha]_{365}^{27}$ −318° (*c* 0.5, pyridine); ν_{max} 2960, 2920 2850 (C–H), 1745 (C=O), 1595, 1495 (C=C aromatic), 1240, and 1215 cm^{-1} (C–O–C). The ^{1}H-n.m.r. data are given in Table II.

Anal. Calc. for $C_{27}H_{28}N_2O_7S$: C, 61.81; H, 5.38; N, 5.34. Found: C, 61.68; H, 5.45; N, 5.30.

*2-(Benzylthio)-4-(α- and β-*D*-lyxopyranosyl)-1-*p*-tolylimidazole* (**9b** *and* **11b**). — These compounds were prepared from **3b** and **5b** (1 g, 3.1 mmol) and benzyl chloride (0.41 mL, 3.1 mmol) as described for **9a** and **11a**. P.l.c. (solvent *C*, four developments) of the product gave **9b** (0.06 g, 5%), R_F 0.29, m.p. 84–86° (from ethanol), $[\alpha]_D^{27}$ ~0°, $[\alpha]_{578}^{27}$ ~0°, $[\alpha]_{546}^{27}$ ~0°, $[\alpha]_{436}^{27}$ +2.5°, $[\alpha]_{365}^{27}$ +11.5° (*c* 0.5, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 261 nm (ε_{mM} 6.6); ν_{max} 3310 (OH), 2920, 2890 (C–H), 1580, 1515, and 1490 cm^{-1} (C=C aromatic). The ^{1}H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{22}H_{24}N_2O_4S$: C, 64.06; H, 5.86; N, 6.79. Found: C, 63.91; H, 5.82; N, 6.69.

The band of R_F 0.23 gave **11b** (0.055 g, 5%), m.p. 172–174° (from ethanol), $[\alpha]_D^{27}$ +7°, $[\alpha]_{578}^{27}$ +7°, $[\alpha]_{546}^{27}$ +7°, $[\alpha]_{436}^{27}$ +15.5°, $[\alpha]_{365}^{27}$ +39° (*c* 0.45, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 262 nm (ε_{mM} 7.0); ν_{max} 3400, 3290 (OH), 2920, 2850 (C–H), 1580, 1515, and 1490 cm^{-1} (C=C aromatic). The ^{1}H-n.m.r. data are given in Table I.

Anal. Calc. for $C_{22}H_{24}N_2O_4S$: C, 64.06; H, 5.86; N, 6.79. Found: C, 64.25; H, 5.60; N, 6.75.

*4-(β-*D*-Lyxopyranosyl)-1-phenylimidazole* (**13a**). — A solution of the crude mixture of **3a** and **5a** (5 g, 16 mmol) in aqueous 90% ethanol (100 mL) was boiled

for 5 min under reflux with Raney nickel (50 mL). The catalyst was removed, the filtrate was concentrated, and the residue was crystallised from ethanol to yield **13a** (0.862 g, 19%). Recrystallisation from ethanol–water gave material with m.p. 210–212°, $[\alpha]_D^{27}$ −49°, $[\alpha]_{578}^{27}$ −51°, $[\alpha]_{546}^{27}$ −59°, $[\alpha]_{436}^{27}$ −97°, $[\alpha]_{365}^{27}$ −150° (*c* 0.5, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 239 nm (ε_{mM} 8.9); ν_{max} 3370, 3220 (OH), 2960, 2930, 2840 (C–H), 1595, and 1505 cm^{-1} (C=C aromatic). The ^1H- and ^{13}C-n.m.r. data are given in Tables I and III, respectively.

Anal. Calc. for $C_{14}H_{16}N_2O_4$: C, 60.86; H, 5.84; N, 10.14. Found: C, 60.64; H, 6.11; N, 10.03.

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