1,2-ANHYDROSACCHARIDES AND 1,2-CYCLIC SULFITES AS SACCHARIDE DONORS IN CONVERGENT SYNTHESIS OF GLUCOPYRANOSYL-, MANNOPYRANOSYL- AND RIBOFURANOSYLBENZOCAMALEXIN

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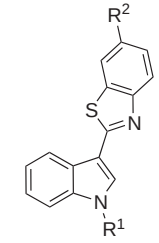
A convergent synthesis of 1-(β-D-glucopyranosyl)-, 1-(α-D-mannopyranosyl)- and 1-(β-D-ribofuranosyl)benzocamalexin was elaborated as an alternative route to the linear approach based on the indoline–indole method. 1,2-Anhydrosaccharides and 1,2-cyclic sulfites as saccharide donors were used in the key glycosylation step. Coupling with benzocamalexin resulted in moderate to excellent yields of nucleoside analogs, depending on the saccharide donor, catalyst and solvent used.

Keywords: Indoles; Glycosides; Phytoalexins; Benzocamalexin; 1,2-Anhydrosacharides; Cyclic sulfites; Nucleosides; Glycosidations; Carbohydrates.

Indole glycosides are a group of nucleoside analogs possessing a broad spectrum of biological activities. Neosidomycin[1a,1b] and SF-2140 [1b,1c], kahakamides A and B [1d] and recently developed glycosides of isoindigo[1e] and oxindole[1f] are compounds with antibacterial properties. On the other hand, rebeccamycin, a microbial metabolite isolated from cultures of *Saccharothrix aerocolonigenes*, possesses anticancer activity[2a]. Intensive structure-activity relationship studies of rebeccamycin analogs uncovered several interesting glycosylindolocarbazoles as attractive cancer chemotherapy agents[2b,2c].

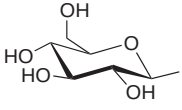
Our research aimed at 1-glycosides derived from natural phytoalexins[3] outlined the structures of 1-α-D-mannopyranosyl- (**1c**), 1-β-D-ribofuranosylbenzocamalexin[4a] (**1d**) and 1-β-D-glucopyranosyl-6-methoxybenzocamalexin[4b] (**1b**) with promising antiproliferative activity. Recently we described the synthesis of compounds **1b**–**1d** via the linear indoline-indole method[5] starting from corresponding glycosylindolines[4]. The linear ap-

proach took advantage of enhanced nucleophilicity of indoline in comparison with the less nucleophilic indole ring thus allowing utilization of either unprotected saccharides[1e,1f] or their peracetylated, commercially and synthetically easily accessible derivatives[4]. On the other hand, a synthetic pathway from glycosylated indoline to the target benzocamalexin moiety inevitably influences the saccharide due to side reactions diminishing the yields and limits the selection of suitable reaction conditions for modification of aglycon[4b]. These inconveniences could be avoided in the convergent approach based on separate preparation of final aglycon structure and its subsequent coupling with appropriate saccharide donor in the glycosylation step. However, indole derivatives exhibit low nucleophilicity and hence highly reactive saccharide donors should be employed.

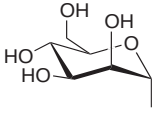


benzocamalexin **1a**
R^1, R^2 = H

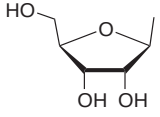
1b, R^2 = OMe
R^1 =



1c, R^2 = H
R^1 =



1d, R^2 = H
R^1 =

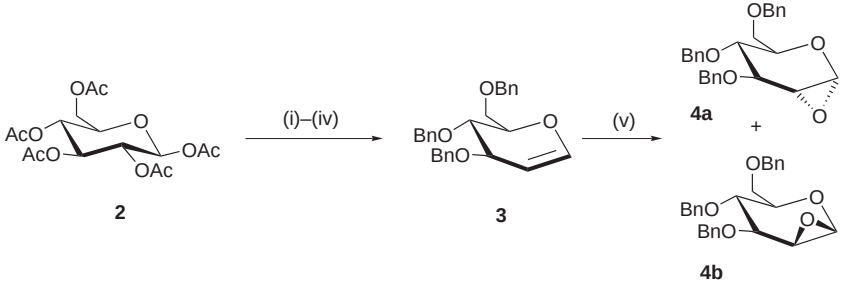


Our initial attempts at glycosylation of benzocamalexin (**1a**) included widely used glycosyl donors, namely tetra-*O*-acetyl-α-D-glucopyranosyl bromide under the Koenigs–Knorr conditions[6,7], trichloroacetimidates[7], tetra-*O*-benzyl-α-D-glucopranosyl chlorides[8], tetra-*O*-benzyl-D-glucopyranose in the Mitsunobu reaction[9] and 5-*O*-(*tert*-butyldimethylsilyl)-2,3-*O*-isopropylidene-α-D-ribofuranosyl chloride in the Robinson method[10]. All of these methods failed in preparation of benzocamalexin glycosides. Continuous search for suitable glycosyl donors finally led us to examine the Danishefsky method using 1,2-anhydrosacharides[11] along with a new type of glycosylation agents setting as epoxide replacement[12,13] – 1,2-cyclic sulfites.

Applicability of 1,2-epoxides and corresponding 1,2-cyclic sulfites in stereoselective synthesis of β-D-glucopyranosyl-, β-D-ribofuranosyl- and α-D-mannopranosylbenzocamalexin is reported.

The benzylated saccharide donor, 1,2-anhydro-α-D-glucopyranose (**4a**), was prepared from commercial penta-*O*-acetyl-β-D-glucose (**2**) in five steps (Scheme 1). Bromination of **2** [14a], reductive elimination with Zn in acetic

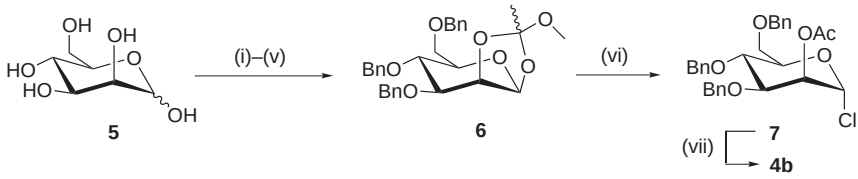
acid[14b] followed by deacetylation[14c] and benzylation[14d] afforded the described 3,4,6-tri-*O*-benzylglucal (**3**)[14e] in a good, 70% overall yield from **2** (Scheme 1). This sequence was performed without time-consuming chromatographic purifications except for compound **3**. Epoxidation of **3**, efficiently performed with the Camp reagent, 3-chloroperoxybenzoic acid (CPBA), and KF afforded a mixture of 1,2-anhydroglucopyranose (**4a**) and 1,2-anhydromannopyranose (**4b**; Scheme 1) in the ratio 9:1, as reported in literature[14f]. Instability of epoxides precluded separation of isomers and a mixture of **4a** and **4b** was used in reaction with saccharide acceptor **1a**.



(i) 33% HBr in AcOH, CH_2Cl_2, 0 °C–r.t., 1.5 h; (ii) Zn, 50% AcOH, –15 °C–r.t., 2.5 h; (iii) K_2CO_3, MeOH, 40 min; (iv) KOH, BnBr, DMSO, 48 h, 70% based on **2**; (v) CPBA, KF, CH_2Cl_2, N_2, 17 h

SCHEME 1

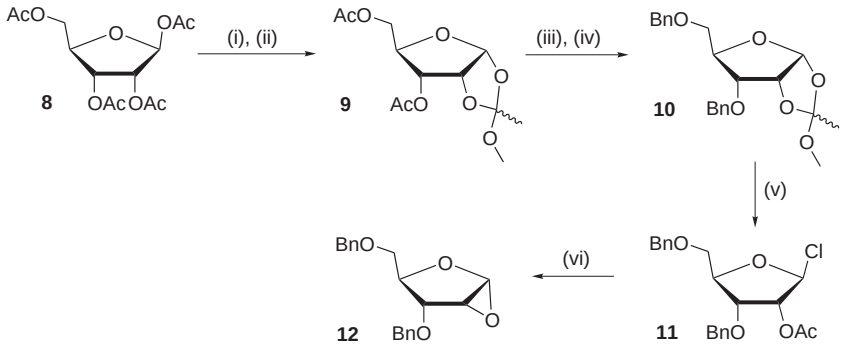
Stereoselective preparation of 1,2-anhydro-β-D-mannopyranose (**4b**) utilized intramolecular ring closure for 2-*O*-acetyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl chlorid (**7**; Scheme 2). Compound **7** was prepared from D-mannose (**5**) peracetylated in a mixture of pyridine/acetic anhydride followed by bromination[14a]. The 1,2-orthoester ring formation[15a] furnished peracetylated 3,4,6-tri-*O*-acetyl-1,2-*O*-(1-methoxyethylidene)-α-D-mannopyranoside which was transformed to the described perbenzylated analog **6** [15b] in overall 75% yield based on **5** (Scheme 2). Again, no column chromatography was employed except for **6** which was subsequently smoothly converted to 1,2-anhydro-β-D-mannopyranose **4b** by the well-known cyclic orthoester ring opening with trimethylsilyl chloride[16] (TMSCl) followed by one-pot hydrolysis of chloride[17] **7**. The course of the reaction was difficult to monitor since 1,2-anhydrosugar **4b** completely decomposes when spotted on TLC plate. However, disappearance of the starting material could be clearly indicated. The reactivity of **4b** allowed its structure verification after quantitative methanolysis to 1-*O*-methyl-3,4,6-tri-*O*-benzyl-α-D-mannopyranoside[18].



(i) Ac_2O, pyridine, 5 h; (ii) 33% HBr in AcOH, CH_2Cl_2, 0 °C–r.t., 2.5 h; (iii) MeOH, Bu_4NBr, Et_3N, 1,2-DCE, N_2, 75 °C, 16 h; (iv) K_2CO_3, MeOH, 2 h; (v) BnBr, KOH, DMSO, 48 h, 75% based on **5**; (vi) TMSCl, CH_2Cl_2, 0 °C, N_2, 1.5 h; (vii) *t*-BuOK, THF, N_2, r.t.–reflux, 1 h

SCHEME 2

The strategy and conditions for preparation of the perbenzylated orthoester **6** (Scheme 2) were used for the synthesis of 1,2-anhydro-α-D-ribofuranose (**12**; Scheme 3). Commercial peracetylated β-D-ribofuranose (**8**) was chlorinated with a mixture of acetyl chloride and methanol serving as a milder source of HCl compared with the reported $SOCl_2$/acetic acid mixture[19]. The orthoester ring formation was to date described for the reaction of 2,3-di-*O*- acetyl-5-*O*-benzyl-β-D-ribofuranosyl chloride with (dimethoxymethyl)dimethylamine[20]. The same orthoester ring formation was in our case achieved by the treatment of crude tetra-*O*-acetyl-β-D-ribofuranosyl chloride with methanol, Bu_4NBr and Et_3N in dry 1,2-dichloroethane (1,2-DCE) at 70 °C. The required 3,5-di-*O*-acetyl-1,2-*O*-(1-methoxyethylidene)-α-D-ribofuranoside (**9**) was obtained from **8** in excellent 98% yield. An exchange of protecting groups yielded compound **10** (77%; Scheme 3). Instability of new, as yet undescribed 1,2-cyclic orthoesters **9** and **10** allowed confirmation of structure only by ^1H and ^{13}C NMR analysis since attempts to obtain an accurate elemental analysis and mass spectra were unsuccessful. The reaction of **10** with TMSCl afforded chloride **11** and one-pot reaction with *t*-BuOK in dry THF afforded 1,2-anhydro-α-D-ribofuranose (**12**) after the SN2 reaction of C-2 acetoxy group with anomeric chlorine as a living group. The opposite ring closure of C-1 acetoxy group with C-2 tosyl living group was reported[21]. The ring closure reaction appeared temperature-sensitive. Heating of the reaction mixture, as in the case of mannopyranosyl derivative (Scheme 2), caused decomposition since no methyl 3,5-di-*O*-benzyl-β-D-ribofuranoside was detected after alcoholysis in dry methanol[21]. Ambient temperature appeared sufficient for the effective epoxide ring formation but some loss could not by avoided since cooling of the reaction produced only diol **17** (Scheme 5). Due to its instability, the structure of compound **12** was confirmed after alcoholysis in dry methanol with the formation of expected methyl 3,5-di-*O*-benzyl-β-D-ribofuranoside[21] in 63% yield.



(i) AcCl, MeOH, CH_2Cl_2, 3 days; (ii) MeOH, Et_3N, Bu_4NBr, 1,2-DCE, N_2, 70 °C, 24 h, 98% based on **8**; (iii) K_2CO_3, MeOH, 30 min; (iv) BnBr, KOH, DMSO, 24 h, 77%; (v) TMSCl, CH_2Cl_2, 0 °C, N_2, 5 min; (vi) *t*-BuOK, THF, N_2, 0 °C–r.t., 1 h

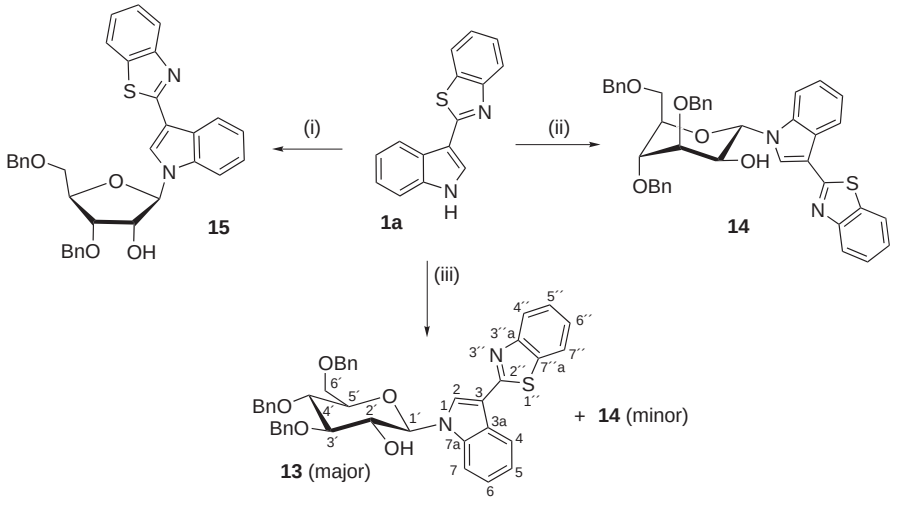
SCHEME 3

The glycosylation step included *in situ* generation of benzocamalexin anion with NaH (1 equivalent) in appropriate solvent (DMF or CH_3CN)[22] and subsequent condensation with a mixture of epoxides **4a** and **4b** (prepared from 2 to 3 equivalents of **3**) under N_2 atmosphere. The reaction mixture was stirred at elevated temperature (Table I) and products isolated by silica gel chromatography. Two compounds, major β-glucopyranoside **13** and minor α-mannopyranoside **14** (Scheme 4) were obtained in good to very good yields (60–81%). The ratio of compounds **13** and **14** appeared to be significantly solvent-dependent (Table I). To the best of our knowledge, similar chemistry of 1,2-anhydrosacharides is not known in glycoside preparations. Plausibly, less polar acetonitrile discriminates more between the reactivities of epoxides **4a** and **4b** (Scheme 1) favoring α-isomer **4a** and thus producing

TABLE I
The effect of reaction conditions on glucosylation of benzocamalexin (**1a**) in the reaction with a mixture of epoxides **4a** and **4b**

Epoxides **4a** and **4b** equiv.	Reaction conditions	Yield, %	Ratio **13**:**14**
2	NaH, DMF, 50 °C, 5 h	60	7:1
3	NaH, DMF, 50 °C, 5 h	81	
2.25	NaH, CH_3CN, 55 °C, 5 h	70	19:1
2.25	NaH, CH_3CN, 18-crown-6, 60 °C, 3 h	79	

a high yield of β-glycoside **13** whereas less reactive compound **4b** is mostly consumed in competitive side and decomposition reactions.



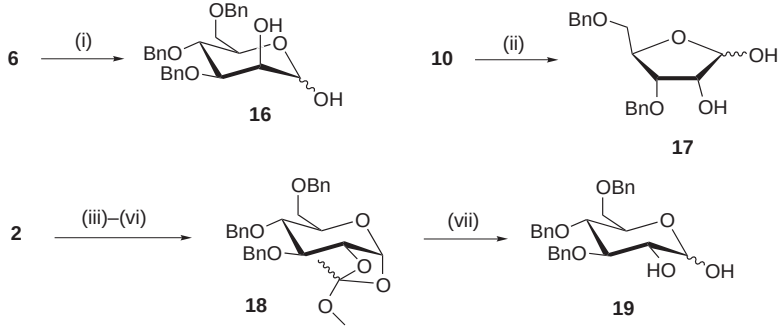
(i) 1. **1a**, NaH, N_2, CH_3CN, 18-crown-6 or 15-crown-5, 40 °C, 30 min, 2. **12**, CH_3CN, N_2, 55 °C, 2 h, 35 or 41%; (ii) 1. **1a**, NaH, N_2, CH_3CN, 18-crown-6, 40 °C, 30 min, 2. **4b**, CH_3CN, N_2, 65 °C, 5 h, 69%; (iii) 1. **1a**, NaH, N_2, CH_3CN, 18-crown-6, 40 °C, 30 min, 2. **4a** and **4b**, CH_3CN, N_2, 60 °C, 3 h, 79%, for other conditions, see Table I

SCHEME 4

The minor α-mannopyranosylbenzocamalexin **14** (Scheme 4) was selectively prepared in a good 69% yield by an analogous reaction of benzocamalexin sodium salt with epoxide donor **4b** obtained in one-pot sequence from orthoester **6** (Scheme 2). Ribosylation of **1a** was not as efficient as previous preparations of glucosyl and mannosyl derivatives (**13** and **14**, respectively). Employing either 18-crown-6 catalysts or 15-crown-5 ether, better fitting Na cation, brought no significant improvement and benzylated β-D-ribofuranosylbenzocamalexin **15** (Scheme 4) was prepared in moderate 35 or 41% yields. Lower yields of ribofuranoside **15** could be ascribed to the above mentioned higher instability of epoxide **12**, compared with pyranosyl analogs **4a** and **4b**. While decomposition and side reactions competed with glycosylation in the case of 1,2-anhydroglucose **4a** and 1,2-anhydromannose **4b**, they became prevalent in ring closure (Scheme 3) and opening (Scheme 4) reactions of 1,2-anhydroribose **12** and, consequently, minimized the yield of ribofuranosylbenzocamalexin **15**.

Anhydrosugars worked well in glycosylation of benzocamalexin **1a** as described above; however, their instability affected the yields of target glycosides. These results prompted us to study 1,2-cyclic sulfites derived from glucose, mannose and ribose as isolable, stable and accessible substitutes for epoxides **4a**, **4b** and **12**. Our interest arose from the reported function of 1,2-cyclic sulfites as an epoxide replacement in preparation of chiral amino alcohols along with their stability[12] described for glucopyranosyl-**20** [23a–23c] and ribofuranosyl- **21** [24c] analogs (Scheme 6). Cyclic sulfites are rarely exploited compounds in glycosylation chemistry; they are mainly used in the synthesis of several C-1, C-4 and C-6 azidosaccharides[24a–24d] and in preparation of uracil derivatives[23a]. To the best of our knowledge, similar reactions of indoles as nucleophiles with 1,2-cyclic sulfites have not been described.

Synthesis of 1,2-*O*-sulfinyl-α-D-glucopyranose (**20**; Scheme 6) was previously accomplished by treatment of $SOCl_2$ or 1,1′-sulfinyldiimidazole [$SO(Im)_2$] with appropriately protected diol **19** (Scheme 5), generated by hydroxylation of the corresponding glucal **3** (Scheme 1)[23b,23c]. In our case, we used conveniently prepared orthoesters **6** and **10** (Schemes 2 and 3). Their acid hydrolysis[15a] afforded in excellent 95 to good 78% yields the required diols **16** and **17** (Scheme 5), known from literature[25a,25b]. Preparation of diol **19** started from penta-*O*-acetyl-β-D-glucose (**2**; Scheme 1) which was transformed in four steps to 3,4,6-tri-*O*-benzyl-1,2-*O*-(1-methoxyethyl-

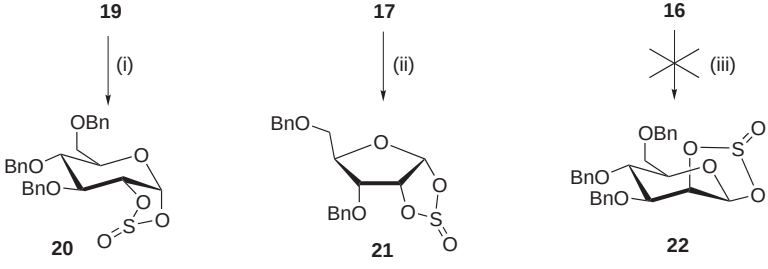


(i) 1.5 M H_2SO_4, dioxane, 110 °C, 1.5 h, 95%; (ii) 1.5 M H_2SO_4, dioxane, 110 °C, 1 h, 78%; (iii) 33% HBr in AcOH, CH_2Cl_2, 0 °C–r.t., 1.5 h; (iv) MeOH, Bu_4NBr, Et_3N, 1,2-DCE, N_2, 45 °C, 16 h; (v) K_2CO_3, MeOH, 2 h; (vi) BnBr, KOH, DMSO, 48 h, 70% from **2**; (vii) 1 M H_2SO_4, dioxane, 110 °C, 2 h, 93%

SCHEME 5

idene)-α-D-glucopyranose (**18**) in 70% overall yield from **2** (Scheme 6) under the same conditions as used for synthesis of orthoester **6** (Scheme 2). The acid hydrolysis[15a] of known orthoester **18** [25c] gave diol **19** [25d] in 93% yield (Scheme 5) without using column chromatography except for the last step.

The reaction of diols **17** and **19** with $SOCl_2$ in the presence of pyridine as acid scavenger in dry CH_2Cl_2 (lit.[12f]) proceeded smoothly and afforded 1,2-cyclic sulfites **20** and **21** (Scheme 6). Compounds **20** and **21** were easy to isolate in very good 83 and 71% yields as a mixture of *endo* and *exo* diastereoisomer at sulfur, as reported[23] (Scheme 6). Unexpectedly, attempts at thionylation of 2,4,6-tri-*O*-benzyl-D-mannopyranose (**16**) failed. Treatment of **16** either with $SOCl_2$ in dry CH_2Cl_2 or with more reactive 1,1′-sulfinyldiimidazole [$SO(Im)_2$] in THF [23b,23c] did not produce the required cyclic sulfite **22** (Scheme 6). Monitoring the reaction by TLC revealed the presence of the unreacted starting material along with strong decomposition. 1,2-Cyclic sulfite **22** is probably highly instable due to the anomeric affect causing destabilization of the saccharide in unfavorable β-configuration.



(i) $SOCl_2$, pyridine, CH_2Cl_2, 0 °C, N_2, 15 min, 83%; (ii) $SOCl_2$, pyridine, CH_2Cl_2, 0 °C, N_2, 1 h, 71%; (iii) $SOCl_2$, pyridine, CH_2Cl_2, 0 °C, N_2, or $SO(Im)_2$, THF, –20 °C, N_2

SCHEME 6

The sodium salt of benzocamalexin **1a** was glycosylated in a model reaction employing the conditions reported for preparation of carbocyclic adenine derivative[13]. The nucleophilic opening of sulfite **20** by 3 h heating at 100 °C in dry DMF under N_2 atmosphere proceeded with complete stereo- and regioselectivity via C-1′ attack to give 1,2-trans glycoside **13** (Scheme 4) albeit in modest 19% yield (Table II, entry 1). Exchange of either the catalyst or base did not lead to improvement of the yield (Table II). In addition, glycosylation carried out at ambient temperature revealed low reactivity of cyclic sulfite and substantial amount of **20** was present in the reaction mix-

ture even after 48 h reaction. Thus, compared with epoxides **4a** and **4b**, the proposed stability of 1,2-cyclic sulfite **20** at ambient temperatures but, hand by hand, their lower reactivity required elevated reaction temperatures (≈100 °C) led to decomposition which was faster than the ring opening S_N2 substitution.

TABLE II
Reaction conditions in glycosylation of benzocamalexin (**1a**) with cyclic sulfite **20**

Entry	Reaction conditions	Yield, %
1	NaH, DMF, 18-crown-6, 100 °C	19
2	NaH, DMF, 15-crown-6, 100 °C	20
3	DBU, DMF, 60 °C	15

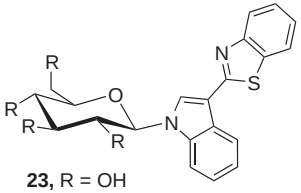
The treatment of benzocamalexin **1a** with KOH (8 equivalents) in DMF in the presence of drying agent Na_2SO_4 appeared to be more promising. The added 1,2-*O*-sulfinyl-α-D-glucopyranose **20** was consumed at room temperature in 0.5 h, providing glycoside **13** in 44% yield (Table III, entry 1). Our effort continued by changing the reagent and temperature but compound **13** was only prepared in a lower yield (Table III, entries 2–7) underlining the low reactivity of **20**.

TABLE III
Reaction conditions in glycosylation of benzocamalexin (**1a**) with cyclic sulfite **20**

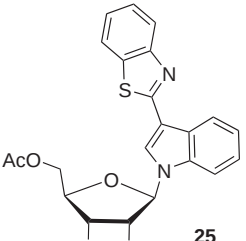
Entry	Reaction conditions	Yield, %1
1	KOH (8.0 equiv.), DMF, Na_2SO_4, r.t.	44
2	KOH (8.0 equiv.), DMF, Na_2SO_4, 0 °C	24
3	*t*-BuOK (8.0 equiv.), DMF, r.t.	31
4	KOH (8.0 equiv.), CH_3CN, Na_2SO_4, r.t.	24
5	KOH (1.2 equiv.), DMF, Na_2SO_4, r.t.	17
6	KOH (1.5 equiv.), DMF, Na_2SO_4,100 °C	28
7	KOH (8.0 equiv.), DMF, mol. sieves 4Å, r.t.	33

The treatment of 3,5-di-*O*-benzyl-1,2-*O*-sulfinyl-α-D-ribofuranoside (**21**; Scheme 6) with saccharide acceptor **1a** under most appropriate reaction conditions (Table III, entry 1) afforded β-riboside **15** although similarly in a moderate 29% yield.

Debenzylation of compounds **13**, **14** and **15** (Scheme 4) was inevitably the last task in development of convergent glycosylation of indole aglycon **1a** inasmuch as deprotected compounds **1c**, **1d** and **23** were tested and revealed antiproliferative activities[4]. The catalytic hydrogenation on Pd black was exploited for many indolocarbazole derivatives[2b–2e,6a]. In our case we proposed a thiazole ring interaction with the catalyst since sulfur acts as a well-known catalytic poison of Pd. On the other hand, deprotection of benzyl ether with Lewis acids BBr_3 (lit.[26a]) and $AlCl_3$/$PhNMe_2$ (lit.[26b]) is described. These debenzylations were used in the preparation of glycosylisoindigo[1e] and oxindole[1f] with good (60%)[1e] to modest (26%)[1f] yields. More efficient deprotection using $FeCl_3$ for simple mono-[27a,27b] and oligosaccharides[27c] was reported as well. Previous reaction conditions[27c] were adjusted in our case of indole glycosides **13**–**15** (Scheme 4) and 4 equivalents of $FeCl_3$ per benzyl group, 0 °C and 45-min reaction time were necessary to deprotect the saccharide moiety. Unfortunately, the presence of decomposition products complicated chromatographic purification of glycosides **1c**, **1d** and **23**. Thus, before isolation, acetylation in a Py/Ac_2O mixture was performed and recently described peracetylated products **24** (81%), **26** (77%)[4a] and the new (tri-*O*-acetyl-β-D-ribofuranosyl)benzocamalexin **25** (75%) were easy to isolate. The described deacetylation of compounds **24**, **26** [4a] and **25** with K_2CO_3 in dry methanol afforded target compound **1c**, **1d** and **23** identical with those reported in literature[4a].



23, R = OH
24, R = OAc



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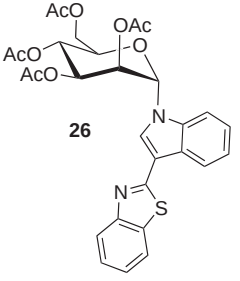

26

We recently reported detailed NMR study of acetylated glycoside **26**. Its β-counterpart adopted undoubtedly common $^4C_1$ conformation as depicted. This conclusion arose from comparison of hydrogen coupling constants of α-D-mannopyranosyl ring: $J(3',4')$ = 8.4 and $J(4',5')$ = 8.3 Hz, that

represent a clear vicinal *trans*-diaxial interaction of hydrogen H-3′, H-4′ and H-5′ (lit.[4a]). The benzylated analog **14** (Scheme 4) revealed considerably lower *trans*-diequatorial coupling constants $J(4',5')$ = 5.3 and $J(3',4')$ = 5.8 Hz thus confirming a transformation into $^1C_4$ conformation. This unusual conformation can be attributed to the bulkiness of the indole moiety which prefers the less hindered equatorial conformation in spite of presented anomeric affect. This stereoelectronic factor is not as dominant in *N*-glycosides as in *O*-glycosides; thus steric hindrance of the indole moiety and benzylated mannopyranosyl ring became prevalent in **14**. The exchange of bulky benzyl protecting groups for small acetyls in **26** diminished the mentioned interactions and caused the anomeric effect to become more important for the mannopyranosyl ring than steric factors: the conformation of **26** flipped back to $^4C_1$.

1,2-Anhydrosacharides derived from glucose (**4a**) and mannose (**4b**) are reactive saccharide donors in the synthesis of 1-glycosylbenzocamalexins. This route is more efficient than the alternative indoline-indole linear approach[4]. Although 1,2-anhydroribofuranose **12** due to its high instability and 1,2-cyclic sulfites **20** and **21** due to low reactivity coupled with benzocamalexin with lover efficiency, both types of saccharide donors can be used in the reactions with indole aglycons which are not suitable for the use of the linear method starting from 1-glycosylindoline.

EXPERIMENTAL

^{1}H and ^{13}C NMR spectra were measured on a Varian Mercury Plus spectrometer operating at 400 MHz for ^{1}H and at 100 MHz for ^{13}C. Chemical shifts (δ) are reported in ppm, downfield from tetramethylsilane used as an internal standard, coupling constants (*J*) in Hz. Microanalyses were performed with a Perkin–Elmer, Model 2400 analyzer. The 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, 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). The ion acceleration voltage was 5 kV. The reaction course was monitored by thin layer chromatography, using plates Macherey–Nagel Alugram®Sil G/UV254. The preparative column chromatography (flash chromatography) was performed on Kieselgel Merck Type 9385, 230–400 mesh.

Benzocamalexin (**1a**)

Solution of commercial indole-3-carbaldehyde (1.0 g, 6.88 mmol) in methanol (10 ml) was treated with 2-aminobenzene-1-thiol (0.86 g, 0.73 ml, 6.88 ml) and 3 drops of concentrated HCl were added. The reaction mixture was heated for 30 min, cooled to room temperature and neutralized with few drops of NH_4OH. The solution was poured into a crushed ice–

water mixture (50 ml) and the precipitated product was filtered off. Yield 0.930 g (54%), lit.[28] 54%; $C_{15}H_{10}N_2S$ (250.3); yellow-grey crystals; m.p. 155–157 °C (methanol), lit.[28] 169.5–170.5 °C.

3,4,6-Tri-*O*-benzylglucal (**3**)

Penta-*O*-acetyl-β-D-glucopyranose (**2**; 2.0 g, 5.12 mmol) was dissolved in dry CH_2Cl_2 (2 ml), cooled to 0 °C and a commercial 33% solution of HBr in AcOH (1.97 ml) was added dropwise into a vigorously stirred solution of **2**. The reaction mixture was stirred at room temperature for 1.5 h, diluted with CH_2Cl_2 (20 ml), washed with ice-cold water (2×) and neutralized with cooled saturated solution of $NaHCO_3$. The organic layer was washed with brine, dried over anhydrous Na_2SO_4, filtered off and concentrated. Well powdered crude bromide was added in several portions into a mixture of Zn (3.15 g, 48.3 mmol) in 50% AcOH at –15 °C during 10 min. Dark grey slurry was stirred at 0 °C for another 2.5 h, then filtered through Celite®, diluted with CH_2Cl_2, washed with cold water and saturated solution of $NaHCO_3$. The organic layer was dried over anhydrous Na_2SO_4 and filtered. The filtrate was concentrated and crude 3,4,6-tri-*O*-acetylglucal was deacetylated with K_2CO_3 (0.06 g, 0.468 mmol) in dry methanol (25 ml) during 40 min The reaction mixture was concentrated under reduced pressure and the residue was dissolved in DMSO (40 ml). The solution was treated with fine powdered KOH (2.57 g, 45.90 mmol), cooled to 0 °C and benzyl bromide (4.37 g, 3.03 ml, 26.6 mmol) was added dropwise. The reaction mixture was stirred vigorously at ambient temperature for 48 h, poured into a crushed ice and extracted with two portions of diethyl ether. Organic extracts were dried with anhydrous Na_2SO_4, and the solvent was evaporated under reduced pressure. Flash column chromatography afforded 3,4,6-tri-*O*-benzylglucal (**3**; 1.49 g, 70% based on **2**); $C_{27}H_{28}O_4$ (416.5); colorless oil. Spectral data were in accordance with those reported in lit.[14e].

1,2-Anhydro-3,4,6-tri-*O*-benzyl-α-D-glucopyranose (**4a**) and
1,2-anhydro-3,4,6-tri-*O*-benzyl-β-D-mannopyranose (**4b**)

KF (0.746 g, 12.84 mmol) was added to 3-chloroperoxybenzoic acid (1.10 g, 6.42 mmol) in dry CH_2Cl_2 (20 ml) and the suspension was kept under N_2 at room temperature with stirring. After 30 min glucal **3** was added (1.07 g, 2.57 mmol) in CH_2Cl_2 (8 ml) and the mixture was stirred for 17 h. Insoluble complexes were filtered off through Florisil, and the solvent was removed under reduced pressure. White solid residue was used immediately in the next glycosylation step.

3,4,6-Tri-*O*-benzyl-1,2-*O*-(1-methoxyethylidene)-β-D-mannopyranoside (**6**)

D-Mannose (**5**; 1.44 g, 7.99 mmol) was dissolved in dry pyridine (5 ml), cooled to 0 °C and acetic anhydride (3 ml) was added dropwise. The reaction mixture was stirred at room temperature for 5 h and crushed ice was added. After stirring for another 30 min, the mixture was washed with diethyl ether (2×). Ether extracts were washed with cold water (2×), saturated $NaHCO_3$ solution (2×), aqueous 1 M HCl (2×), dried (anhydrous Na_2SO_4), filtered and evaporated. The residue was dissolved in dry CH_2Cl_2 (4 ml) and ice-cold solution was treated with 33% HBr solution in AcOH. The reaction mixture was kept for 2.5 h at ambient temperature, then diluted with CH_2Cl_2, washed with cold water (2×) and neutralized with saturated $NaHCO_3$ solution. The organic layer was washed with brine, dried (anhydrous Na_2SO_4),

filtered and concentrated. The crude bromide was dissolved in dry 1,2-dichloroethane (20 ml) and Et_3N (1.62 g, 2.23 ml, 15.9 mmol), methanol (0.28 g, 0.356 ml, 8.79 mmol) and Bu_4NBr (1.28 g, 3.99 mmol) were added under N_2 atmosphere. The reaction mixture was stirred at 75 °C overnight, cooled to room temperature and concentrated. The dark residue was dissolved in diethyl ether and the precipitated salt was removed by filtration trough a pad of silica gel. The filtrate was concentrated and the pale yellow residue was dissolved in dry methanol. Fine powdered K_2CO_3 (0.110 g, 0.80 mmol) was added and the reaction mixture was stirred for 2 h. The deacetylated product was concentrated and the residue was dissolved in DMSO (40 ml). The solution was cooled to 0 °C and powdered KOH (4.34 g, 77.5 mmol) was added followed by benzyl bromide (7.34 g, 5.15 ml, 43.0 mmol). The reaction mixture was stirred for 48 h, poured into a crushed ice–water mixture, extracted with cold diethyl ether (2×), dried (anhydrous Na_2SO_4), and filtered. The residue was purified by flash column chromatography (cyclohexane–ethyl acetate 5:1). Yield 3.03 g (75%); $C_{30}H_{34}O_7$ (506.6); white solid; m.p. 83–87 °C (diethyl ether–hexane); lit.[15b] 74–76 °C. Spectral data were in accordance with those reported in lit.[15b].

1,2-Anhydro-3,4,6-tri-*O*-benzyl-β-D-mannopyranoside (**4b**)

The benzylated orthoester **6** (0.182 g, 0.36 mmol) was dissolved in dry CH_2Cl_2 (3.5 ml) under N_2 atmosphere and the solution was cooled to 0 °C. TMSCl (0.047 g, 0.055 ml, 0.432 mmol) was added with a syringe and the reaction mixture was stirred at room temperature for 1.5 h, then diluted with CH_2Cl_2, filtered through Florisil, and evaporated. Crude colorless chloride **7** was immediately dissolved in dry THF (3.5 ml) under N_2 atmosphere and the solution was treated with *t*-BuOK (0.060 g, 0.534 mmol) at room temperature. The reaction mixture was heated for 1 h, cooled to room temperature, diluted with CH_2Cl_2 and washed with brine (2×). The aqueous layer was extracted with another portion of CH_2Cl_2, combined organic extracts were dried (anhydrous Na_2SO_4), filtered and evaporated under reduced pressure affording crude white solid epoxide **4a** immediately used in glycosylation reactions.

3,5-Di-*O*-acetyl-1,2-*O*-(1-methoxyethylidene)-α-D-ribofuranoside (**9**)

Commercial peracetylated β-D-ribose **8** (3.215 g, 10.1 mmol) was dissolved in dry CH_2Cl_2 (70 ml). Acetyl chloride (7.9 g, 7.18 ml, 101 mmol) and dry methanol (0.642 g, 0.82 ml, 20.2 mmol) were added and the reaction mixture was kept without stirring at room temperature for 3 days. The reaction mixture was concentrated and residue was coevaporated several times with toluene until the smell of acetic acid disappeared. The crude chloride (colorless oil) was dissolved in dry 1,2-dichloroethane (80 ml), and Et_3N (5.71 g, 7.86 ml, 56.4 mmol), dry methanol (0.903 g, 1.14 ml, 28.19 mmol) and Bu_4NBr (1.52 g, 4.7 mmol) were added to the stirred solution. The reaction mixture was heated at 75 °C under N_2 atmosphere for 24 h, cooled to room temperature and concentrated. Diethyl ether was added to the dark brown residue and insoluble salt was removed by filtration through a pad of silica gel. The pale yellow solution was concentrated and the residue was subjected to column chromatography (cyclohexane–ethyl acetate 3:1). Yield 2.87g (98%); mixture of two diastereoisomers of orthoester in the ratio 10:1; major diastereoisomer $C_{12}H_{18}O_8$ (290.3); colorless oil. ^1H NMR ($CDCl_3$): 1.69 s, 3 H (CH_3, orthoester); 2.10 s, 3 H (CH_3, acetyl); 2.16 s, 3 H (CH_3, acetyl); 3.21 s, 3 H (OCH_3, orthoester); 4.15 dd, 1 H, *J*(5a,5b) = 12.3, *J*(4,5a) = 5.1 (H-5a); 4.23 ddd, 1 H, *J*(3,4) = 9.2, *J*(4,5a) = 5.1, *J*(4,5b) = 2.5 (H-4); 4.38 dd, 1 H, *J*(5a,5b) = 12.3, *J*(4,5b) = 2.5 (H-5b); 4.66 dd,

1 H, *J*(3,4) = 9.2, *J*(2,3) = 5.2 (H-3); 4.95 dd, 1 H, *J*(2,3) = 5.2, *J*(1,2) = 4.0 (H-2); 5.95 d, 1 H, *J*(1,2) = 4.0 (H-1). ^{13}C NMR ($CDCl_3$): 20.53 and 20.76 (CH_3, acetyl); 22.80 (CH_3, orthoester); 49.55 (OCH_3, orthoester); 62.24 (C-5); 72.23, 76.00 and 77.75 (C-2–C-4); 104.18 (C-1); 124.96 (Cq-orthoester); 170.08 and 170.64 (CO acetyl).

3,5-Di-*O*-benzyl-1,2-*O*-(1-methoxyethylidene)-α-D-ribofuranoside (**10**)

K_2CO_3 (0.220 g, 1.59 mmol) was added to a solution of peracetylated orthoester **9** (2.315 g, 7.98 mmol) in dry methanol (50 ml). The mixture was stirred at room temperature for 30 min, evaporated to dryness and the residue was dissolved in DMSO (25 ml). The solution was cooled to 0 °C and finely powdered KOH (2.68 g, 47.9 mmol) was added followed by dropwise addition of benzyl bromide (4.36 g, 3.03 ml, 25.5 mmol). The reaction mixture was stirred at room temperature for 24 h and partitioned between diethyl ether and cold water. The aqueous layer was extracted with diethyl ether, combined organic layers were dried (anhydrous Na_2SO_4), filtered and evaporated. The residue was purified by silica gel column chromatography (cyclohexane–ethyl acetate 3:1). Yield 2.37 g (77%); $C_{22}H_{26}O_6$ (386.4); pale yellow oil. ^{1}H NMR ($CDCl_3$): 1.72 s, 3 H (CH_3); 3.23 s, 3 H (OCH_3); 3.57 dd, 1 H, *J*(5a,5b) = 11.2, *J*(4,5a) = 4.0 (H-5a); 3.77 dd, 1 H, *J*(5a,5b) = 11.2, *J*(4,5b) = 2.1 (H-5b); 3.86 dd, 1 H, *J*(3,4) = 9.0, *J*(2,3) = 4.7 (H-3); 4.08 ddd, 1 H, *J*(3,4) = 9.0, *J*(4,5a) = 4.0, *J*(4,5b) = 2.1 (H-4); 4.50 d, 1 H, *J* = 12.2 (CH_2); 4.54 d, 1 H, *J* = 12.4 (CH_2); 4.57 d, 1 H, *J* = 13.3 (CH_2); 4.64 dd, 1 H, *J*(2,3) = 4.7, *J*(1,2) = 4.0 (H-2); 4.72 d, 1 H, *J*(1,2) = 4.0 (H-1); 7.26–7.35 bm, 10 H (H arom.). ^{13}C NMR ($CDCl_3$): 22.74 (CH_3); 49.05 (OCH_3); 68.05 (C-5); 72.56 and 73.73 (2 × CH_2Bn); 77.41, 78.18 and 78.85 (C-2–C-4); 104.47 (C-1); 124.97 (Cq-orthoesther); 127.91, 127.96, 128.29, 128.60, 128.59, 137.57 and 138.14 (C arom.).

1,2-Anhydro-3,5-*O*-benzyl-α-D-ribofuranoside (**12**)

Trimethylsilyl chloride (0.092 g, 0.108 ml, 0.854 mmol) was added into a solution of benzylated orthoester **10** (0.3 g, 0.776 mmol) in dry CH_2Cl_2 (6 ml) cooled to 0 °C under N_2 atmosphere. The reaction mixture was stirred at decreased temperature for 5 min before concentration under reduced pressure. Crude chloride **11** (colorless oil) was immediately dissolved in dry THF (6 ml) under N_2 atmosphere. The solution was cooled to 0 °C and treated with *t*-BuOK (0.13 g, 1.16 mol). The reaction mixture was stirred at 0 °C for 15 min and at ambient temperature for another 45 min, filtered through Florisil, washed with dry THF and evaporated under reduced pressure. The residue (pale yellow oil) was subjected immediately to glycosylation reaction.

3,4,6-Tri-*O*-benzyl-D-mannopyranose (**16**)

1.5 M aqueous solution of H_2SO_4 (10.8 ml) was added to a stirred solution of benzylated orthoester **6** (3.06 g, 6.04 mol) in dioxane (30 ml). The reaction mixture was stirred at 110 °C for 1.5 h, cooled to room temperature and carefully neutralized with powdered $NaHCO_3$ while stirring. Precipitated inorganic salts were filtered off and the filtrate was concentrated under reduced pressure. The resulting residue was partitioned between CH_2Cl_2 and water, the organic layer was washed with brine, dried (anhydrous Na_2SO_4), filtered and concentrated in vacuo to afford 2.59 g (95%). Compound **16**: $C_{27}H_{30}O_6$ (450.5); white solid; m.p. 92–95 °C (hexane–ethyl acetate), lit.[25a] 96–98 °C. Spectral data were in accordance with those reported in lit.[25a]

3,5-di-*O*-benzyl-D-ribofuranose (**17**)

Diol **17** was prepared according to the procedure for synthesis of **16** after 1-h heating. Yield 78%; $C_{19}H_{22}O_5$ (330.4); white solid; m.p. 85–87 °C, lit.[25b] 79.8 °C. Spectral data were in accordance with those reported in lit.[25b]

3,4,6-Tri-*O*-benzyl-1,2-*O*-(1-methoxyethylidene)-α-D-glucopyranoside (**18**)

Perbenzylated orthoester **18** was prepared according to the procedure for synthesis of mannopyranosyl orthoester **6** in overall yield 70% from commercial penta-*O*-acetyl-β-D-glucopyranose (**2**). $C_{30}H_{34}O_7$ (506.6); pale-yellow oil. Spectral data were in accordance with those reported in lit.[25c]

3,4,6-Tri-*O*-benzyl-D-glucopyranose (**19**)

Diol **19** was prepared according to the procedure for synthesis of **16**. 1 M aqueous solution of H_2SO_4 was used and the reaction mixture was stirred for 2 h. Yield 1.93 g (93%); $C_{27}H_{30}O_6$ (450.5); white solid; m.p. 85–87 °C (hexane–ethyl acetate), lit.[25d] 80–82 °C. Spectral data were in accordance with those reported in lit.[25d]

3,4,6-Tri-*O*-benzyl-1,2-*O*-sulfinyl-α-D-glucopyranoside (**20**)

Diol **19** (0.250 g, 0.555 mmol) was dissolved in dry CH_2Cl_2 (2 ml) under N_2 atmosphere at 0 °C, and pyridine (0.219 g, 0.222 ml, 2.77 mmol) and $SOCl_2$ (0.092 g, 0.056 ml, 0.777 mmol) were added to the cooled solution. The reaction mixture was stirred for 15 min, dissolved in CH_2Cl_2 and the solution was washed with ice-cold water (2×). The organic layer was dried over anhydrous Na_2SO_4, filtered through a pad of Florisil and evaporated. Pure product **20** was obtained in the yield 0.229 g (83%). $C_{27}H_{28}O_7S$ (496.6); colorless oil. It was used in glycosylation reaction. Its physical data were identical with those reported in lit.[23b]

3,5-Di-*O*-benzyl-1,2-*O*-sulfinyl-α-D-ribofuranoside (**21**)

Sulfite **21** was prepared according to procedure for synthesis of **20** during 1 h. Yield 71%; $C_{19}H_{20}O_6S$ (376.4); colorless oil. It was used in glycosylation reaction. Its physical data were identical with those reported in lit.[24c]

3-(Benzothiazol-2-yl)-1-(3,4,6-tri-*O*-benzyl-β-D-glucopyranosyl)-1*H*-indole (**13**)

Method A: A solution of benzocamalexin **1a** (0.04 g, 0.159 mmol) in dry CH_3CN (1 ml) was treated with 18-crown-6 (0.021 g, 0.0799 mmol) and NaH (8.3 mg, 0.208 mmol), and the reaction was stirred at 40 °C for 30 min. The mixture of epoxides **4a** and **4b** (freshly prepared from 0.360 mmol of glucal **3**) in dry CH_3CN (1 ml) was added into a previously prepared solution of benzocamalexin salt. The reaction mixture was stirred under N_2 atmosphere at 60 °C for 3 h, cooled to room temperature and concentrated. The residue was dissolved in ethyl acetate, washed with 1 M aqueous solution of HCl and brine. The organic layer was dried (anhydrous Na_2SO_4), filtered and concentrated. Column chromatography (cyclohexane–ethyl acetate 5:1) afforded compounds **13** and **14** (0.086 g, 79% overall yield) in the ratio 19:1 and benzocamalexin **1a** (6.7 mg, 17%) was recovered. Glycosides **13** and **14**

were separated by column chromatography (cyclohexane–ethyl acetate 5:1), which afforded compounds **13** (0.081 g, 75%) and **14** (4.0 mg 4%).

Method B: Anhydrous Na_2SO_4 (1.16 g, 8.15 mmol) and KOH (0.203 g, 3.62 mmol) were added to a solution of benzocamalexin **1a** (0.113 g, 0.453 mmol) in dry DMF (5 ml). The reaction mixture was vigorously stirred at room temperature for 30 min and a solution of sulfite **20** (0.449 g, 0.906 mmol) in DMF (5 ml) was added. Stirring was continued for another 30 min and the reaction mixture was partitioned between ethyl acetate and ice-cold water. The organic layer was washed with brine, dried (anhydrous Na_2SO_4), filtered and concentrated. The residue was subjected to column chromatography (cyclohexane–ethyl acetate 5:1) and compound **13** (0.136 g) was obtained in 44% yield along with the starting compound **1a** (0.06 g, 53%).

Compound **13**: For $C_{42}H_{38}N_2O_5S$ (682.8) calculated: 73.88% C, 5.61% H, 4.10% N; found: 73.63% C, 5.77% H, 3.96% N; pale yellow crystals; m.p. 165–168 °C (ethyl acetate–petroleum ether). ^{1}H NMR ($CDCl_3$): 3.73–3.81 bm, 3 H (H-5′, H-6′a and H-6′b); 3.84 dd, 1 H, *J*(2′,3′) = 8.1, *J*(3′,4′) = 9.2 (H-3′); 3.92 dd, 1 H, *J*(3′,4′) ≈ *J*(4′,5′) = 9.2 (H-4′); 4.12 bs, 1 H (OH, CH_3COOD exchangeable); 4.33 dd, 1 H, *J*(1′,2′) = 8.9, *J*(2′,3′) = 8.1 (H-2′); 4.47 d, 1 H, *J* = 12.1 (CH_2); 4.56 d, 1 H, *J* = 12.1 (CH_2); 4.68 d, 1 H, *J* = 10.7 (CH_2); 4.94 d, 1 H, *J* = 10.7 (CH_2); 4.98 d, 1 H, *J* = 11.3 (CH_2); 5.03 d, 1 H, *J* = 11.3 (CH_2); 5.38 d, 1 H, *J*(1′,2′) = 8.9 (H-1′); 7.04 t, 1 H, *J* = 7.5; 7.14 t, 1 H, *J* = 7.5; 7.25–7.41 bm, 17 H (H arom.); 7.45 d, 1 H, *J* = 8.2; 7.78 d, 1 H, *J* = 7.8; 7.87 d, 1 H, *J* = 8.0; 8.04 s, 1 H; 8.26 d, 1 H, *J* = 7.9 (H arom). ^{13}C NMR ($CDCl_3$): 68.77 (C-6′); 73.11 (C-2′); 73.72 and 75.42 (3 × CH_2Bn); 75.84, 78.16 and 85.60 (C-3′–C-5′); 87.87 (C-1′); 111.97, 112.08, 121.05, 121.38, 122.01, 122.23, 123.20, 124.25 and 126.27 (C aglycon); 127.84, 127.91, 128.10, 128.12, 128.19, 128.21, 128.59, 128.72 and 128.80 (Bn); 133.71 and 136.11 (C aglycon); 138.23, 138.27, 138.72 (Bn); 153.16 and 162.78 (C aglycon). MS MALDI-TOF, *m/z* (%): 683 (100) $[M + H]^+$, 705 (6) $[M + Na]^+$, 721 (10) $[M + K]^+$.

3-(Benzothiazol-2-yl)-1-(3,4,6-tri-*O*-benzyl-α-D-mannopyranosyl)-1*H*-indole (**14**)

Compound **14** was prepared according to the procedure for synthesis of **13** (method *A*), starting from epoxide **4b** (freshly prepared from orthoester **6**). Column chromatography (cyclohexane–ethyl acetate 5:1) afforded the title compound **14** (69%) and the starting benzocamalexin **1a** (28%). Compound **14**: For $C_{42}H_{38}N_2O_5S$ (682.8) calculated: 73.88% C, 5.61% H, 4.10% N; found: 73.96% C, 5.43% H, 4.28%N; pale yellow oil. ^{1}H NMR ($CDCl_3$): 2.83 bs, 1 H (OH, CH_3COOD exchangeable); 3.66 dd, 1 H, *J*(6′a,6′b) = 10.3, *J*(5′,6′a) = 4.2 (H-6′a); 3.86 dd, 1 H, *J*(6′a,6′b) = 10.3, *J*(5′,6′b) = 5.7 (H-6′b); 3.92 ddd, 1 H, *J*(5′,6′b) = 5.7, *J*(5′,6′a) = 4.2, *J*(4′,5′) = 5.3 (H-5′); 3.99 dd, 1 H, *J*(3′,4′) = 5.8, *J*(4′,5′) = 5.3 (H-4′); 4.13 dd, 1 H, *J*(3′,4′) = 5.8, *J*(2′,3′) = 3.6 (H-3′); 4.47 d, 1 H, *J* = 12.0 (CH_2); 4.52 dd, 1 H, *J*(1′,2′) = 5.6, *J*(2′,3′) = 3.6 (H-2′); 4.57 d, 1 H, *J* = 12.0 (CH_2); 4.62 d, 1 H, *J* = 11.6 (CH_2); 4.68 d, 1 H, *J* = 4.8 (CH_2); 4.69 d, 1 H, *J* = 6.4 (CH_2); 4.76 d, 1 H, *J* = 11.6 (CH_2); 5.91 d, 1 H, *J*(1′,2′) = 5.6 (H-1′);7.24–7.40 bm, 18 H (H arom.); 7.45 m, 1 H; 7.63 d, 1 H, *J* = 8.4; 7.87 s, 1 H; 7.88 d, 1 H, *J* = 6.0; 8.03 d, 1 H, *J* = 7.6; 8.39 d, 1 H, *J* = 8.0 (H arom.). ^{13}C NMR ($CDCl_3$): 67.31 (C-2′); 67.72 (C-6′); 73.31, 73.33 and 73.38 (3 × CH_2Bn); 73.40 (C-4′); 74.11 (C-3′); 78.51 (C-5′); 82.11 (C-1′); 111.98, 112.49, 121.18, 121.27, 122.21, 122.30, 123.55, 124.20, 125.93, 126.00 and 126.99 (C aglycon); 127.73, 127.80, 127.90, 127.94, 128.21, 128.40, 128.50, 128.54 and 128.89 (Bn); 133.92 (C aglycon); 137.09, 137.23 and 137.67 (Bn); 137.84, 153.76 and 162.32 (C aglycon). MS MALDI-TOF, *m/z* (%): 683 (100) $[M + H]^+$.

3-(Benzothiazol-2-yl)-1-(3,5-di-*O*-benzyl-β-D-ribofuranosyl)-1*H*-indole (**15**)

Compound **15** was prepared according to the procedure for synthesis of **13** (method *A*), starting from epoxide **12** (freshly prepared form orthoester **10**) and employing 15-crown-5 as catalyst instead of 18-crown-6 ether. Column chromatography (cyclohexane–ethyl acetate 5:1) afforded the required compound **15** (41%) and benzocamalexin **1** (54%). Method *B* afforded ribofuranosylbenzocamalexin **15** in 29% yield and starting compound **1a** (67%) after column chromatography (cyclohexane–ethyl acetate 5:1). Compound **15**: For $C_{34}H_{30}N_2O_4S$ (562.7) calculated: 72.58% C, 5.37% H, 4.98% N; found: 72.39% C, 5.55% H, 5.08% N; pale yellow oil. ^{1}H NMR ($CDCl_3$): 3.73 bs, 1 H (OH, CH_3COOD exchangeable); 3.63 dd, 1 H, *J*(5′a,5′b) = 10.6, *J*(4′,5′a) = 2.3 (H-5′a); 3.84 dd, 1 H, *J*(5′a,5′b) = 10.8, *J*(4′,5′b) = 2.5 (H-5′b); 4.32 m, 2 H (H-3′, H-4′); 4.47 dd, 1 H, *J*(2′,3′) = 4.6, *J*(1′,2′) = 4.5 (H-2′); 4.59 d, 1 H, *J* = 11.9 (CH_2); 4.63 s, 2 H (2 × CH_2); 4.72 d, 1 H, *J* = 11.9 (CH_2); 6.05 d, 1 H, *J*(1′,2′) = 4.5 (H-1′); 7.28–7.38 bm, 13 H (H arom.); 7.45 dt, 1 H, *J* = 8.2, 7.1, 1.2; 7.56 d, 1 H, *J* = 8.1; 7.84 dd, 1 H, *J* = 7.7, 0.9; 8.02 d, 1 H, *J* = 8.19; 8.26 s, 1 H; 8.46 td, 1 H, *J* = 7.7, 0.9 (H arom.). ^{13}C NMR ($CDCl_3$): 69.02 (C-5′); 73.00 and 73.71 (2 × CH_2Bn); 74.15, 77.49 and 81.15 (C-2′–C-4′); 90.60 (C-1′); 110.53, 112.25, 121.19, 121.52, 122.15, 122.20, 123.35, 124.12, 125.90, 126.19 and 126.91 (C aglycon); 127.91, 127.94, 128.15, 128.50, 128.56 and 128.74 (2 × Bn); 133.87 (C aglycon); 136.38 (Bn); 136.73 (C aglycon); 137.56 (Bn); 154.00 and 162.86 (C aglycon). MS MALDI-TOF, *m/z* (%): 563 (100) $[M + H]^+$.

Debenzylation/Acetylation of Compounds **13**–**15**. General Procedure

$FeCl_3$ (4 equivalents per benzyl group) was added to a solution of compounds **13**, **14** and **15** (0.058 mmol) dissolved in dry CH_2Cl_2 (2 ml) under N_2 atmosphere at 0 °C. The reaction mixture was stirred for 45 min and 0.1 ml of water was added to quench the reaction. The reaction mixture was diluted with methanol (10 ml) and filtered through a pad of silica gel. The filtrate was concentrated and rest of water was coevaporated with toluene (2×). The residue was dissolved in dry pyridine (0.8 ml) and Ac_2O (0.5 ml) was added dropwise. The reaction mixture was stirred overnight and partitioned between ethyl acetate and water. The organic layer was washed with saturated $NaHCO_3$ solution (2×), aqueous 1 M HCl and brine, dried over anhydrous Na_2SO_4, filtered and concentrated. Column chromatography (cyclohexane–ethyl acetate 5:1) afforded acetylated compounds **24** (81%), **25** (75%) and **26** (77%).

*3-(Benzothiazol-2-yl)-1-(2,3,4,6-tetra-O-acetyl-*β*-D-glucopyranosyl)-1H-indole* (**24**): $C_{29}H_{28}N_2O_9S$ (580.6); white crystals; m.p. 224–226 °C (methanol), lit.[4a] 228–230 °C. Spectral data were identical with those reported in lit.[4a]

*3-(Benzothiazol-2-yl)-1-(2,3,5-tri-O-acetyl-*β*-D-ribofuranosyl)-1H-indole* (**25**): For $C_{26}H_{24}N_2O_7S$ (508.5) calculated: 61.41% C, 4.76% H, 5.51% N; found: 61.21% C, 4.92% H, 5.38% N; pale yellow amorphous solid. ^{1}H NMR ($CDCl_3$): 2.09 s, 3 H (CH_3); 2.17 s, 3 H (CH_3); 2.29 s, 3 H (CH_3); 4.44–4.48 bm, 3 H (H-4′, H-5′a, H-5′b); 5.51 dd, 1 H, *J*(2′,3′) = 5.4, *J*(3′,4′) = 4.2 (H-3′); 5.61 dd, 1 H, *J*(1′,2′) = 5.7, *J*(2′,3′) = 5.4 (H-2′); 6.24 s, 1 H (H-1′); 7.33–7.38 m, 3 H; 7.47 dt, 1 H, *J* = 7.7, 1.2; 7.57 m, 1 H; 7.89 d, 1 H, *J* = 7.6; 8.03 d, 1 H, *J* = 7.6; 8.15 s, 1 H; 8.47 m, 1 H (H arom.). ^{13}C NMR ($CDCl_3$): 20.43, 20.60 and 20.71 (CH_3CO); 63.05 (C-5′); 70.46, 73.80 and 80.00 (C-2′–C-4′); 87.34 (C-1′); 110.28, 113.48, 121.33, 121.67, 122.36, 122.51, 123.73, 124.40, 125.74, 126.11, 126.22, 133.90, 136.48, 153.82 and 162.00 (C arom.); 169.34, 169.61 and 170.52 (CH_3CO). MS MALDI-TOF, *m/z* (%): 509 (100) $[M + H]^+$, 531 (23) $[M + Na]^+$, 547 (7) $[M + K]^+$.

3-(Benzothiazol-2-yl)-1-(2,3,4,6-tetra-O-acetyl-α-D-mannopyranosyl)-1H-indole (**26**): $C_{29}H_{28}N_2O_9S$ (580.6); white crystals; m.p. 135–137 °C (methanol), lit.[4a] 133–135 °C. Spectral data were identical with those reported in lit.[4a]

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