ISSN 1068-1620, Russian Journal of Bioorganic Chemistry, 2008, Vol. 34, No. 6, pp. 730–738. © Pleiades Publishing, Ltd., 2008.
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Synthesis of Heteroaromatic *N*-β-Glycosides of *N*-Acetylglucosamine under Phase Transfer Conditions: II.[1] Indolin-2-one Glycosaminides

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Received November 16, 2007; in final form, December 19, 2007

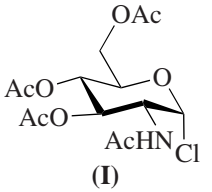
Abstract—Regioselective *N*-β-glucosamination of various unsubstituted or C4-, C5-, or C6-monosubstituted indolin-2-ones under phase transfer conditions was studied. The regioselectivity was unambiguously proved by ^{1}H NMR spectroscopy and X-ray analysis. The presence of substituent at C7 of the aromatic ring leads to the formation of either a mixture of isomeric *N*-β- and *O*-β-*D*-glucosaminides, or only oxazoline and/or 2-acetamidoglycal irrespective of the reaction conditions.

Key words: amido-imidole tautomers, 15-crown-5, β*-elimination, N-*β*-glucosaminides, phase transfer catalysis, regioselectivity, X-ray analysis*

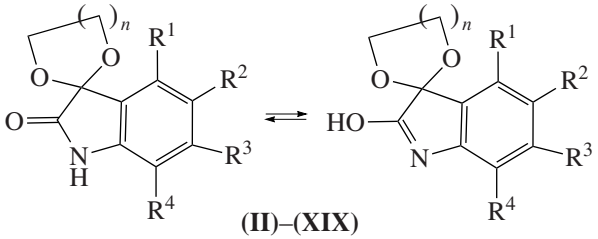
DOI: 10.1134/S1068162008060137

INTRODUCTION

The reaction of 2-acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-α-*D*-glucosaminyl chloride (**I**) with benzoxazolone-2, 5-methylbenzoxazolone-2, and benzthiazolone-2, we had previously investigated under various phase transfer conditions, showed these amido-imidole tautomers to regioselectively form the corresponding *N*-β-glucosaminides [1–3][3]. In continuation of these studies, we investigated the phase transfer reaction of α-chloride (**I**) with the close structural analogues of these ketals, indolin-2-ones (**II**)–(**XIX**), which are also amido-imidole tautomers [4], and examined the effect of the structure of compounds (**II**)–(**XIX**) and the glycosylation conditions on the yields and the composition of the products of the reaction under study.



(I)



(II)–(XIX)

	n	R^1	R^2	R^3	R^4		*n*	R^1	R^2	R^3	R^4
(II)	1	H	H	H	H	**(XI)**	2	H	H	Cl	H
(III)	2	H	H	H	H	**(XII)**	2	H	H	H	Me
(IV)	2	H	Me	H	H	**(XIII)**	2	Me	H	H	Me
(V)	2	H	MeO	H	H	**(XIV)**	2	H	Me	H	Me
(VI)	2	H	Br	H	H	**(XV)**	2	H	H	Me	Me
(VII)	2	H	NO_2	H	H	**(XVI)**	2	Cl	H	H	Cl
(VIII)	2	H	Cl	H	H	**(XVII)**	2	H	Cl	H	Cl
(IX)	2	H	H	H	Cl	**(XVIII)**	2	H	H	Cl	Cl
(X)	2	Cl	H	H	H	**(XIX)**	2	H	Br	H	Me

[1] For communication I see [1].

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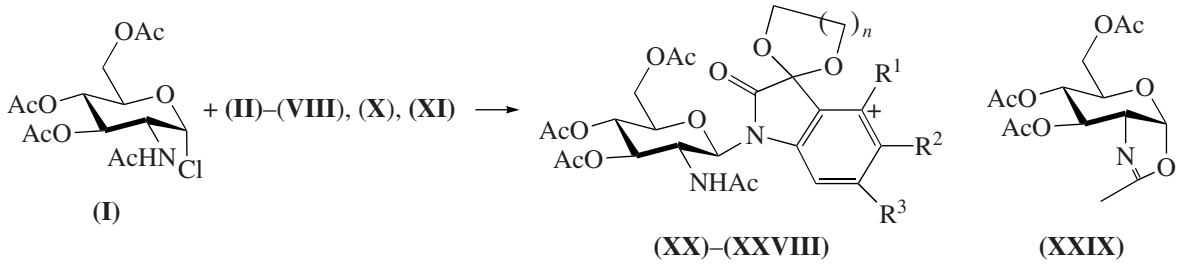
[3] Abbreviations: TEBAC, benzyltriethylammonium chloride.

RESULTS AND DISCUSSION

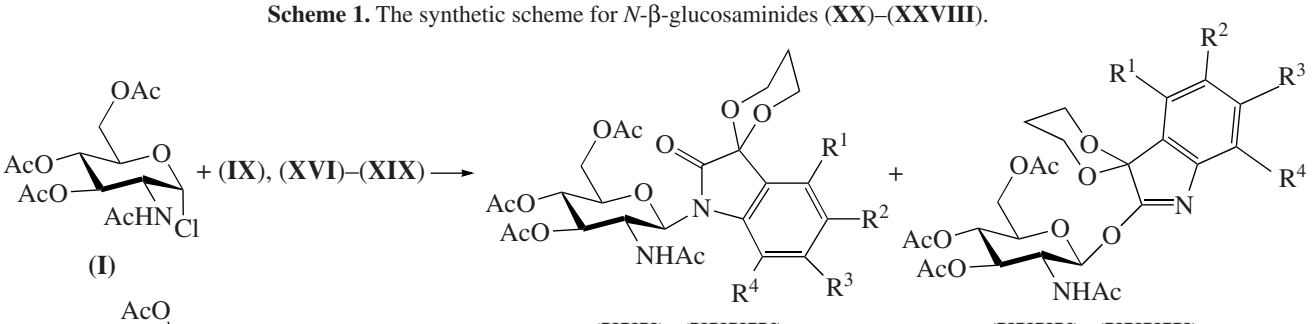
Stoichiometric glycosylation of ketals (**II**)–(**XIX**) with α-chloride (**I**) (Schemes 1 and 2) was carried out under various phase transfer conditions used previously [5–14] or described in literature [13, 14]. The ratios of the substrate, reagents, the base, and the crown ether are given in the Note to Table 1.



(I) **(XX)–(XXVIII)** **(XXIX)**

	n	R^1	R^2	R^3
(XX)	1	H	H	H
(XXI)	2	H	H	H
(XXII)	2	H	Me	H
(XXIII)	2	H	MeO	H
(XXIV)	2	H	Br	H
(XXV)	2	H	NO_2	H
(XXVI)	2	H	Cl	H
(XXVII)	2	Cl	H	H
(XXVIII)	2	H	H	Cl

Scheme 1. The synthetic scheme for *N*-β-glucosaminides (**XX**)–(**XXVIII**).



(I) **(XXX)–(XXXIV)** **(XXXV)–(XXXIX)**

(XL)

	R^1	R^2	R^3	R^4
(XXX), (XXXV)	H	H	H	Cl
(XXXI), (XXXVI)	Cl	H	H	Cl
(XXXII), (XXXVII)	H	Cl	H	Cl
(XXXIII), (XXXVIII)	H	H	Cl	Cl
(XXXIV), (XXXIX)	H	Br	H	Me

Scheme 2. The synthetic scheme for the mixture of *N*-β- and *O*-β-glucosaminides (**XXX**)–(**XXXIV**) and (**XXXV**)–(**XXXIX**); structure of 2-acetamidoglycal (**XL**).

The experimental data obtained (Table 1) allowed us to maintain reasonably that the direction of the reaction, the yield, and the composition of the product mixture were dictated by the position and the nature of the substituents in the carbocyclic ring of indolin-2-ones (**II**)–(**XIX**).

As in the cases described earlier in [1–3, 11, 12], the tautomerism of the starting heterocycle (see figure) made possible the formation of the two products, *O*-β- and/or *N*-β-glucosaminides. According to the literature data [4], just the oxo form of indolin-2-ones is the prevailing form usually participating in the chemical transformations. Thus, it should be logical to expect that the formation of *N*-glycosides will also be the main direction of the reaction under discussion.

In was found that the absence of the substituents in the aromatic ring (compounds (**II**) and (**III**)) or the presence of the substituent only at C5 of the indoline system resulted in the formation of presumably *N*-β-glucosaminides (**XX**)–(**XXVI**) (Scheme 1). As in the

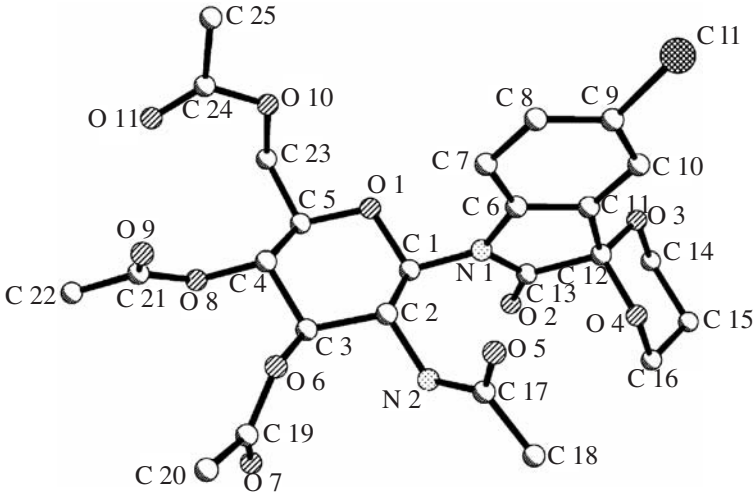
Table 1. Reaction time, yields, and the products of glycosylation of (**II**)–(**XIX**)

Glycosyl acceptor (reagent)	Reaction conditions*	Reaction time**, h	Yield of the glycoside or the mixture of glycosides, %	Reaction products
(**II**)	**A**	5	20	(**XX**), (**XXIX**)
(**III**)	**A**	5	23	(**XXI**), (**XXIX**)
(**III**)	**G**	5	–	(**XXIX**)
(**IV**)	**A**	5	16	(**XXII**), (**XXIX**)
(**IV**)	**B**	>8	–	–
(**IV**)	**C**	5	7	(**XXII**), (**XXIX**)
(**IV**)	**D**	3	7	(**XXII**), (**XXIX**)
(**IV**)	**E**	9	11	(**XXII**), (**XXIX**)
(**IV**)	**F**	7	14	(**XXII**), (**XXIX**)
(**IV**)	**G**	5	–	(**XXIX**)
(**V**)	**A**	3	6	(**XXIII**), (**XXIX**)
(**VI**)	**A**	4	29	(**XXIV**), (**XXIX**)
(**VII**)	**A**	6	40	(**XXV**), (**XXIX**)
(**VII**)	**B**	9	40	(**XXV**), (**XXIX**)
(**VIII**)	**A**	4	26	(**XXVI**), (**XXIX**)
(**IX**)	**A**	3	76***	(**XXX**), (**XXXV**)
(**IX**)	**B**	7	63***	(**XXX**), (**XXXV**)
(**IX**)	**C**	2.5	84***	(**XXX**), (**XXXV**)
(**IX**)	**D**	0.5	76***	(**XXX**), (**XXXV**)
(**X**)	**A**	10	18	(**XXVII**), (**XXIX**)
(**XI**)	**A**	10	12	(**XXVIII**), (**XXIX**)
(**XII**)	**A**	4	–	(**XXIX**), (**XL**)
(**XII**)	**B**	10	–	(**XXIX**)
(**XII**)	**F**	7	–	(**XXIX**), (**XL**)
(**XII**)	**G**	5	–	(**XXIX**)
(**XIII**)	**A**	4	–	(**XXIX**), (**XL**)
(**XIII**)	**B**	11	–	(**XXIX**)
(**XIII**)	**F**	8	–	(**XXIX**), (**XL**)
(**XIII**)	**G**	3	–	(**XXIX**)
(**XIV**)	**A**	4.5	–	(**XXIX**), (**XL**)
(**XV**)	**A**	5	–	(**XXIX**), (**XL**)
(**XVI**)	**A**	2	68***	(**XXXI**), (**XXXVI**)
(**XVII**)	**A**	2	64***	(**XXXII**), (**XXXVII**)
(**XVIII**)	**A**	2	63***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**B**	3	52***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**C**	1	45***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**D**	0.75	30***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**E**	4	43***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**F**	2	64***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XVIII**)	**G**	5	24***	(**XXXIII**), (**XXXVIII**), (**XXIX**)
(**XIX**)	**A**	6.5	16***	(**XXXIV**), (**XXXIX**), (**XXIX**)

Notes: * The ratio of chloride (**I**)–acceptor–K_2CO_3 –crown ether; temperature, *t*; and the solvent are given. **A**, 1 : 1 : 4.5 : 0.2, 20–22°C, CH_3CN; **B**, 1 : 1 : 4.5, 20–22°C, CH_3CN; **C**, 1 : 1 : 4.5 : 0.2, 50°C, CH_3CN; **D**, 1 : 1 : 4.5 : 0.2, 80°C, CH_3CN; **E**, 1 : 1 : 1, CH_3CN; **F**, 1 : 1 : 4.5 : 0.2, 42°C, CH_2Cl_2; **G**, chloride (**I**)–reagent–saturated aqueous K_2CO_3–TEBAC, $CHCl_3$.

** Until the complete conversion of substrate (**I**).

*** The total yield of *N*-β- and *O*-β-glucosaminides.



The molecular structure of *N*-β-glycoside (**XXVI**).

case of glucosaminylation of benzazoles [1], the formation of significant amount of oxazoline (**XXIX**) was noted (TLC, comparison with the notorious reference).

The structures of the resulting glucosaminides (**XX**)–(**XXVI**) were established by ^{1}H NMR spectroscopy (Table 2).

The chemical shifts of the signals of backbone protons (δ 5.58–5.63 ppm), their interposition, and also the values of coupling constants for the anomeric proton (8.8–10.4 Hz, Table 2) are close to those previously obtained for *N*-β-glucosaminides [1–3, 11]. This fact allowed us to refer compounds (**XX**)–(**XXVI**) synthesized to *N*-β-derivatives.

The study of the effect of the substituent localization in the aromatic ring of indolin-2-ones on the reaction route using the reaction of chloride (**I**) with four isomeric monochloro derivatives (**VIII**)–(**XI**) demonstrated that in the case of glycosylation of 4-, 5- and 6-chloroindolin-2-ones (**X**), (**VIII**), and (**XI**) the process occurred in the same way as for glycosyl acceptors (**II**)–(**VII**). This was also proved by ^{1}H NMR spectroscopy data for glycosides (**XXVI**)–(**XXVIII**) (Table 2).

As opposed to three isomers under study, 7-chloroindolin-2-one (**IX**) was found to react smoothly with chloride (**I**) without generation of side products (Table 1). However, the chromatographically homogenous (TLC) product isolated by column chromatography appeared to be the mixture of two compounds, presumably glycosides (**XXX**) and (**XXXV**), according to ^{1}H NMR spectroscopy data. This was proved by doubling of the signals of all protons in the ^{1}H NMR spectrum. In particular, the doublet of the anomeric proton with δ = 5.70 ppm ($J_{1,2}$ = 10.2 Hz) conformed to *N*-β-glucosaminides [1–3] in the values of the chemical shift and the coupling constant, whereas the doublet with a chemical shift equal to 6.15 ppm ($J_{1,2}$ = 9.6 Hz) evidently refered to the isomeric *O*-β-glucosaminide. The spectrum contained the doubled signals of backbone protons H3 (with δ = 5.10 and 5.32 ppm and coupling constants = 9.9 and 9.6 Hz[a1], respectively) and H4 (with δ = 4.94 and 5.19 ppm and coupling constants = 9.6 and 9.9 Hz[a2]). The signals of protons H2, H5, H6, OAc and NAc moieties, aliphatic, and aromatic protons were also doubled.

The results obtained throw doubt on the rightness of the previous conclusion concerning the structure of (**XX**)–(**XXVIII**) as *N*-β-glycosides. Thus, we carried out the X-ray study of the crystals of glycoside (**XXVI**) (Tables 3–5, figure) that unambiguously proved its structure as *N*-β-glucosaminide. The tetrahydropyran ring was in the chair conformation (the folding parameters were: S = 1.20, Θ = 3.5°, Ψ = 9.9° [15]). All substituents in the ring are in the equatorial position. The pentamerous pyrroline ring was in the envelope conformation, whereas the *m*-dioxane ring spiro-joint with it was in the chair conformation (the folding parameters were: S = 1.12, Θ = 1.9°, Ψ = 16.9°).

The comparison of ^{1}H NMR spectra of glycosides (**XX**)–(**XXV**), (**XXVII**), and (**XXVIII**) with that of (**XXVI**) with the structure established showed that they are *N*-β-glucosaminides as was expected.

Thus, glucosaminylation of indolin-2-ones without substituents in the aromatic ring or bearing the substituent only at C4, C5 or C6 of the aromatic ring resulted in the regioselective formation of the corresponding *N*-β-glycosides (**XX**)–(**XXVIII**) under the phase transfer conditions. Therefore, the second product generated upon glycosylation of (**IX**) and (**XVI**)–(**XVIII**) is the *O*-β-isomer.

It should be noted that among approaches (**A**–**G**) used, the best results for glycosylation of (**II**)–(**VIII**), (**X**), and (**XI**) were obtained by method **A**.

During the further investigations, the essential influence of the nature of the substituent at C7 of indolin-2-ones on the direction of the reaction with chloride (**I**) was revealed. Thus, 7-methylindolin-2-one (**XII**) did

Table 2. Chemical shifts (ppm), multiplicity of signals, and coupling constant, Hz (in parentheses) in the ^{1}H NMR spectra of (**XX**)–(**XXVIII**)

	(**XX**)*	(**XXI**)	(**XXII**)*	(**XXVI**)	(**XXIII**)	(**XXIV**)*	(**XXV**)	(**XXVII**)	(**XXVIII**)
H1 ($J_{1,2}$)	5.58d (9.9)	5.63d (10.4)	5.59d (9.6)	5.58d (10.0)	5.59d (10.0)	5.58d (9.9)	5.63d (9.6)	5.61d (10.0)	5.61d (8.8)
H2 ($J_{2,3}$)	4.59m	4.54m	4.53m	4.53m	4.52m	4.53m	4.57m	4.55ddd (9.6)	4.53m
H3 ($J_{3,4}$)	5.31dd (9.6)	5.32dd (9.6)	5.30dd (9.2)	5.30dd (9.6)	5.31dd (9.6)	5.30dd (9.6)	5.33dd (10.0)	5.33dd (10.0)	5.32br. s
H4 ($J_{4,5}$)	5.17dd (10.8)	5.18dd (9.6)	5.16dd (9.0)	5.19dd (8.4)	5.16dd (9.6)	5.19dd (9.3)	5.25dd (9.6)	5.22 (9.2)	5.32br. s
H5 ($J_{5,6a}$; $J_{5,6b}$)	4.11m	4.13m	4.11m	4.12m	4.09ddd (2.0; 5.0)	4.11m	4.16m	4.15m	4.17m
H6$_{a,b}$ (J_{gem})	4.11m	4.13m	4.11m	4.12m	4.13m	4.11m	4.16m	4.15m	4.17m
NAc	1.61s	1.60s	1.60s	1.60s	1.60s	1.60s	1.60s	1.64s	1.63s
OAc	1.92s, 2.01s, 2.03s	1.91s, 2.01s, 2.03s	1.91s, 2.01s, 2.03s	1.91s, 2.01s, 2.04s	1.91s, 2.01s, 2.03s	1.92s, 2.01s, 2.04s	1.92s, 2.01s, 2.05s	1.93s, 2.03s, 2.05s	1.95s, 2.03s, 2.07s
NH ($J_{NH,2}$)	7.98d (9.6)	7.98d (9.2)	7.97d (9.0)	8.00d (9.2)	7.95d (9.6)	8.00d (9.3)	8.07d (9.6)	8.03d (9.2)	8.03d (9.6)
–(CH$_2$)$_3$–	4.48m, 4.34m	1.65m, 2.17m, 3.91m, 4.71m	1.65d, 2.15m, 3.91m, 4.71m	1.65d, 2.17m, 3.94m, 4.68m	1.65m, 2.17m, 3.91m, 4.72m	1.67m, 2.18m, 3.93m, 4.68m	1.70m, 2.26m, 3.98m, 4.69m	1.66m, 2.24m, 3.96m, 4.76m	1.69m, 2.18m, 3.93m, 4.71m
R'	–	–	2.27s	–	3.74s	–	–	–	–
CH$_{arom}$	7.11m, 7.35d, 7.43m	7.08m, 7.36m	7.17m, 7.22m	7.37br. s, 7.44br. s	6.92m, 7.27m	7.39d, 7.48d, 7.57d	7.71d, 8.08s, 8.32d	7.11d, 7.39m	7.16d, 7.38d, 7.48s

Note: * The working frequency is 300 MHz.

not form the corresponding glucosaminide (Table 1). The reaction mixture was found to contain oxazoline (**XXIX**) and 2-acetamidoglycal (**XL**) (TLC, the comparison with the reference compound [16], ^{1}H NMR spectroscopy data).

The route of the reaction of glycosyl donor (**I**) with monosubstituted derivatives (**IV**)–(**XII**) was dictated by the two structural specialties of glycosyl acceptors, namely, the localization and the nature of the substituents in the indoline ring.

Thus, unsubstituted indolin-2-ones (**II**) and (**III**) and monosubstituted derivatives bearing the substituent at C4, C5 or C6, (**IV**)–(**VIII**), (**X**), and (**XI**), were transformed to *N*-β-glucosaminides.

Indolin-2-ones monosubstituted at C7 resulted either in the mixture of *N*-β- and *O*-β-glucosaminides [in the case of 7-chloro derivative (**IX**)], or could not be glycosylated at all [7-methylindolin-2-one (**XII**)]. In this case, substrate (**I**) was converted either to oxazoline (**XXIX**), or to the mixture of oxazoline (**XXIX**) and 2-acetamido glycal (**XL**).

The analysis of the nature of substituents at C5 in indolin-2-ones (**II**)–(**VIII**) demonstrated the yield of the glycoside to be the maximum (40%) in the case of 5-nitro derivative (**VII**). The comparison of the yields of glycosides (**XXII**)–(**XXVI**) allowed us to claim that the more extend the electron donor properties of the substituents at N5 appeared, the lower were the yields

of the target glycosides [from 26 and 29% for 5-chloro and 5-bromo derivatives (**VIII**) and (**VI**) to 16 and 6% for 5-methyl- and 5-methoxyindolin-2-ones (**IV**) and (**V**), respectively]. In the case of 4- and 6-chloro derivatives (**X**) and (**XI**), the yields were low, 18 and 12%, respectively.

It was found that the reaction of chloride (**I**) with dichloro-substituted derivatives (**XVI**)–(**XVIII**) proceeded similarly to glycosylation of 7-chloro derivative (**IX**) (Table 1). According to the ^{1}H NMR spectroscopy data, the mixture of the two glycosides, (**XXXI**) and (**XXXVI**), (**XXXII**) and (**XXXVII**), or (**XXXIII**) and (**XXXVIII**), was generated in all three cases. The values of the chemical shifts, integral intensities, and coupling constants of the protons are close to those obtained for the products of glycosylation of 7-chloroindolin-2-one (**IX**). The formation of the only side product, oxazoline (**XXIX**), should be noted.

The comparison of glycosylation conditions carried out using (**XVIII**) as an example showed that the formation of the mixture of glycosides (**XXXIII**) and (**XXXVIII**) was observed in all cases irrespective of the nature of the two phase system, temperature and the presence of the catalyst. Thus, in the case of 7-chloro-substituted indolin-2-ones the composition of the reaction products was dictated by the presence of the chlorine atom at C7 of the indoline backbone. The position of the second chlorine atom did non play the important role in the specification of the glycosylation route.

We failed to separate the mixture of isomeric glycosides either by column chromatography, or by HPLC.

It was found that the reaction of chloride (**I**) with dimethylindolin-2-ones (**XIII**)–(**XV**) did not give the glycosylation products, resulting in oxazoline (**XXIX**) and 2-acetamido glycal (**XL**) (TLC, the comparison with reference compounds).

However, interaction of α-*D*-glucosaminyl chloride (**I**) with 5-bromo-7-methyl-3,3-trimethylenedioxyindolin-2-one (**XIX**) (Scheme 2) allowed us to establish that this glycosyl acceptor resulted in the mixture of two products, (**XXXIV**) and (**XXXIX**), according to the ^{1}H NMR spectroscopy data (Table 1). Obviously, in the case of the methyl group at N7 of glycosyl acceptors (**XIII**)–(**XV**) and (**XIX**), the route of the reaction was dictated by the nature of the substituent at C5. Thus, the presence of the methyl group displaying the +I-effect (the positive induction effect) resulted in the two side processes, intramolecular substitution yielding oxazoline (**XXIX**) or elimination of hydrogen chloride because of the attack of the base (the deprotonated form of glycosyl acceptors) for the hydrogen atom at C2 in glycosyl donor (**I**) and the formation of unsaturated derivative (**XL**). Introduction of the electronegative bromine atom (–I > +M)[4] at N5 of the indoline ring resulted in glycosylation to isomeric *O*-β- and *N*-β-glu-

[4] The negative induction effect exceeds the positive mesomeric effect.

Table 3. Coordinates (×10^4, Å) and equivalent isotropic caloric parameters (U × 10^3, Å^2) of atoms in the structure of (**XXVI**)*

	x	*y*	*z*	U_{eq}
Cl1	5791(1)	2961(1)	1069(1)	36(1)?
N1	10500(2)	588(1)	446(1)	20(1)
N2	10629(2)	–1383(1)	1132(1)	22(1)
O1	10282(2)	–277(1)	–563(1)	21(1)
O2	12641(2)	999(1)	677(1)	29(1)
O3	11218(1)	3007(1)	1053(1)	21(1)
O4	10925(1)	1726(1)	1862(1)	21(1)
O5	8741(2)	–940(1)	1646(1)	30(1)
O6	9676(1)	–3110(1)	318(1)	21(1)
O7	11540(2)	–3964(1)	544(1)	31(1)
O8	10443(1)	–2971(1)	–1063(1)	20(1)
O9	8457(2)	–3685(1)	–1076(1)	36(1)
O10	8958(2)	–671(1)	–1777(1)	23(1)
O11	8639(2)	–2208(1)	–2273(1)	48(1)
C1	10750(2)	–371(2)	104(1)	19(1)
C2	10115(2)	–1292(2)	460(1)	18(1)
C3	10392(2)	–2256(2)	43(1)	18(1)
C4	9975(2)	–2107(2)	–678(1)	19(1)
C5	10637(2)	–1148(2)	–961(1)	19(1)
C6	9264(2)	1032(2)	564(1)	18(1)
C7	8067(2)	744(2)	306(1)	23(1)
C8	6993(2)	1347(2)	483(1)	24(1)
C9	7135(2)	2192(2)	892(1)	21(1)
C10	8341(2)	2480(2)	1151(1)	20(1)
C11	9398(2)	1883(2)	981(1)	16(1)
C12	10802(2)	2001(2)	1179(1)	17(1)
C13	11482(2)	1160(2)	739(1)	20(1)
C14	12560(2)	3197(2)	1260(1)	26(1)
C15	12730(2)	2930(2)	1989(1)	28(1)
C16	12233(2)	1843(2)	2123(1)	27(1)
C17	9913(2)	–1110(2)	1677(1)	21(1)
C18	10678(3)	–1025(2)	2319(1)	30(1)
C19	10368(2)	–3937(2)	535(1)	21(1)
C20	9479(3)	–4789(2)	750(2)	31(1)
C21	9577(2)	–3707(2)	–1240(1)	24(1)
C22	10211(3)	–4514(2)	–1656(1)	32(1)
C23	10315(2)	–902(2)	–1682(1)	23(1)
C24	8220(2)	–1379(2)	–2104(1)	26(1)
C25	6888(3)	–984(2)	–2232(1)	32(1)

Note: * The error for determination of coordinates and caloric parameters is given in parentheses.

Table 4. The bond lengths (Å) in the structure of (**XXVI**)*

Cl1–C9	1.737(2)	N1–C13	1.381(3)
N1–C6	1.412(3)	N1–C1	1.442(3)
N2–C17	1.361(3)	N2–C2	1.448(3)
O1–C1	1.422(2)	O1–C5	1.429(2)
O2–C13	1.214(3)	O3–C12	1.397(2)
O3–C14	1.458(3)	O4–C12	1.416(2)
O4–C16	1.447(3)	O5–C17	1.224(3)
O6–C19	1.358(3)	O6–C3	1.439(2)
O7–C19	1.203(3)	O8–C21	1.352(3)
O8–C4	1.442(2)	O9–C21	1.195(3)
O10–C24	1.358(3)	O10–C23	1.436(3)
O11–C24	1.207(3)	C1–C2	1.535(3)
C2–C3	1.529(3)	C3–C4	1.515(3)
C4–C5	1.527(3)	C5–C23	1.513(3)
C6–C7	1.382(3)	C6–C11	1.390(3)
C7–C8	1.397(3)	C8–C9	1.376(3)
C9–C10	1.392(3)	C10–C11	1.374(3)
C11–C12	1.501(3)	C12–C13	1.565(3)
C14–C15	1.507(3)	C15–C16	1.524(4)
C17–C18	1.508(3)	C19–C20	1.496(3)
C21–C22	1.487(3)	C24–C25	1.481(4)

Note: * The error for determination of bond length is given in parentheses.

cosaminides along with intramolecular substitution. Thus, the electron characteristics of the substituent at of C5 indolin-2-ones played a crucial role in the route of the process in the case of 5,7-disubstituted glycosyl acceptors.

Thus, we have for the first time carried out glucosaminylation of indolin-2-one derivatives (**II**)–(**XIX**), clarified the factors dictating the route of glycosylation, and demonstrated the composition of the reaction products to primarily depend on the presence, the nature, and the localization of substituents in the aromatic carbocyclic ring of indolin-2-ones.

EXPERIMENTAL

Melting points were taken on a PTP-1 instrument. The values of optical rotation were measured on a Polamat-A polarimeter (λ = 546 nm) at 20–22°C. The ^{1}H NMR spectra (δ, ppm; coupling constant, Hz) were measured on Varian VXR-300 (300 IHz) and Varian Mercury-400 (400 IHz) spectrometers in DMSO-d_6 using Me_4Si as the internal standard.

The crystals of (**XXVI**) are rhombic, $C_{25}H_{29}N_2O_{11}Cl$, at –173°C a = 10.255(1), b = 12.976(1), c = 19.985(1) Å, V = 2659.2(3) Å^3, M_r = 568.95, Z = 4, the spatial group $P2_12_12_1$, d_{calc} = 1.421 g/cm^3, μ(MoK_α) = 0.208 mm^{-1}, F(000) = 1192. The parameters of the elementary cell and the intensity of 14227 reflections (6090 independent, R_{int} = 0.039) were measured on an Xcalibur-3 diffractometer (MoK_α, NND-detector, graphite monochromator, ω-scanning, $2\theta_{max}$ = 55°).

The structure was decoded by the direct method using the SHELXTL software complex [17]. The positions of hydrogen atoms were revealed from the difference synthesis of electron density and were isotropically defined. The structure was specified from the squares of the structural amplitudes by the full matrix method of minimum squares in the anisotropic approximation for nonhydrogen atoms up to wR_2 = 0.078 from 6073 reflections (R_1 = 0.043 from 5017 reflections with $F > 4\sigma(F)$, S = 1.029).

TLC was carried out on Sorbfil-AFV-UV (Sorbpolimer, Russia) plates. The spots were visualized by treating with 2% sulfuric acid in 1-butanol followed by heating to 200–300°C. Benzene–ethanol, 10 : 1, was used as the developing system. The compounds were separated by column chromatography on Silica gel 60 (0.063–0.200 mm, Merck, Germany), elution with benzene ⟶ 15 : 1 benzene–2-propanol. The elemental analysis data correspond to the values calculated.

Indolin-2-ones (**II**)–(**XIX**) were synthesized as described in [18]. The reference oxazoline (**XXIX**) was synthesized according to Lemieux [16]. α-*D*-Glucosaminyl chloride was obtained as described in [19]. Triethylbenzylammonium chloride (99%, Aldrich) and 15-crown-5 (98%, Merck) were also used in this study.

Acetonitrile was refluxed over phosphorus(V) oxide, rectified, refluxed over freshly calcined potash, and distilled using a Vigreux column. Dichloromethane was distilled from phosphorus(V) oxide, refluxed over freshly calcined potassium carbonate to remove acidic impurities, and distilled. Anhydrous K_2CO_3 was prepared by calcination for 5 h at 340–360°C.

Glycosides (**XX**)–(**XXVIII**) were synthesized by method **A**. The target compounds were isolated by column chromatography.

***1-N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-2-oxo-3,3-ethylenedioxyindoline (XX)** was obtained by glycosylation of 2-oxo-3,3-ethylenedioxyindoline (**II**) (0.20 g, 1.37 mmol) with chloride (**I**) (0.50 g, 1.37 mmol); yield 0.14 g (20%); mp 155°C (decomp.); $[\alpha]_{546}$ –29° (*c* 1.0; $CHCl_3$).

***N*-(*2*-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-3,3-trimethylenedioxyindolin-2-one (XXI)** was obtained by the reaction of chloride (**I**) (0.50 g,

1.37 mmol) with indolin-2-one (**III**) (0.20 g, 1.37 mmol); yield 0.12 g (18%); mp 234–237°C; $[\alpha]_{546}$ = –60.4° (*c* = 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-5-methyl-3,3-trimethylenedioxyindolin-2-one (XXII)** was synthesized from substrate (**I**) (0.50 g, 1.37 mmol) and ketal (**IV**) (0.30 g, 1.37 mmol); yield 0.08 g (11%); mp 178–180°C; $[\alpha]_{546}$ = –7.3° (*c* = 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-b-*D*-glucopyranosyl)-3,3-trimethylenedioxy-5-chloroindolin-2-one (XXIV)** was prepared from α-chloride (**I**) (0.50 g, 1.37 mmol) and compound (**VI**) (0.25 g, 1.37 mmol); yield 0.20 g (26%); mp 114°C (decomp.); $[\alpha]_{546}$ = –81.2° (*c* = 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-5-methoxy-3,3-trimethylenedioxyindolin-2-one (XXIII)** was synthesized from substrate (**I**) (0.50 g, 1.37 mmol) and ketal (**V**) (0.30 g, 1.37 mmol); yield 0.047 g (6%) as amorphous substance; $[\alpha]_{546}$ = –2° (*c* = 1.0, $CHCl_3$).

1-*N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-5-bromo-3,3-trimethylenedioxyindolin-2-one (XXV) was obtained by glycosylation of compound (**VII**) (0.40 g, 1.37 mmol) with chloride (**I**) (0.50 g, 1.37 mmol); yield 0.29 g (29%); mp 231–235°C; $[\alpha]_{546}$ = –52° (*c* = 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-5-nitro-3,3-trimethylenedioxyindolin-2-one (XXVI)** was obtained from substrate (**I**) (0.50 g, 1.37 mmol) and ketal (**VIII**) (0.34 g, 1.37 mmol); yield 0.318 g (40%); mp 270–272°C; $[\alpha]_{546}$ = –19° (*c* = 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-3,3-trimethylenedioxy-4-chloroindolin-2-one (XXVII)** was obtained from α-chloride (**I**) (0.50 g, 1.37 mmol) and compound (**XI**) (0.25 g, 1.37 mmol); yield 0.14 g (18%); mp 244–245°C (decomp.); $[\alpha]_{546}$ = –67° (*c* 1.0, $CHCl_3$).

***N*-(2-Acetamido-3,4,6-tri-*O*-acetyl-2-deoxy-β-*D*-glucopyranosyl)-3,3-trimethylenedioxy-6-chloroindolin-2-one (XXVIII)** was obtained from α-chloride (**I**) (0.50 g, 1.37 mmol) and compound (**XII**) (0.25 g, 1.37 mmol); yield 0.09 g (12%); mp 212–214°C (decomp.); $[\alpha]_{546}$ –79° (*c* 1.0, $CHCl_3$).

2-Acetamido-3,4,6-tri-*O*-acetyl-1,2-dideoxy-*D*-arabino-hex-1-enopyranose (XL) was isolated by column chromatography as colorless syrup, $[\alpha]_{546}$ = –46° (*c* = 1.0, $CHCl^3$); ^{1}H NMR (400 MHz, DMSO-d_6): 1.85 (3 H, s, NAc), 1.98, 2.01, and 2.03 (9 H, 3s, 3OAc), 4.15 (1 H, m, I5), 4.34 (2 H, m, H6a, H6b), 5.08 (1 H, dd, $J_{4,3}$ 6, $J_{4,5}$ 6, H4), 5.34 (1 H, d, $J_{3,4}$ 6, H3), 7.11 (1 H, s, H1), 8.80 (1 H, s, NH). Lit. [20]: colorless syrup, $[\alpha]_D$ –24.6° (*c* 0.5, $CHCl_3$).

Table 5. The valent angles in the structure o (**XXVI**)*

Angle	grad	Angle	grad
C13–N1–C6	111.4(2)	C13–N1–C1	122.3(2)
C6–N1–C1	126.2(2)	C17–N2–C2	121.7(2)
C1–O1–C5	111.6(2)	C12–O3–C14	113.3(2)
C12–O4–C16	113.8(2)	C19–O6–C3	117.7(2)
C21–O8–C4	118.0(2)	C24–O10–C23	117.5(2)
O1–C1–N1	108.1(2)	O1–C1–C2	111.0(2)
N1–C1–C2	112.2(2)	N2–C2–C3	111.8(2)
N2–C2–C1	109.8(2)	C3–C2–C1	107.8(2)
O6–C3–C4	108.5(2)	O6–C3–C2	109.1(2)
C4–C3–C2	111.2(2)	O8–C4–C3	108.3(2)
O8–C4–C5	106.7(2)	C3–C4–C5	109.3(2)
O1–C5–C23	108.0(2)	O1–C5–C4	109.0(2)
C23–C5–C4	115.3(2)	C7–C6–C11	121.7(2)
C7–C6–N1	128.6(2)	C11–C6–N1	109.6(2)
C6–C7–C8	117.0(2)	C9–C8–C7	120.9(2)
C8–C9–C10	121.9(2)	C8–C9–Cl1	119.6(2)
C10–C9–Cl1	118.4(2)	C11–C10–C9	117.2(2)
C10–C11–C6	121.2(2)	C10–C11–C12	129.3(2)
C6–C11–C12	109.5(2)	O3–C12–O4	112.4(2)
O3–C12–C11	109.9(2)	O4–C12–C11	108.3(2)
O3–C12–C13	114.5(2)	O4–C12–C13	109.1(2)
C11–C12–C13	102.0(2)	O2–C13–N1	125.4(2)
O2–C13–C12	127.8(2)	N1–C13–C12	106.7(2)
O3–C14–C15	110.2(2)	C14–C15–C16	110.1(2)
O4–C16–C15	110.1(2)	O5–C17–N2	122.4(2)
O5–C17–C18	122.8(2)	N2–C17–C18	114.8(2)
O7–C19–O6	123.4(2)	O7–C19–C20	125.7(2)
O6–C19–C20	110.9(2)	O9–C21–O8	122.8(2)
O9–C21–C22	126.3(2)	O8–C21–C22	110.9(2)
O10–C23–C5	112.4(2)	O11–C24–O10	122.6(2)
O11–C24–C25	126.1(2)	O10–C24–C25	111.3(2)

Note: * The error for determination of angle value is given in parentheses.

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