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Note

Syntheses of partially protected D-galactopyranosylthioureas: new D-galactopyranosylimidazoline-2-thiones and D-galactopyranosylaminothiazoles*

JOSÉ FUENTES MOTA†, JOSÉ MANUEL GARCIA FERNANDEZ, CARMEN ORTIZ MELLET, MARIA ANGELES PRADERA ADRIAN,

Departamento de Química Orgánica, Facultad de Química, Universidad de Sevilla, 41071 Sevilla (Spain)

AND REYES BABIANO CABALLERO

Departamento de Química Orgánica, Facultad de Ciencias, Universidad de Extremadura, 06071 Badajoz (Spain)

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We have described the syntheses of several fully acylated glycopyranosylthioureas[1–3], -4-imidazoline-2-thiones[1,3], and -aminothiazoles[1–3]. Partially acylated analogues are useful for modification of the sugar structure and for the synthesis of oligosaccharides[4], and we now describe such derivatives of glycopyranosylthioureas (**1–4**) and -5-methyl-4-imidazoline-2-thione (**5**), together with fully acylated **6** and 5-aryl-2-β-D-galactopyranosylaminothiazoles (**7–10**).

N-Phenacyl-*N'*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)thioureas (**1–4**) were prepared by reaction of 2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl isothiocyanate[5] with the corresponding phenacylamine hydrochloride. Compounds **1–4** had ν_{max} at 3450–3490 (OH) and 1675–1685 cm^{-1} (Ar-C=O), and the ^{13}C-n.m.r. spectra contained signals for CH_2 (50.8–51.5 p.p.m.), CO (192.8–193.9 p.p.m.), and C=S (183.3–184.1 p.p.m.) characteristic of *N*-phenacylthioureas[2]. The chemical shifts for the H-4 resonances were in the range 4.52–4.60 p.p.m., indicating HO-4 to be unsubstituted. The ^1H-n.m.r. spectra of **1–4** in $(CD_3)_2SO$ allowed the observation of NH signals and the measurement of $J_{4,OH}$ values. The assignments of sugar ^{13}C resonances were assisted by a ^{13}C–^1H (500 MHz) correlation experiment[6] performed on **2**.

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†Author for correspondence.

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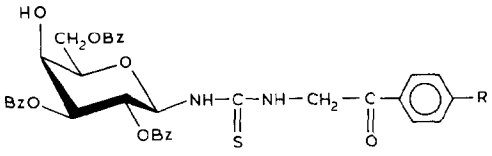
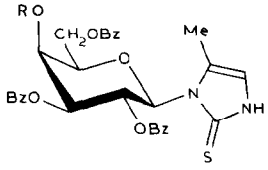


1 R = H
2 R = Me
3 R = OMe
4 R = Br



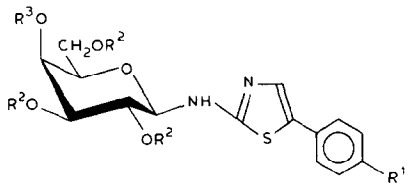
5 R = H
6 R = Bz

5-Methyl-1-[2,3,6-tri- (**5**) and 2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl]-4-imidazoline-2-thiones (**6**) were obtained by reaction of the corresponding galactopyranosyl isothiocyanate[5,7] with aminoacetone hydrochloride. Compounds **5** and **6** had λ_{max} 275 nm[1,2,8], ν_{max} 1620–1625 cm^{-1} (C=C)[9], δ 6.23–6.24 for H-4[1,2], and δ 163.2–163.5 for the C=S group[2] as reported for related 4-imidazoline-2-thiones. Additionally, **5** had ν_{max} 3450 cm^{-1}(OH) and δ 4.37 for H-4, whereas the corresponding proton in **6** resonated at δ 6.14. The ^{13}C-n.m.r. spectra of **5** and **6** showed anomalous α-effects[5,10] due to benzoylation on C-4.

The $^3J_{H,H}$ values for **1–6** showed that the $^4C_1$(D) conformation preponderated in solutions in chloroform and methyl sulphoxide.

Treatment of **1–4** with acetic anhydride and phosphoric acid[2,11] yielded the (4-*O*-acetyl-2,3,6-tri-*O*-benzoyl-β-D-galactopyranosylamino)-5-arylthiazoles (**7–10**), which had λ_{max} ~300 nm characteristic of related aryl-substituted aminothiazoles[2,3,11], and no i.r. absorption for phenacyl groups. The resonances of H-4 were in the range δ 6.84–8.20 (*cf.* δ 6.23–6.24 for **5** and **6**). The chemical shifts of C-2 (~165 p.p.m.) and C-4 (~134 p.p.m.) also confirmed the aminothiazole structure[2]. The assignments of the ^{13}C sugar resonances were in agreement with those described above for **1–4** and reported for other D-galactopyranosyl compounds[3,11,12].

The $^3J_{H,H}$ values for **7–10** indicated a preponderant but not exclusive $^4C_1$(D)



7 R^1 = H, R^2 = Bz, R^3 = Ac
8 R^1 = Me, R^2 = Bz, R^3 = Ac
9 R^1 = OMe, R^2 = Bz, R^3 = Ac
10 R^1 = Br, R^2 = Bz, R^3 = Ac
11 R^1 = Me, R^2 = R^3 = H

conformation in solution, as described for other poly-*O*-benzoylglycosyl compounds[3,13].

Deacylation of **8** with methanolic sodium methoxide yielded 2-(β-D-galactopyranosylamino)-5-(*p*-tolyl)thiazole (**11**).

EXPERIMENTAL

General methods. — Melting points are uncorrected. Optical rotations were measured at 21 ±2°, using 1- and 10-cm cells. I.r. spectra were recorded for KBr discs. T.l.c. was carried out on Silica Gel HF_{254} (Merck) with detection by u.v. light, iodine vapour, or charring with sulphuric acid. Column chromatography was performed on Silica Gel 60 (Merck, 230 mesh). ^{1}H-N.m.r. spectra were recorded at 200 and 500 MHz. Assignments were confirmed by decoupling and H/D exchange experiments. ^{13}C-N.m.r. spectra were measured at 50.3 and 125.7 MHz, and signal assignments were assisted by means of APT[14] spectra and ^{13}C–^{1}H (500 MHz) correlation experiments[6].

N-Phenacyl-N′-(2,3,6-tri-O-benzoyl-β-D-galactopyranosyl)thioureas (**1–4**). — A solution of phenacylamine hydrochloride (0.93 mol) in water (5 mL) was neutralised with sodium hydrogencarbonate (0.93 mmol) and gradually added to a solution of 2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl isothiocyanate[5] (0.5 g, 0.93 mmol) in acetone (12 mL) under nitrogen. The resulting solution was stirred at room temperature for *t* h and then concentrated. The solid residue was collected, washed with water, and crystallised from ethanol. The following compounds were prepared in this manner.

N-Phenacyl-*N′*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)thiourea (**1**; 0.3 g, 48%; *t* 1.5 h), m.p. 128–129°, $[\alpha]_D^{23}$ +60° (*c* 0.7, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 234 and 264 nm (ε_{mM} 45.5 and 19.8); ν_{max} 3450 (OH), 3320 (NH), 1720 (CO ester), 1680 (CO ketone), 1600, 1580 (C=C aromatic), 1520 (NH), 1275 (C–O–C and C=S), 770 and 715 cm^{-1} (CH aromatic). N.m.r. data: ^{1}H ($CDCl_3$), δ 8.10–7.10 (m, 22 H, 4 Ph, NH, N′H), 6.19 (bt, 1 H, $J_{1,NH} = J_{1,2}$ = 9.4 Hz, H-1), 6.06 (t, 1 H, $J_{2,3}$ 9.4 Hz, H-2), 5.73 (dd, 1 H, $J_{3,4}$ 2.9 Hz, H-3), 4.89 (bs, 1 H, OH), 4.89 (m, 2 H, CH_2), 4.76 (dd, 1 H, $J_{6,6'}$ 11.5, $J_{5,6}$ 6.0 Hz, H-6), 4.62 (dd, 1 H, $J_{5,6'}$ 6.0 Hz, H-6′), 4.60 (d, 1 H, $J_{4,5}$ 0 Hz, H-4), and 4.44 (t, 1 H, H-5): ^{1}H [$(CD_3)_2SO$], δ 8.76 (d, 1 H, $J_{1,NH}$ 9.4 Hz, NH), 8.23 (bs, 1 H, N′H), 5.83 (d, 1 H, $J_{4,OH}$ 5.7 Hz, HO-4); ^{13}C ($CDCl_3$), δ 193.6 (CO phenacyl), 183.3 (C=S), 167.2, 165.7, 165.5 (3 Ph*C*O), 134.0–127.9 (24 C, aromatic), 83.2 (C-1), 74.1 (C-5), 73.9 (C-3), 69.7 (C-2), 67.9 (C-4), 62.9 (C-6), and 51.5 (CH_2).

Anal. Calc. for $C_{36}H_{32}N_2O_9S$: C, 64.66; H, 4.82; N, 4.19. Found: C, 64.37; H, 5.00; N, 3.91.

N-(*p*-Methylphenacyl)-*N′*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-thiourea (**2**; 0.40 g, 63%; *t* 2 h), m.p. 206–207°, $[\alpha]_D^{23}$ +54° (*c* 0.7, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 233 and 273 nm (ε_{mM} 50.7 and 25.6); ν_{max} 3480 (OH), 3250 (NH), 1725 (CO ester), 1685 (CO ketone), 1600, 1580 (C=C aromatic), 1505 (NH), 1270

(C–O–C and C=S), 810, 760 and 715 cm^{-1} (CH aromatic). N.m.r. data: ^1H (500 MHz, $CDCl_3$), δ 8.10–7.10 (m, 21 H, 3 Ph, 4 aromatic, NH, N'H), 6.08 (m, 1 H, H-1), 5.97 (t, 1 H, $J_{1,2} = J_{2,3}$ = 9.8 Hz, H-2), 5.70 (dd, 1 H, $J_{3,4}$ 2.8 Hz, H-3), 4.92 (m, 2 H, CH_2), 4.74 (dd, 1 H, $J_{6,6'}$ 11.8, $J_{5,6}$ 6.3 Hz, H-6), 4.60 (m, 1 H, H-6'), 4.57 (m, 1 H, $J_{4,5}$ 0.0 Hz, H-4), 4.36 (t, 1 H, $J_{5,6'}$ 6.3 Hz, H-5), 3.92 (bs, 1 H, OH), and 2.38 (s, 3 H, CH_3); ^1H [$(CD_3)_2SO$], δ 8.75 (d, 1 H, $J_{1,NH}$ 9.6 Hz, NH), 8.20 (bs, 1 H, N'H), 5.80 (d, 1 H, $J_{4,OH}$ 5.4 Hz, HO-4); ^{13}C [$(CD_3)_2SO$], δ 193.9 (CO phenacyl), 184.1 (C=S), 165.5, 165.2, 165.0 (3 Ph*C*O), 144.0 (C-4 phenacyl), 133.4–127.7 (23 C, aromatic), 82.1 (C-1), 75.0, 73.4 (C-5,3), 69.3 (C-2), 66.0 (C-4), 63.4 (C-6), 51.1 (CH_2), and 21.2 (CH_3); in $CDCl_3$ at 125.7 MHz: δ 81.5 (C-1), 72.3 (C-3), 72.1 (C-5), 68.0 (C-2), 66.1 (C-4), and 60.9 (C-6).

Anal. Calc. for $C_{37}H_{34}N_2O_9S$: C, 65.09; H, 5.02; N, 4.10. Found: C, 65.09; H, 5.11; N, 3.94.

N-(*p*-Methoxyphenacyl)-*N'*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-thiourea (**3**; 0.52 g, 80%; *t* 4 h), m.p. 118–120°, $[\alpha]_D^{23}$ +48.5° (*c* 0.7, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 233 and 283 nm (ε_{mM} 113.3 and 60.0); ν_{max} 3490 (OH), 3340, 3240 (NH), 1720 (CO ester), 1675 (CO ketone), 1600, 1575, 1540 (C=C aromatic), 1515 (NH), 1275 (C–O–C and C=S), 835, 765 and 715 cm^{-1} (CH aromatic). N.m.r. data: ^1H ($CDCl_3$), δ 8.10–6.80 (m, 21 H, 3 Ph, 4 aromatic, NH, N'H), 6.10 (bt, 1 H, $J_{1,2} = J_{1,NH}$ = 9.6 Hz, H-1), 5.97 (t, 1 H, $J_{2,3}$ 9.6 Hz, H-2), 5.58 (dd, 1 H, $J_{3,4}$ 2.9 Hz, H-3), 4.90 (m, 3 H, OH, CH_2), 4.71 (dd, 1 H, $J_{6,6'}$ 11.8, $J_{5,6}$ 6.3 Hz, H-6), 4.58 (dd, 1 H, $J_{5,6'}$ 6.3 Hz, H-6'), 4.52 (d, 1 H, $J_{4,5}$ 0.0 Hz, H-4), 4.33 (t, 1 H, H-5), and 3.84 (s, 3 H, CH_3); ^1H [$(CD_3)_2SO$], δ 8.74 (d, 1 H, $J_{1,NH}$ 9.5 Hz, NH), 8.23 (bs, 1 H, N'H), 5.84 (d, 1 H, $J_{4,OH}$ 5.5 Hz, HO-4); ^{13}C [$(CD_3)_2SO$], δ 192.8 (CO phenacyl), 184.0 (C=S), 165.5, 165.2, 165.0 (3 Ph*C*O), 163.4 (C-4 phenacyl), 133.5–127.4 (21 C, aromatic), 114.0 (C-3,5 phenacyl), 82.0 (C-1), 75.0, 73.3 (C-5,3), 69.3 (C-2), 66.0 (C-4), 63.4 (C-6), 55.5 (CH_3), and 50.8 (CH_2).

Anal. Calc. for $C_{37}H_{34}N_2O_{10}S$: C, 63.59; H, 4.90; N, 4.01. Found: C, 63.10; H, 4.77; N, 3.99.

N-(*p*-Bromophenacyl)-*N'*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-thiourea (**4**; 0.50 g, 72%; *t* 3 h), m.p. 130–132°, $[\alpha]_D^{23}$ +56° (*c* 0.8, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 232 and 265 nm (ε_{mM} 49.6 and 25.6); ν_{max} 3480 (OH), 3340 (NH), 1720 (CO ester), 1680 (CO ketone), 1600, 1585, 1550 (C=C aromatic), 1520 (NH), 1275 (C–O–C and C=S), 820, 770 and 715 cm^{-1} (CH aromatic). N.m.r. data: ^1H ($CDCl_3$), δ 8.10–7.10 (m, 21 H, 3 Ph, 4 aromatic, NH, N'H), 6.12 (bt, 1 H, $J_{1,2}$ 9.5 Hz, H-1), 5.99 (t, 1 H, $J_{2,3}$ 9.5 Hz, H-2), 5.63 (dd, 1 H, $J_{3,4}$ 2.9 Hz, H-3), 4.89 (m, 2 H, CH_2), 4.81 (bs, 1 H, OH), 4.73 (d, 1 H, $J_{6,6'}$ 11.6, $J_{5,6}$ 6.5 Hz, H-6), 4.59 (dd, 1 H, $J_{5,6'}$ 6.5 Hz, H-6'), 4.54 (d, 1 H, $J_{4,5}$ 0.0 Hz, H-4), and 4.38 (t, 1 H, H-5); ^1H [$(CD_3)_2SO$], δ 8.75 (d, 1 H, $J_{1,NH}$ 9.5 Hz, NH), 8.22 (bs, 1 H, N'H), 5.82 (d, 1 H, $J_{4,OH}$ 5.4 Hz, HO-4); ^{13}C ($CDCl_3$), δ 193.9 (CO phenacyl), 184.0 (C=S), 165.5, 165.2, 165.0 (3 Ph*C*O), 133.7–127.9 (24 C, aromatic), 82.0 (C-1), 74.9, 73.1 (C-5,3), 69.3 (C-2), 65.9 (C-4), 63.4 (C-6), and 51.1 (CH_2).

Anal. Calc. for $C_{36}H_{31}BrN_2O_9S$: C, 57.83; H, 4.18; N, 3.75. Found: C, 57.93; H, 4.23; N, 3.74.

5-Methyl-1-[2,3,6-tri- (**5**) *and 2,3,4,6-tetra-*O*-benzoyl-β-*D*-galactopyranosyl]-4-imidazoline-2-thiones* (**6**). — A solution of aminoacetone hydrochloride (0.25 g, 2.29 mmol) in water (8 mL) was neutralised with sodium hydrogencarbonate (0.19 g, 2.29 mmol) and gradually added to a solution of the corresponding tetra-[7] or tri-benzoylated[5] D-galactopyranosyl isothiocyanate (2.29 mmol) in acetone (20 mL) under nitrogen. The resulting solution was kept at room temperature for *t* h and then concentrated. The residue was purified by column chromatography (ether–hexane gradient). The following compounds were prepared in this manner.

5-Methyl-1-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-4-imidazoline-2-thione (**5**; 0.47 g, 35%; *t* 4 h), amorphous solid, $[\alpha]_D^{21}$ +30° (*c* 1, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 239 and 275 nm (ε_{mM} 16.6 and 28.5); ν_{max} 3450 (OH), 3300 (NH), 1720 (CO ester), 1625 (C=C imidazoline), 1595, 1580, 1485 (C=C aromatic and NH), 1270 (C–O–C and C=S), 705 and 690 cm^{-1} (CH aromatic). N.m.r. data ($CDCl_3$): ^1H, δ 8.02–7.04 (m, 15 H, 3 Ph), 6.62 (d, 1 H, $J_{1',2'}$ 9.8 Hz, H-1'), 6.24 (s, 1 H, H-4), 6.21 (t, 1 H, $J_{2',3'}$ 9.8 Hz, H-2'), 5.51 (dd, 1 H, $J_{3',4'}$ 2.7 Hz, H-3'), 4.72 (dd, 1 H, $J_{6'a,6'b}$ 11.5, $J_{5',6'a}$ 6.6 Hz, H-6'a), 4.43 (dd, 1 H, $J_{5',6'b}$ 6.6 Hz, H-6'b), 4.37 (m, 1 H, H-4'), 4.24 (t, 1 H, H-5'), and 2.49 (s, 3 H, CH_3); ^{13}C, δ 165.8, 165.4, 165.0 (3 Ph*C*O), 163.5 (C-2), 133.5–128.1 (18 C, phenyl), 126.4 (C-5), 112.2 (C-4), 83.7 (C-1'), 76.5, 75.8 (C-3',5'), 69.4 (C-2'), 68.7 (C-4'), 62.6 (C-6'), and 10.9 (CH_3).

Anal. Calc. for $C_{31}H_{28}N_2O_8S$: C, 63.25; H, 4.79; N, 4.76. Found: C, 63.25; H, 4.49; N, 4.62.

5-Methyl-1-(2,3,4,6-tetra-*O*-benzoyl-β-D-galactopyranosyl)-4-imidazoline-2-thione (**6**; 0.47 g, 30%; *t* 24 h), amorphous solid, $[\alpha]_D^{21}$ +124° (*c* 0.54, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 234 and 275 nm (ε_{mM} 49.3 and 21.2); ν_{max} 3350 (NH), 1715 (CO ester), 1620 (C=C imidazoline), 1590, 1570, 1480 (C=C aromatic and NH), 1265 (C–O–C and C=S), 750 and 705 cm^{-1} (CH aromatic). N.m.r. data ($CDCl_3$): ^1H, δ 10.21 (bs, 1 H, NH), 8.05–7.22 (m, 20 H, 4 Ph), 6.80 (d, 1 H, $J_{1',2'}$ 9.8 Hz, H-1'), 6.25 (t, 1 H, $J_{2',3'}$ 9.8 Hz, H-2'), 6.23 (s, 1 H, H-4), 6.14 (d, 1 H, $J_{3',4'}$ 3.3, $J_{4',5'}$ 0.0 Hz, H-4'), 5.83 (dd, 1 H, H-3'), 4.70–4.41 (m, 3 H, H-5',6'a,6'b), and 2.67 (s, 3 H, CH_3); ^{13}C, δ 165.4, 165.4, 165.2, 165.0 (4 Ph*C*O), 163.2 (C-2), 133.6–128.2 (24 C, phenyl), 126.5 (C-5), 112.3 (C-4), 83.4 (C-1'), 74.1 (C-5'), 71.8 (C-3'), 68.2 (C-2'), 67.7 (C-4'), 61.8 (C-6'), and 10.9 (CH_3).

Anal. Calc. for $C_{38}H_{32}N_2O_9S$: C, 65.88; H, 4.65; N, 4.04. Found: C, 66.29; H, 4.89; N, 3.64.

*5-Aryl-2-(2,3,4,6-tetra-*O*-acyl-β-*D*-galactopyranosylamino)thiazoles* (**7–10**). — To a solution of *N*-phenacyl-*N'*-(2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)thiourea (**1–4**) (0.47 mmol) in acetic anhydride (4.7 mL) was added phosphoric acid (0.23 mL). The mixture was stirred at room temperature for *t* h, monitored by t.l.c. (using ether–hexane, 4:1), then poured into ice–water (100 mL). The solid was collected, and a solution in dichloromethane (30 mL) was washed with saturated aq. sodium hydrogencarbonate (2 × 30 mL) and then water (2 × 15 mL), dried ($MgSO_4$), and concentrated. Solutions of the residues in aqueous 96% ethanol were treated with Amberlist IR-45 (HO^-) resin (7 mL),

filtered, and concentrated, and the resulting syrups were purified as indicated. The following compounds were prepared in this manner.

2-(4-*O*-Acetyl-2,3,6-tri-*O*-benzoyl-β-D-galactopyranosylamino)-5-phenylthiazole (**7**; 0.18 g, 55%; *t* 24 h), purified by p.l.c. (ether–hexane, 4:1), had m.p. 108–110° (from ethanol), $[\alpha]_D^{22}$ +43° (*c* 0.6, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 230, 281, and 298 nm (ε_{mM} 31.8, 12.2, and 9.4); ν_{max} 3315 (NH), 1750, 1720 (CO ester), 1600, 1580, 1520 (C=C aromatic and NH), 1270 (C–O–C), 760, 715 and 690 cm^{-1} (CH aromatic). N.m.r. data ($CDCl_3$): ^1H, δ 8.07–7.27 (m, 22 H, 20 aromatic, H-4, NH), 5.82 (d, 1 H, $J_{3',4'}$ 2.3, $J_{4',5'}$ 0.0 Hz, H-4'), 5.73 (d, 1 H, $J_{1',2'}$ 6.6 Hz, H-2'), 5.73 (dd, 1 H, $J_{1',3'}$ 3.8 Hz, virtual coupling, H-3'), 5.29 (dd, 1 H, H-1'), 4.62–4.37 (m, 3 H, H-5',6'a,6'b), and 2.02 (s, 3 H, Ac); ^{13}C, δ 169.6 (CH_3CO), 166.7, 166.0, 165.5 (3 Ph*C*O), 165.2 (C-2), 134.1 (C-4), 133.6–125.5 (25 C, 24 aromatic, C-5), 84.7 (C-1'), 72.2 (C-5'), 71.3 (C-3'), 69.1 (C-2'), 67.5 (C-4'), 61.8 (C-6'), and 20.4 (CH_3CO).

Anal. Calc. for $C_{38}H_{32}N_2O_9S$: C, 65.88; H, 4.66; N, 4.04. Found: C, 65.60: H, 4.43; N, 3.86.

2-(4-*O*-Acetyl-2,3,6-tri-*O*-benzoyl-β-D-galactopyranosylamino)-5-(*p*-tolyl)-thiazole (**8**; 0.19 g, 57%; *t* 24 h), amorphous solid, purified by p.l.c. (ether–hexane, 4:1), had $[\alpha]_D^{20}$ +71° (*c* 0.5, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 226, 282, and 303 nm (ε_{mM} 38.5, 19.3, and 25.5); ν_{max} 3315 (NH), 1750, 1725 (CO ester), 1600, 1580, 1530 (C=C aromatic and NH), 1270 (C–O–C), 815, 715 and 690 cm^{-1} (CH aromatic). N.m.r. ($CDCl_3$) data: ^1H, δ 8.07–7.07 (m, 21 H, 3 Ph, 4 aromatic, H-4, NH), 5.84 (d, 1 H, $J_{3',4'}$ 1.2, $J_{4',5'}$ 0.0 Hz, H-4'), 5.76 (d, 1 H, $J_{1',2'}$ 5.6 Hz, H-2'), 5.76 (dd, 1 H, $J_{1',3'}$ 4.2 Hz, virtual coupling, H-3'), 5.33 (dd, 1 H, H-1'), 4.63–4.39 (m, 3 H, H-5',6'a,6'b), 2.35 (s, 3 H, CH_3), and 2.19 (s, 3 H, Ac); ^{13}C, δ 169.6 (CH_3CO), 166.5, 165.8, 165.4 (3 Ph*C*O), 165.2 (C-2), 136.8–125.4 (26 C, 24 aromatic, C-4,5), 84.7 (C-1'), 72.2 (C-5'), 71.4 (C-3'), 69.0 (C-2'), 67.5 (C-4'), 61.8 (C-6'), 21.0 (CH_3), and 20.4 (CH_3CO).

Anal. Calc. for $C_{39}H_{34}N_2O_9S$: C, 66.28; H, 4.85; N, 3.96. Found: C, 66.28; H, 4.79; N, 3.67.

2-(4-*O*-Acetyl-2,3,6-tri-*O*-benzoyl-β-D-galactopyranosylamino)-5-(*p*-methoxyphenyl)thiazole (**9**; 0.22 g, 60%; *t* 24 h), m.p. 109–112° (from ethanol–water), $[\alpha]_D^{20}$ +65° (*c* 0.5, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 231, 282, and 300 nm (ε_{mM} 40.2, 16.2, and 17.0); ν_{max} 3315 (NH), 1750, 1720 (CO ester), 1600, 1580, 1530 (C=C aromatic and NH), 1275 (C–O–C), 830, 710 and 690 cm^{-1} (CH aromatic). N.m.r. data ($CDCl_3$): ^1H, δ 8.06–6.84 (m, 20 H, 3 Ph, 4 aromatic, H-4), 6.29 (bd, 1 H, $J_{1',NH}$ 6.0 Hz, NH), 5.82 (d, 1 H, $J_{3',4'}$ 1.7, $J_{4',5'}$ 0.0 Hz, H-4'), 5.72 (d, 1 H, $J_{1',2'}$ 6.2 Hz, H-2'), 5.72 (dd, 1 H, $J_{1',3'}$ 3.6 Hz, virtual coupling, H-3'), 5.29 (m, 1 H, H-1'), 4.62–4.37 (m, 3 H, H-5',6'a,6'b), 3.82 (s, 3 H, CH_3), and 2.20 (s, 3 H, Ac); ^{13}C, δ 169.7 (CH_3CO), 166.7, 165.9, 165.2 (3 Ph*C*O), 164.8 (C-2), 158.7–114.1 (26 C, 24 aromatic, C-4,5), 84.7 (C-1'), 72.1 (C-5'), 71.3 (C-3'), 69.1 (C-2'), 67.5 (C-4'), 61.8 (C-6'), 55.2 (CH_3), and 20.5 (CH_3CO).

Anal. Calc. for $C_{39}H_{34}N_2O_{10}S$: C, 64.81; H, 4.74; N, 3.88. Found: C, 64.64; H, 4.62; N, 3.54.

2-(4-*O*-Acetyl-2,3,6-tri-*O*-benzoyl-β-D-galactopyranosyl)-5-(*p*-bromophenyl)thiazole (**10**; 0.20 g, 54%; *t* 24 h), amorphous solid, purified by p.l.c. (ether–hexane, 4:1), had $[\alpha]_D^{20}$ +83° (*c* 0.5, dichloromethane); $\lambda_{max}^{CH_2Cl_2}$ 233, 284, and 304 nm (ε_{mM} 37.4, 15.9, and 19.2); ν_{max} 3310 (NH), 1750, 1720 (CO ester), 1600, 1580, 1520 (C=C aromatic and NH), 1270 (C–O–C), 820, 710 and 690 cm^{-1} (CH aromatic). N.m.r. data ($CDCl_3$): ^1H, δ 8.06–7.09 (m, 21 H, 3 Ph, 4 aromatic, H-4, NH), 5.84 (bs, 1 H, $J_{3',4'} \approx J_{4',5'} \approx 0.0$ Hz, H-4'), 5.75 (d, 2 H, H-2',3'), 5.31 (t, 1 H, $J_{1',2'}$ 4.9, $J_{1',3'}$ 4.9 Hz, virtual coupling, H-1'), 4.65–4.39 (m, 3 H, H-5',6'a,6'b), and 2.19 (s, 3 H, Ac); ^{13}C, δ 169.7 (CH_3CO), 166.5, 166.0, 165.8 (3 Ph*C*O), 165.2 (C-2), 134.5 (C-4), 133.6–120.5 (25 C, 24 aromatic, C-5), 84.6 (C-1'), 72.3 (C-5'), 71.4 (C-3'), 69.1 (C-2'), 67.5 (C-4'), 61.8 (C-6'), and 20.4 (*C*H_3CO).

Anal. Calc. for $C_{38}H_{31}BrN_2O_9S$: C, 59.15; H, 4.05; N, 3.63. Found: C, 59.10; H, 4.03; N, 3.30.

*2-(β-D-Galactopyranosylamino)-5-(*p*-tolyl)thiazole* (**11**). — A solution of **8** (0.14 g, 0.2 mmol) in methanol (5 mL) and methanolic 0.5% sodium methoxide (0.3 mL) was stirred at room temperature for 15 h and monitored by t.l.c. (ether–hexane, 6:1). The resulting solid was collected and a solution in methanol (15 mL) was treated with Amberlist IR-120 (H^+) resin (5 mL), filtered, and concentrated to give amorphous **11** (0.053 g, 75%), $[\alpha]_D^{22}$ −24° (*c* 0.8, pyridine); λ_{max}^{EtOH} 302 nm (ε_{mM} 18.5); ν_{max} 3300 (OH), 1650, 1560, 1540 (C=C aromatic and NH), and 810 cm^{-1} (CH aromatic). N.m.r. data [$(CD_3)_2SO$]: ^1H, δ 7.45 (s, 1 H, H-4), 7.35–7.10 (m, 4 H, 4 aromatic), 5.57 (d, 1 H, OH), 5.20–5.05 (m, 3 H, HO-3), 4.59 (t, 1 H, $J_{1',2'} = J_{1',NH} = 9.1$ Hz, H-1'), 4.05–2.95 (m, 6 H, H-2',3',4',5',6'a,6'b), and 2.28 (s, 3 H, CH_3); ^{13}C, δ 167.4 (C-2), 133.1 (C-4), 136.1–125.0 (7 C, 6 aromatic, C-5), 85.8 (C-1'), 76.5 (C-5'), 74.3 (C-3'), 69.9 (C-2'), 68.3 (C-4'), 60.5 (C-6'), and 20.8 (CH_3).

Anal. Calc. for $C_{16}H_{20}N_2O_5S$: C, 59.99; H, 6.29; N, 8.75. Found: C, 59.87; H, 6.32; N, 8.59.

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REFERENCES

1 J. Fuentes Mota, M. C. Ortiz Mellet, and M. A. Pradera Adrian, *An. Quim., Ser. C*, 80 (1984) 48–53.

2 J. Fuentes Mota, M. A. Pradera Adrian, C. Ortiz Mellet, J. M. Garcia Fernandez, R. Babiano Caballero, and J. A. Galbis Perez, *Carbohydr. Res.*, 173 (1988) 1–16.

3 J. FUENTES MOTA, M. A. PRADERA ADRIAN, M. C. ORTIZ MELLET, AND J. M. GARCIA FERNANDEZ, *An. Quim., Ser. C,* 83 (1987) 124–127.
4 A. H. HAINES, *Adv. Carbohydr. Chem. Biochem.,* 33 (1976) 11–109.
5 J. FUENTES MOTA, J. M. GARCIA FERNANDEZ, C. ORTIZ MELLET, M. A. PRADERA ADRIAN, AND R. BABIANO CABALLERO, *Carbohydr. Res.,* 188 (1989) 35–44.
6 G. A. PEARSON, *J. Magn. Reson.,* 64 (1985) 487–500.
7 R. BABIANO CABALLERO, J. FUENTES MOTA, AND J. A. GALBIS PEREZ, *Carbohydr. Res.,* 154 (1986) 280–288.
8 J. FERNANDEZ-BOLAÑOS, F. GARCIA GONZALEZ, J. GASH GOMEZ, AND M. MENENDEZ GALLEGO, *Tetrahedron,* 19 (1963) 1883–1892.
9 A. R. KATRITZKY AND A. P. AMBLER, in A. R. KATRITZKY (Ed.), *Physical Methods in Heterocyclic Chemistry,* Vol. II, Academic Press, London, 1963, p. 228.
10 B. MATSUHIRO AND P. BAKER, *Carbohydr. Res.,* 89 (1981) 326–328, and references therein.
11 J. FUENTES MOTA, M. A. PRADERA ADRIAN, M. C. ORTIZ MELLET, AND J. M. GARCIA FERNANDEZ, *Carbohydr. Res.,* 153 (1986) 318–324.
12 K. BOCK AND C. PEDERSEN, *Adv. Carbohydr. Chem. Biochem.,* 41 (1983) 27–66.
13 R. C. BEIER, B. P. MUNDY, AND G. A. STROBEL, *Can. J. Chem.,* 58 (1980) 2800–2804.
14 B. COXON, *Tetrahedron,* 22 (1966) 2281–2302.
15 S. L. PATT AND J. N. SHOOLERY, *J. Magn. Reson.,* 46 (1982) 535–539.