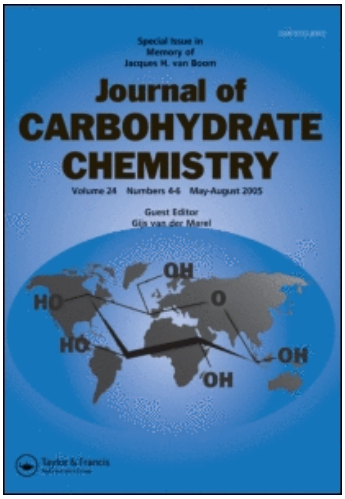

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SYNTHESIS OF N-HETARYLTHIOUREA DERIVATIVES OF CARBOHYDRATES[1]

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ABSTRACT

The syntheses of N-hetaryl(thiazole-2-yl, 2-thiazoline-2-yl, 4,4-diphenyloxazoline-2-yl, cis-3a,4,5,6,7,7a-hexahydrobenzoxazole-2-yl)-N'-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)thioureas (1a-1d), N-hetaryl(2-thiazoline-2-yl, 4,4-diphenyloxazoline-2-yl)-N'-(2,3,4,6-tetra-O-benzoyl-β-D-galactopyranosyl)thioureas (2b, 2c) and 1,3,4,6-tetra-O-acetyl-2-deoxy-2-[3-(4',4'-diphenyl-2'-yl)thioureido]-β-D-glucopyranose (3c) are described. The structures and conformational properties of prepared compounds are based on analytical and spectroscopic (UV, IR, NMR and MS) data.

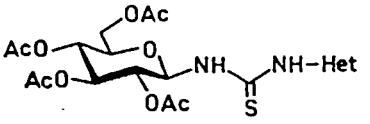
INTRODUCTION

The glycosylthioureas are compounds of pharmaceutical interest and they have been widely used in the syntheses of N-nucleosides and

glycosylaminoheterocycles.[2,3] As far as we are aware reports of hetarylthiourea carbohydrate derivatives are limited and generally report on the syntheses of pyridine derivatives[2,4] and compounds with two sugar moieties.[2,5] We now describe the preparation of the N-glycosyl-N'-hetarylthioureas **1a-1d**, **2b**, **2c** and the 2-deoxy-2-thioureidoglucosyl derivative **3c**.

RESULTS AND DISCUSSION

The acylated glycosylthioureas **1a-1d**, **2b** and **2c** were prepared by reaction of the corresponding per-O-acylglycosyl isothiocyanates and hetarylamines. Compound **1d** was isolated as a pair of diastereomers

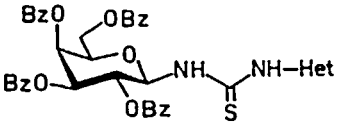


1a - 1d

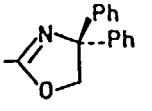
Het =

a

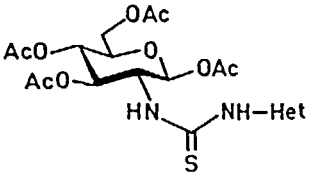
b



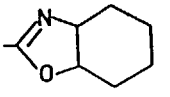
2b, 2c



c



3c



d

Table 1. ^{1}H NMR chemical shifts (δ, ppm) of compounds 1a-1d, 2b, 2c and 3c in $CDCl_3$

Comp.	Sugar moiety							NH	N'H	Heterocycle	
	H-1	H-2	H-3	H-4	H-5	H-6	H-6'			H-4(4',3a)	H-5(5',7a)
1a	5.83t	5.22t	5.36t	5.13t	3.90ddd	4.30dd	4.14dd	bs[a]	bs[a]	7.39d(1H)	6.88d(1H)
1b	5.77dd	5.17t	5.32t	5.11t	3.85ddd	4.28dd	4.17dd	13.08d	8.20bs	4.74m(2H)	3.17t(2H)
1c[b]	5.75t	5.18-4.92	5.36t	5.18-4.92	3.88ddd	4.31dd	4.16dd	11.90bs	7.05bd	--	4.89s(2H)
1c[c]	5.84bt	5.05t	5.32t	4.94t	←--------- 4.20-3.85m -----→			11.95bs	7.05bd	--	4.94s(2H)
1d[d]	5.78t	5.18t	5.33t	5.12t	3.86m	4.33dd	4.15dd	6.43bs	12.30d	4.48m(1H)	4.92m(1H)
	5.76t	5.16t	5.32t	5.11t	3.86m	4.28dd	4.15dd	6.43bs	12.32d	4.48m(1H)	4.92m(1H)
2b	6.14dd	5.91t	5.76t	6.03d	←------- 4.65-4.35m --------→			13.36d	8.20bs	4.71m(2H)	3.08t(2H)
2c[b]	←---------- 6.20-5.66m ----------→				4.60-4.35m	4.65dd	4.60-4.35m	11.95bs	8.20-7.20	--	4.85m(2H)
3c[b]	5.84d	5.10q	5.31t	5.20t	3.86m	4.30dd	4.13dd	6.61d	11.85bs	--	4.86bs

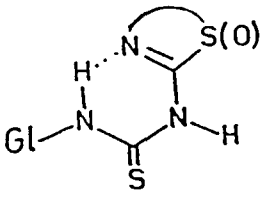
a. Very broad peak indistinguishable from the base line. b. Data for major tautomer. c. In $(CD_3)_2SO$ at 130°C. d. Pair of diastereomers.

Table 2. ^{1}H NMR coupling constants (Hz) of compounds 1a-1d, 2b, 2c and 3c in $CDCl_3$

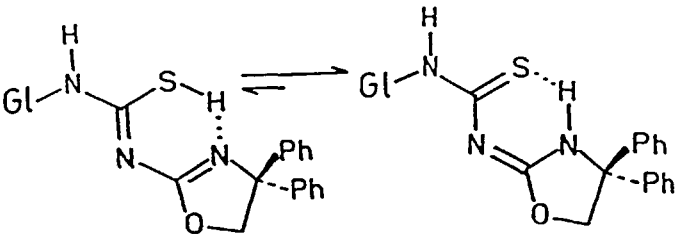
Compound	Sugar moiety								Heterocycle
	$J_{1,2}$	$J_{2,3}$	$J_{3,4}$	$J_{4,5}$	$J_{5,6}$	$J_{5,6'}$	$J_{6,6'}$	$J_{1(2),NH}$	$J_{4,5}$
1a	9.3	9.3	9.3	9.3	4.2	1.7	12.3	9.3	3.7
1b	9.7	9.7	9.7	9.7	4.5	2.3	12.5	8.6	6.8
1c	9.3	9.3	9.3	9.3	4.4	1.8	10.6	9.3	-
1d	9.0	9.0	9.0	9.0	4.8	2.3	13.2	9.0	-
2b	9.3	9.3	3.4	0.0	-	-	-	7.9	7.0
2c	-	-	-	-	5.6	-	11.0	-	-
3c	8.7	8.7	8.7	8.7	5.0	2.5	12.5	8.7	-

since the starting amine was a racemic mixture.[8] In the case of galactopyranosyl compounds (2b and 2c), the benzoyl group was used as protecting group since the corresponding acetyl derivatives could not be isolated with analytical purity. Compound 3c was prepared by reaction of 1,3,4,6-tetra-O-acetyl-2-deoxy-2-isothiocyanato-β-D-glucopyranose and 2-amino-4,4-diphenyl-2-oxazoline.

The structures of compounds 1a-1d, 2b, 2c and 3c were based on analytical, UV, IR and ^{1}H (Tables 1, 2) and ^{13}C NMR (Table 3) data. The product 1a had λ_{max} at 253 nm, 1b at 274 nm, 1c, 1d and 3c at 230-234 nm, characteristic of thiazole,[9] 2-thiazoline[5] and aminooxazoline[8] rings respectively. The UV absorptions of heterocyclic moieties of 2b-2c overlapped those of the benzoyl groups. The shift at lower wavenumber of NH ($\Delta\nu \approx 250$ cm^{-1}) and C=N ($\Delta\nu$ 20-40 cm^{-1}), with respect to other non-bonded thiazolines, 2-amino-2-thiazolines and 2-amino-2-oxazolines,[10] indicates that a strong intramolecular hydrogen bond is



1b, 1d, 2b



1c, 2c, 3c

Gl = SUGAR MOIETY

Scheme 1

present in compounds **1b-1d**, 2b-2c and 3c (Scheme 1). The wavenumber of ν_{NH} and ν_{CN} in **1b** and **2b** are coincident with those reported for N-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)-N'-(4-chlorophenyl)-N-(2-thiazolin-2-yl)thiourea 4,[5] where the NH is intramolecularly bonded. Dilution studies in carbon tetrachloride solutions[11] performed on **1b**, 2b and **1d** confirmed the intramolecular bonds. The spectra showed a broad absorption with maxima at 3098-3030 cm^{-1} whose relative absorbance with respect to ν_{CH} (alkyl) was invariable with dilution ($1 \cdot 10^{-2}$ - $0.25 \cdot 10^{-2}$ molar). The δ values of NH in **1b** and 2b (13.08 and 13.36 ppm) also agree with the presence of these hydrogen bonds (Scheme 1), in agreement with that previously described for related compounds.[5]

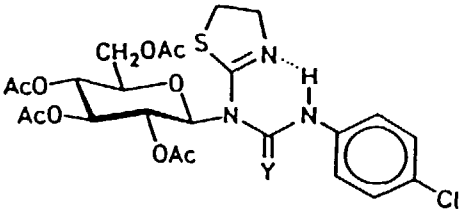


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Table 3. ^{13}C NMR chemical shifts (δ, ppm) for the sugar moieties of compounds 1a-1d, 2b, 2c and 3c in $CDCl_3$.

	C-1	C-2	C-3	C-4	C-5	C-6
1a	82.7	70.2	73.0	68.1	73.5	61.6
1b	82.6	69.8	73.2[a]	68.1	73.3[a]	61.6
1c[b]	82.0	70.1	73.1[a]	68.1	73.3[a]	61.5
1d	82.6	70.1	73.3[a]	68.1	73.5[a]	61.6
	83.1	70.0	72.7[a]	68.4	73.1[a]	61.9
2b	83.2	68.5[a]	72.1	68.3[a]	73.0	62.1
2c[b]	82.7	69.2	71.8	68.2	72.7	61.9
3c	92.0	55.9	72.6[a]	67.6	72.5[a]	61.4

a. Assignments may be interchanged. b. Signals for the major compound.

The ^1H NMR spectra of 1c, 2c and 3c indicated that these compounds in methyl sulphoxide solutions exist as the tautomeric equilibrium mixture shown in Scheme 1. The ^1H resonances were pairs of signals with similar J values which coalesced to single signals on heating at 130 °C. The δ values of NH (SH) are indicative of hydrogen bonds. The magnitudes of $J_{1,NH}$ ($J_{2,N'H}$ in 3c) are 8.7-9.3 Hz, showing antiperiplanar position[12] for N'H(NH) and H-1(H-2) and ruling out other possible hydrogen bonds. The assignments of ^{13}C-resonances are based on APT spectra[13] and literature data for glycosyl[3,5,7,14,15] and heterocyclic[5,12] related compounds.

The N-(cis-3a,4,5,6,7,7a-hexahydrobenzoxazole-2-yl)-N'-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)thiourea (1d) was obtained by reaction

of the corresponding isothiocyanate and the racemic amine. According to the ^{1}H and ^{13}C NMR spectra **1d** was isolated as a pair of diastereomers. The δ values of N'H (12.30d and 12.32d) are indicative of the hydrogen bonds shown in Scheme 1.

The $^{3}J_{H,H}$ values for **1a-1d**, **2b** and **3c** showed that the $^{4}C_{1}$ (D) conformation (sugar ring) preponderates in solutions in chloroform and methyl sulphoxide. Generally 1,3-disubstituted alkylthioureas exist in solution in conformational equilibrium (C-N bonds) between the (Z,E), (Z,Z) and (E,Z) forms.[16,17] In compounds **1b**, **1c** and **2b** the (Z,E) conformation is fixed by an internal hydrogen bond (Scheme 1). The $J_{1,NH}$ and δ H-1 values agree with those previously described for (Z,E) conformations of alkylthioureas.[18]

The mass spectra of per-O-acetylglucopyranosylthioureas (**1a-1d**) show as the main fragmentation pathway the cleavage of the glycosidic bond[19] (m/z 331) and formation of the fragments m/z 271, 211, 169, 127 109, characteristic of per-O-acetyl sugar derivatives.[20-21] Other significant peaks are assigned to hetarylisothiocyanates[19] and hetarylamines. Additionally compound **1a** showed the described fragments of 2-aminothiazole[22] and **1b** the fragments of 2-aminothiazoline[22] (see Experimental). The compound **1c** shows an ion at m/z 165(23%) which is assigned to the fluorenyl cation.

The mass spectra of **2b** and **2c** were similar to those for the corresponding per-O-acetyl derivatives **1b-1c**.

The EI mass spectrum of **3c** (see Experimental) shows as the main primary fragmentation the loss of acetic acid (m/z 567). Peaks for the fluorenyl cation (165) and 2-amino-4,4-diphenyloxazoline were also observed.

EXPERIMENTAL

General Procedures. Melting points were determined on a Gallenkamp MFB 595 apparatus and are uncorrected. Optical rotations were measured at 22 ºC with a Perkin-Elmer 141 MC polarimeter. UV spectra were recorded using a Beckman DU-7 spectrophotometer. IR spectra for KBr discs were measured with a Perkin-Elmer 299 instrument. When solutions in carbon tetrachloride were used, the spectra were recorded on a Bomen Michelson MB-100 FT IR spectrophotometer; the solutions ($1.00 \cdot 10^{-2}$, $0.75 \cdot 10^{-2}$, $0.50 \cdot 10^{-2}$ and $0.25 \cdot 10^{-2}$ molar) were prepared with freshly distilled carbon tetrachloride and a fixed, 1.00 mm path length NaCl cell was used. ^{1}H NMR (200.13 MHz) and ^{13}C NMR (50.33 MHz) were obtained with a Varian XL-200 spectrometer for solutions in $CDCl_3$ or DMSO-d_6 with tetramethylsilane (Me_4Si) as internal reference. The spectra are reported as chemical shifts downfield from Me_4Si. Assignments of ^{1}H signals were confirmed by decoupling and H/D exchange experiments. Proton-decoupled APT[13] (attached proton test) spectra were used to assist in carbon signal assignments. Mass spectra (EI mode) were taken on a Kratos MS-80RFA instrument operated at an ionizing energy of 35 eV, ionizing current 100 μA, accelerating voltage 4 KV, resolution 1000 (10% valley definition). The elemental composition of the ions was determined by a peak-matching method relative to PFK on the same instrument, the resolution being 10000 (10% valley definition). Metastable peaks in the field-free region were obtained on the same instrument; the fragment ion scan (FIS, B:E constant) was used. TLC was performed on silica gel 30 F_{254} (Merck) plates with detection by UV light or/and by charring with 10% sulphuric acid, and column

chromatography was carried out with silica gel 60 (Merck). Microanalyses were performed in the Analytical Chemistry Department at Sevilla University.

N(N')-Hetaryl-N'(N)-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)-thioureas (1a-1d). A solution of the corresponding 2-aminoheterocycle[8] (1.28 mmol) in acetone (5 mL) was added dropwise to a solution of 2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl isothiocyanate[6,7] (0.5 g, 1.28 mmol) in acetone (5 mL) under nitrogen. The resulting solution was refluxed (1a) or kept at room temperature for t h (1b-1d) and then concentrated under diminished pressure, and the residue was purified by column chromatography using an ether-hexane 4:1, 5:1, 6:1 gradient as eluant to give a white foam (1a, 1b, 1d) or solid crystallised from ethanol (1c).

N-(2,3,4,6-Tetra-O-acetyl-β-D-glucopyranosyl)-N'-(thiazole-2-yl-thiourea (1a, 0.113 g, 22%, t 4 h) had $[\alpha]_D^{22}$ -20.1° (c 0.6, chloroform); UV ($CHCl_3$) 296 and 253 nm (ε_{mM} 27.0 and 15.1); IR (KBr) 3470 and 3220 (NH), 1750 (C=O), 1620 (thiazole ring), 1550 (NH), 1505, 1425 (thiazole ring) and 1230 cm^{-1} (C=S and C-O-C); ^1H NMR ($CDCl_3$) Tables 1 and 2, and δ 2.09, 2.05, 2.03, and 2.02 (4s, 12H, 4OAc); ^{13}C NMR ($CDCl_3$) Table 3 and δ 180.4 (C=S), 170.2, 169.8 (2C) and 169.3 (4C=O), 161.1 (C-2 heterocycle), 128.2 (C-4 heterocycle), 111.7 (C-5 heterocycle), 20.7 and 20.5 (3C) ($4CH_3$); MS: m/z 331 (4, glycosidic moiety), 271 (2), 211 (3), 169 (11), 142 (80, thiazole-2-yl isothiocyanate), 127 (4), 109 (10), 100 (21, 2-aminothiazole), 85 (7), 73 (43) and 60 (100). Anal. Calcd for $C_{18}H_{23}N_3O_9S_2$: C, 44.16; H, 4,74; N, 8.59. Found: C, 43.89; H, 5.00; N, 8.34.

N-(2,3,4,6-Tetra-O-acetyl-β-D-glucopyranosyl)-N'-(2-thiazoline-2-yl)-thiourea (1b, 0.37 g, 58%, t 2 h) had $[\alpha]_D^{22}$ -3.9° (c 1.0, chloroform);

UV (CH_2Cl_2) 274 and 240 nm (ϵ_{mM} 12.4 and 9.0); IR (KBr) 3310 (N'H), 3080 (NH), 1745 (C=O), 1600 (C=N), 1550 (NH) and 1225 cm^{-1} (C=S and C-O-C). (in CCl_4) 3030 (NH) and 1609 (C=N); ^1H NMR ($CDCl_3$) Tables 1 and 2, and δ 2.08, 2.03, 2.02 and 2.01 (4s, 12H, 4OAc); ^{13}C NMR ($CDCl_3$) Table 3 and δ 182.8 (C=S), 170.6, 169.9, 169.5 and 169.4 (4C=O), 163.5 (C-2 heterocycle), 55.5 (C-4 heterocycle), 25.1 (C-5 heterocycle), 20.7, 20.6 and 20.5 (2C) ($4CH_3$); MS: m/z 331 (25, glycosidic moiety), 271 (4), 211 (4), 169 (68), 144 (11, 2-thiazoline-2-yl isothiocyanate), 127 (22), 109 (50), 102 (55, 2-amino-2-thiazoline) and 60 (100). Anal. Calcd for $C_{18}H_{25}N_3O_9S_2$: C, 43.98; H, 5.13; N, 8.55. Found: C, 43.92; H, 5.15; N, 8.47.

N-(4,4-Diphenyloxazoline-2-yl)-N'-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)thiourea (1c, 0.33 g, 40%, t 24 h) had mp 97-98 °C; $[\alpha]_D^{22}$ +9.1° (c 0.7 chloroform); UV (CH_2Cl_2) 277, 251 and 234 nm (ϵ_{mM} 8.4, 21.8 and 11.5); IR (KBr) 3300 (NH), 1620 (C=N), 1600 (C=C aromatic), 1510 (NH), 1230 (C=S and C-O-C), 750 and 705 cm^{-1} (CH aromatic); ^1H NMR ($CDCl_3$) Tables 1 and 2, and δ 7.45-7.20 (m, 10H, 2Ph), 2.08, 2.03 and 2.01 (3s, 12H, 4OAc); ^1H NMR (DMSO-d_6 at 130 °C) Table 1 and δ 7.50-7.20 (m, 10H, 2Ph), 2.02, 1.98, 1.96 and 1.92 (4s, 12H, 4OAc); ^{13}C NMR ($CDCl_3$) Table 3 and δ 193.3 (C=S), 170.6, 170.3, 169.8 and 169.4 (4C=O), 166.7 (C-2 heterocycle), 141.3-126.0 (12C, 2Ph), 79.7 (C-5 heterocycle), 77.1 (C-4 heterocycle), 20.6 and 20.4 (3C) ($4CH_3$); MS: m/z 331 (10, glycosidic moiety), 280 (2, 4,4-diphenyloxazoline-2-yl isothiocyanate), 280 (2), 271 (2), 238 (7, 2-amino-4,4-diphenyloxazoline), 211 (2), 169 (39), 165 (23, fluorenyl cation), 161 (100), 127 (12), 109 (27) and 60 (35). Anal. Calcd for $C_{30}H_{33}N_3O_{10}S$: C, 57.40; H, 5.30; N, 6.70. Found: C, 57.11; H, 5.23; N, 6.48.

N-(cis-3a,4,5,6,7,7a-Hexahydrobenzoxazole-2-yl)-N'-(2,3,4,6-tetra-O-acetyl-β-D-glucopyranosyl)thiourea (1d, pair of diastereomers, 0.5 g. 73%, t 24 h) had UV (CH_2Cl_2) 270 and 231 nm (ϵ_{mM} 10.8 and 4.7); IR (KBr) 3320 (NH), 3100 (N'H), 1750 (C=O), 1680 (C=N), 1560 (NH), 1230 (C=S and C-O-C), (in CCl_4) 3038 (N'H) and 1684 (C=N); ^1H NMR ($CDCl_3$) Tables 1 and 2, and δ 2.75-1.10 (m, 8H, $4CH_2$), 2.22, 2.20, 2.16 and 2.14 (4s, 12H, 4OAc); ^{13}C NMR ($CDCl_3$) major diastereomer Table 3 and δ 180.9 (C=S), 170.6, 169.9, 169.5 and 169.4 (4C=O), 155.3 (C-2 heterocycle), 75.5 (C-7a heterocycle), 58.5 (C-3a heterocycle), 26.3, 26.1, 21.3 and 19.3 ($4CH_2$), 20.7 and 20.5 (3C) ($4CH_3$), distinguishable signals of minor diastereomer table 3, and δ 180.6 (C=S), 156.5 (C-2 heterocycle), 75.8 (C-7a heterocycle), 58.7 (C-3a heterocycle), 26.2, 25.8, 21.2, 19.1 ($4CH_2$), 20.5 (3C) and 20.3 ($4CH_3$); MS: m/z 331 (43, glycosidic moiety), 271 (7), 182 (4, hexahydrobenzoxazole-2-yl isothiocyanate), 169 (100), 140 (25, 2-aminohexahydrobenzoxazole), 127 (18), 109 (39) and 97 (61). Anal. Calcd for $C_{22}H_{31}N_3O_{10}S$: C, 49.90; H, 5.90; N, 7.94. Found: C, 49.74; H, 5.85; N, 7.89.

N(N')-Hetaryl-N'(N)-(2,3,4,6-tetra-O-benzoyl-β-D-galactopyranosyl)-thioureas (2b, 2c). A solution of the corresponding 2-aminoheterocycle (0.785 mmol) in acetone (20 mL) was added dropwise to a solution of 2,3,4,6-tetra-O-benzoyl-β-D-galactopyranosyl isothiocyanate[7] (0.5 g, 0.785 mmol) in acetone (5 mL) under nitrogen. The resulting solution was kept at room temperature for t h and then concentrated under diminished pressure, and the residue was crystallised from ethanol.

N-(2,3,4,6-Tetra-O-benzoyl-β-D-galactopyranosyl)-N'-(2-thiazoline-2-yl)thiourea (2b, 0.4 g, 70%, t 1.5 h) had mp 124 °C; $[\alpha]_D^{22}$ +150.4° (c 1.0, chloroform); UV (CH_2Cl_2) 233 nm (ϵ_{mM} 45.5); IR (KBr) 3320 (N'H),

3090 (NH), 1725 (C=O), 1600 (C=N and C=C aromatic), 1560 (NH), 1270 (C=S and C-O-C), 770 and 710 cm^{-1}(CH aromatic),(in CCl_4) 3098 (NH) and 1603 (C=N); ^1H NMR ($CDCl_3$) Tables 1 and 2 and δ 8.07-7.17 (m, 20H, 4Ph); ^{13}C NMR ($CDCl_3$) Table 3 and δ 182.7 (C=S), 166.2, 165.5 and 165.3 (2C) (4C=O), 162.7 (C-2 heterocycle), 133.3-128.1 (24C, 4Ph), 55.4 (C-4 heterocycle), 25.1 (C-5 heterocycle); MS: m/z 579 (7, glycosidic moiety), 122 (29), 105 (100) and 77 (40). Anal. Calcd for $C_{38}H_{33}N_3O_9S_2$: C, 61.69; H, 4.50; N, 5.68. Found C, 61.90; H, 4.78; N, 5.42.

N-(4,4-Diphenyloxazoline-2-yl)-N'-(2,3,4,6-tetra-O-benzoyl-β-D-galactopyranosyl)thiourea (2c, 0.43 g, 63%, t 24 h) had mp 125 °C; $[\alpha]_D^{22}$ +108.1° (c 0.7, chloroform); UV (CH_2Cl_2) 233 nm (ε_{mM} 57.1); IR (KBr) 3300 (NH), 1725 (C=O), 1620 (C=N), 1600 (C=C aromatic), 1270 (C=S and C-O-C), 750 and 710 cm^{-1} (CH aromatic); ^1H NMR ($CDCl_3$) Tables 1 and 2 , and δ 8.20-7.20 (m, 31H, 6Ph and N'H); ^{13}C NMR ($CDCl_3$) Table 3 and δ 191.9 (C=S), 166.3, 166.0 and 165.3 (2C) (4C=O), 163.5 (C-2 heterocycle), 141.3-126.0 (36C, 6Ph), 80.4 (C-5 heterocycle) and 77.2 (C-4 heterocycle); MS: m/z 579 (6, glycosidic moiety), 2.80 (1, 4,4-diphenyloxazoline-2-yl isothiocyanate), 238 (9, 2-amino-4,4-diphenyl-oxazoline), 165 (20, fluorenyl cation), 161 (100), 105 (20) and 77 (9). Anal. Calcd for $C_{50}H_{41}N_3O_{10}S$: C, 68.56; H, 4.72; N, 4.80. Found: C, 68.67; H, 4.68; N, 4.60.

1,3,4,6-Tetra-O-acetyl-2-deoxy-2-[3-(4',4'-diphenyloxazoline-2'-yl)thioureido]-β-D-glucopyranose (3c). A solution of 2-amino-4,4-diphenyloxazoline (0.29 g, 1.20 mmol) in acetone (15 mL) was added dropwise to a solution of 1,3,4,6-tetra-O-acetyl-2-deoxy-2-isothiocyanato β-D-glucopyranose[23] (0.46 g 1.20 mmol) in acetone (10 mL) under

nitrogen. The resulting solution was kept at room temperature for 24 h and then concentrated under diminished pessure, and the residue was purified by column chromatography using an ether-hexane 4:1, 5:1, 6:1 gradient as eluant. On recrystallisation from ethanol, white crystals of pure compound 3c were obtained (0.28 g, 37%), mp 103-104 °C; $[\alpha]_D^{22}$ 0° (c 1, chloroform); UV (CH_2Cl_2) 276, 256 and 230 nm (ϵ_{mM} 13.0, 23.6 and 7.8); IR (KBr) 3320 and 3170 (NH), 1750 (C=O), 1625 (C=N), 1600 (C=C aromatic), 1525 (NH), 1230 (C=S and C-O-C), 755 and 705 cm^{-1} (CH aromatic); ^1H NMR ($CDCl_3$) Tables 1 and 2, and δ 7.38-7.24 (m, 10H, 2Ph), 2.10, 2.08, 2.04 and 2.00 (4s, 12H, 4OAc); ^{13}C NMR ($CDCl_3$) Table 3 and δ 191.1 (C=S), 170.6, 170.3, 169.2 and 169.0 (4C=O), 165.8 (C-2 heterocycle), 141.1-126.0 (12C, 2 Ph), 77.1 (in DMSO-d_6, C-5 heterocycle), 74.3 (in DMSO-d_6, C-4 heterocycle), 20.8, 20.7, 20.6 and 20.5 ($4CH_3$); MS: m/z 567 (32, M^+-AcOH), 537 (8), 508 (89), 507 (61), 490 (83), 448 (29), 405 (40), 363 (32), 238 (9, 2-amino-4,4-diphenyloxazoline), 222 (23), 180 (60), 179 (85), 165 (75, fluorenyl cation), 161 (71) and 77 (29). Anal. Calcd for $C_{30}H_{33}N_3O_{10}S$: C, 57.41; H, 5.30; N, 6.70. Found: C, 57.60; H, 5.52; N, 6.43.

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