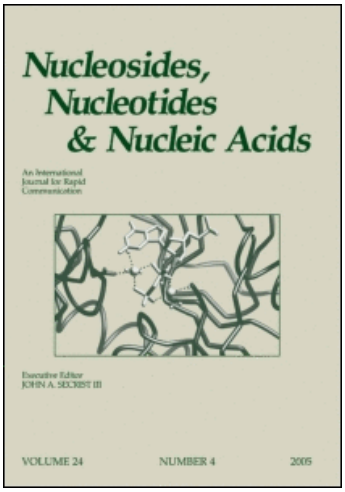

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Synthesis of Some New 1,3/ or 1,4-Bis(Glucopyranosyl-1,2,4-Triazol-5-Ylthio)Propanes/ or Butanes as Potential Antimicrobial Agents

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SYNTHESIS OF SOME NEW 1,3/ OR 1,4-BIS(GLUCOPYRANOSYL-1,2,4-TRIAZOL-5-YLTHIO)PROPANES/ OR BUTANES AS POTENTIAL ANTIMICROBIAL AGENTS

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▫ *Glucosidation of the appropriate 1,3 or 1,4-bis(4-amino or arylideneamino-2,4-dihydro-3-thioxo-3H-1,2,4-triazol-5-ylthio)propanes or butanes with 2,3,4,6-tetra-O-acetyl-α-D-glucopyranosyl bromide followed by chromatographic separation gave the corresponding N-, S-, and N,S-bis(glucosides). Chemical transformation leading to new functionalities has been achieved. Antimicrobial screening of 10 selected compounds resulted in their activity against Aspergillus fumigatus, Penicillium italicum, Syncephalastrum racemosum, Candida albicans, Staphylococcus aureus, Pseudomonas aeruginosa, Bacillus subtilis, and Escherichia coli.*

Keywords Synthesis, Glucosidation, *bis*(Triazoles), *bis*(Glucosides), Antimicrobial

INTRODUCTION

1,2,4-Triazole and its derivatives represent one of the most biologically active classes of compounds, possessing a wide spectrum of activities including antibacterial, antifungal, antiviral, antiinflammatory, anticonvulsant, antidepressant, antihypertensive, analgesic, and hypoglycemic properties.[1–13] The synthesis and investigation of biological activity of 1,2,4-triazole glycosides[14–17] have been stimulated by the finding that ribavirin (β-D-ribofuranosyl-1,2,4-triazole-3-carboxamide),[14] is remarkable in its broad-spectrum activity against DNA and RNA viruses.[15,16] Ribavirin has been developed clinically[17] and approved for human use in many pharmaceutical preparations. Recently, considerable attention has been directed to the synthesis of *bis*(compounds) as useful precursors for the synthesis of crown and azacrown compounds, which in turn are of great importance

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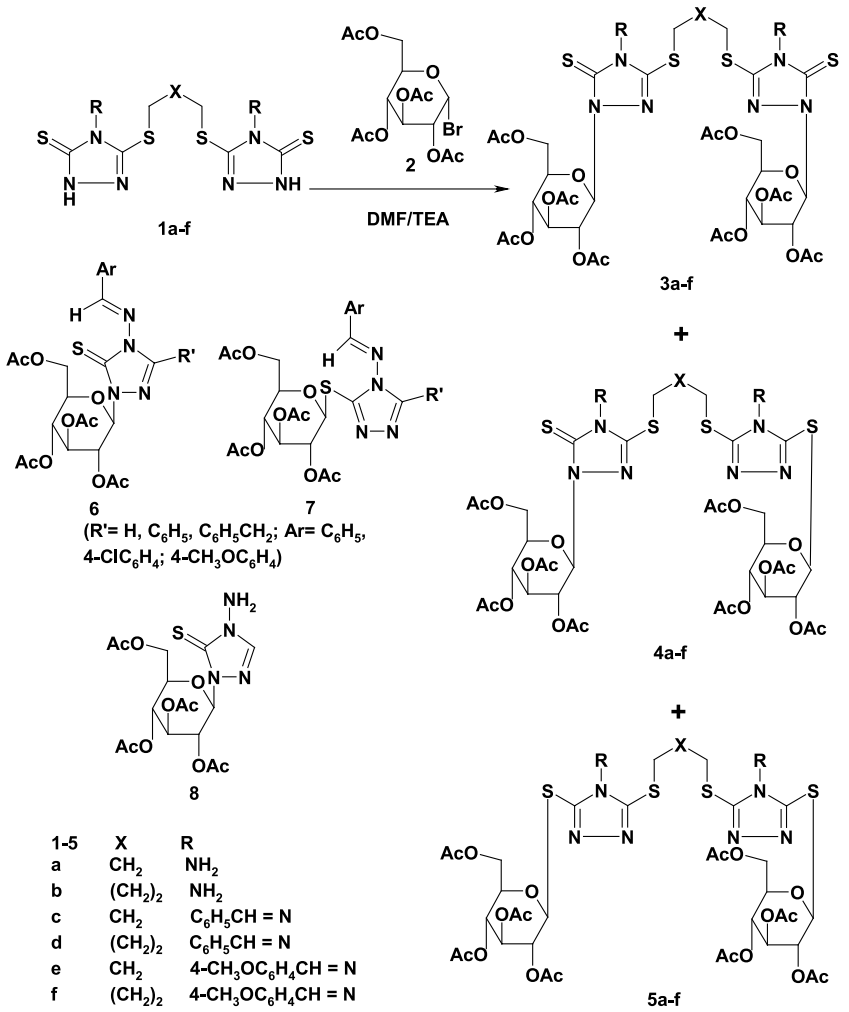
in supramolecular chemistry.[18] Also, the importance of *bis*(compounds) comes from the fact that many biologically active natural and synthetic products have molecular symmetry.[19] Therefore, the present study targeted the synthesis of the new title compounds as a part of a program addressed to prepare some new biologically active compounds.[20–28]

RESULTS AND DISCUSSION

In the current report, the 1,3 or 1,4-*bis*(4-amino or arylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)propanes or butanes (**1a–f**) were allowed to react



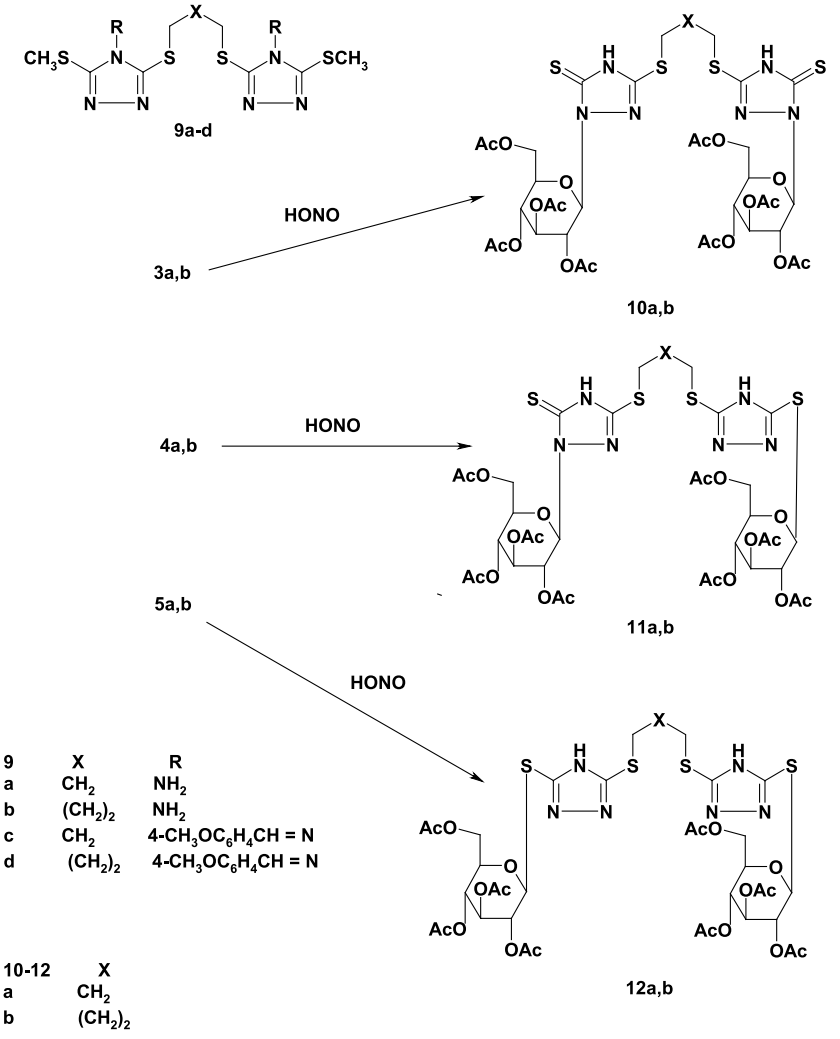
SCHEME 1 Synthesis of *N*-, *S*- and *N*,*S*-*bis*(glucosides) **3a–f**, **4a–f** and **5a–f** via glucosidation of compounds **1a–f**.

with 2.2 molar equivalents of 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (**2**) in *N*,*N*-dimethylformamide containing triethylamine (Scheme 1). The resulting mixture of products (95–100% overall yield) was chromatographically separated to yield three products, namely, 1,3 or 1,4-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino or arylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propanes or butanes (**3a–f**), 1-[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino or arylideneamino-4*H*-1,2,4-triazol-5-ylthio]-3 or 4-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino or arylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]-propanes or butanes (**4a–f**) and 1,3 or 1,4-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino or arylideneamino-4*H*-1,2,4-triazol-5-ylthio]propanes or butanes (**5a–f**). The structures of compounds **3–5** were established based on the following facts:

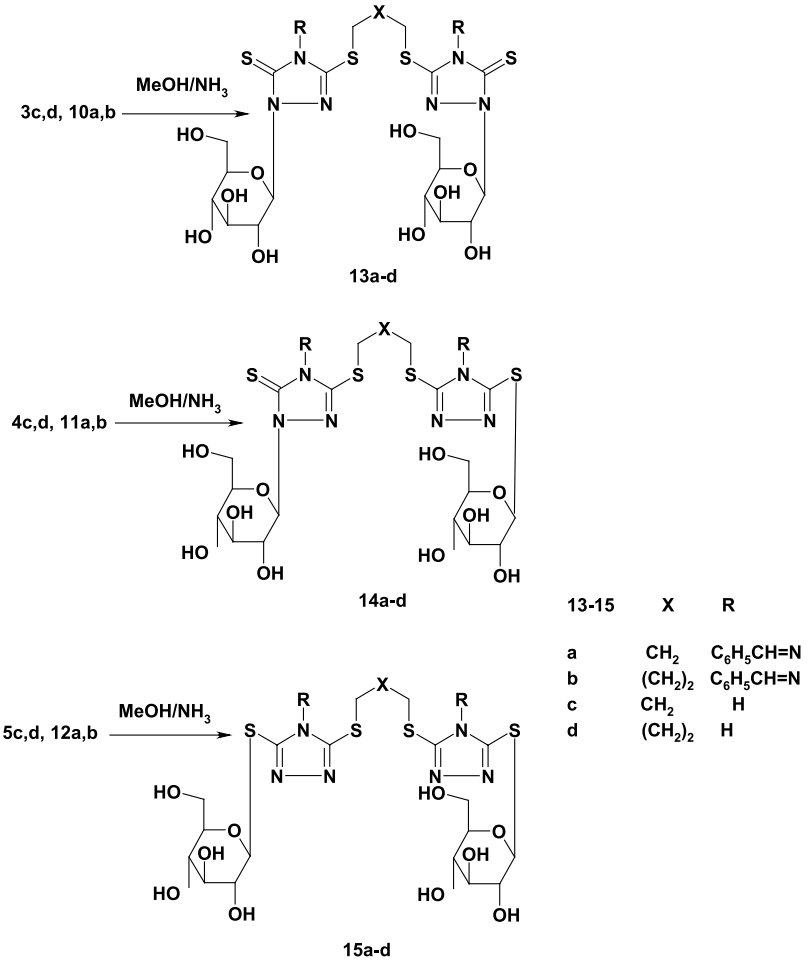
1. The β-*N*-configuration of compounds **3a–f** is supported by their ^{1}H NMR data which revealed the anomeric proton around δ 6.2 with a coupling constant value 9.1–9.6 Hz consistent with reported data for β-*N*-glycosides.[20–23,25–28]
2. The β-*S*-configuration of compounds **5a–f** is also assigned from their ^{1}H NMR data which showed the anomeric proton around δ 5.6 with a coupling constant value 8.7–10.1 consistent with reported data for β-*S*-glycosides.[28]
3. For all the *N-bis*(glucosides) **3c–f**, the CH=N and the anomeric protons appear around δ 10.0 and 6.2 more downfield than those for the *S-bis*(glucosides) **5c–f** which appear around δ 8.5 and 5.6, respectively, consistent with reported[28] data for both 2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-arylideneamino-2,4-dihydro-3-thixo-3*H*-1,2,4-triazoles (**6**) and 3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-arylideneamino-4*H*-1,2,4-triazoles (**7**), respectively. Such downfield shifts in *N*-glucosyl derivatives are readily explained by the anisotropic deshielding by the C=S (similar downfield shifts of the anomeric proton and the CH=N proton by an adjacent C=S were reported for pyrimidine and 1,2,4-triazole nucleosides).[28,29] Also, the NH_2 and anomeric protons of compounds **3a,b** appear around δ 4.7 and 6.00, respectively, consistent with similar reported[28] data for 2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazole (**8**).
4. The reported ^{1}H NMR spectral data of the dimethylthio compounds **9a–d** revealing their NH_2 and CH=N protons at δ 5.87 and 8.51, respectively, consistent with obtained data for compounds **5a–f** is a further evidence for the assigned structures of the later compounds.
5. For all *N*,*S-bis*(glucosides) **4a–f**, the appearance of both CH=N and anomeric protons of β-*N*-type around δ 10.3 and 6.1, respectively, supports the presence of β-*N*-glucosyl moiety. Also, the appearance of CH=N and anomeric protons of β-*S*-type around δ 8.7 and 5.3, respectively, supports the presence of β-*S*-glucosyl moiety. Comparing the relative integration ratios of CH=N or anomeric proton signals of both glucosyl moieties revealed that compounds **4a–f** contain one glucosyl moiety of each type. Futhermore, The mass spectrum of compound **4a**

showed the correct parent ion peak at m/z 577 (M^+). All these facts together with the fact that compounds **4a–f** gave the correct analytical data assigned the structure of the latter compounds.

Deamination of compounds **3a,b**, **4a,b**, and **5a,b** into compounds **10a,b**, **11a,b**, and **12a,b**, respectively (Scheme 2), was achieved almost quantitatively by the action of nitrous acid in acetic acid. The structure of the latter compounds was inferred from their correct analytical and spectral data. Thus, the ^1H NMR data of these compounds not only showed the absence of the NH_2 protons at δ 5.1–4.75 but also revealed the presence of the D_2O exchangeable NH proton signal at δ 8.4–8.2. Further evidence comes from the disappearance of NH_2 bands at 3348–3329,



SCHEME 2 Deamination of compounds **3a,b**, **4a,b**, and **5a,b**.



SCHEME 3 Deacetylation of compounds **3c,d**, **4c,d**, **5c,d**, **10a,b**, **11a,b**, and **12a,b**.

3298–3213 cm^{-1} and the appearance of the characteristic NH band at 3476–3400 cm^{-1} in compounds **10a,b**, **11a,b**, and **12a,b**.

Deacetylation of compounds **3c,d**, **4c,d**, **5c,d**, **10a,b**, **11a,b**, and **12a,b** (Scheme 3) via methanolic ammonia treatment led to the formation of the free nucleosides **13a–d**, **14a–d**, and **15a–d**. The ^1H NMR data of the latter compounds revealed the absence of the acetyl protons at δ 2.2–1.90 and the appearance of the D_2O exchangeable OH protons at δ 5.0–4.0. The IR data of these compounds showed also the absence of the acetyl carbonyl function at 1755–1740 cm^{-1} and the appearance of the characteristic OH band at 3600–3200 cm^{-1}.

BIOLOGICAL EVALUATION

The antimicrobial activity (in vitro) of compounds **3a,c,d,f**, **4b,d**, **5c,f**, **12a**, and **13b** was tested against *Aspergillus fumigatus*, *Penicillium italicum*,

TABLE 1 Antimicrobial Activity of Compounds **3a**,**c**,**d**,**f**, **4b**,**d**, **5c**,**f**, **12a**, and **13b** Compared to Standard Antimicrobial Agents

	Compound								
	3a[a]			**3c**[a]			**3d**[a]		
	Concentration (mg/mL)								
Test organisms	5	2.5	1	5	2.5	1	5	2.5	1
Aspergillus fumigatus	+ + +	+ +	+	0	0	0	0	0	0
Penicillium italicum	+ + +	+ + +	+ +	0	0	0	0	0	0
Syncephalastrum racemosum	+ + +	+ +	+	0	0	0	+	0	0
Candida albicans	+ +	+ +	+	0	0	0	0	0	0
Staphylococcus aureus	+ +	+ +	+ +	+	0	0	+ +	+ +	+ +
Pseudomonas aeruginosa	+ + +	+ +	+	0	0	0	+ +	+ +	+ +
Bacillus subtilis	+ + +	+ +	+	+ +	+ +	+ +	0	0	0
Escherichia coli	+	+	0	0	0	0	0	0	0

	Compound								
	3f[a]			**4b**[a]			**4d**[a]		
	Concentration (mg/mL)								
Test organisms	5	2.5	1	5	2.5	1	5	2.5	1
Aspergillus fumigatus	+	0	0	0	0	0	+	0	0
Penicillium italicum	+ + +	+ +	+ +	+	+	+	+ +	+ +	+ +
Syncephalastrum racemosum	+ + +	+ +	+ +	0	0	0	0	0	0
Candida albicans	+ +	+ +	+ +	0	0	0	0	0	0
Staphylococcus aureus	+ +	+ +	+ +	0	0	0	+ +	+ +	+ +
Pseudomonas aeruginosa	+ +	+	0	0	0	0	0	0	0
Bacillus subtilis	+ +	+	+	0	0	0	+ +	+ +	+ +
Escherichia coli	+ +	+ +	+ +	0	0	0	0	0	0

	Compound								
	5c[a]			**5f**[a]			**12a**[a]		
	Concentration (mg/mL)								
Test organisms	5	2.5	1	5	2.5	1	5	2.5	1
Aspergillus fumigatus	+ + +	+ +	+	+ +	+	0	+	0	0
Penicillium italicum	+ + +	+ +	+ +	+ +	+	+	+ +	+ +	+ +
Syncephalastrum racemosum	+ +	+	0	0	0	0	0	0	0
Candida albicans	+ +	+	0	+ +	+	0	0	0	0
Staphylococcus aureus	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +
Pseudomonas aeruginosa	+ + +	+ +	+	+ + +	+ +	0	+ +	+ +	+ +
Bacillus subtilis	+ + +	+ +	+ +	+ +	+	0	+ +	+ +	+ +
Escherichia coli	+ +	+ +	+ +	+ +	+ +	+	+	+	0

(*continued*)

TABLE 1 Continued

	Compound					
	13b[a]			**St.**[b]		
	Concentration (mg/mL)					
Test organisms	5	2.5	1	5	2.5	1
Aspergillus fumigatus	0	0	0	+ + +	+ + +	+ +
Penicillium italicum	0	0	0	+ + +	+ + +	+ +
Syncephalastrum racemosum	0	0	0	+ + +	+ + +	+ + +
Candida albicans	0	0	0	+ +	+ +	+ +
Staphylococcus aureus	0	0	0	+ +	+ +	+ +
Pseudomonas aeruginosa	+ +	+ +	+ +	+ + +	+ + +	+ +
Bacillus subtilis	+ +	+ +	+ +	+ + +	+ + +	+ +
Escherichia coli	+	0	0	+ +	+ +	+ +

Note: The test was done using the diffusion agar technique. Inhibition values = 0.1–0.5 cm beyond control = +; Inhibition values = 0.6–1.0 cm beyond control = + +; Inhibition values = 1.0–1.5 cm beyond control = + + +; 0 = Not detected.

[a]100 μL of each conc. was tested (5, 2.5, 1.0 mg/L); Well diameter = 0.6 cm.

[b]St. = Reference standard; chloramphenicol was used as a standard antibacterial agent and terbinafin was used as a standard antifungal agent.

Syncephalastrum racemosum, *Candida albicans*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Bacillus subtilis*, and *Escherichia coli*. The inhibitory effects of the tested compounds against the mentioned organisms are given in Table 1. It can be noted that compounds **3a,d,f**, **4d**, **5c,f**, and **12a** showed the greatest inhibitory effect against one or more types of bacteria or fungi compared to compounds **3c**, **13b**, and **4b**. Thus, while compounds **3a,d,f**, **4d**, **5c,f**, and **12a** revealed both antibacterial and antifungal activities, compounds **3c** and **13b** showed only antibacterial activity. Also, compound **4b** exhibited only antifungal activity.

EXPERIMENTAL

All melting points are uncorrected. IR spectra were recorded on a Perkin-Elmer 1430 spectrometer. ^{1}H NMR spectra were recorded at 200 MHz with a Varian GEMINI 200 spectrometer. Mass spectra were recorded on a GCMS-QP 1000 EX (70EV) spectrometer. Elemental analyses were carried out at the Micro Analytical Center, Cairo University, Giza, Egypt. Antimicrobial screening of compounds **3a,c,d,f**, **4b,d**, **5c,f**, **12a**, and **13b** was carried out at the Medical Mycology Lab, the Regional Center for Mycology and Biotechnology, Al Azhar University, Cairo, Egypt. The starting 1,3 or 1,4-*bis*(4-amino or arylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propanes or butanes (**1a–f**)[30] and 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (**2**)[31] were prepared as reported. TLC was performed on Fluka silica gel 60 F_{254} aluminum sheets, and products were detected using 254 nm light. Fluka silica gel 60 (70–230 mesh) was used for column chromatography.

General procedure for the synthesis of compounds 3a–f, 4a–f, and 5a–f. To a solution of each of compounds **1a–f** (10 mmol) in *N*,*N*-dimethylformamide (7 mL) and triethylamine (25 mmol, 3.5 mL) was added 2,3,4,6-tetra-*O*-acetyl-α-D-glucopyranosyl bromide (**2**) (9.04 g, 22 mmol) and the reaction mixture was stirred overnight. The next day, the reaction mixture was diluted with cold water and left in an ice bath for 2 h. The precipitate was then collected by filtration, dried at room temperature, and subjected to silica gel (70–230 mesh) column chromatography. Compounds **3a–f** eluted first with petroleum ether (bp 40–60°C)→60% ethyl acetate/petroleum ether (bp 40–60°C), followed by compounds **4a–f** with 60% ethyl acetate/petroleum ether (bp 40–60°C)→80% ethyl acetate/petroleum ether (bp 40–60°C) and finally compounds **5a–f** with 80% ethyl acetate/petroleum ether (bp 40–60°C)→100% ethyl acetate. The chromatographically separated crude products were recrystallized from dichloromethane/petroleum ether (bp 40–60°C) to give colorless crystals of compounds **3a–f**, **4a–f**, and **5a–f**. R_f values of compounds of the latter compounds were determined on TLC aluminum sheets using ethyl acetate/petroleum ether (bp 40–60°C) [60:40, v/v] as a developing system.

1,3-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (3a). Using the general procedure, **1a** gave **3a** (15%); R_f 0.85; mp 70°C; IR (KBr) 3329, 3221(NH_2), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 6.00 (d, 2H, *J* = 9.3 Hz, H-1′), 5.84 (t, 2H, *J* = 9.2 Hz, H-2′), 5.37 (t, 2H, *J* = 9.3 Hz, H-3′), 5.26 (t, 2H, *J* = 9.6 Hz, H-4′), 4.70 (s, 4H, D_2O exchangeable NH_2), 4.29 (dd, 2H, *J* = 5.2, 12.4 Hz, H-6′), 4.14 (dd, 2H, *J* = 1.9, 12.4 Hz, H-6″), 3.95 (ddd, 2H, *J* = 1.9, 5.2, 9.6 Hz, H-5′), 3.31 (t, 4H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 2.16 (quintet, 2H, *J* = 6.6 Hz, $SCH_2C\underline{H}_2$), 2.06, 2.05, 2.02, 1.91 (4s, 6H each, CH_3CO). Anal. Calcd for $C_{35}H_{48}N_8O_{18}S_4$: C, 42.16; H, 4.85; N, 11.24. Found: C, 42.22; H, 4.94; N, 11.14.

1,4-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (3b). Using the general procedure, **1b** gave **3b** (12%); R_f 0.87; mp 94°C; IR (KBr) 3333, 3221(NH_2), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 6.01 (d, 2H, *J* = 9.3 Hz, H-1′), 5.79 (t, 2H, *J* = 9.3 Hz, H-2′), 5.38 (t, 2H, *J* = 9.4 Hz, H-3′), 5.23 (t, 2H, *J* = 9.3 Hz, H-4′), 4.77 (s, 4H, D_2O exchangeable NH_2), 4.30 (dd, 2H, *J* = 4.5, 12.6 Hz, H-6′), 4.15 (d, 2H, *J* = 12.6 Hz, H-6″), 3.99 (ddd, 2H, *J* = 3.0, 4.8, 10.2 Hz, H-5′), 3.31 (t, 2H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 3.13 (t, 2H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.18 (quintet, 4H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.12, 2.07, 2.03, 1.95 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{36}H_{50}N_8O_{18}S_4$: C, 42.77; H, 4.98; N, 11.08. Found: C, 42.75; H, 4.77; N, 11.01.

1,3-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-benzylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (3c). Using the general procedure, **1c** gave **3c** (10%); R_f 0.86; mp 200°C;

IR (KBr) 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.40 (s, 2H, CH=N), 7.82 (dd, 4H, *J* = 1.6, 7.6 Hz, ArH), 7.47 (m, 6H, ArH), 6.13 (d, 2H, *J* = 9.4 Hz, H-1′), 5.85 (t, 2H, *J* = 9.3 Hz, H-2′), 5.39 (t, 2H, *J* = 9.3 Hz, H-3′), 5.24 (t, 2H, *J* = 9.6 Hz, H-4′), 4.30 (dd, 2H, *J* = 4.6, 12.5 Hz, H-6′), 4.14 (dd, 2H, *J* = 1.9, 12.5 Hz, H-6″), 3.97 (ddd, 2H, *J* = 1.3, 4.9, 9.5 Hz, H-5′), 3.30 (t, 4H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.08 (quintet, 2H, *J* = 6.3 Hz, $SCH_2C\underline{H}_2$), 2.06, 2.04, 2.01, 1.94 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{49}H_{56}N_8O_{18}S_4$: C, 50.16; H, 4.81; N, 9.55. Found: C, 50.00; H, 4.69; N, 9.74.

1,4-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-benzylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (3d). Using the general procedure, **1d** gave **3d** (11%); R_f 0.82; mp 84°C; IR (KBr) 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.41 (s, 2H, CH=N), 7.84 (d, 4H, *J* = 6.9 Hz, ArH), 7.48 (m, 6H, ArH), 6.17 (d, 2H, *J* = 9.3 Hz, H-1′), 5.85 (t, 2H, *J* = 9.4 Hz, H-2′), 5.41 (t, 2H, *J* = 9.4 Hz, H-3′), 5.26 (t, 2H, *J* = 9.7 Hz, H-4′), 4.32 (dd, 2H, *J* = 4.9, 12.4 Hz, H-6′), 4.17 (d, 2H, *J* = 12.6 Hz, H-6″), 4.00 (ddd, 2H, *J* = 2.7, 4.8, 9.9 Hz, H-5′), 3.31 (t, 2H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 3.17 (t, 2H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.06 (quintet, 4H, *J* = 6.3 Hz, $SCH_2C\underline{H}_2$), 2.03, 2.02, 1.98, 1.94 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{50}H_{58}N_8O_{18}S_4$: C, 50.58; H, 4.92; N, 9.44. Found: C, 50.74; H, 4.99; N, 9.36.

1,3-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-(4-methoxybenzylideneamino)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (3e). Using the general procedure, **1e** gave **3e** (11%); R_f 0.86; mp 96–98°C; IR (KBr) 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.15 (s, 2H, CH=N), 7.79 (d, 4H, 8.5 Hz, ArH), 6.94 (d, 4H, *J* = 8.8 Hz, ArH), 6.15 (d, 2H, *J* = 9.1 Hz, H-1′), 5.84 (t, 2H, *J* = 9.2 Hz, H-2′), 5.39 (t, 2H, *J* = 9.4 Hz, H-3′), 5.28 (t, 2H, *J* = 9.5 Hz, H-4′), 4.36 (dd, 2H, *J* = 4.8, 12.2 Hz, H-6′), 4.18 (dd, 2H, *J* = 2.0, 12.4 Hz, H-6″), 3.96 (ddd, 2H, *J* = 1.9, 4.6, 9.7 Hz, H-5′), 3.87 (s, 6H, OCH_3), 3.31 (t, 4H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 2.16 (quintet, 2H, *J* = 6.6 Hz, $SCH_2C\underline{H}_2$), 2.08, 2.05, 2.03, 2.01 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{51}H_{60}N_8O_{20}S_4$: C, 49.67; H, 4.90; N, 9.09. Found: C, 49.60; H, 5.08; N, 9.13.

1,4-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-(4-methoxybenzylideneamino)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (3f). Using the general procedure, **1f** gave **3f** (12%); R_f 0.83; mp 84°C; IR (KBr) 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.16 (s, 2H, CH=N), 7.80 (d, 4H, *J* = 8.7 Hz, ArH), 6.96 (d, 4H, *J* = 9.0 Hz, ArH), 6.16 (d, 2H, *J* = 9.6 Hz, H-1′), 5.85 (t, 2H, *J* = 9.4 Hz, H-2′), 5.39 (t, 2H, *J* = 9.4 Hz, H-3′), 5.26 (t, 2H, *J* = 9.6 Hz, H-4′), 4.33 (dd, 2H, *J* = 5.1, 12.7 Hz, H-6′), 4.17 (dd, 2H, *J* = 1.8, 13.2 Hz, H-6″), 3.96 (ddd, 2H, *J* = 2.4, 5.1, 9.9 Hz, H-5′), 3.87 (s, 6H, OCH_3), 3.30 (t, 2H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 3.16 (t, 2H, *J* = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.22 (quintet, 4H,

J = 6.3 Hz, $SCH_2C\underline{H}_2$), 2.06, 2.04, 2.03, 2.02 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{52}H_{62}N_8O_{20}S_4$: C, 50.07; H, 5.01; N, 8.98. Found: C, 49.98; H, 4.97; N, 9.04.

1-[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino-4*H*-1,2,4-triazol-5-ylthio]-3-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (4a). Using the general procedure, **1a** gave **4a** (17%); R_f 0.64; mp 90–92°C; IR (KBr) 3344, 3213 (NH_2), 1740 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.99 (d, 1H, *J* = 9.3 Hz, H-1′ of *N*-gluc.), 5.80 (t, 1H, *J* = 9.2 Hz, H-2′ of *N*-gluc.), 5.36 (t, 1H, *J* = 9.3 Hz, H-3′ of *N*-gluc.), 5.25 (t, 1H, *J* = 9.3 Hz, H-4′ of *N*-gluc.), 5.23 (d, 1H, *J* = 8.9 Hz, H-1′ of *S*-gluc.), 5.22 (t, 1H, *J* = 8.9 Hz, H-2′ of *S*-gluc.), 5.07 (t, 1H, *J* = 8.4 Hz, H-3′ of *S*-gluc.), 5.06 (t, 1H, *J* = 8.3 Hz, H-4′ of *S*-gluc.), 4.70 (s, 2H, D_2O exchangeable NH_2 of *N*-gluc.), 5.00 (s, 2H, D_2O exchangeable NH_2 of *S*-gluc.), 4.38–4.02 (m, 4H, H-6′, H-6″ of *N*-gluc. and *S*-gluc.), 3.95 (m, 1H, H-5′ of *N*-gluc.), 3.72 (m, 1H, H-5′ of *S*-gluc.), 3.44 (t, 2H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 3.30 (t, 2H, *J* = 6.5 Hz, $SC\underline{H}_2CH_2$), 2.27 (m, 2H, $SCH_2C\underline{H}_2$), 2.12, 2.11, 2.07, 2.06, 2.05, 2.03, 2.02, 2.01 (8s, 3H each, CH_3CO); Ms: m/z 996 (M^+). Anal. Calcd. for $C_{35}H_{48}N_8O_{18}S_4$: C, 42.16; H, 4.85; N, 11.24. Found: C, 42.10; H, 4.83 N, 11.03.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino-4*H*-1,2,4-triazol-5-ylthio]-4-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-amino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (4b). Using the general procedure, **1b** gave **4b** (21%); R_f 0.67; mp 98°C; IR (KBr) 3336, 3217 (NH_2), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.98 (d, 1H, *J* = 9.3 Hz, H-1′ of *N*-gluc.), 5.76 (t, 1H, *J* = 9.3 Hz, H-2′ of *N*-gluc.), 5.37 (t, 1H, *J* = 9.4 Hz, H-3′ of *N*-gluc.), 5.23 (d, 1H, *J* = 8.7 Hz, H-1′ of *S*-gluc.), 5.22 (t, 1H, *J* = 9.6 Hz, H-4′ of *N*-gluc.), 5.05 (s, 2H, D_2O exchangeable NH_2 of *S*-gluc.), 5.04 (t, 1H, *J* = 8.7 Hz, H-2′ of *S*-gluc.), 5.02 (t, 1H, *J* = 8.6 Hz, H-3′ of *S*-gluc.), 4.97 (t, 1H, *J* = 8.3 Hz, H-4′ of *S*-gluc.), 4.75 (s, 2H, D_2O exchangeable NH_2 of *N*-gluc.), 4.30–4.03 (m, 4H, H-6′, H-6″ of *N*-gluc. and *S*-gluc.), 3.96 (m, 1H, H-5′ of *N*-gluc.), 3.79 (m, 1H, H-5′ of *S*-gluc.), 3.31(t, 2H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 3.08 (t, 2H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 2.18 (m, 4H, $SCH_2C\underline{H}_2$), 2.13, 2.12, 2.08, 2.07, 2.03, 2.02, 1.96, 1.95 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{36}H_{50}N_8O_{18}S_4$: C, 42.77; H, 4.98; N, 11.08. Found: C, 42.68; H, 4.99; N, 10.94.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-benzylideneamino-4*H*-1,2,4-triazol-5-ylthio]-3-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-benzylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (4c). Using the general procedure, **1c** gave **4c** (17%); R_f 0.69; mp 103–104°C; IR (KBr) 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.39 (s, 1H, CH=N of *N*-gluc.), 8.74 (s, 1H, CH=N of *S*-gluc.), 7.82 (m, 4H, ArH), 7.50 (m, 6H, ArH), 6.11 (d, 1H, *J* = 9.2 Hz, H-1′ of *N*-gluc.), 5.84 (t, 1H, *J* = 9.2 Hz, H-2′ of *N*-gluc.), 5.41 (d, 1H, *J* = 10.2 Hz, H-1′ of *S*-gluc.), 5.39 (t, 1H,

J = 9.2 Hz, H-3′ of *N*-gluc.), 5.24 (t, 1H, J = 9.5 Hz, H-4′ of *N*-gluc.), 5.22 (t, 1H, J = 9.8 Hz, H-2′ of *S*-gluc.), 5.12 (t, 1H, J = 9.4 Hz, H-3′ of *S*-gluc.), 5.08 (t, 1H, J = 9.3 Hz, H-4′ of *S*-gluc.), 4.14–4.00 (m, 4H, H-6′, H-6″ of *N*-gluc. and *S*-gluc.), 3.95 (m, 1H, H-5′ of *N*-gluc.), 3.79 (m, 1H, H-5′ of *S*-gluc.), 3.40 (t, 2H, J = 6.8 Hz, $SC\underline{H}_2CH_2$), 3.32 (t, 2H, J = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.19 (quintet, 2H, J = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.12, 2.09, 2.08, 2.05, 2.02, 1.97, 1.95, 1.98 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{49}H_{56}N_8O_{18}S_4$: C, 50.16; H, 4.81; N, 9.55. Found: C, 50.10; H, 4.75; N, 9.38.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-benzylideneamino-4*H*-1,2,4-triazol-5-ylthio]-4-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-benzylideneamino-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (4d). Using the general procedure, **1d** gave **4d** (22%); R_f 0.67; mp 78°C; IR (KBr) 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.41 (s, 1H, CH=N of *N*-gluc.), 8.76 (s, 1H, CH=N of *S*-gluc.), 7.85 (m, 4H, ArH), 7.51 (m, 6H, ArH), 6.17 (d, 1H, J = 9.3 Hz, H-1′ of *N*-gluc.), 5.84 (t, 1H, J = 9.3 Hz, H-2′ of *N*-gluc.), 5.44 (d, 1H, J = 10.2 Hz, H-1′ of *S*-gluc.), 5.41 (t, 1H, J = 9.4 Hz, H-3′ of *N*-gluc.), 5.28 (t, 1H, J = 9.0 Hz, H-4′ of *N*-gluc.), 5.25 (t, 1H, J = 10.0 Hz, H-2′ of *S*-gluc.), 5.18 (t, 1H, J = 9.9 Hz, H-3′ of *S*-gluc.), 5.11 (t, 1H, J = 9.9 Hz, H-4′ of *S*-gluc.), 4.32 (dd, 1H, J = 4.8, 12.6 Hz, H-6′ of *N*-gluc.), 4.24 (dd, 1H, J = 4.5, 12.7 Hz, H-6′ of *S*-gluc.), 4.16 (d, 1H, J = 12.0 Hz, H-5′ of *N*-gluc.), 4.03 (d, 1H, J = 12.3 Hz, H-5′ of *S*-gluc.), 3.84 (m, 1H, H-5′ of *N*-gluc.), 3.78 (m, 1H, H-5′ of *S*-gluc.), 3.36 (t, 2H, J = 6.4 Hz, $SC\underline{H}_2CH_2$), 3.13 (t, 2H, J = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.00 (quintet, 4H, J = 6.3 Hz, $SCH_2C\underline{H}_2$), 2.01, 1.99, 1.98, 1.97, 1.95, 1.94, 1.93, 1.92 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{50}H_{58}N_8O_{18}S_4$: C, 50.58; H, 4.92; N, 9.44. Found: C, 50.52; H, 4.77; N, 9.55.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-(4-methoxybenzylideneamino)-4*H*-1,2,4-triazol-5-ylthio]-3-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-(4-methoxybenzylideneamino)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (4e). Using the general procedure, **1e** gave **4e** (15%); R_f 0.67; mp 100–102°C; IR (KBr) 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.15 (s, 1H, CH=N of *N*-gluc.), 8.54 (s, 1H, CH=N of *S*-gluc.), 7.80 (d, 2H, J = 8.2 Hz, ArH of *N*-gluc.), 7.77 (d, 2H, J = 8.6 Hz, ArH of *S*-gluc.), 7.01 (d, 2H, J = 8.2 Hz, ArH of *N*-gluc.), 6.94 (d, 2H, J = 8.6 Hz, ArH of *S*-gluc.), 6.15 (d, 1H, J = 9.2 Hz, H-1′ of *N*-gluc.), 5.84 (t, 1H, J = 9.5 Hz, H-2′ of *N*-gluc.), 5.41 (d, 1H, J = 10.3 Hz, H-1′ of S-gluc.), 5.36 (t, 1H, J = 9.5 Hz, H-3′ of *N*-gluc.), 5.27 (t, 1H, J = 9.4 Hz, H-4′ of *N*-gluc.), 5.22 (t, 1H, J = 8.5 Hz, H-2′ of *S*-gluc.), 5.14 (t, 1H, J = 9.5 Hz, H-3′ of *S*-gluc.), 5.13 (t, 1H, J = 9.5 Hz, H-4′ of *S*-gluc.), 4.29 (dd, 1H, J = 4.8, 12.0 Hz, H-6′ of *N*-gluc.), 4.22 (dd, 1H, J = 1.8, 12.4 Hz, H-6′ of *S*-gluc.), 4.18 (dd, 1H, J = 2.0, 12.7 Hz, H-6″ of *N*-gluc.), 3.96 (ddd, 1H, J = 2.3, 4.9, 9.9 Hz, H-5′ of *N*-gluc.), 4.02 (dd, 1H, J = 1.8, 9.5 Hz, H-6″ of *S*-gluc.), 3.87 (s, 6H, OCH_3), 3.78 (ddd, 1H, J = 2.2, 4.7, 12.4 Hz, H-5′ of

S-gluc.), 3.28 (t, 2H, J = 6.4 Hz, $SC\underline{H}_2CH_2$), 3.19 (t, 2H, J = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.19 (quintet, 2H, J = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.13, 2.11, 2.08, 2.07, 2.05, 2.04, 2.03, 2.01 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{51}H_{60}N_8O_{20}S_4$: C, 49.67; H, 4.90; N, 9.09. Found: C, 49.74; H, 5.01; N, 8.92.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-(4-methoxybenzylideneamino)-4*H*-1,2,4-triazol-5-ylthio]-4-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-4-(4-methoxybenzylideneamino)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (4f). Using the general procedure, **1f** gave **4f** (18%); R_f 0.67 mp 97°C; IR (KBr) 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 10.17 (s, 1H, CH=N of *N*-gluc.), 8.59 (s, 1H, CH=N of *S*-gluc.), 7.81 (d, 2H, J = 8.4 Hz, ArH of *N*-gluc.), 7.79 (d, 2H, J = 8.5 Hz, ArH of *S*-gluc.), 6.99 (d, 2H, J = 8.4 Hz, ArH of *N*-gluc.), 6.96 (d, 2H, J = 8.5 Hz, ArH of *S*-gluc.), 6.18 (d, 1H, J = 9.6 Hz, H-1′ of *N*-gluc.), 5.87 (t, 1H, J = 9.4 Hz, H-2′ of *N*-gluc.), 5.39 (d, 1H, J = 10.1 Hz, H-1′ of *S*-gluc.), 5.35 (t, 1H, J = 9.4 Hz, H-3′ of *N*-gluc.), 5.28 (t, 1H, J = 9.6 Hz, H-4′ of *N*-gluc.), 5.20 (t, 1H, J = 8.6 Hz, H-2′ of *S*-gluc.), 5.14 (t, 1H, J = 9.8 Hz, H-3′ of *S*-gluc.), 5.11 (t, 1H, J = 9.9 Hz, H-4′ of *S*-gluc.), 4.28 (dd, 1H, J = 5.0, 12.5 Hz, H-6′ of *N*-gluc.), 4.23 (dd, 1H, J = 1.4, 12.5 Hz, H-6′ of *S*-gluc.), 4.17 (dd, 1H, J = 2.5, 12.8 Hz, H-6″ of *N*-gluc.), 3.96 (ddd, 1H, J = 2.5, 5.3, 9.7 Hz, H-5′ of *N*-gluc.), 4.04 (dd, 1H, J = 1.9, 9.1 Hz, H-6″ of *S*-gluc.), 3.87 (s, 6H, OCH_3), 3.76 (ddd, 1H, J = 2.2, 4.7, 12.4 Hz, H-5′ of *S*-gluc.), 3.29, (t, 2H, J = 6.4 Hz, $SC\underline{H}_2CH_2$), 3.17 (t, 2H, J = 6.3 Hz, $SC\underline{H}_2CH_2$), 2.16 (quintet, 4H, J = 6.4, Hz, $SCH_2C\underline{H}_2$), 2.09, 2.07, 2.06, 2.04 2.03, 2.02, 2.00, 1.99 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{52}H_{62}N_8O_{20}S_4$: C, 50.07; H, 5.01; N, 8.98. Found: C, 49.92; H, 5.02; N, 8.71.

1,3-bis[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino-4*H*-1,2,4-triazol-5-ylthio]propane (5a). Using the general procedure, **1a** gave **5a** (63%); R_f 0.15; mp 86°C; IR (KBr) 3348, 3298(NH_2), 1728 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.22 (d, 2H, J = 8.7 Hz, H-1′), 5.21 (t, 2H, J = 8.7 Hz, H-2′), 5.13 (s, 4H, D_2O exchangeable NH_2), 5.03 (t, 2H, J = 10.1 Hz, H-3′), 4.95 (t, 2H, J = 10.2 Hz, H-4′), 4.18 (d, 2H, J = 13.8 Hz, H-6′), 4.08 (dd, 2H, J = 5.7, 13.2 Hz, H-6″), 3.76 (ddd, 2H, J = 3.6, 9.5, 12.0 Hz, H-5′), 3.32 (t, 4H, J = 6.7 Hz, $SC\underline{H}_2CH_2$), 2.17 (quintet, 2H, J = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.10, 2.08, 2.00, 1.98 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{35}H_{48}N_8O_{18}S_4$: C, 42.16; H, 4.85; N, 11.24. Found: C, 42.00; H, 4.74; N, 10.97.

1,4-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-amino-4*H*-1,2,4-triazol-5-ylthio]butane (5b). Using the general procedure, **1b** gave **5b** (64%); R_f 0.09; mp 88°C; IR (KBr) 3330, 3228 (NH_2), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.22 (d, 2H, J = 8.7 Hz, H-1′), 5.07 (t, 2H, J = 8.7 Hz, H-2′), 5.05 (s, 4H, D_2O exchangeable NH_2), 5.03 (t, 2H, J = 8.7 Hz, H-3′), 4.98 (t, 2H, J = 8.3 Hz, H-4′), 4.19 (d, 2H, J = 13.4 Hz, H-6′), 4.07 (dd, 2H, J = 5.1, 13.5 Hz, H-

6″), 3.79 (ddd, 2H, *J* = 3.5, 9.3, 12.4 Hz, H-5′), 3.31 (t, 4H, *J* = 6.7 Hz, $SC\underline{H}_2CH_2$), 2.16 (quintet, 4H, *J* = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.11, 2.06, 2.01, 1.94 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{36}H_{50}N_8O_{18}S_4$: C, 42.77; H, 4.98; N, 11.08. Found: C, 42.57; H, 4.85; N, 10.87.

1,3-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-benzylideneamino-4*H*-1,2,4-triazol-5-ylthio]propane (5c). Using the general procedure, **1c** gave **5c** (69%); R_f 0.12; mp 82°C; IR (KBr) 1747 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.73 (s, 2H, CH=N), 7.85 (d, 4H, *J* = 7.7 Hz, ArH), 7.53 (m, 6H, ArH), 5.43 (d, 2H, *J* = 10.1 Hz, H-1′), 5.22 (t, 2H, *J* = 9.1 Hz, H-2′), 5.14 (t, 2H, *J* = 9.4 Hz, H-3′), 5.10 (t, 2H, *J* = 9.3 Hz, H-4′), 4.23 (dd, 2H, *J* = 4.7, 12.6 Hz, H-6′), 4.02 (d, 2H, *J* = 12.5 Hz, H-6″), 3.78 (ddd, 2H, *J* = 2.3, 4.6, 12.2 Hz, H-5′), 3.42 (t, 4H, *J* = 6.8 Hz, $SC\underline{H}_2CH_2$), 2.31 (quintet, 2H, *J* = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.05, 2.04, 2.02, 2.00 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{49}H_{56}N_8O_{18}S_4$: C, 50.16; H, 4.81; N, 9.55. Found: C, 50.22; H, 4.82; N, 9.51.

1,4-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-benzylideneamino-4*H*-1,2,4-triazol-5-ylthio]butane (5d). Using the general procedure, **1d** gave **5d** (62%); R_f 0.12; mp 91°C; IR (KBr) 1751 (CO acetate); ^1H NMR ($CDCl_3$) δ 8.72 (s, 2H, CH=N), 7.85 (d, 4H, *J* = 6.9 Hz, ArH), 7.51 (d, 6H, *J* = 7.5 Hz, ArH), 5.43 (d, 2H, *J* = 10.1 Hz, H-1′), 5.26 (t, 2H, *J* = 9.0 Hz, H-2′), 5.14 (t, 2H, *J* = 9.6 Hz, H-3′), 5.10 (t, 2H, *J* = 9.6 Hz, H-4′), 4.22 (dd, 2H, *J* = 1.2, 12.3 Hz, H-6′), 4.02 (d, 2H, *J* = 9.0 Hz, H-6″), 3.76 (ddd, 2H, *J* = 2.3, 4.6, 12.2 Hz, H-5′), 3.30 (t, 4H, *J* = 6.8 Hz, $SC\underline{H}_2CH_2$), 2.28 (quintet, 4H, *J* = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.04, 2.02, 2.00, 1.98 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{50}H_{58}N_8O_{18}S_4$: C, 50.58; H, 4.92; N, 9.44. Found: C, 50.62; H, 4.87; N, 9.29.

1,3-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-(4-methoxybenzylideneamino)-4*H*-1,2,4-triazol-5-ylthio]propane (5e). Using the general procedure, **1e** gave ***5e***′ (73%); R_f 0.12; mp 87°C; IR (KBr) 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.45 (s, 2H, CH=N), 7.71 (d, 4H, *J* = 8.6 Hz, ArH), 6.89 (d, 4H, *J* = 8.7 Hz, ArH), 5.42 (d, 2H, *J* = 9.9 Hz, H-1′), 5.21 (t, 2H, *J* = 8.9 Hz, H-2′), 5.12 (t, 2H, *J* = 9.7 Hz, H-3′), 5.10 (t, 2H, *J* = 9.7 Hz, H-4′), 4.24 (dd, 2H, *J* = 1.1, 12.5 Hz, H-6′), 4.04 (d, 2H, *J* = 9.3 Hz, H-6″), 3.84 (s, 6H, OCH_3), 3.74 (ddd, 2H, *J* = 2.0, 4.6, 12.5 Hz, H-5′), 3.25 (t, 4H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.14 (quintet, 2H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.02, 2.00, 1.99, 1.95 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{51}H_{60}N_8O_{20}S_4$: C, 49.67; H, 4.90; N, 9.09. Found: C, 49.53; H, 4.81; N, 8.99.

1,4-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4-(4-methoxybenzylideneamino)-4*H*-1,2,4-triazol-5-ylthio]butane (5f). Using the general procedure, **1f** gave **5f** (70%); R_f 0.14; mp 65°C; IR (KBr)

1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.57 (s, 2H, CH=N), 7.79 (d, 4H, *J* = 8.8 Hz, ArH), 6.98 (d, 4H, *J* = 8.9 Hz, ArH), 5.41 (d, 2H, *J* = 10.1 Hz, H-1′), 5.20 (t, 2H, *J* = 8.6 Hz, H-2′), 5.13 (t, 2H, *J* = 9.8 Hz, H-3′), 5.11 (t, 2H, *J* = 9.9 Hz, H-4′), 4.22 (dd, 2H, *J* = 1.0, 12.4 Hz, H-6′), 4.00 (dd, 2H, *J* = 1.9, 9.1 Hz, H-6″), 3.87 (s, 6H, OCH_3), 3.78 (ddd, 2H, *J* = 2.2, 4.7, 12.4 Hz, H-5′), 3.29 (t, 4H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.16 (quintet, 4H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.00, 1.99, 1.96, 1.93 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{52}H_{62}N_8O_{20}S_4$: C, 50.07; H, 5.01; N, 8.98. Found: C, 50.22; H, 4.96; N, 8.72.

Deamination of compounds 3a,b, 4a,b, and 5a,b. General procedure. To a cold stirred solution (at 0°C) of each of compounds **3a,b**, **4a,b** and **5a,b** (1 mmol) in acetic acid (10 mL) was added dropwise, while stirring, a solution of sodium nitrite (0.6 g in 1 mL water) over a period of 1 h. The reaction mixture was kept in the refrigerator overnight, diluted with an ice-water mixture (40 g) and left at room temperature for 1 h. The precipitate was collected by filtration and dried at room temperature. The filtrate was extracted by dichloromethane, washed with water (3 × 20 mL), and dried (Na_2SO_4). After evaporation of the solvent under reduced pressure, the formed residue was added to the previously collected dry precipitate and the combined crude product was recrystallised from dichloromethane/petroleum ether (bp 40–60°C) to give colorless crystals of compounds **10a,b**, **11a,b**, and **12a,b**.

1,3-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (10a). Using the general procedure, **3a** gave **10a** (90%); mp 89–91°C; IR (KBr) 3440 (NH), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.29 (s, 2H, D_2O exchangeable NH), 5.61 (d, 2H, *J* = 9.2 Hz, H-1′), 5.57 (t, 2H, *J* = 9.1 Hz, H-2′), 5.37 (t, 2H, *J* = 9.3 Hz, H-3′), 5.25 (t, 2H, *J* = 9.5 Hz, H-4′), 4.29 (dd, 2H, *J* = 4.8, 12.5 Hz, H-6′), 4.16 (dd, 2H, *J* = 2.5, 12.6 Hz, H-6″), 3.97 (ddd, 2H, *J* = 1.8, 5.1, 9.5 Hz, H-5′), 3.29 (t, 4H, *J* = 6.6 Hz, $SC\underline{H}_2CH_2$), 2.18 (quintet, 2H, *J* = 6.6 Hz, $SCH_2C\underline{H}_2$), 2.06, 2.03, 2.01, 1.91 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{35}H_{46}N_6O_{18}S_4$: C, 43.47; H, 4.79; N, 8.69. Found: C, 43.45; H, 4.65; N, 8.72.

1,4-*bis*[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (10b). Using the general procedure, **3b** gave **10b** (88%); mp 83°C; IR (KBr) 3400 (NH), 1747 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.23 (s, 2H, D_2O exchangeable NH), 5.64 (d, 2H, *J* = 8.9 Hz, H-1′), 5.53 (t, 2H, *J* = 9.3 Hz, H-2′), 5.36 (t, 2H, *J* = 9.0 Hz, H-3′), 5.25 (t, 2H, *J* = 9.1 Hz, H-4′), 4.27 (dd, 2H, *J* = 4.5, 12.7 Hz, H-6′), 4.18 (dd, 2H, *J* = 2.5, 12.6 Hz, H-6″), 3.95 (ddd, 2H, *J* = 1.9, 5.2, 9.3 Hz, H-5′), 3.22 (t, 4H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.18 (quintet, 4H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.10, 2.09, 2.08, 2.02 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{36}H_{48}N_6O_{18}S_4$: C, 44.07; H, 4.93; N, 8.57. Found: C, 39.82; H, 4.91; N, 8.39.

1-[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4*H*-1,2,4-triazol-5-ylthio]-3-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]propane (11a). Using the general procedure, **4a** gave **11a** (78%); mp 78°C; IR (KBr) 3476 (NH), 1755 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.38, 8.20 (2s, 2H, D_2O exchangeable NH), 5.62 (d, 1H, *J* = 9.4 Hz, H-1′ of *N*-gluc.), 5.58 (t, 1H, *J* = 9.2 Hz, H-2′ of *N*-gluc.), 5.38 (t, 1H, *J* = 9.4 Hz, H-3′ of *N*-gluc.), 5.36 (d, 1H, *J* = 8.9 Hz, H-1′ of *S*-gluc.), 5.26 (t, 1H, *J* = 9.3 Hz, H-4′ of *N*-gluc.), 5.24 (t, 1H, *J* = 8.9 Hz, H-2′ of *S*-gluc.), 5.13 (t, 1H, *J* = 8.6 Hz, H-3′ of *S*-gluc.), 5.12 (t, 1H, *J* = 8.3 Hz, H-4′ of *S*-gluc.), 4.36-4.00 (m, 4H, H-6′, H-6″ of *N*-gluc. and *S*-gluc.), 3.97 (m, 1H, H-5′ of *N*-gluc), 3.85 (m, 1H, H-5′ of *S*-gluc), 3.24 (t, 4H, *J* = 6.5 Hz, $SC\underline{H}_2CH_2$), 2.17 (quintet, 2H, *J* = 6.5 Hz, $SCH_2C\underline{H}_2$), 2.08, 2.06, 2.05, 2.03, 1.99, 1.97, 1.95 1.91 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{35}H_{46}N_6O_{18}S_4$: C, 43.47; H, 4.79; N, 8.69. Found: C, 43.41; H, 4.84; N, 8.66.

1-[3-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosylthio)-4*H*-1,2,4-triazol-5-ylthio]-4-[2-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio]butane (11b). Using the general procedure, **4b** gave **11b** (79%); mp 82°C; IR (KBr) 3400 (NH), 1747 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.24, 8.20 (2s, 2H, D_2O exchangeable NH), 5.64 (d, 1H, *J* = 8.9 Hz, H-1′ of *N*-gluc.), 5.53 (t, 1H, *J* = 9.3 Hz, H-2′ of *N*-gluc.), 5.36 (t, 1H, *J* = 9.0 Hz, H-3′ of *N*-gluc.), 5.32 (d, 1H, *J* = 9.5 Hz, H-1′ of *S*-gluc.), 5.26 (t, 1H, *J* = 9.1 Hz, H-4′ of *N*-gluc.), 5.25 (t, 1H, *J* = 10.1 Hz, H-2′ of S-gluc.), 5.13 (t, 1H, *J* = 9.6 Hz, H-3′ of *S*-gluc.), 5.11 (t, 1H, *J* = 9.7 Hz, H-4′ of *S*-gluc.), 4.31-4.0 (m, 4H, H-6′, H-6″ of both *N*-gluc. and *S*-gluc.), 3.95 (m, 1H, H-5′ of *N*-gluc.), 3.87 (m, 1H, H-5′ of *S*-gluc.), 3.22 (t, 4H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.18 (quintet, 4H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.08, 2.06, 2.05, 2.04, 2.03, 2.01, 1.98, 1.97 (8s, 3H each, CH_3CO). Anal. Calcd. for $C_{36}H_{48}N_6O_{18}S_4$: C, 44.07; H, 4.93; N, 8.57. Found: C, 44.12; H, 4.84; N, 8.68.

1,3-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4*H*-1,2,4-triazol-5-ylthio]propane (12a). Using the general procedure, **5a** gave **12a** (74%); mp 68–70°C; IR (KBr) 3402 (NH), 1751 (CO acetate) cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.20 (s, 2H, D_2O exchangeable NH), 5.32 (d, 2H, *J* = 8.7 Hz, H-1′), 5.27 (t, 2H, *J* = 10.2 Hz, H-2′), 5.13 (t, 2H, *J* = 9.6 Hz, H-3′), 5.12 (t, 2H, *J* = 9.7 Hz, H-4′), 4.22 (m, 4H, H-6′, H-6″), 3.86 (ddd, 2H, *J* = 3.0, 6.9, 12.9 Hz, H-5′), 3.27 (t, 4H, *J* = 6.9 Hz, $SC\underline{H}_2CH_2$), 2.19 (quintet, 2H, *J* = 6.7 Hz, $SCH_2C\underline{H}_2$), 2.09, 2.05, 2.04, 2.01 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{35}H_{46}N_6O_{18}S_4$: C, 43.47; H, 4.79; N, 8.69. Found: C, 43.40; H, 4.62; N, 8.51.

1,4-*bis*[3-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosylthio)-4*H*-1,2,4-triazol-5-ylthio]butane (12b). Using the general procedure, **5b** gave **12b** (76%); mp 75–76°C; IR (KBr) 3400 (NH), 1747 (CO acetate) cm^{-1}; ^1H

NMR ($CDCl_3$) δ 8.21 (s, 2H, D_2O exchangeable NH), 5.31 (d, 2H, *J* = 9.5 Hz, H-1′), 5.25 (t, 2H, *J* = 10.1 Hz, H-2′), 5.13 (t, 2H, *J* = 9.6 Hz, H-3′), 5.11 (t, 2H, *J* = 9.7 Hz, H-4′), 4.23 (m, 4H, H-6′, H-6″), 3.84 (ddd, 2H, *J* = 3.0, 7.0, 12.7 Hz, H-5′), 3.22 (t, 4H, *J* = 6.4 Hz, $SC\underline{H}_2CH_2$), 2.17 (quintet, 4H, *J* = 6.4 Hz, $SCH_2C\underline{H}_2$), 2.07, 2.05, 2.03, 2.00 (4s, 6H each, CH_3CO). Anal. Calcd. for $C_{36}H_{48}N_6O_{18}S_4$: C, 44.07; H, 4.93; N, 8.57. Found: C, 43.99; H, 4.79; N, 8.36.

Deacetylation of compounds 3c,d, 4c,d, 5c,d, 10a,b, 11a,b, and 12a,b. General procedure. Dry gaseous ammonia was passed through a solution of each of compounds **3c,d**, **4c,d**, **5c,d**, **10a,b**, **11a,b**, and **12a,b** (1 mmol) in dry methanol (10 mL) for about 1 h with cooling and stirring then stirred at room temperature over night. The resulting mixture was then concentrated at reduced pressure to afford a solid residue which was washed several times via boiling in chloroform (100 mL) and decantation. The residue was dried at room temperature, column chromatographed (chloroform→20% methanol/chloroform), and recrystallized from methanol to give pale crystals of compounds **13a–d**, **14a–d**, and **15a–d**. R_f values of the latter compounds were determined using TLC aluminum sheets and chloroform/methanol (60:40, v/v) as a developing system.

1,3-*bis*(4-benzylideneamino-2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)propane (13a). Using the general procedure, **3c** gave **13a** (95%); R_f 0.90; mp 188°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 9.99 (s, 2H, CH=N), 7.90 (d, 4H, *J* = 8.1 Hz, ArH), 7.58 (m, 6H, ArH), 5.66 (d, 2H, *J* = 9.0 Hz, H-1′), 5.27, 5.20, 5.15, 4.61 (4 brs, 2H each, D_2O exchangeable OH), 3.86 (t, 2H, *J* = 9.2 Hz, H-2′), 3.67 (t, 2H, *J* = 9.1 Hz, H-3′), 3.62–3.07 (m, 12H, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 2.18 (quintet, 2H, *J* = 6.6 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{33}H_{40}N_8O_{10}S_4$: C, 47.36; H, 4.82; N, 13.39. Found: C, 47.31; H, 4.77; N, 13.24.

1,4-*bis*(4-benzylideneamino-2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)butane (13b). Using the general procedure, **3d** gave **13b** (81%); R_f 0.94; mp 202°C; IR (KBr) 3400–2245 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 9.97 (s, 2H, CH=N), 7.91 (dd, 4H, *J* = 1.8, 7.3 Hz, ArH), 7.59 (m, 6H, ArH), 5.68 (d, 2H, *J* = 9.3 Hz, H-1′), 5.30 (brs, 4H, D_2O exchangeable OH), 5.12, 4.66 (2 brs, 2H each, D_2O exchangeable OH), 3.87 (t, 2H, *J* = 9.2 Hz, H-2′), 3.68 (t, 2H, *J* = 9.1 Hz, H-3′), 3.61–3.18 (m, 12H, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 1.90 (br, 4H, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{34}H_{42}N_8O_{10}S_4$: C, 47.99; H, 4.97; N, 13.17. Found: C, 47.74; H, 4.73; N, 12.99.

1,3-*bis*(2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)propane (13c). Using the general procedure, **10a** gave **13c** (74%); R_f 0.89; mp 191–193°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.73 (s, 2H, D_2O exchangeable NH), 5.26 (d, 2H, *J* = 9.2 Hz, H-1′), 5.5–4.5

(br, 8H, D_2O exchangeable OH), 4.00–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 2.06 (quintet, 2H, J = 6.4 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{19}H_{30}N_6O_{10}S_4$: C, 36.18; H, 4.79; N, 13.32. Found: C, 36.14; H, 4.84; N, 13.24.

1,4-*bis*(2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)butane (13d). Using the general procedure, **10b** gave **13d** (79%); R_f 0.92; mp 177°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.68 (s, 2H, D_2O exchangeable NH), 5.24 (d, 2H, J = 8.7 Hz, H-1′), 6.00-3.80 (br, 8H, D_2O exchangeable OH), 3.74–3.09 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 1.75 (quintet, 4H, J = 6.4 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{20}H_{32}N_6O_{10}S_4$: C, 37.26; H, 5.00; N, 13.03. Found: C, 37.26; H, 4.98; N, 13.16.

1-(4-Benzylideneamino-3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)-3-(4-benzylideneamino-2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)propane (14a). Using the general procedure, **4c** gave **14a** (80%); R_f 0.51; mp 160°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 9.98 (s, 1H, CH=N of *N*-gluc.), 9.07 (s, 1H, CH=N of *S*-gluc.), 7.92 (m, 4H, ArH), 7.60 (m, 6H, ArH), 5.67 (d, 1H, J = 9.0 Hz, H-1′ of *N*-gluc.), 5.48 (d, 1H, J = 4.5 Hz, OH of *S*-gluc.), 5.27, 5.21, 5.16, (3 brs, 1H each, D_2O exchangeable OH of *N*-gluc.), 5.03, 4.99 (2 brs, 1H each, D_2O exchangeable OH of *S*-gluc.), 4.87 (d, 1H, J = 9.2 Hz, H-1′ of *S*-gluc.), 4.61 (brs, 1H, D_2O exchangeable OH of *N*-gluc.), 4.51 (brs, 1H, D_2O exchangeable OH of *S*-gluc.), 3.92–3.03 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$ of both *N*- and *S*-gluc.), 2.18 (quintet, 2H, J = 6.4 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{33}H_{40}N_8O_{10}S_4$: C, 47.36; H, 4.82; N, 13.39. Found: C, 47.24; H, 4.80; N, 13.42.

1-(4-Benzylideneamino-3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)-4-(4-benzylideneamino-2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)butane (14b). Using the general procedure, **4d** gave **14b** (77%); R_f 0.57; mp 213°C; ^1H NMR (DMSO-d_6) δ 9.97 (s, 1H, CH=N of *N*-gluc.), 9.09 (s, 1H, CH=N of *S*-gluc.), 7.93 (m, 4H, ArH), 7.60 (m, 6H, ArH), 5.67 (d, 1H, J = 9.1 Hz, H-1′ of *N*-gluc.), 5.32 (d, 1H, J = 4.6 Hz, D_2O exchangeable OH of *N*-gluc.), 5.23 (t, 1H, J = 5.1 Hz, D_2O exchangeable 6′-OH of *N*-gluc.), 5.12 (d, 1H, J = 5.2 Hz, D_2O exchangeable OH of *N*-gluc.), 5.05 (d, 1H, J = 4.9 Hz, D_2O exchangeable OH of *N*-gluc.), 4.89 (d, 1H, J = 9.1 Hz, H-1′ of *S*-gluc.), 4.67 (d, 1H, J = 5.12 Hz, D_2O exchangeable OH of *S*-gluc.), 4.66 (t, 1H, J = 4.6 Hz, D_2O exchangeable 6′-OH of *S*-gluc.), 4.57 (d, 1H, J = 5.2 Hz, D_2O exchangeable OH of *S*-gluc.), 4.53 (d, 1H, J = 4.5 Hz, D_2O exchangeable OH of *S*-gluc.), 3.67–3.03 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$ of both *N*- and *S*-gluc.), 1.84 (m, 4H, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{34}H_{42}N_8O_{10}S_4$: C, 47.99; H, 4.97; N, 13.17. Found: C, 47.81; H, 4.84; N, 13.09.

1-(3-β-D-Glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)-3-(2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)-propane (14c). Using the general procedure, **11a** gave **14c** (71%); R_f 0.56; mp 220°C; IR (KBr) 3400–3245 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.74 (s, 2H, D_2O exchangeable NH), 5.26 (d, 1H, J = 9.2 Hz, H-1′ of *N*-gluc.), 5.01 (d, 1H, J = 9.5 Hz, H-1′ of *S*-gluc.), 5.55–4.45 (br, 8H, D_2O exchangeable OH), 4.00–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$ of both *N*- and *S*-gluc.), 2.01 (quintet, 2H, J = 6.3 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{19}H_{30}N_6O_{10}S_4$: C, 36.18; H, 4.79; N, 13.32. Found: C, 36.22; H, 4.71; N, 13.45.

1-(3-β-D-Glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)-4-(2-β-D-glucopyranosyl-2,4-dihydro-3-thioxo-3*H*-1,2,4-triazol-5-ylthio)butane (14d). Using the general procedure, **11b** gave **14d** (75%); R_f 0.52; mp 94–95°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.68, 8.23 (2s, 2H, D_2O exchangeable NH), 5.23 (d, 1H, J = 8.7 Hz, H-1′ of *N*-gluc.), 4.94 (d, 1H, J = 9.30 Hz, H-1′ of *S*-gluc.), 5.98–3.95 (br, 8H, D_2O exchangeable OH), 3.79–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$ of both *N*- and *S*-gluc.), 1.77 (quintet, 4H, J = 6.4 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{20}H_{32}N_6O_{10}S_4$: C, 37.26; H, 5.00; N, 13.03. Found: C, 37.18; H, 5.02; N, 12.98.

1,3-*bis*(4-benzylideneamino-3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)propane (15a). Using the general procedure, **5c** gave **15a** (83%); R_f 0.16; mp 143°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 9.09 (s, 2H, CH=N), 7.92 (m, 4H, ArH), 7.60 (m, 6H, ArH), 5.48 (d, 2H, J = 4.5 Hz, D_2O exchangeable OH), 5.05, 4.98 (2brs, 2H each, D_2O exchangeable OH), 4.88 (d, 2H, J = 9.0 Hz, H-1′), 4.52 (t, 2H, J = 4.6 Hz, D_2O exchangeable 6′-OH), 3.89–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 2.18 (quintet, 2H, J = 6.4 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{33}H_{40}N_8O_{10}S_4$: C, 47.36; H, 4.82; N, 13.39. Found: C, 47.43; H, 4.75; N, 13.26.

1,4-*bis*(4-benzylideneamino-3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)butane (15b). Using the general procedure, **5d** gave **15b** (77%); R_f 0.11; mp 156°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 9.10 (s, 2H, CH=N), 7.91 (m, 4H, ArH), 7.57 (m, 6H, ArH), 4.87 (d, 2H, J = 9.2 Hz, H-1′), 4.69 (d, 2H, J = 5.0 Hz, D_2O exchangeable OH), 4.67 (t, 2H, J = 4.8 Hz, D_2O exchangeable 6′-OH), 4.57 (d, 2H, J = 5. 1 Hz, D_2O exchangeable OH), 4.54 (d, 2H, J = 4.8 Hz, D_2O exchangeable OH), 3.71–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 1.81 (m, 4H, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{34}H_{42}N_8O_{10}S_4$: C, 47.99; H, 4.97; N, 13.17. Found: C, 48.02; H, 4.71; N, 13.36.

1,3-*bis*(3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)propane (15c). Using the general procedure, **12a** gave **15c** (74%); R_f 0.17; mp 133°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.72 (s, 2H, D_2O

exchangeable NH), 5.00 (d, 2H, J = 9.5 Hz, H-1′), 5.55–4.45 (br, 8H, D_2O exchangeable OH), 4.00–3.00 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 2.02 (quintet, 2H, J = 6.3 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{19}H_{30}N_6O_{10}S_4$: C, 36.18; H, 4.79; N, 13.32. Found: C, 36.14; H, 4.87; N, 13.41.

1,4-*bis*(3-β-D-glucopyranosylthio-4*H*-1,2,4-triazol-5-ylthio)butane (15d). Using the general procedure, **12b** gave **15d** (80%); R_f 0.15; mp 149–151°C; IR (KBr) 3600–3200 (OH) cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.22 (s, 2H, D_2O exchangeable NH), 4.96 (d, 2H, J = 9.3 Hz, H-1′), 5.55–4.45 (br, 8H, D_2O exchangeable OH), 4.01–3.07 (m, 16H, H-2′, H-3′, H-4′, H-6′, H-6″, H-5′, $SC\underline{H}_2CH_2$), 1.75 (quintet, 4H, J = 6.3 Hz, $SCH_2C\underline{H}_2$). Anal. Calcd. for $C_{20}H_{32}N_6O_{10}S_4$: C, 37.26; H, 5.00; N, 13.03. Found: C, 37.30; H, 4.92; N, 13.14.

REFERENCES

1. Jones, D.H.; Slack, R.; Squires, S.; Wooldridge, K.R.H. Antiviral chemotherapy. I. The activity of pyridine and quinoline derivatives against neurovaccina in mice. J. Med. Chem. **1965**, *8*, 676–680.
2. Goswami, B.N.; Kataky, J.C.S.; Baruah, J.N. Synthesis and antibacterial activity of 1-(2,4-dichlorobenzoyl)-4-substituted thiosemicarbazides, 1,2,4-triazoles and their methyl derivatives. J. Heterocycl. Chem. **1984**, *21*, 1225–1229.
3. Holla, B.S.; Kalluraya, B.; Sridhar, K.R. Synthesis of 4-(5-nitro-2-furfurylidene)amino-3-mercapto-5-(substituted)-1,2,4-triazoles as possible antibacterial agents. Curr. Sci. **1987**, *56*, 236–238.
4. Abdou, N.A.; Amin, F.M. Synthesis and biological activity of certain 5-mercapto-3-(3-pyridyl)-4*H*-1,2,4-triazole derivatives. Mansoura J. Pharm. Sci. **1990**, *6*, 25–29.
5. Mishra, R.K.; Tewari, R.K.; Srivastava, S.K.; Bahel, S.C. Synthesis and antifungal activity of some 1,4-disubstitued-thiosemicarbazides, 2,5-disubstituted-1,3,4-thiadiazoles and 3,4-disubstituted-5-mercapto-1,2,4-triazoles. J. Indian Chem. Soc. **1991**, *68*, 110–112.
6. Unangst, P.C.; Shurum, G.P.; Connor, D.T.; Dyer, R.D.; Schrier, D.J. Novel 1,2,4-oxadiazoles and 1,2,4-thiadiazoles as dual 5-lipoxygenase and cyclooxygenase inhibitors. J. Med. Chem. **1992**, *35*, 3691–3698.
7. Mullican, M.D.; Wilson, M.W.; Connor, D.T.; Kostlan, C.R.; Schrier, D.J.; Dyer, R.D. Design of 5-(3,5-di-*tert*-butyl-4-hydroxyphenyl)-1,3,4-thiadiazoles, -1,3,4-oxadiazoles, and -1,2,4-triazoles as orally active, nonulcerogenic antiinflammatory agents. J. Med. Chem. **1993**, *36*, 1090–1099.
8. Sugden, J.K.; Yoloye, T.O. Medicinal applications of indole derivatives. Pharm. Acta Helv. **1978**, *53*, 65–92.
9. Shams El-Dine, Sh.A.; Hazzaa, A.A.B. Synthesis of compounds with potential fungicidal activity. Pharmazie **1974**, *29*, 761–763.
10. Misato, T.; Ko, K.; Honma, Y.; Konno, K.; Taniyama, E. 1,3,4-Thiadiazole derivatives as fungicides. Chem. Abstr. **1977**, *87*, 147054a.
11. Cansiz, A.; Servi, S.; Koparir, M.; Altintas, M.; Digrak, M. J. Chem. Soc. Pak. **2001**, *23*, 237–239.
12. Stillings, M.R.; Welbourn, A.P.; Walter, D.S. Substituted 1,3,4-thiadiazoles with anticonvulsant activity. 2. Aminoalkyl derivatives. J. Med. Chem. **1986**, *29*, 2280–2284.
13. Kane, J.M.; Dudley, M.W.; Sorensen, S.M.; Miller, F.P. 2,4-Dihydro-3*H*-1,2,4-triazole-3-thiones as potential antidepressant agents. J. Med. Chem. **1988**, *31*, 1253–1258.
14. Witkowski, J.T.; Robins, R.K.; Sidwell, R.W.; Simon, L.N. Design, synthesis, and broad spectrum antiviral activity of 1-β-D-ribofuranosyl-1,2,4-triazole-3-carboxamide and related nucleosides. J. Med. Chem. **1972**, *15*, 1150–1154.
15. *The Pharmacology of Ribavirin*; Smith, R.A., Kirkpatrick, W., Eds.; Academic Press: London, 1980; 133–156.
16. *In Vitro and In Vivo Inhibition of DNA Viruses by Ribavirin*; Sidwell, R.W., Ed.; Academic Press: Orlando, FL, 1984; 19–32.
17. *Clinical Applications of Ribavirin*; Smith, R.A., Knight, V., Smith, J.A.D., Eds.; Academic Press: Orlando, FL, 1984; 222.
18. Ibrahim, Y.A.; Behbeheni, H.; Khalil, N.S. Efficient route to 20–32 membered macrocyclic crown diamides via ring closing metathesis. Tetrahedron **2004**, *60*, 8429–8436, and references cited therein.

19. *Drug Design*; Ariens, E.J., Ed.; Academic Press: New York, 1971; 2–4.
20. Khalil, N.S.A.M.; Mansour, A.K.; Eid, M.M. Synthesis of some novel 6-benzyl(or substituted benzyl)-2-β-D-glucopyranosyl-1,2,4-triazolo[4,3-*b*][1,2,4]triazines as potential antimicrobial chemotherapeutics. Nucleosides Nucleotides Nucleic Acids **2004**, *23*, 1889–1910.
21. Khalil, N.S.A.M. Synthesis of some novel *N*-ribosyl-1,2,4-triazin-6(1*H*)- ones or thiones as potential antibacterial and antifungal chemotherapeutics. Nucleosides Nucleotides Nucleic Acids **2005**, *24*, 111–120.
22. Khalil, N.S.A.M. Synthesis of novel α-L-arabinopyranosides of monocyclic β-lactams with potential antimicrobial activity. Nucleosides Nucleotides Nucleic Acids **2005**, *in press*.
23. Mansour, A.K.; Eid, M.M.; Khalil, N.S.A.M. Selective synthesis and reactions of 6-substituted-2-β-galactosyl-1,2,4-triazines of potential anticancer activity. Nucleosides Nucleotides Nucleic Acids **2003**, *22*, 21–44.
24. Mansour, A.K.; Eid, M.M.; Khalil, N.S.A.M. Synthesis of some new 2-α-L-arabinopyranosyl-1,2,4-triazines as potential antitumor chemotherapeutics. Nucleosides Nucleotides Nucleic Acids **2003**, *22*, 1805–1823.
25. Mansour, A.K.; Eid, M.M.; Khalil, N.S.A.M. Synthesis of some *N*-galactosides of 3-aryl-5-benzyl(or substituted benzyl)-1,2,4-triazin-6(1*H*)- ones or thiones of expected biological activity. Nucleosides Nucleotides Nucleic Acids **2003**, *22*, 1825–1833.
26. Mansour, A.K.; Eid, M.M.; Khalil, N.S.A.M. Synthesis and reactions of some new heterocyclic carbohydrazides and related compounds as potential anticancer agents. Molecules **2003**, *8*, 744–755.
27. Mansour, A.K.; Ibrahim, Y.A.; Khalil, N.S.A.M. Selective synthesis and structure of 6-arylvinyl-2- and 4-glucosyl-1,2,4-triazines of expected interesting biological activity. Nucleosides Nucleotides **1999**, *18*, 2265–2283.
28. Ibrahim, Y.A.; Abbas, A.A.; Elwahy, A.H.M. Selective synthesis and structure of 2-*N*- and 3-*S*-glucosyl-1,2,4-triazoles of potential biological interest. Carbohydr. Lett. **1999**, *35*, 331–338.
29. Cleve, G.; Hoyer, G.A.; Schulz, G.; Vorbrueggen, H. Synthesis of nucleosides. VIII. NMR and CD spectra of pyrimidine nucleosides and their 2-thio analogs. Chem. Ber. **1973**, *106*, 3062–3072.
30. Ahmed, A.A.M. Synthesis and reactions of some new bis(heterocycles) and hetero macrocycles using versatile starting materials. M.Sc. Thesis; Faculty of Science, Department of Chemistry, Cairo University: Giza, Egypt, 2004.
31. *Vogel's Textbook of Practical Organic Chemistry*, 4th Ed.; Furniss, B.S., Hannaford, A.J., Rogers, V., Smith, P.W.G., Tatchell, A.R., Eds.; Longman Group Limited: Harlow, UK, 1978; 457.