SYNTHESIS OF 1-GLYCOSYL DERIVATIVES OF BENZOCAMALEXIN

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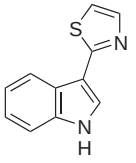
The linear synthesis of 1-(β-D-glucopyranosyl)-, 1-(β-D-galactopyranosyl)-, 1-(β-D-mannopyranosyl)- and 1-(β-D-ribofuranosyl)benzocamalexin was elaborated from indoline as a starting compound and corresponding pentaacetylhexoses or 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-D-ribose as suitable glycosyl donors.

Keywords: Indole; Glycosides; Nucleosides; Phytoalexins; Camalexin; Benzocamalexin; Natural products; Plant hormones; Alkaloids.

The synthesis of indole *N*-glycosides appeared to be of a great importance after isolation of indole nucleoside antibiotics such as rebeccamycin[1], staurosporin[2], neosidomycin[3] and SF-2140 [3b–3d,4]. In addition, indole nucleosides are the targets for synthesis of new compounds with attractive biological effects[5].

Benzocamalexin **2** is a simple analog of camalexin **1** which is a unique representative of phytoalexins biosynthesized by a few wild crucifers e.g. *Camelina sativa* and *Arabidopsis thaliana*[6]. Camalexin exhibits antifungal activities against *Alternaria brassicae Cladosporium* sp. or *Alternaria brassicicola*[6a,6b] and a significant cytotoxic activity against human breast cancer cell line SKBr3 [7]. Phytoalexins form a part of the induced chemical defence of plants in response to several forms of stress, including microbial attack[8]. Synthesis of benzocamalexin was reported[9,10]; however, its biological activity was not examined because of its poor solubility in aqueous medium[10]. In accord with our interest in the synthesis of nucleoside analogs derived from indole phytoalexins, we have also studied the synthesis of

1-glycosyl derivatives of benzocamalexin. Since a good method of enhancing water solubility of poorly soluble indoles is the preparation of corresponding *N*-glycosides[5e], the enhanced solubility of benzocamalexin *N*-glycosides compared with benzocamalexin itself is also expected.



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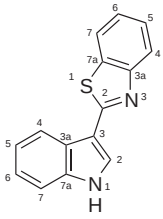

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The main goal of the present work was the synthesis of four 1-glycosylbenzocamalexins derived from D-glucose, D-galactose, D-mannose and D-ribose. We decided for a linear approach, using the so-called indoline-indole method[11], which offers the possibility to take advantage of enhanced nucleophilicity of indoline in comparison with the less nucleophilic indole ring. High reactivity of indoline facilitates its reaction with either unprotected saccharides or their peracetylated, commercially and synthetically easily accessible derivatives[11,12].

Preparation of starting indoline *N*-glycosides **4a**–**4d** (Scheme 1) derived from hexoses was performed using improved described syntheses[13]. Using methanol instead of ethanol and also employing column chromatography for purification of the prepared compounds instead of recrystallization allowed us to prepare corresponding 1-glycosylindolines in higher yields – **4a** (85%), **4b** (69%) as well as mixture of anomers **4c** and **4d** (77%) instead of the described 74% (**4a**), 58% (**4b**) and 26% (mixture of anomers **4c** and **4d**). In the previous work[13c], formation of two anomers **4c** and **4d** was described; however, the anomers were not separated and their ratio was not given. In our case, ^{1}H NMR spectrum of the reaction mixture after work-up revealed the ratio of **4c**:**4d** = 1.65:1, deduced from integrated intensities of the signals assigned to anomeric protons. After several unsuccessful attempts to separate anomers **4c** and **4d**, it appeared that complete separation by flash chromatography is not possible because of fast epimerization of **4c** and **4d** on silica gel. Anyway, pure **4c** and **4d** were obtained in low yields by flash chromatography and subjected to detailed ^{1}H NMR and ^{13}C NMR analyses including HH COSY, HMQC and NOE difference experiments. In the case of 1-(β-ribofuranosyl)indoline **4e** (Scheme 1) the use of starting 1,2,3,5-tetra-*O*-acetyl-D-ribofuranose did not seem advantageous since its reaction with indoline was described to produce only 1-acetylindoline as

sole product[11]. In contrast, the formation of *N*-glycosidic bond could be achieved by the reaction of 1-*O*-acetyl-2,3,5-tri-*O*-benzoyl-D-ribofuranose (**10d**, Scheme 1) with indoline, as reported[13b]. Although compound **10d** can be obtained in a three-step procedure in 96% yield[14], its reaction with indoline in ethanol was described to afford only 45% yield of 1-ribofuranosylindoline derivative **4e** [13b] (Scheme 1). We have found that a change of the solvent can significantly improve the yield of desired product **4e**. The best yield (84%) was obtained in chloroform after reflux for 24 h (Table I, entry 4).

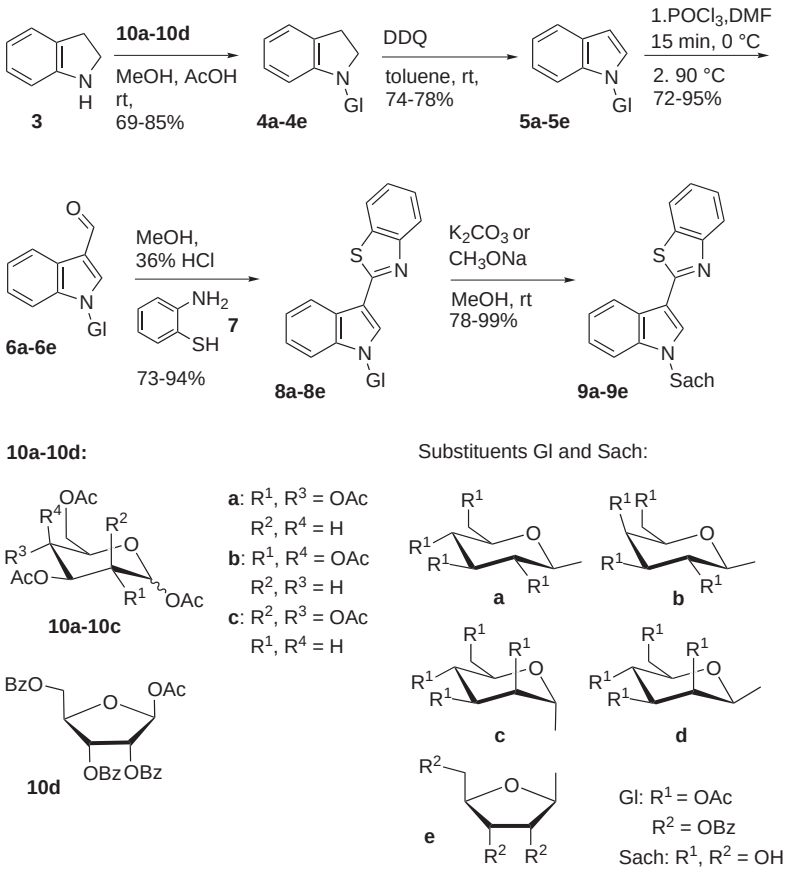
After preparation of 1-glycosylindolines **4a**–**4e**, our synthesis continued with further aglycon transformations. Oxidation of indoline *N*-glycosides with 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) was carried out under similar conditions as published for **4a** [13b,13d], **4b** [13c] and **4e** [13b]. In all cases using toluene as a solvent at room temperature instead of boiling *m*-xylene[13b–13d] provided comparable yields of **5a** (87%), **5e** (76%) and improved the yield of **5b** (85%) compared with the published 48% [13c]. Oxidation of a mixture of 1-(α-mannopyranosyl)- **4c** and 1-(β-mannopyranosyl)indoline **4d** provided a mixture of both 1-mannopyranosylindoles **5c** and **5d** in the ratio α:β = 1.3:1 and an overall yield of 74% after work-up. The previously not described 1-mannopyranosylindoles appeared more stable than indolines **4c** and **4d** and their separation by column chromatography afforded compounds **5c** (42%) and **5d** (32%).

The mixture of indoles **5c** and **5d** is enriched in β-anomer compared to indolines **4c** and **4d**. To explain this fact oxidations of isolated compound **4c** and **4d** was performed. Compound **4c** afforded a 2:1 mixture of **5c** and **5d** whereas compound **4d** gave the sole product **5d**. Hence α-anomer **4c** appeared to be less stable during the oxidation reaction, presumably because of a dehydrogenation under the effect of DDQ usually accompanied by

TABLE I
Influence of solvent on the yield of ribosylation in the reaction of indoline with **10d**

Entry	Solvent	Reaction time, h	Yield, %
1	EtOH	6.5	45
2	MeOH	8	26
3	CH_2Cl_2	48	54
4	$CHCl_3$	24	84

anomerization[11]. Instability of α-anomer **4c** was observed also during NMR measurement. ^{1}H NMR spectrum taken after dissolution showed the presence of a single compound. After some time required for HH COSY, HMQC and NOE measurements, ca. 20% of β-anomer **4d** was present. During the same NMR measurements with pure **4d**, no signals of α-anomer appeared in spectra. The epimerization of α-anomer **4c** in $CDCl_3$ solution is proposed via acid catalyzed ring opening and subsequent cyclization[11] proceeded to the thermodynamically more stable β-isomer **4b**. On the basis of these observations, **4c** could be designated as a kinetic and **4b** as a thermodynamic product in the indoline glycosidation reaction (Scheme 1).



SCHEME 1

The prepared indoles **5a**–**5e** were subjected to the Vilsmeier reaction according to the described preparation of 1-(2,3,4,6-tetra-*O*-acetyl-β-D-glucopyranosyl)indole-3-carbaldehyde[15] (**6a**). Using the same conditions, aldehydes **6a** (83%), **6b** (72%), **6c** (85%), **6d** (77%) and **6e** (95%) were obtained in good to excellent yields. During the Vilsmeier formylation further epimerization of indoles **5c** and **5d** was not observed. The prepared indole-3-carbaldehydes are key intermediates with reactive aldehyde groups, which allow further functional transformations. The reaction of aldehydes and ketones with suitably substituted 2-aminobenzenethiols provides a wide range of benzothiazoles. Previous works used this reaction for preparation of unsubstituted[9] and 1-substituted[10] benzocamalexins. We extended this method into the area of 1-glycosides.

Cyclocondensation of indole-3-carbaldehydes **6b**–**6e** with 2-aminobenzenethiol (**7**) in methanol in the presence of a catalytic amount of 36% aqueous HCl afforded, after 15 min at room temperature (**6a** required reflux for 30 min), good yields of benzocamalexins **8a** (83%), **8b** (94%), **8c** (81%), **8d** (73%) and **8e** (81%) (Scheme 1).

Appropriate benzocamalexin derivatives for biological screening were afforded by final deprotection. This was achieved by treatment of peracetylated compounds **8a**–**8d** with a catalytic amount of powdered K_2CO_3 in methanol[14] at room temperature for 1–4 h. This efficient deprotection afforded new, to date not described 1-glycopyranosylbenzocamalexins **9a** (99%), **9b** (96%), **9c** (93%) and **9d** (91%) in excellent yields. The removal of benzoyl groups of **8e** with 0.1 M solution of sodium methoxide in dry methanol[16] afforded 1-(β-ribofuranosyl)benzocamalexin **9e** (78%) (Scheme 1).

The structure of the prepared nucleoside analogs was confirmed by spectral methods. In ^{1}H and ^{13}C NMR spectra, the signals were assigned on the basis of 2D H-H COSY and HMQC heterocorrelated spectra. The β-anomeric configuration of new glucopyranosyl **8a**, **9a** and new galactopyranosyl derivatives **6b**–**9b** (Scheme 1) was confirmed by vicinal *trans*-diaxial coupling constants $J(1,2)$ = 9.0–11.9 Hz.

In starting mannopyranosides **4c** and **4d**, the anomeric configuration was determined in literature[13c] only on the basis of coupling constants of anomeric protons. The data published for H-1′ of α-anomer are δ 4.89 ppm, d, $J(1,2) \approx 1$ Hz and those for β-anomer are δ 4.78 ppm, d, $J(1,2)$ = 2.4 Hz. In our opinion the values of coupling constants are too close to make a reliable assignment. Therefore we performed NOE experiments with **4c** and **4d** (Fig. 1). In the case of **4d**, the irradiation of anomeric proton H-1′ markedly increased the intensity of signals H-5′ (14.3%) and the opposite irradiation

of H-5′ resulted in increased intensity of the H-1′ signal (11.8%). The observed NOE between H-5′ and H-1′ evidences their *cis*-diaxial orientation of H-1′ and H-5′ and thus confirms the β-anomeric configuration of **4d**. NOE experiments performed with compound **4c** revealed no interaction between H-1′ and H-5′ contrary to the previous case. Irradiation of the H-5′ signal increased only the intensity of the H-3′ signal (5.8%) related to their *cis*-diaxial orientation. Irradiation of H-1′ enhanced only signals of H-2′ (4.8%) related to their proximity and H-7 (4.5%) but again with no influence on the H-5′ signal. The absence of these interactions, so remarkable in the previous case, indicates that H-1′ and H-5′ are on the opposite sides of the mannopyranosyl ring and **4c** has α-anomeric configuration.

The results are opposite to those presented in the literature[13c] and our ^{1}H NMR spectra of **4c** and **4d** do not correspond with the published ones. New data for the H-1′ shift of α-anomer **4c** are δ 4.79 ppm, d, J(1,2) = 2.2 Hz and for β-anomer **4d** δ 4.91 ppm, J(1,2) = 1.1 Hz. Consequently, the correct assignment of α- and β-configuration for compounds **4c** and **4d** is opposite.

Reliable determination of configuration of **4c** and **4d** on the basis of NOE experiments allowed us to apply coupling constants of anomeric protons also to other synthesized mannopyranosides. Thus compounds **5c**–**9c**, showing coupling constants J(1,2) = 2.2–3.6 Hz, were assigned as α-anomers whereas compounds **5d**–**9d** with J(1,2) = 0–1.1 Hz were assigned as β-anomers. This conclusion was confirmed by NOE experiments with α-**8c**, J(1,2) = 3.5 Hz and β-**8d**, J(1,2) = 1.1 Hz (Fig. 2).

In the case of ribofuranosides the synthesis started from described β-anomers of **4e** and **5e** [13b]. Since during the synthetic path from **4e** to **9e** no epimerization was observed, the prepared compounds **6e**, **8e** and **9e** should possess β-configuration. This presumption arose from the similarity

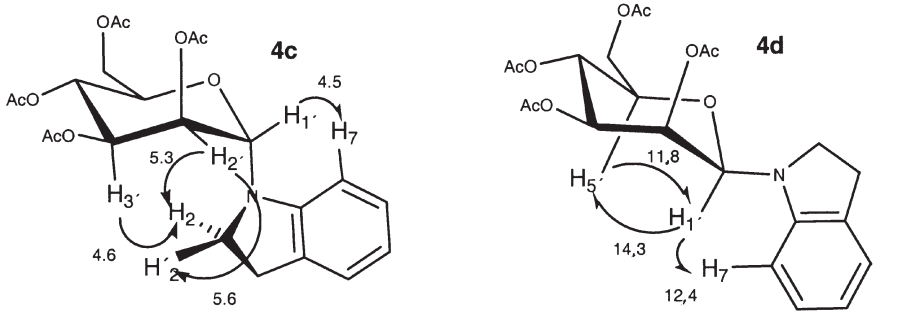


FIG. 1
NOE enhancements in compounds **4c** and **4d**

of coupling constants of anomeric protons, which vary within 4.4–5.8 Hz. The predicted β-anomeric configuration of 1-ribofuranosylbenzocamalexin **8e** was confirmed by NOE experiments which disclosed interaction between H-1′ and H-4′ (Fig. 3).

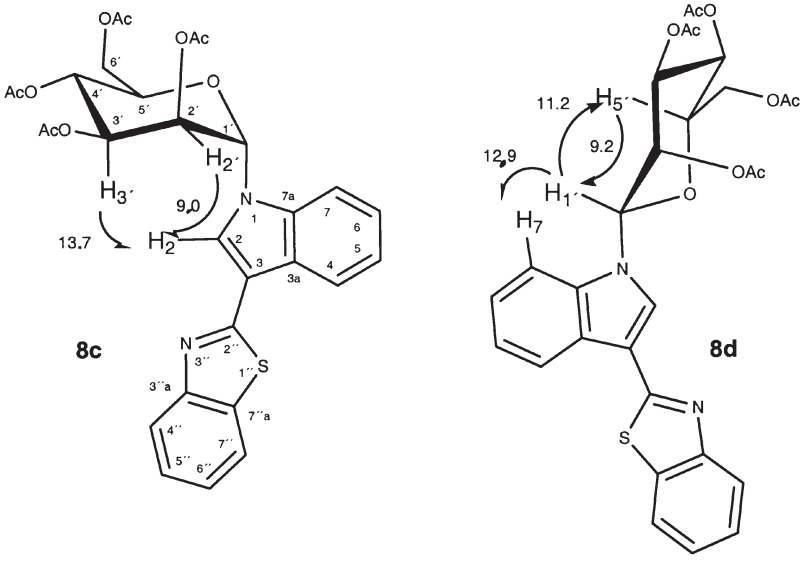


FIG. 2
NOE enhancements in compounds **8c** and **8d**

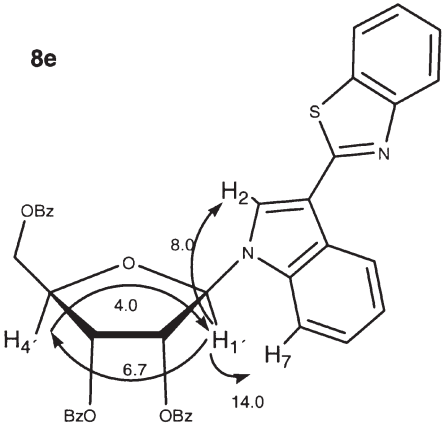


FIG. 3
NOE enhancements in compound **8e**

During determination of anomeric configuration by NOE experiments, additional NOEs were observed, which can be exploited for descriptions of aglycon conformation in saccharide moieties.

The irradiation of anomeric proton H-1′ of **4d** markedly increased the intensity of signal H-7 (12.4%). This spatial proximity of hydrogens indicates the conformational position of the indoline skeleton relative to the mannopyranosyl ring as depicted in Fig. 1. In the other α-anomer, **4c**, the observed interaction between H-3′ and H-2 (4.6%), H-2′ and H-2 (5.3%) and H′-2 (5.6%) as well as H-1′ and H-7 (4.8%) allow us to propose the orientation of the indoline skeleton with the benzene ring directed to the side of the mannopyranosyl ring oxygen atom (Fig. 1).

NOE effects in mannopyranosylbenzocamalexin **8c** revealed strong interactions between H-2 and H-2′ or H-3′ whereas in the case of **8d** between H-1′ and H-7. These results indicate conformational orientation of benzocamalexin moieties as shown in Fig. 2.

Finally in the case of **8e**, strong interactions between H-1′ and H-2 or H-7 (Fig. 3) indicate spatial proximity of these hydrogens. On this basis the conformational orientation of benzocamalexin aglycon relative to the saccharide ring could not be determined.

As primary in vitro screening for growth inhibition and cytotoxicity, compounds **9a**–**9e** were submitted to NCI (National Cancer Institute, Bethesda, U.S.A.) and evaluated for their cytotoxic potency on three human cell lines, such as NCI-H460 lung cancer, MCF7 breast cancer and SF-268 glioma. A compound is considered active when it reduces the growth of any of the cell lines to 32% or less and it is then passed on for evaluation in the full panel of sixty cell lines. Compounds **9c** and **9e** were active in this test. The panel of sixty human tumour cell lines is organized into subpanels representing leukaemia, melanoma and cancers of lung, colon, kidney, ovary, breast, prostate and central nervous system. The test compounds were dissolved in DMSO and evaluated using five concentrations at ten-fold dilutions, the highest being 10^{-4} mol l^{-1} and the others 10^{-5}–10^{-8} mol l^{-1}. They did not show a level of activity sufficient to enter the subsequent in vivo step.

The synthesis of five novel, to date not described 1-glycosylbenzocamalexins was accomplished by using the indoline-indole method, which allowed to evaluate their anticancer effect depending on different saccharide moieties. Binding of aglycon with β-D-ribose or α-D-mannose outlined the main motifs of 1-glycosylbenzocamalexins suitable for further studies in order to improve their biological activity.

EXPERIMENTAL

^{1}H and ^{13}C NMR spectra were measured on a Varian Gemini 2000 NMR spectrometer operating at 300 MHz for ^{1}H and at 75 MHz for ^{13} C, using tetramethylsilane as an internal standard. Chemical shifts (δ) are reported in ppm, downfield from tetramethylsilane, coupling constants (*J*) in Hz. The assignment of proton and carbon atom signals is based on HH COSY, HMQC spectra and NOE difference spectra of compounds **4c**, **4d**, **8c**, **8d**, **8e** and **9e**. Microanalyses were performed with a Perkin–Elmer, Model 2400 analyzer. The EI mass spectra were recorded on a Finigan SSQ 700 spectrometer at ionization energy 70 eV, whereas MALDI-TOF mass spectra were measured on a MALDI IV (Shimadzu, Kratos Analytical) instrument. For MALDI measurements the analyzed samples were dissolved in an acetonitrile–water mixture (1:1). The Matrix, 2,5-dihydroxybenzoic acid (DHB), was dissolved in the same mixture. Solutions of a sample and the matrix were mixed in the ratio 1:10. After drying on target, the samples were bombarded with a 3 ns dose (100 doses) of a nitrogen laser (λ 337 nm). Ion acceleration voltage was 5 kV. The reaction course was monitored by thin layer chromatography using Silufol plates (Kavalier®). The preparative column chromatography (flash chromatography) was performed on Kieselgel Merck Type 9385, 230–400 mesh.

Peracetylation of D-glucose, D-galactose and D-mannose was accomplished by a classic reaction in pyridine/Ac_2O and a mixture of anomers was used for subsequent reactions.

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl)indoline (**4a**)

Peracetylated β-D-glucose (5.0 g, 12.80 mmol) was dissolved in methanol (100 ml). Indoline (3.05 g, 2.87 ml, 25.60 mmol) and acetic acid (5 ml) were added to the solution and the reaction mixture was stirred at room temperature for 24 h. The precipitated product was filtered off and recrystallized from methanol. Yield 4.89 g (85%), lit.[13c] 74%; $C_{22}H_{27}NO_9$ (449.5); white crystals; m.p. 117–118 °C (methanol), lit.[13c] 119–120 °C.

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-galactopyranosyl)indoline (**4b**)

Peracetylated β-D-galactose (1.83 g, 4.69 mmol) was dissolved in 10 ml of methanol and to the solution were added indoline (1.39 g, 1.32 ml, 11.72 mmol) and acetic acid (1.7 ml). The reaction mixture was stirred at room temperature for 24 h, concentrated under reduced pressure and residue was subjected to column chromatography (cyclohexane–ethyl acetate 3:1). Yield 1.44 g (69%), lit.[13c] 58%; $C_{22}H_{27}NO_9$ (449.5); white crystals; m.p. 110–112 °C (methanol), lit.[13c] 109–110 °C.

1-(2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl)indoline (**4c**) and
1-(2,3,4,6-Tetra-*O*-acetyl-β-D-mannopyranosyl)indoline (**4d**)

Compounds **4c** and **4d** were prepared according to the procedure for synthesis of **4b**. Yield 77% as a mixture of anomers with α:β ratio 1.65:1, lit.[13c] 26%. Samples of **4c** and **4d** for detailed NMR characterization were prepared by additional column chromatography (cyclohexane–ethyl acetate 5:1) yielding **4a** (29%) **4b** (14%) and mixture of **4a** and **4b** (34%).

Compound **4c**: For $C_{22}H_{27}NO_9$ (449.5) calculated: 58.79% C, 6.06% H, 3.12% N; found: 58.89% C, 6.21% H, 3.23% N; white solid; m.p. 92–95 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 2.05 s, 3 H (CH_3); 2.06 s, 3 H (CH_3); 2.09 s, 3 H (CH_3); 2.18 s, 3 H (CH_3); 2.97–3.15 m,

2 H (H-3, H′-3); 3.31 q, 1 H, *J*(2,2′) = *J*(2,3) = *J*(2,3′) = 8.3 (H-2); 3.81 dt, 1 H, *J*(2,2′) = *J*(2,3) = 8.3, *J*(2,3′) = 3.0 (H′-2); 4.18 dd, 1 H, *J*(6′,6″) = 11.5, *J*(5′,6′) = 1.9 (H-6′); 4.25 m, 1 H (H-5′); 4.32 dd, 1 H, *J*(6′,6″) = 11.3, *J*(5′,6″) = 6.0 (H′-6′); 4.79 d, 1 H, *J*(1′,2′) = 2.2 (H-1′); 5.31–5.39 m, 1 H (H-3′, H-4′); 5.57 t, 1 H, *J*(2′,3′) = 2.5, *J*(1′,2′) = 2.2 (H-2′); 6.75 td, 1 H, *J* = 5.9, 1.9 (H-5); 7.05–7.14 m, 3 H (H-4, H-5, H-6). ^{13}C NMR (75 MHz, $CDCl_3$): 21.02, 21.08, 21.20 (CH_3CO); 29.14 (CH_2 aglycon); 50.21 (NCH_2 aglycon); 62.64 (C-6′); 66.31 (C-4′); 68.73 (C-2′); 69.30 (C-5′); 70.28 (C-3′); 87.08 (C-1′); 111.31 (C-7); 120.72 (C-5); 124.51 (C-6); 127.69 (C-4); 130.57 (C-3a); 150.66 (C-7a); 169.85, 170.33, 170.68, 170.82 (CH_3CO). Difference NOE spectra ($CDCl_3$): irradiated at δ 4.79 (H-1′) enhanced signals (H-2′, 4.8%), (H-7, 4.5%); irradiated at δ 5.57 (H-2′) enhanced signals (H-1′, 7.4%), (H-2, 5.3%), (H′-2, 5.6%); irradiated at δ 5.31–5.39 (H-3′ and H-4′) enhanced signals (H-5′, 5.6%), (H-2, 4.6%); irradiated at δ 4.25 (H-5′) enhanced signals (H-3′, 5.8%). MS MALDI-TOF, *m/z* (%): 488 $[M + K]^+$ (6), 472 $[M + Na]^+$ (52), 450 $[M + H]^+$ (100).

Compound **4d**: For $C_{22}H_{27}NO_9$ (449.5) calculated: 58.79% C, 6.06% H, 3.12% N; found: 58.91% C, 6.15% H, 3.04% N; white solid; m.p. 130–139 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 2.00 s, 3 H (CH_3); 2.05 s, 3 H (CH_3); 2.07 s, 3 H (CH_3); 2.21 s, 3 H (CH_3); 2.90–3.07 m, 2 H (H-3, H′-3); 3.34 ddd, 1 H, *J*(2,2′) = 9.2, *J*(2,3) = 9.2, *J*(2,3′) = 6.7 (H-2); 3.60 q, 1 H, *J*(2,2′) = *J*(2′,3) = *J*(2′,3′) = 8.7 (H′-2); 3.82 ddd, 1 H, *J*(4′,5′) = 9.4, *J*(5′,6′) = 6.2, *J*(5′,6″) = 2.7 (H-5′); 4.15 dd, 1 H, *J*(6′,6″) = 12.1, *J*(5′,6′) = 2.7 (H-6′); 4.26 dd, 1 H, *J*(6′,6″) = 12.1, *J*(5′,6″) = 6.2 (H′-6′); 4.91 d, 1 H, *J*(1′,2′) = 1.1 (H-1′); 5.13 dd, 1 H, *J*(3′,4′) = 10.1, *J*(2′,3′) = 3.1 (H-3′); 5.27 t, 1 H, *J*(3′,4′) = 10.1, *J*(4′,5′) = 10.0 (H-4′); 5.65 dd, 1 H, *J*(2′,3′) = 3.1, *J*(1′,2′) = 1.1 (H-2′); 6.62 d, 1 H, *J*(6,7) = 7.8 (H-7); 6.75 t, 1 H, *J*(4,5) = *J*(5,6) = 7.31 (H-5); 7.04–7.09 m, 2 H (H-4, H-6). ^{13}C NMR (75 MHz, $CDCl_3$): 20.86, 20.98, 21.01, 21.44 (CH_3CO); 29.03 (CH_2 aglycon); 48.40 (NCH_2 aglycon); 63.08 (C-6′); 66.44 (C-4′); 69.86 (C-2′); 72.63 (C-3′); 74.30 (C-5′); 85.15 (C-1′); 108.85 (C-7); 119.88 (C-5); 124.81 (C-6); 127.37 (C-4); 139.83 (C-3a); 150.07 (C-7a); 169.85, 170.23, 170.38, 170.78 (CH_3CO). Difference NOE spectra ($CDCl_3$): irradiated at δ 4.91 (H-1′) enhanced signals (H-2′, 11.0%), (H-5′, 14.3%), (H-7, 12.4%); irradiated at δ 5.65 (H-2′) enhanced signals (H-1′, 6.8%), (H-3′, 7.9%), (H-2, 3.4%); irradiated at δ 5.13 (H-3′) enhanced signals (H-2′, 9.4%), (H-5′, 6.6%); irradiated at δ 5.27 (H-4′) enhanced signals (H-2′, 2.5%), (H-5′, 4.5%), (H-6′, 2.4%); irradiated at δ 3.82 (H-5′) enhanced signals (H-1′, 11.8%), (H-3′, 6.0%), (H-4′, 3.0%); MS MALDI-TOF, *m/z* (%): 488 $[M + K]^+$ (18), 472 $[M + Na]^+$ (73), 450 $[M + H]^+$ (100).

1-(2,3,5-Tri-*O*-benzoyl-β-D-ribofuranosyl)indoline (**4e**)

1-*O*-Acetyl-2,3,5-tri-*O*-benzoyl-β-D-ribofuranose (**12**; 2.58 g, 5.07 mmol) was dissolved in CH_2Cl_2 (80 ml). Indoline (2.84 ml, 3.02 g, 25.3 mmol) and a catalytic amount of AcOH (3.1 ml) were added to the solution and the reaction mixture was refluxed for 24 h. Since TLC showed full consumption of starting saccharide **12**, the reaction mixture was washed with 1 M aqueous HCl and a saturated solution of aqueous $NaHCO_3$, the organic layer was dried with anhydrous Na_2SO_4 and evaporated under reduced pressure. The residue was subjected to column chromatography (benzene–ethyl acetate 70:1). Yield 2.40 g (84%), lit.[13b] 45%; $C_{34}H_{29}NO_7$ (563.6); white foam. ^{1}H NMR spectrum was identical with that of the compound prepared according to the procedure described in literature[13b].

1-(2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl)-1*H*-indole (**5c**) and
1-(2,3,4,6-Tetra-*O*-acetyl-β-D-mannopyranosyl)-1*H*-indole (**5d**)

A mixture of anomers **4c** and **4d** (0.38 g 0.845 mmol) was dissolved in dry toluene (3 ml). DDQ was dissolved in 3 ml of toluene and, within 15 min, was added dropwise to the mixture. The reaction mixture was stirred at room temperature for 2 h, diluted with toluene (10 ml) and washed with 4% aqueous solution of K_2CO_3 (2×). The organic layer was dried with anhydrous Na_2SO_4 and toluene was evaporated on a vacuum evaporator. The residue was subjected to column chromatography (cyclohexane–ethyl acetate 5:1). Both anomers were obtained in yields 42% (**5c**) and 32% (**5d**).

Compound **5c**: For $C_{22}H_{25}NO_9$ (447.4) calculated: 59.06% C, 5.63% H, 3.13% N; found: 59.19% C, 5.60% H, 3.06% N; white foam. ^{1}H NMR (300 MHz, $CDCl_3$): 2.03 s, 3 H (CH_3); 2.05 s, 3 H (CH_3); 2.11 s, 3 H (CH_3); 2.17 s, 3 H (CH_3); 3.68 m, 1 H (H-5′); 4.06 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6′) = 2.6 (H-6′); 4.33 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6″) = 6.3 (H′-6′); 5.40 t, 1 H, *J*(3′,4′) = *J*(4′,5′) = 8.9 (H-4′); 5.50 dd, 1 H, *J*(3′,4′) = 8.9, *J*(2′,3′) = 3.2 (H-3′); 5.97 d, 1 H, *J*(1′,2′) = 2.7 (H-1′); 6.06 t, 1 H, *J*(2′,3′) = 3.2, *J*(1′,2′) = 2.7 (H-2′); 6.63 d, 1 H, *J* = 3.34 (H-3); 7.15–7.26 m, 2 H; 7.48 d, 1 H, *J* = 3.42 and 7.62 d, 2 H, *J* = 8.5 (H arom.). ^{13}C NMR (75 MHz, $CDCl_3$): 20.74 (CH_3CO); 61.63 (C-6′); 65.92, 67.66, 70.18, 70.75 (C-2′–C-5′); 82.09 (C-1′); 104.57, 111.79, 121.10, 122.72, 124.99, 129.19, 136.64 (C arom.); 169.56, 169.84, 170.48, 170.60 (CH_3CO). MS MALDI-TOF, *m/z* (%): 486 $[M + K]^+$ (100), 470 $[M + Na]^+$ (54), 448 $[M + H]^+$ (7).

Compound **5d**: For $C_{22}H_{25}NO_9$ (447.4) calculated: 59.06% C, 5.63% H, 3.13% N; found: 59.21% C, 5.55% H, 3.01% N; white foam. ^{1}H NMR (300 MHz, $CDCl_3$): 1.99 s, 3 H (CH_3); 2.02 s, 3 H (CH_3); 2.09 s, 3 H (CH_3); 2.10 s, 3 H (CH_3); 3.95 m, 1 H (H-5′); 4.23 d, 1 H, *J*(6′,6″) = 12.3 (H-6′); 4.33 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6″) = 5.7 (H′-6′); 5.32 dd, 1 H, *J*(3′,4′) = 10.0, *J*(2′,3′) = 3.0 (H-3′); 5.57 t, 1 H, *J*(3′,4′) = *J*(4′,5′) = 10.0 (H-4′); 5.57 d, 1 H, *J*(2′,3′) = 3.0 (H-2′); 5.84 s, 1 H (H-1′); 6.52 d, 1 H, *J*(2,3) = 3.3 (H-3); 7.13 t, 1 H, *J* = 7.4; 7.19–7.24 m, 2 H; 7.41 d, 1 H, *J* = 8.2 and 7.59 d, 1 H, *J* = 7.7 (H arom.). ^{13}C NMR (75 MHz, $CDCl_3$): 20.60, 20.76 (CH_3CO); 62.62 (C-6′); 65.59, 69.54, 71.40, 75.39 (C-2′–C-5′); 82.32 (C-1′); 103.42, 109.92, 120.57, 121.19, 122.23, 125.1, 128.76, 135.26 (C arom.); 169.49, 169.72, 170.08, 170.70 (CH_3CO). MS MALDI-TOF, *m/z* (%): 486 $[M + K]^+$ (50), 470 $[M + Na]^+$ (100), 448 $[M + H]^+$ (19).

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl)-1*H*-indole (**5a**)

Product **5a** was prepared according to procedure for synthesis of mannopyranosylindolines **5c** and **5d**. Yield 87%, lit.[13c] 78%; $C_{22}H_{25}NO_9$ (447.4); white crystals; m.p. 146–149 °C (methanol), lit.[13c] 148–149 °C.

1′-(2,3,4,6-Tetra-*O*-acetyl-β-D-galactopyranosyl)-1*H*-indole (**5b**)

Compound **5b** was prepared according to the procedure for synthesis of mannopyranosylindolines **5c** and **5d**. Yield 85%, lit.[13c] 48%; $C_{22}H_{25}NO_9$ (447.4); white crystals; m.p. 129–131 °C (methanol), lit.[13c] 128–129 °C.

1-(2,3,5-Tri-*O*-benzoyl-β-D-ribofuranosyl)-1*H*-indole (**5e**)

Compound **5e** was prepared according to the procedure for synthesis of manno-pyranosylindolines **5c** and **5d**. Yield 76%, lit.[13c] 78%; $C_{34}H_{27}NO_7$ (561.6); white foam.

Vilsmeier Reaction for Preparation of Aldehydes **6a**–**6e**

New 1-glycosylindole-3-carbaldehydes **6b**–**6e** were prepared applying procedure reported for preparation of glucosylindole-3-carbaldehyde **6a** [15]. 1-Glycosylindoles **5a**–**5e** (2.7 mol) were dissolved in dry DMF and the solution was cooled to 0 °C. A solution of $POCl_3$ (0.7 ml) in dry DMF (2.3 ml) was prepared at 0 °C and added dropwise to the ice-cooled solution of 1-glycosylindole. The reaction mixture was stirred at 0 °C for 15 min and at 80–90 °C for 2 h. Since the starting material was consumed, the reaction mixture was cooled to room temperature and poured into a mixture of crushed ice and water. The water solution was carefully neutralized with 4% aqueous solution of K_2CO_3 and the precipitated product was filtered off and washed with water.

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl)-1*H*-indole-3-carbaldehyde (**6a**)

Yield 83%, lit.[15] 84%; $C_{23}H_{25}NO_{10}$ (475.5); white crystals; m.p. 203–205 °C (methanol), lit.[15] 203–204 °C.

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-galactopyranosyl)-1*H*-indole-3-carbaldehyde (**6b**)

Yield 72%. For $C_{23}H_{25}NO_{10}$ (475.5) calculated: 58.10% C, 5.30% H, 2.95% N; found: 58.03% C, 5.09% H, 2.79% N; white crystals; m.p. 205–206 °C (dichloromethane–cyclohexane). ^{1}H NMR (300 MHz, $CDCl_3$): 1.68 s, 3 H (CH_3); 2.01 s, 3 H (CH_3); 2.03 s, 3 H (CH_3); 2.27 s, 3 H (CH_3); 4.18–4.27 m, 3 H (H-5′, H-6′, H′-6′); 5.31 dd, 1 H, *J*(2′,3′) = 9.9 *J*(3′,4′) = 3.1 (H-3′); 5.58 d, 1 H, *J*(3′,4′) = 3.1 (H-4′); 5.61 d, 1 H, *J*(1′,2′) = 9.5 (H-1′); 5.70 t, 1 H, *J*(1′,2′) = 9.5, *J*(2′,3′) = 9.9 (H-2′); 7.31–7.39 m, 2 H; 7.50 d, 1 H, *J* = 7.3; 7.93 s, 1 H and 8.31 d, 1 H, *J* = 6.7 (H arom.); 10.06 s, 1 H (CHO). ^{13}C NMR (75 MHz, $CDCl_3$): 20.12, 20.56, 20.68 and 20.76 (CH_3CO); 61.38 (C-6′); 67.11, 68.30, 71.11, 73.96 (C-2′–C-5′); 84.04 (C-1′); 110.25, 120.06, 122.55, 123.65, 124.60, 125.35, 135.52, 136.87 (C arom.); 168.72, 170.01, 170.42 (CH_3CO); 185.16 (CHO). EI MS, *m/z* (%): 475 $[M]^+$ (6), 331 (20), 169 (35), 144 (11), 109 (21), 43 (8).

1-(2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl)-1*H*-indole-3-carbaldehyde (**6c**)

Yield 85%. For $C_{23}H_{25}NO_{10}$ (475.5) calculated: 58.10% C, 5.30% H, 2.95% N; found: 58.29% C, 5.35% H, 3.10% N; white crystals; m.p. 143–144 °C (dichloromethane–cyclohexane). ^{1}H NMR (300 MHz, $CDCl_3$): 2.00 s, 3 H (CH_3); 2.09 s, 6 H (2 × CH_3); 2.16 s, 3 H (CH_3); 3.79 m, 1 H (H-5′); 4.06 d, 1 H, *J*(6′,6″) = 12.3 (H-6′); 4.52 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6″) = 7.4 (H′-6′); 5.36 t, 1 H, *J*(3′,4′) = *J*(4′,5′) = 7.5 (H-4′); 5.41 d, 1 H, *J*(3′,4′) = 7.5 (H-3′); 6.02 d, 1 H, *J*(1′,2′) = 2.5 (H-1′); 6.04 t, 1 H, *J*(1′,2′) = *J*(2′,3′) = 2.5 (H-2′); 7.35 m, 2 H; 7.63 d, 1 H, *J* = 6.8; 8.08 s, 1 H and 8.32 m, 1 H (H arom.); 10.08 s, 1 H (CHO). ^{13}C NMR (75 MHz, $CDCl_3$): 20.68 (CH_3CO); 61.03 (C-6′); 65.97, 67.00, 69.54, 72.47 (C-2′–C-5′); 81.36 (C-1′); 112.03, 120.31, 122.45, 123.90, 124.86, 125.45, 135.77, 137.33 (C arom.); 169.42, 169.55, 170.32, 170.53 (CH_3CO); 185.16 (CHO). MS MALDI-TOF, *m/z* (%): 514 $[M + K]^+$ (10), 498 $[M + Na]^+$ (85), 476 $[M + H]^+$ (100).

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-mannopyranosyl)-1*H*-indole-3-carbaldehyde (**6d**)

Yield 77%. For $C_{23}H_{25}NO_{10}$ (475.5) calculated: 58.10% C, 5.30% H, 2.95% N; found: 58.19% C, 5.48% H, 2.81% N; white solid; m.p. 73–75 °C (dichloromethane–cyclohexane). ^{1}H NMR (300 MHz, $CDCl_3$): 2.02 s, 6 H (2 × CH_3); 2.13 6 H (2 × CH_3); 4.03 m, 1 H (H-5′); 4.23 d, 1 H, *J*(6′,6″) = 11.9 (H-6′); 4.39 dd, 1 H, *J*(6′,6″) = 11.9, *J*(5′,6″) = 6.1 (H′-6′); 5.38 m, 2 H (H-3′, H-4′); 5.63 s, 1 H (H-2′); 5.94 s, 1 H (H-1′); 7.95–7.41 m, 2 H; 7.95 s, 1 H and 8.31 m, 1 H (H arom.); 10.06 s, 1 H (CHO). ^{13}C NMR (75 MHz, $CDCl_3$): 20.55, 20.72, 20.78 (CH_3CO); 62.39 (C-6′); 65.19, 68.64, 70.00, 75.88 (C-2′–C-5′); 82.25 (C-1′); 109.91, 119.55, 122.47, 123.69, 124.65, 125.12, 135.70, 135.85 (C arom.); 169.15, 169.61, 170.03, 170.60 (CH_3CO); 184.90 (CHO). MS MALDI-TOF, *m/z* (%): 514 $[M + K]^+$ (32), 498 $[M + Na]^+$ (100), 476 $[M + H]^+$ (12).

1-(2,3,5-Tri-*O*-benzoyl-β-D-ribofuranosyl)-1*H*-indole-3-carbaldehyde (**6e**)

Yield 95%. For $C_{35}H_{27}NO_8$ (589.6) calculated: 71.30% C, 4.62% H, 2.38% N; found: 71.52% C, 4.33% H, 2.69% N; white solid; m.p. 80–83 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 4.72 dd, 1 H, *J*(5′,5″) = 12.1, *J*(4′,5′) = 3.1 (H-5′); 4.77 m, 1 H (H-4′); 4.98 dd, 1 H, *J*(5′,5″) = 12.1, *J*(4′,5″) = 2.7 (H′-5′); 5.98–6.03 m, 2 H (H-3′, H-2′); 6.45 d, 1 H, *J*(1′,2′) = 4.4 (H-1′); 7.28–7.63 bm, 12 H (H arom.); 7.97 d, 5 H, *J* = 9.15; 8.13 d, 2 H, *J* = 7.62 and 8.29 d, 1 H, *J* = 7.1 (H arom.); 9.71 s, 1 H (CHO). ^{13}C NMR (75 MHz, $CDCl_3$): 63.16 (C-5′); 70.97, 74.60, 80.57 (C-4′–C-2′); 88.13 (C-1′); 110.45, 119.92, 122.60, 123.68, 124.71, 125.69, 128.66, 128.89, 129.28, 129.86, 133.89, 133.98, 134.88, 136.62 (C arom.); 165.04, 165.34, 166.15 (CH_3CO); 185.03 (CHO). EI MS, *m/z* (%): 561 $[M]^+$ (8), 445 (17), 201 (22), 105 (100), 77 (27).

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-glucopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**8a**)

1-Glucopyranosylindole-3-carbaldehyde **6a** (1.0 g, 2.10 mmol) was dissolved in methanol (8 ml). 2-Aminobenzenethiol (0.26 g, 0.22 ml, 2.10 mmol) and 1 drop of 36% HCl were added to the solution. The reaction mixture was refluxed for 30 min and cooled to 0 °C. The precipitated product was filtered off and recrystallized form methanol. Yield 1.01 g (83%). For $C_{29}H_{28}N_2O_9S$ (580.6) calculated: 59.99% C, 4.86% H, 4.82% N; found: 60.21% C, 4.98% H, 4.69% N; white crystals; m.p. 228–230 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 1.68 s, 3 H (CH_3); 2.03 s, 3 H (CH_3); 2.09 s, 3 H (CH_3); 2.10 s, 3 H (CH_3); 4.05 m, 1 H (H-5′); 4.19 dd, 1 H, *J*(6′,6″) = 12.5, *J*(5′,6′) = 2.5 (H-6′); 4.34 dd, 1 H, *J*(6′,6″) = 12.5, *J*(5′,6″) = 4.9 (H′-6′); 5.33 t, 1 H, *J* = 9.6; 5.48 t, 1 H, *J* = 9.3 and 5.58 t, 1 H, *J* = 9.1 (H-2′–H-4′); 5.71 d, 1 H, *J*(1′,2′) = 8.9 (H-1′); 7.33–7.39 m, 3 H; 7.46–7.52 m, 2 H; 7.89 d, 1 H, *J* = 8.0; 8.06 d, 2 H, *J* = 8.3 and 8.48 m, 1 H (H arom.). ^{13}C NMR (75 MHz, $CDCl_3$): 20.11, 20.63, 20.78 (CH_3CO); 61.86 (C-6′); 68.05, 70.75, 73.16, 75.08 (C-2′–C-5′); 83.65 (C-1′); 110.35, 113.57, 121.37, 121.96, 122.40, 122.72, 123.91, 124.62, 126.06, 126.23, 126.76, 133.75, 136.66, 153.80, 162.11 (C arom.); 168.69, 169.41, 170.18, 170.65 (CH_3CO). EI MS, *m/z* (%): 580 $[M]^+$ (5), 331 (5), 250 (42), 169 (38), 109 (25), 43 (100).

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-galactopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**8b**)

1-Galactopyranosylindole-3-carbaldehyde **6b** (0.388 g, 0.789 mmol) was dissolved in methanol (5 ml) and 2-aminobenzenethiol (0.197 g, 0.168 ml, 1.57 mmol) and 1 drop of 36% HCl were added. The reaction mixture was stirred at room temperature for 15 min, neutralized

with several drops of 28% aqueous solution of NH_4OH, concentrated under reduced pressure and the residue was subjected to column chromatography (cyclohexane–ethyl acetate 1:1). Yield 0.450 g (94%). For $C_{29}H_{28}N_2O_9S$ (580.6) calculated: 59.99% C, 4.86% H, 4.82% N; found: 59.82% C, 4.64% H, 5.08% N; white crystals; m.p. 169–170 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 1.69 s, 3 H (CH_3); 2.02 s, 3 H (CH_3); 2.05 s, 3 H (CH_3); 2.32 s, 3 H (CH_3); 4.18–4.27 m, 3 H (H-5′, H-6′, H′-6′); 5.31 dd, 1 H, *J*(2′,3′) = 9.6, *J*(3′,4′) = 3.1 (H-3′); 5.60 d, 1 H, *J*(3′,4′) = 3.1 (H-4′); 5.64 d, 1 H, *J*(1′,2′) = 9.2 (H-1′); 5.77 t, 1 H, *J*(1′,2′) = 9.2, *J*(2′,3′) = 9.6 (H-2′); 7.33–7.39 m, 3 H; 7.49 t, 1 H, *J* = 8.0; 7.57 m, 1 H; 7.89 d, 1 H, *J* = 7.9; 8.07 d, 1 H, *J* = 8.1; 8.13 bs, 1 H and 8.44 m, 1 H (H arom.). ^{13}C NMR (75 MHz, $CDCl_3$): 20.19, 20.60, 20.71, 20.87 (CH_3CO); 61.86 (C-6′); 67.21, 68.22, 71.32, 73.84 (C-2′–C-5′); 84.38 (C-1′); 110.60, 113.18, 121.38, 121.76, 122.27, 122.67, 123.83, 124.59, 126.06, 126.28, 127.21, 133.72, 136.59, 153.11, 162.25 (C arom.); 168.70, 170.06, 170.16, 170.45 (CH_3CO). EI MS, *m/z* (%): 580 $[M]^+$ (9), 331 (3), 250 (50), 169 (43), 109 (35), 43 (100).

1-(2,3,4,6-Tetra-*O*-acetyl-α-D-mannopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**8c**)

Compound **8c** was prepared according to the procedure for synthesis of 1-galactopyranosylbenzocamalexin **8b**. Yield 81%. For $C_{29}H_{28}N_2O_9S$ (580.6) calculated: 59.99% C, 4.86% H, 4.82% N; found: 60.12% C, 4.71% H, 4.98% N; white crystals; m.p. 133–135 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 2.04 s, 3 H (CH_3); 2.09 s, 3 H (CH_3); 2.15 s, 3 H (CH_3); 2.18 s, 3 H (CH_3); 3.80 m 1 H, (H-5′); 4.09 dd, 1 H, *J*(6′,6″) = 12.5, *J*(5′,6′) = 2.6 (H-6′); 4.49 dd, 1 H, *J*(6′,6″) = 12.5 *J*(5′,6″) = 6.7 (H′-6′); 5.40 t, 1 H, *J*(3′,4′) = *J*(4′,5′) = 8.3 (H-4′); 5.54 dd, 1 H, *J*(3′,4′) = 8.4, *J*(2′,3′) = 3.2 (H-3′); 6.07 d, 1 H, *J*(1′,2′) = 3.5 (H-1′); 6.11 t, 1 H, *J*(1′,2′) = 3.5, *J*(2′,3′) = 3.3 (H-2′); 7.32–7.42 bm, 3 H (H-5, H-6, H-5″); 7.48 dt, 1 H, *J*(6″,7″) = 8.0, *J* = 1.4 (H-6″); 7.69 m, 1 H (H-7); 7.89 d, 1 H, *J*(4″,5″) = 8.4 (H-4″); 8.07 d, 1 H, *J*(6″,7″) = 8.0 (H-7″); 8.23 s, 1 H (H-2); 8.56 m, 1 H (H-4). ^{13}C NMR (75 MHz, $CDCl_3$): 20.91, 20.95, 20.97, 20.98 (CH_3CO); 61.52 (C-6′); 66.09 (C-4′); 67.58 (C-2′); 70.07 (C-3′); 72.06 (C-5′); 81.85 (C-1′); 112.20 (C-7); 114.17 (C-3); 121.50 (C-4″); 122.13 (C-4); 122.79 (C-7″); 123.03 (C-5); 124.26 (C-6); 124.71 (C-5″); 126.19 (C-6″); 126.34 (C-3a); 126.82 (C-2); 134.09 (C-7″a); 137.33 (C-7a); 154.25 (C-3″a); 162.02 (C-2″); 169.61, 169.78, 170.60, 170.63 (CH_3CO). Difference NOE spectra ($CDCl_3$): irradiated at δ 6.07 (H-1′) enhanced signals (H-2, 9.0%), (H-7, 5.7%); irradiated at δ 6.11 (H-2′) enhanced signals (H-3′, 1.3%), (H-2, 9.0%), (H-7, 5.9%); irradiated at δ 5.54 (H-3′) enhanced signals (H-5′, 7.7%), (H-2, 13.7%); irradiated at δ 5.40 (H-4′) enhanced signals (H-5′, 5.2%), (H-2, 5.9%); irradiated at δ 3.80 (H-5′) enhanced signals (H-3′, 4.9%), (H-4′, 4.9%), (H-6′, 0.9%). EI MS, *m/z* (%): 580 $[M]^+$ (5), 331 (3), 250 (30), 169 (27), 109 (25), 43 (100).

1-(2,3,4,6-Tetra-*O*-acetyl-β-D-mannopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**8d**)

Compound **8d** was prepared according to the procedure for synthesis of 1-galactopyranosylbenzocamalexin **8b**. Yield 73%. For $C_{29}H_{28}N_2O_9S$ (580.6) calculated: 59.99% C, 4.86% H, 4.82% N; found: 60.09% C, 4.66% H, 4.75% N; white crystals; m.p. 188–189 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 2.00 s, 3 H (CH_3); 2.04 s, 3 H (CH_3); 2.11 s, 3 H (CH_3); 2.13 s, 3 H (CH_3); 4.02 m, 1 H (H-5′); 4.28 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6′) = 2.2 (H-6′); 4.39 dd, 1 H, *J*(6′,6″) = 12.3, *J*(5′,6″) = 6.1 (H′-6′); 5.36 dd, 1 H, *J*(3′,4′) = 10.0, *J*(2′,3′) = 3.0 (H-3′); 5.45 t, 1 H, *J*(3′,4′) = *J*(4′,5′) = 10.0 (H-4′); 5.61 dd, 1 H, *J*(1′,2′) = 1.1, *J*(2′,3′) = 3.3 (H-2′); 5.94 d, 1 H, *J*(1′,2′) = 1.1 (H-1′); 7.31–7.38 bm, 3 H (H-5, H-6, H-5″); 7.42–7.50 bm, 2 H (H-7, H-6″); 7.88 d, 1 H, *J*(4″,5″) = 8.1 (H-4″); 8.04 d, 1 H, *J*(6″,7″) = 8.1 (H-7″); 8.07 s, 1 H (H-2); 8.48 m, 1 H

(H-4). ^{13}C NMR (75 MHz, $CDCl_3$): 20.81, 20.91, 20.98, 21.07 (CH_3CO); 62.76 (C-6′); 65.57 (C-4′); 69.19 (C-2′); 71.32 (C-3′); 75.99 (C-5′); 82.31 (C-1′); 110.06 (C-7); 113.086 (C-3); 121.43 (C-4″); 122.05 (C-4); 122.59 (C-7″); 122.70 (C-5); 123.89 (C-6); 124.58 (C-5″); 125.81 (C-3a); 126.24 (C-6″); 127.34 (C-2); 133.95 (C-7″a); 135.68 (C-7′a); 154.14 (C-3″a); 162.24 (C-2″); 169.47, 169.74, 170.14, 170.78 (CH_3CO). Difference NOE spectra ($CDCl_3$): irradiated at δ 5.94 (H-1′) enhanced signals (H-2′, 3.7%), (H-3′, 3.0%), (H-5′, 11.2%), (H-7, 12.9%), (H-2, 4.6%); irradiated at δ 5.61 (H-2′) enhanced signals (H-1′, 4.0%), (H-2, 2.6%), (H-7, 2.2%); irradiated at δ 5.45 (H-4′) enhanced signals (H-5′, 6.5%), (H-2, 2.7%), (H-7, 3.3%); irradiated at δ 4.02 (H-5′) enhanced signals (H-1′, 9.2%), (H-3′, 6.9%), (H-4′, 4.0%). EI MS, *m/z* (%): 580 $[M]^+$ (7), 250 (42), 169 (28), 109 (28), 43 (100).

1-(2,3,5-Tri-*O*-benzoyl-β-D-ribofuranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**8e**)

Yield 81%. For $C_{41}H_{30}N_2O_7S$ (694.8) calculated: 70.88% C, 4.35% H, 4.03% N; found: 71.06% C, 4.59% H, 3.92% N; pale yellow crystals; m.p. 167–168 °C (methanol). ^{1}H NMR (300 MHz, $CDCl_3$): 4.77 dd, 1 H, *J*(5′,5″) = 12.2, *J*(4′,5′) = 3.2 (H-5′); 4.84 m, 1 H (H-4′); 4.93 dd, 1 H, *J*(5′,5″) = 12.2, *J*(4′,5″) = 2.6 (H′-5′); 6.02 t, 1 H, *J*(2′,3′) = *J*(3′,4′) = 5.7 (H-3′); 6.06 t, 1 H, *J*(2′,3′) = 5.7, *J*(1′,2′) = 5.5 (H-2′); 6.51 d, 1 H, *J*(1′,2′) = 5.5 (H-1′); 7.22–7.59 bm, 13 H (H arom.); 7.65 d, 1 H, *J* = 8.2 (H-7); 7.82 d, 1 H, *J* = 7.8 (H-4″); 7.94–8.00 m, 5 H (H-7″ and 4 H of OBz); 8.10 s, 1 H (H-2); 8.15–8.18 m, 2 H (OBz); 8.47 d, 1 H, *J* = 7.7 (H-4). ^{13}C NMR (75 MHz, $CDCl_3$): 63.92 (C-5′); 71.50 (C-3′); 74.64 (C-2′); 80.66 (C-4′); 88.11 (C-1′); 110.58 (C-7); 113.85 (C-3); 121.36 (C-4″); 122.12 (C-4); 122.63 (C-7″); 122.70 (C-5); 124.00 (C-6); 124.49 (C-5″); 126.06 (C-2); 126.10 (C-6″); 126.53 (C-3a); 128.71, 128.72, 128.91, 129.50, 129.97, 130.00, 133.59, 133.91 (OBz); 134.16 (C-7″a); 136.61(C-7a); 154.10 (C-3″a); 162.18 (C-2″); 165.16, 165.44, 165.40 (CH_3CO). Difference NOE spectra ($CDCl_3$): irradiated at δ 6.51 (H-1′) enhanced signals (H-2′ and H-3′, 5.7%), (H-4′, 6.2%), (H-2, 8.0%), (H-7, 14.0%); irradiated at δ 6.06 (H-2′ and H-3′) enhanced signals (H-1′, 4.8%), (H-4′, 3.2%), (H-5′, 4.3%), (H′-5′, 3.3%); irradiated at δ 4.84 (H-4′) enhanced signals (H-1′, 4.0%), (H-2′ and H-3′, 7.0%). EI MS, *m/z* (%): 694 $[M]^+$ (4), 445 (16), 249 (16), 201 (29), 105 (100) 77 (23).

1-(β-D-Glucopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**9a**)

1-Glucopyranosylbenzocamalexin **8a** (0.1 g, 0.172 mmol) was dissolved in 20 ml of dry methanol and a catalytic amount of fine powdered K_2CO_3 (2.5 mg, 0.0172 mmol) was added. The reaction mixture was stirred for 4 h, filtered through a short column of silica gel and evaporated to dryness. The residue was recrystallized from a mixture of methanol–diethyl ether. Yield 0.07 g (99%). For $C_{21}H_{20}N_2O_5S$ (412.5) calculated: 61.15% C, 4.89% H, 6.79% N; found: 61.31% C, 5.13% H, 6.92% N; pale yellow solid; m.p. >300 °C decomposition (methanol–diethyl ether). ^{1}H NMR (300 MHz, DMSO-d_6): 3.41 t, 1 H, *J* = 9.0; 3.50 d, 1 H, *J* = 8.7; 3.56 m, 2 H; 3.75 m, 1 H and 3.89 t, 1 H, *J* = 8.9 (H saccharide, H-2′–H-6′); 4.14 bs, 4 H (CD_3COOD exchangeable, 4 × OH); 5.59 d, 1 H, *J* = 9.0 (H-1′); 7.30–7.34 bm, 2 H; 7.39 td, 1 H, *J* = 8.0, 1.2; 7.50 td, 1 H, *J* = 8.2, 1.2; 7.74 m, 1 H; 8.00 d, 1 H, *J* = 8.1; 8.06 d, 1 H, *J* = 7.5; 8.37 s, 1 H and 8.45 m, 1 H (H arom.). ^{13}C NMR (75 MHz, DMSO-d_6): 60.98 (C-6′); 69.84, 71.87, 77.41, 79.63 (C-2′–C-5′); 85.23 (C-1′); 110.62, 111.97, 120.96, 121.64, 121.74, 123.03, 124.45, 125.22, 126.21, 129.53, 133.11, 136.90, 153.54, 162.38 (C arom.). MS MALDI-TOF, *m/z* (%): 435 $[M + Na]^+$ (54), 413 $[M + H]^+$ (79).

1-(β-D-Galactopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**9b**)

Compound **9b** was prepared according to the procedure for synthesis of 1-glucopyranosylbenzocamalexin **9a**. Yield 96%. For $C_{21}H_{20}N_2O_5S$ (412.5) calculated: 61.15% C, 4.89% H, 6.79% N; found: 61.28% C, 4.67% H, 6.69% N; pale yellow solid; m.p. >300 °C decomposition (methanol–diethyl ether). ^{1}H NMR (300 MHz, DMSO-d_6): 3.58 m, 3 H; 3.76 t, 1 H, *J* = 5.9; 3.84 d, 1 H, *J* = 2.4 and 4.17 t, 1 H, *J* = 9.1 (H saccharide, H-2′–H-6′); 4.64 bs, 2 H (CD_3COOD exchangeable, 2 × OH); 5.08 bs, 1 H (CD_3COOD exchangeable, OH); 5.28 bs, 1 H (CD_3COOD exchangeable, OH); 5.49 d, 1 H, *J* = 8.7 (H-1′); 7.28–7.34 bm, 2 H; 7.38 td, 1 H, *J* = 7.5, 0.6; 7.50 td, 1 H, *J* = 8.1, 1.1; 7.81 m, 1 H; 7.99 d, 1 H, *J* = 8.1; 8.08 d, 1 H, *J* = 7.5; 8.38 s, 1 H and 8.42 m, 1 H (H arom.). ^{13}C NMR (75 MHz, DMSO-d_6): 60.62 (C-6′); 68.62, 69.11, 74.05, 78.07 (C-2′–C-5′); 86.55 (C-1′); 110.34, 112.42, 120.97, 121.63, 121.68, 121.74, 122.92, 124.47, 125.36, 126.25, 130.07, 133.06, 136.55, 153.67, 162.35 (C arom.). MS MALDI-TOF, *m/z* (%): 435 $[M + Na]^+$ (89), 413 $[M + H]^+$ (69).

1-(α-D-Mannopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**9c**)

Compound **9c** was prepared according to the procedure for synthesis of 1-glucopyranosylbenzocamalexin **9a**. Yield 93%. For $C_{21}H_{20}N_2O_5S$ (412.5) calculated: 61.15% C, 4.89% H, 6.79% N; found: 61.38% C, 5.11% H, 6.99% N; pale yellow solid; m.p. >300 °C decomposition (methanol–diethyl ether). ^{1}H NMR (300 MHz, DMSO-d_6): 3.67 m, 1 H; 3.79 m, 2 H; 3.99 m, 2 H; 4.42 bs, 4 H (CD_3COOD exchangeable, 4 × OH); 4.45 t, 1 H, *J* = 8.7 (H saccharide, H-2′–H-6′); 5.49 d, 1 H, *J* = 2.8 (H-1′); 7.23–7.41 bm, 3 H; 7.53 m, 1 H; 7.80 m, 1 H; 8.01 d, 1 H, *J* = 7.8; 8.06 d, 1 H, *J* = 7.8; 8.36 s, 1 H and 8.43 m, 1 H (H arom.). ^{13}C NMR (75 MHz, DMSO-d_6): 60.58 (C-6′); 66.74, 69.83, 72.23, 80.56 (C-2′–C-5′); 80.70 (C-1′); 110.73, 112.89, 121.37, 121.62, 121.73, 123.41, 124.89, 125.83, 126.68, 130.29, 133.53, 137.29, 154.11, 162.84 (C arom.). MS MALDI-TOF, *m/z* (%): 435 $[M + Na]^+$ (56), 413 $[M + H]^+$ (100).

1-(β-D-Mannopyranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**9d**)

Compound **9c** was prepared according to the procedure for synthesis of 1-glucopyranosylbenzocamalexin **9a**. Yield 91%. For $C_{21}H_{20}N_2O_5S$ (412.5) calculated: 61.15% C, 4.89% H, 6.79% N; found: 61.25% C, 5.20% H, 7.05% N; pale yellow solid; m.p. >300 °C decomposition (methanol–diethyl ether). ^{1}H NMR (300 MHz, DMSO-d_6): 3.53 m, 1 H; 3.55–3.63 bm, 2 H; 3.73 dd, 1 H, *J* = 9.2, 3.2; 3.79 t, 1 H, *J* = 11.4 and 3.96, dd, 1 H, *J* = 7.5, 2.0 (H saccharide, H-2′–H-6′); 4.01 bs, 4 H (CD_3COOD exchangeable, 4 × OH); 5.96 s, 1 H (H-1′); 7.28–7.41 bm, 3 H; 7.51 m, 1 H; 7.75 m, 1 H; 7.99 d, 1 H, *J* = 7.8; 8.05 d, 1 H, *J* = 7.2; 8.42 m, 1 H and 8.51 s, 1 H (H arom.). ^{13}C NMR (75 MHz, DMSO-d_6): 61.15 (C-6′); 66.47, 70.55, 73.54, 80.36 (C-2′–C-5′); 82.37 (C-1′); 109.98, 111.32, 120.76, 121.59, 121.68, 121.74, 122.90, 124.27, 124.44, 126.24, 130.54, 132.94, 136.17, 153.64, 162.39 (C arom.). MS MALDI-TOF, *m/z* (%): 435 $[M + Na]^+$ (71), 413 $[M + H]^+$ (100).

1-(β-D-Ribofuranosyl)-3-(1,3-benzothiazol-2-yl)-1*H*-indole (**9e**)

Compound **8e** (0.690 g, 0.993 mmol) was dissolved in dry methanol (20 ml) and 1 M solution of sodium methoxide in dry methanol (7 ml) was added dropwise. The reaction mixture was stirred at room temperature overnight, neutralized with Amberlite IR 120 (H^+) and

filtered through silica gel. Methanol was evaporated under reduced pressure and the residue was recrystallized from a mixture methanol–diethyl ether. Yield 0.295 g (78%). For $C_{20}H_{18}N_2O_4S$ (382.4) calculated: 62.81% C, 4.74% H, 7.33% N; found: 63.08% C, 4.55% H, 7.48% N; pale yellow solid; m.p. 284–286 °C (methanol–diethyl ether). ^{1}H NMR (300 MHz, DMSO-d_6): 3.66 dd, 1 H, J(5′,5″) = 11.9, J(4′,5′) = 3.4 (H-5′); 3.75 dd, 1 H, J(5′,5″) = 11.9, J(4′,5″) = 3.3 (H′-5′); 4.05 m, 1 H; 4.16 t, 1 H, J(2′,3′) = 4.3 (H-3′); 4.37 t, 1 H, J = 5.5 (H-2′); 4.60–5.80 bs, 3 H (D_2O exchangeable, 3 × OH); 6.0 d, 1 H, J(1′,2′) = 5.8, 7.33–7.44 bm, 3 H (H-6″, H-6, H-5); 7.54 t, 1 H, J = 8.2 (H-5″); 7.77 m, 1 H (H-7); 8.02 d, 1 H, J = 7.9 (H-4″); 8.08 d, 1 H, J = 7.7 (H-7″); 8.43 m, 1 H (H-4); 8.56 s, 1 H (H-2). ^{13}C NMR (75 MHz, DMSO-d_6): 61.47 (C-5′); 70.41 (C-3′); 74.77 (C-2′); 85.54 (C-4′); 89.45 (C-1′); 111.39 (C-7); 111.80 (C-3); 121.43 (C-4″); 122.25 (C-4); 122.32 (C-7″); 122.62 (C-5); 123.92 (C-6); 125.15 (C-5″); 125.71 (C-3a); 126.90 (C-6″); 128.80 (C-2); 133.50 (C-7″a); 136.95 (C-7a); 153.93 (C-3″a); 162.85 (C-2″). MS MALDI-TOF, *m/z* (%): 405 $[M + Na]^+$(28), 383 $[M + H]^+$ (100).

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