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PREPARATION OF 1-ARYL-2-(BENZYLTHIO)-(1,2-DIDEOXY-D-*glycero*-β-L-*gluco*-HEPTOFURANO)[1,2-*d*]-2-IMIDAZOLINES, AND NEW, ACYCLIC *C*-NUCLEOSIDES OF THE IMIDAZOLE*

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ABSTRACT

The reaction of 1-aryl-(1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thiones with benzyl chloride and an equivalent amount of sodium hydrogencarbonate yields 1-aryl-2-(benzylthio)-(1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]-2-imidazolines (**2**). If the reaction is carried out in the absence of sodium hydrogencarbonate, the 1-aryl-2-(benzylthio)-4-(D-*galacto*-pentitol-1-yl)imidazoles are obtained. These compounds are also obtained by acid-catalyzed isomerization of compounds **2**.

INTRODUCTION

The reaction of amino sugars with alkyl and aryl isothiocyanates yields 1-alkyl(aryl)-(1,2-dideoxy-D-glycofurano)[1,2-*d*]imidazolidine-2-thiones[1] which are useful intermediates in the synthesis of imidazole derivatives having interesting pharmacological and biological properties[2,3]. We have recently described[4] the preparation of 1-aryl-(1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thiones (**1**) by reaction between aryl isothiocyanates and 2-amino-2-deoxy-D-*glycero*-L-*gluco*-heptose. We now report the preparation of some of their 2-benzylthio derivatives, and the isomerization to acyclic *C*-nucleosides of the imidazole.

RESULTS AND DISCUSSION

The reaction of 1-aryl-(1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thiones (**1**) with benzyl chloride and the equivalent amount of sodium hydrogencarbonate yields 1-aryl-2-(benzylthio)-(1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]-2-imidazolines (**2**). The structures of these compounds

*Taken, in part, from the Ph. D. Thesis of F.R.V.

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TABLE I

^{1}H-N.M.R DATA[a] (90 MHz) FOR **3a**, **3b**, AND **3c**

Compound No.	*H-1'*	*H-2'*	*H-3'*[b]	*H-4'*[b]	*H-5'*[b]	*H-6'*	*H-7'*[b]	*H-7''*[b]	*OAc*	*S-CH$_2$*	*phenyl*	p-*tolyl*	p-*bromophenyl*
3a	5.78 d $J_{1',2'}$ 5.9	4.57 d $J_{2',3'}$ 0.0	5.52 d $J_{3',4'}$ 2.6	3.87 dd $J_{4',5'}$ 9.6	5.34 dd $J_{5',6'}$ 2.6	5.35–5.60 m $J_{6',7'}$ 5.0 $J_{6',7''}$ 6.9	4.35 dd $J_{7',7''}$ 11.6	3.95 dd	1.94 s (3 H) 2.02 s (3 H) 2.09 s (6 H)	4.32 s (2 H)	7.60–7.15 m (10 H)		
3b	5.72 d $J_{1',2'}$ 5.6	4.54 d $J_{2',3'}$ 0.0	5.53 d $J_{3',4'}$ 2.3	3.92 dd $J_{4',5'}$ 9.6	5.47 dd $J_{5',6'}$ 2.6	5.35–5.60 m $J_{6',7'}$ 5.0 $J_{6',7''}$ 7.3	4.37 dd $J_{7',7''}$ 11.2	3.96 dd	2.00 s (3 H) 2.04 s (3 H) 2.10 s (6 H)	4.32 s (2 H)	7.50–7.20 m (5 H)	2.35 s (3 H) 7.15 s (4 H)	
3c	5.72 d $J_{1',2'}$ 5.6	4.56 d $J_{2',3'}$ 0.0	5.52 d $J_{3',4'}$ 2.8	3.85 dd $J_{4',5'}$ 9.5	5.30 dd $J_{5',6'}$ 2.6	5.33–5.60 m $J_{6',7'}$ 5.0 $J_{6',7''}$ 7.0	4.36 dd $J_{7',7''}$ 11.4	3.94 dd	1.93 s (3 H) 2.02 s (3 H) 2.09 s (6 H)	4.30 s (2 H)	7.40–7.15 m (5 H)		7.55–7.05 m (4 H)

[a]Recorded in $CDCl_3$ at 35.5°, δ scale (internal Me_4Si), J in Hz. [b]Values obtained by extrapolation back to zero concentration of $Eu(fod)_3$.

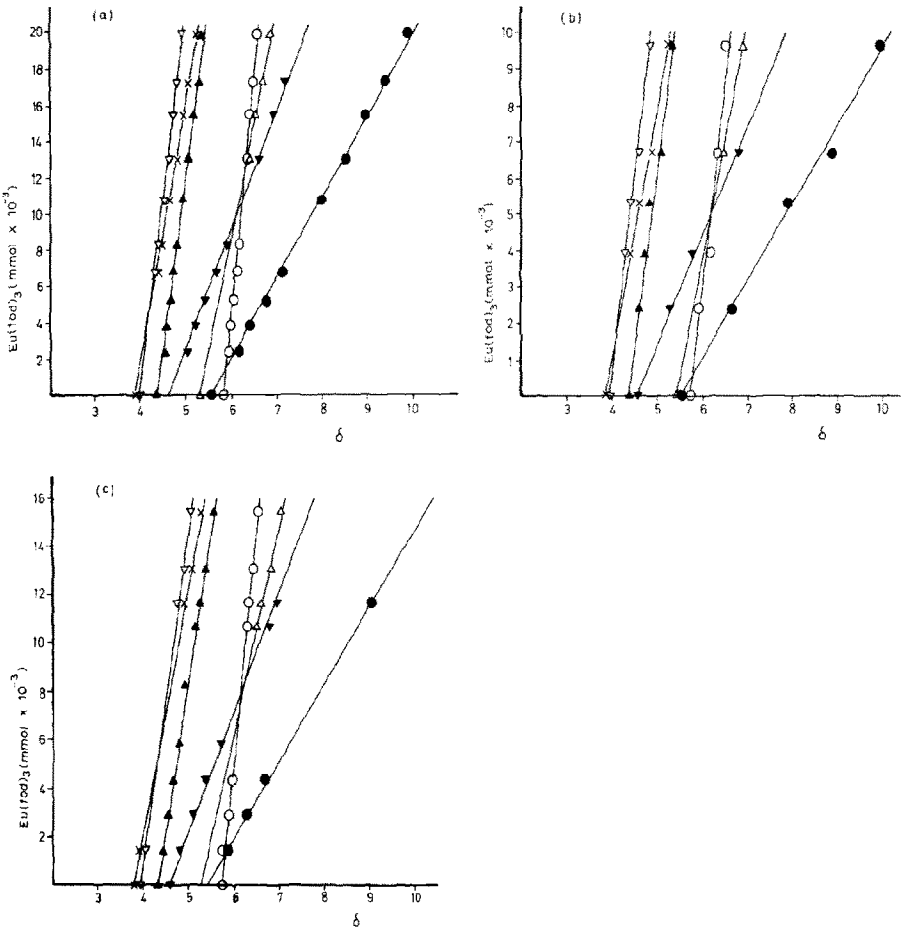


Fig. 1. Plot of the chemical shifts of the proton resonances of (a) 2-(benzylthio)-1-phenyl-(3,5,6,7-tetra-*O*-acetyl-1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]-2-imidazoline (**3a**); (b) 2-(benzylthio)-1-*p*-tolyl-(3,5,6,7-tetra-*O*-acetyl-1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]-2-imidazoline (**3b**); and (c) 2-(benzylthio)-1-(*p*-bromophenyl)-(3,5,6,7-tetra-*O*-acetyl-1,2-dideoxy-D-*glycero*-β-L-*gluco*-heptofurano)[1,2-*d*]-2-imidazoline (**3c**), *vs.* the mmol of $Eu(fod)_3$ added. Values for the unperturbed chemical shifts were estimated by extrapolation back to zero concentration of $Eu(fod)_3$. ○, H-1′; ▼, H-2′; ●, H-3′; ×, H-4′; △, H-5′; ▲, H-7′; ▽, H-7″.

were demonstrated by elemental analyses and spectral data (u.v. and i.r.). The structure of the glycofuranoid ring was proved by periodate oxidation, ~1 molar equivalent of formic acid being produced in each case.

Conventional treatment of **2** with acetic anhydride in pyridine gave the corresponding tetra-*O*-acetyl derivatives (**3**), whose ^{1}H-n.m.r.-spectral data are collected in Table I. Complete sets of proton–proton spin-coupling constants were determined for compounds **3** in the presence of $Eu(fod)_3$; chemical values were esti-

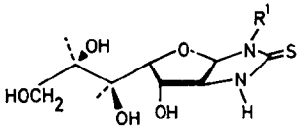
TABLE II

VALUES OF J (Hz) AND ϕ (DEGREES) FOR THE FURANOID-RING PROTONS

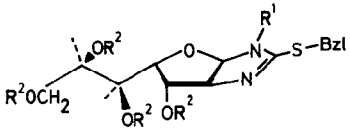
i,j	$J_{i,j}$	$\phi_{i,j}$ *(calculated)*[7]	$\phi_{i,j}$ *(taken from models)*[8,9]		
			$^4T_3$	E_3	^4E
1,2	5.9	31	19	37	0
2,3	0.0	78	70	60	83
3,4	2.6	53	60	60	60

mated by extrapolation of the approximately linearly dependent, paramagnetically altered, field positions to zero concentration of added lanthanide, as illustrated in Fig. 1. The J values in the absence of $Eu(fod)_3$ may be taken to be almost the same as these values, as the coupling constants are generally not greatly influenced by addition of a shift reagent[5,6]; in addition, the $J_{1',2'}$ and $J_{2',3'}$ values were found invariable before and after the addition of the shift reagent. The dihedral angles (ϕ) between all of the vicinal protons were calculated from these values of J by applying a modified Karplus equation[7]. By comparing these ϕ values with those obtained from models[8,9] (see Table II), it may be assumed that the most favored conformation of the furanoid rings is intermediate between the E_3 and $^4T_3$ forms.

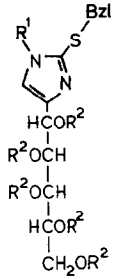
If the benzylation of **1** is conducted in the absence of sodium hydrogencarbonate, isomerization of the glycosyl moiety occurs, and the 1-aryl-2-(benzyl-



1



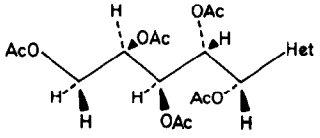
2 R^2 = H
3 R^2 = Ac



4 R^2 = H
5 R^2 = Ac

a R^1 = Ph
b R^1 = C_6H_4Me-*p*
c R^1 = C_6H_4Br-*p*

Bzl = $PhCH_2$



D-*galacto*

TABLE III

^{1}H-N.M R. DATA [a] (90 MHz) FOR **5a**, **5b**, AND **5c**

Compound No.	*H-1'*	*H-2'*	*H-3'*	*H-4'*	*H-5'*	*H-5''*	*OAc*	*H-5*	*S-CH$_2$*	*phenyl*	p-*tolyl*	p-*bromophenyl*
5a	6.09 d $J_{1',2'}$ 3.4	5.76 dd $J_{2',3'}$ 8.7	5.55 dd $J_{3',4'}$ 2.2	5.37 m $J_{4',5'}$ 4.9 $J_{4',5''}$ 7.0	4.33 dd $J_{5',5''}$ 11.6	3.98 dd	2.05 s (3 H) 2.09 s (3 H) 2.12 s (6 H) 2.14 s (3 H)	7.04 s	4.26 s (2 H)	6.95–7.50 m 7.22 s		
5b	6.06 d $J_{1',2'}$ 3.3	5.71 dd $J_{2',3'}$ 8.3	5.50 dd $J_{3',4'}$ 2.0	5.32 m $J_{4',5'}$ 4.6 $J_{4',5''}$ 7.1	4.30 dd $J_{5',5''}$ 11.4	3.93 dd	2.01 s (3 H) 2.05 s (3 H) 2.08 s (6 H) 2.11 s (3 H)	6.98 s	4.23 s	7.20 s	6.80–7.30 m 2.35 s (3 H)	
5c	6.03 d $J_{1',2'}$ 3.1	5.70 dd $J_{2',3'}$ 8.4	5.49 dd $J_{3',4'}$ 2.1	5.33 m $J_{4',5'}$ 4.6 $J_{4',5''}$ 7.3	4.31 dd $J_{5',5''}$ 11.5	3.94 dd	2.01 s (3 H) 2.05 s (3 H) 2.07 s (3H) 2.08 s (3 H) 2.11 s (3 H)	6.97 s	4.21 s	7.18 s		6.75–7.55 m

[a]Recorded in $CDCl_3$ at 35.5°, δ scale (internal Me_4Si), J in Hz.

thio)-4-(D-*galacto*-pentitol-1-yl)imidazoles (**4**) are obtained. These compounds are also obtained by trifluoroacetic acid-catalyzed isomerization of compounds **2**. The structures of compounds **4** were demonstrated by elemental analyses and spectral data (u.v. and i.r). The presence of the pentahydroxypentyl chain was proved by periodate oxidation, showing a periodate consumption of 4 mol per mol of substance. Assignment of the D-*galacto* configuration is based on the configuration of the sugar precursor, and is consistent with the Richtmyer–Hudson rules[10]. The structure was also proved by preparation of their pentaacetates (**5**). The vicinal spin-coupling constants observed between H-1′, H-2′ and H-3′, H-4′ are of small magnitude (see Table III), indicating *gauche*-disposed protons, and the value of $J_{2',3'}$ indicated *trans*-periplanar protons. These values established that the molecules exist essentially in the fully extended, planar, zigzag conformation. The intermediate values of $J_{4',5'}$ and $J_{4',5''}$ (4.7 and 7.2 Hz) are in agreement with the chain-end flexibility encountered in other examples of acyclic-sugar derivatives[11,12].

EXPERIMENTAL

General methods. — Solutions were concentrated *in vacuo* at temperatures below 40°. Melting points were determined with a Gallenkamp apparatus, and are uncorrected. Optical rotations were measured at 20 ±2° with a Perkin–Elmer 141 polarimeter (10-cm cell). I.r. spectra (KBr discs) were recorded with Beckman IR-33 and Perkin–Elmer 399 spectrophotometers, and u.v. spectra with a Beckman 25 instrument. ^{1}H-N.m.r. spectra (90 MHz, internal Me_4Si) were recorded with a Perkin–Elmer R-32 spectrometer, and coupling constants were measured directly from spectra recorded at 300-Hz sweep-width (temperature of the probe, 35.5°). Assignments were confirmed by double resonance, and overlapping signals were gradually shifted and separated from one another by incremental addition of Eu(fod)$_3$. T.l.c. was performed on silica gel GF_{254} (Merck) with 3:1 ethyl acetate–ethanol and detection with u.v. light and iodine vapor. Consumption of periodate and formic acid produced were determined as previously described[13–15].

2-(Benzylthio)-1-phenyl-(1,2-dideoxy-D-glycero-*β*-L-gluco-*heptofurano)*-[*1,2*-d]-*2-imidazoline* (**2a**). — A solution of 1-phenyl-(1,2-dideoxy-D-*glycero*-*β*-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thione[4] (**1a**; 1 g, 3 mmol) in 90% ethanol (10 mL) was treated with $NaHCO_3$ (0.26 g, 3 mmol) and benzyl chloride (0.4 mL, 3 mmol). The mixture was boiled under reflux for 1 h, cooled, and concentrated to two-thirds of its original volume, and the product (**2a**) then crystallized (1.042 g, 81%). Recrystallized from 1:1 ethanol–water, it had m.p. 176–177°, $[\alpha]_D^{22}$ −80.5° (*c* 0.7, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 250 nm (ε_{mM} 11.00); ν_{max} 3500–3100 (OH), 2950, 2930 and 2865 (C–H), 1595, 1580, 1480 and 1440 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{21}H_{24}N_2O_5S$: C, 60.56; H, 5.80; N, 6.72; S, 7.69. Found: C, 60.65; H, 6.01; N, 6.62; S, 7.67. Formic acid produced: 0.94 mol.

2-(Benzylthio)-1-phenyl-(3,5,6,7-tetra-O-*acetyl-1,2-dideoxy*-D-glycero-*β*-L-

gluco-*heptofurano)*[*1,2*-d]-*2-imidazoline* (**3a**). — Conventional treatment of **2a** (0.3 g, 0.72 mmol) with pyridine (3 mL) and acetic anhydride (2 mL) gave **3a** (0.366 g, 86%). Crystallized from ethanol it had m.p. 124–126°, $[\alpha]_D^{18}$ −82.3° (*c* 0.52, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 248 nm (ε_{mM} 11.50); ν_{max} 1730 (C=O), 1490 and 1445 (C=C aromatic), 1250 and 1220 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table I.

Anal. Calc. for $C_{29}H_{32}N_2O_9S$: C, 59.57; H, 5.51; N, 4.79; S, 5.48. Found: C, 59.60; H, 5.64; N, 4.77; S, 5.82.

*2-(Benzylthio)-1-*p-*tolyl-(1,2-dideoxy-*D-glycero-*β*-L-gluco-*heptofurano)*-*[*1,2*-d]-*2-imidazoline* (**2b**). — A solution of 1-*p*-tolyl-(1,2-dideoxy-D-*glycero*-*β*-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thione[4] (**1b**; 1.02 g, 3 mmol) in 90% ethanol (10 mL) was treated with $NaHCO_3$ (0.26 g, 3 mmol) and benzyl chloride (0.4 mL, 3 mmol). The mixture was boiled under reflux for 1 h; **2b** crystallized when it was cooled to 0° (1.113 g, 88%). Recrystallized from ethanol, it had m.p. 188–189°, $[\alpha]_D^{22}$ −66.5°, $[\alpha]_{578}^{22}$ −69.6°, $[\alpha]_{546}^{22}$ −81.3°, $[\alpha]_{436}^{22}$ −126.4°, $[\alpha]_{365}^{22}$ −325.7° (*c* 0.51, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 248 nm (ε_{mM} 12.50); ν_{max} 3500–3100 (OH), 1595, 1500 and 1490 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{22}H_{26}N_2O_5S$: C, 61.40; H, 6.05; N, 6.51; S, 7.44. Found: C, 61.66; H, 6.30; N, 6.44; S, 7.42. Formic acid produced: 0.91 mol.

*2-(Benzylthio)-1-*p-*tolyl-(3,5,6,7-tetra-*O-*acetyl-1,2-dideoxy-*D-glycero-*β*-L-gluco-*heptofurano)*[*1,2*-d]-*2-imidazoline* (**3b**). — Conventional treatment of **2b** (0.129 g, 0.3 mmol) with pyridine (1.2 mL) and acetic anhydride (0.65 mL, 6.9 mmol) gave **3b** (0.157 g, 87%). Recrystallized from 96% ethanol, it had m.p. 147–148°, $[\alpha]_D^{22}$ −83.4°, $[\alpha]_{578}^{22}$ −87.2°, $[\alpha]_{546}^{22}$ −101.6°, $[\alpha]_{436}^{22}$ −194.2°, $[\alpha]_{365}^{22}$ −364.8° (*c* 0.54, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 246 nm (ε_{mM} 11.50); ν_{max} 1735 (C=O), 1460 and 1440 (C=C aromatic), 1250 and 1220 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table I.

Anal. Calc. for $C_{30}H_{34}N_2O_9S$: C, 60.20; H, 5.68; N, 4.68; S, 5.35. Found: C, 59.93; H, 5.26; N, 4.61; S, 5.81.

*2-(Benzylthio)-1-*p-*bromophenyl-(1,2-dideoxy-*D-glycero-*β*-L-gluco-*hepto-furano)*[*1,2*-d]-*2-imidazoline* (**2c**). — A solution of 1-(*p*-bromophenyl)-(1,2-dideoxy-D-*glycero*-*β*-L-*gluco*-heptofurano)[1,2-*d*]imidazolidine-2-thione[4] (**1c**; 0.98 g, 2.4 mmol) in 90% ethanol (12 mL) was treated with $NaHCO_3$ (0.21 g, 2.4 mmol) and benzyl chloride (0.3 mL, 2.4 mmol). The mixture was boiled under reflux for 1.5 h, cooled to room temperature, and a precipitate of ionic salts filtered off; **2c** crystallized when the filtrate was cooled to 0° and water (1 mL) added; yield 0.751 g (68%). Recrystallized from ethanol, it had m.p. 199–201°, $[\alpha]_D^{26}$ −96.7°, $[\alpha]_{578}^{26}$ −101.8°, $[\alpha]_{546}^{26}$ −282.7°, $[\alpha]_{436}^{26}$ −247.6°, $[\alpha]_{365}^{26}$ −520.9° (*c* 0.55, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 259 nm (ε_{mM} 12.60); ν_{max} 3500–3000 (OH), 2960, 2940 and 2870 (C–H), 1595, 1580, 1485 and 1445 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{21}H_{23}BrN_2O_5S$: C, 50.91; H, 4.67; Br, 16.13; N, 5.65; S, 6.47. Found: C, 50.94; H, 4.77; Br, 16.11; N, 5.67; S, 6.67. Formic acid produced: 0.95 mol.

*2-(Benzylthio)-1-*p-*bromophenyl-(3,5,6,7-tetra-*O-*acetyl-1,2-dideoxy-*D-gly-

cero-*β*-L-gluco-*heptofurano*)[*1,2*-d]-*2-imidazolidine* (**3c**). — Conventional treatment of **2c** (0.3 g, 0.6 mmol) with pyridine (2 mL) and acetic anhydride (1.5 mL, 15.9 mmol) gave **3c** (0.304 g, 80%). Recrystallized from 90% ethanol, it had m.p. 130–132°, $[\alpha]_D^{18}$ −85.3°, $[\alpha]_{578}^{18}$ −89.2°, $[\alpha]_{546}^{18}$ −104.7°, $[\alpha]_{436}^{18}$ −210.9°, $[\alpha]_{365}^{18}$ −422.5° (*c* 0.65, pyridine); ν_{max} 2960, 2920, 2900 and 2890 (C–H), 1730 (C=O), 1470 and 1445 (C=C aromatic), 1250 and 1215 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table I.

Anal. Calc. for $C_{29}H_{31}BrN_2O_9S$: C, 52.48; H, 4.52; Br, 12.06; N, 4.22; S, 4.82. Found: C, 52.22; H, 4.54; Br, 11.69; N, 4.23; S, 5.23.

*2-(Benzylthio)-4-(*D-galacto-*pentitol-1-yl)-1-phenylimidazole* (**4a**). — (*a*). A solution of **1a** (ref. 4; 0.5 g, 1.5 mmol) in 90% ethanol (5 mL) was treated with benzyl chloride (0.2 mL, 1.5 mmol), boiled under reflux for 2.5 h, cooled, evaporated, an aqueous solution of the syrupy residue (0.136 g, 24%) extracted with ether (3 × 25 mL) and the product crystallized from water. Recrystallized from 90% ethanol, it had m.p. 156–158°, $[\alpha]_D^{18}$ +30.4° (*c* 0.5, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 265 nm (ε_{mM} 6.00); ν_{max} 3380 (OH), 1590, 1485 and 1445 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{21}H_{24}N_2O_5S$: C, 60.56; H, 5.80; N, 6.72; S, 7.69. Found: C, 60.34; H, 5.69; N. 6.72; S, 7.91. Periodate consumption: 4.15 mol.

(*b*) Compound **4a** was also obtained from a solution of **2a** (0.29 g, 0.7 mmol) in absolute ethanol (3.5 mL) that was treated with trifluoroacetic acid (0.4 mL). The mixture was boiled under reflux for 1 h, and the trifluoroacetic acid removed by repeated evaporation with ethanol under diminished pressure. An aqueous solution of the resulting syrup was washed with ethyl acetate (3 × 22 mL), and the product (0.102 g, 35%) crystallized from water. Recrystallized from 90% ethanol, it gave pure **4a**.

*2-(Benzylthio)-4-(penta-*O-*acetyl-*D-galacto-*pentitol-1-yl)-1-phenylimidazole* (**5a**). — Conventional treatment of **4a** (0.1 g, 0.24 mmol) with pyridine (1.2 mL) and acetic anhydride (0.6 mL, 6.4 mmol) gave **5a** (0.144 g, 99%). Recrystallized from ethanol, it had m.p. 92–94°, $[\alpha]_D^{18}$ +65.1° (*c* 0.52, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 262 nm (ε_{mM} 5.50); ν_{max} 1740 (C=O), 1585 and 1490 (C=C aromatic), and 1230 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table III.

Anal. Calc. for $C_{31}H_{34}N_2O_{10}S$: C, 59.41; H, 5.46; N, 4.46; S, 5.11. Found: C, 59.71; H, 5.55; N, 4.44; S, 5.63.

*2-(Benzylthio)-4-(*D-galacto-*pentitol-1-yl)-1-*p-*tolylimidazole* (**4b**). — (*a*) A solution of **1b** (ref. 4; 1.02 g, 3 mmol) in 90% ethanol was treated with benzyl chloride (0.4 mL, 3 mmol), and the mixture was boiled under reflux for 3 h, cooled, and evaporated. A solution of the resulting syrup in water (20 mL) was washed with ethyl acetate (3 × 20 mL), made neutral with $NaHCO_3$, and kept in a refrigerator to crystallize (0.8 g, 63%). Recrystallization from 90% ethanol gave **4b**; m.p. 143–145, $[\alpha]_D^{19}$ +18.6°, $[\alpha]_{578}^{19}$ 19.5°, $[\alpha]_{546}^{19}$ 22.2°, $[\alpha]_{436}^{19}$ 42.1°, $[\alpha]_{365}^{19}$ 77.2° (*c* 0.43, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 264 nm (ε_{mM} 6.00); ν_{max} 3360–3220 (OH), 3040 and 3010 (C–H aromatic), 2930, 2910 and 2880 (C–H), 1590, 1505 and 1490 cm^{-}(C=C aromatic).

Anal. Calc. for $C_{22}H_{26}N_2O_5S$: C, 61.40; H, 6.05; N, 6.51; S, 7.44. Found: C, 61.08; H, 6.11; N, 6.47; S, 7.58. Periodate consumption: 4.15 mol.

(*b*) Compound **4b** was also prepared from a solution of **2b** (0.2 g, 0.46 mmol) in ethanol (3 mL) that was treated with trifluoroacetic acid (0.3 mL). The mixture was boiled under reflux for 1 h, and evaporated under diminished pressure. The resulting syrup was diluted with water (15 mL), and made neutral with 0.1M NaOH; **4b** (0.072 g, 36%) crystallized from this solution.

*2-(Benzylthio)-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)-1-*p*-tolylimidazole* (**5b**). — Conventional treatment of **4b** (0.1 g, 0.23 mmol) with pyridine (0.75 mL) and acetic anhydride (0.7 mL, 7.42 mmol) gave **5b** (0.133 g, 89%), which was purified by dissolving in the minimal volume of ethanol, pouring into ice–water (75 mL), and keeping for 4 days at 0°. The resulting, amorphous solid was filtered off, and dried; m.p. 71–72°, $[\alpha]_D^{19}$ +69.4°, $[\alpha]_{578}^{19}$ 71.7°, $[\alpha]_{546}^{19}$ 82.6°, $[\alpha]_{436}^{19}$ 149.4°, $[\alpha]_{365}^{19}$ 250.3° (*c* 0.54, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 262 nm (ε_{mM} 5.50); ν_{max} 1750 (C=O), 1515, 1510 and 1495 (C=C aromatic), and 1220 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table III.

Anal. Calc. for $C_{32}H_{36}N_2O_{10}S$: C, 60.00; H, 5.62; N, 4.37; S, 5.00. Found: C, 59.82; H, 5.48; N, 4.30; S, 5.46.

*2-(Benzylthio)-1-(*p*-bromophenyl)-4-(*D*-galacto-pentitol-1-yl)imidazole* (**4c**). — (*a*) A solution of **1c** (ref. 4; 0.423 g, 1.27 mmol) in 90% ethanol (6 mL) was treated with benzyl chloride (0.13 mL, 1.04 mmol), and the mixture was boiled under reflux for 3 h, cooled, evaporated, and the resulting syrup dissolved in 96% ethanol. This solution was evaporated to a dry foam that crystallized from water (7 mL); yield 0.331 g, 64%. Recrystallization from 1:2 ethanol–water gave **4c**; m.p. 168–170°, $[\alpha]_D^{17}$ +16.2° $[\alpha]_{578}^{17}$ 18.6°, $[\alpha]_{546}^{17}$ 19.5°, $[\alpha]_{436}^{17}$ 38.0°, $[\alpha]_{365}^{17}$ 70.2° (*c* 0.50, pyridine); $\lambda_{max}^{96\%\ EtOH}$ 271 nm (ε_{mM} 6.50); ν_{max} 3350–3180 (OH), 2920 and 2850 (C–H), 1580 and 1505 cm^{-1} (C=C aromatic).

Anal. Calc. for $C_{21}H_{23}BrN_2O_5S$: C, 50.90; H, 4.64; Br, 16.16; N, 5.65; S, 6.46. Found: C, 50.56; H, 4.39; Br, 16.33; N, 5.79; S, 6.81. Periodate consumption: 4.07 mol.

(*b*) Compound **4c** was also prepared from a solution of **2c** (0.26 g, 0.52 mmol) in ethanol (4 mL) that was treated with trifluoroacetic acid to 10% concentration. The mixture was boiled under reflux for 1.5 h, cooled and evaporated under diminished pressure. The resulting syrup was dissolved in water (10 mL), and the solution made neutral with $NaHCO_3$, and kept in a refrigerator to crystallize (0.204 g, 79%).

*2-(Benzylthio)-1-(*p*-bromophenyl)-4-(penta-*O*-acetyl-*D*-galacto-pentitol-1-yl)imidazole* (**5c**). — Conventional treatment of **4c** (0.129 g, 0.26 mmol) with pyridine (1.3 mL) and acetic anhydride (0.63 mL, 6.76 mmol) gave **5c** (0.144 g, 79%). Recrystallized from 96% ethanol, it had m.p. 103-105°, $[\alpha]_D^{19}$ +60.2°, $[\alpha]_{578}^{19}$ 60.4°, $[\alpha]_{546}^{19}$ 69.9°, $[\alpha]_{436}^{19}$ 126.6°, $[\alpha]_{365}^{19}$ 212.4° (*c* 0.49, pyridine); ν_{max} 2980, 2940 and 2890 (C–H), 1730 (C=O), 1595 and 1460 (C=C aromatic), and 1215 cm^{-1} (C–O–C); ^{1}H-n.m.r. data are given in Table III.

Anal. Calc. for $C_{31}H_{33}BrN_2O_{10}S$: C, 52.77; H, 4.71; Br, 11.32; N, 3.97; S, 4.54. Found: C, 53.03; H, 4.74; Br, 11.40; N, 3.85; S, 4.88.

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