BENZINDOLES

19.* SCHIFF BASES IN THE ANGULAR BENZINDOLE SERIES

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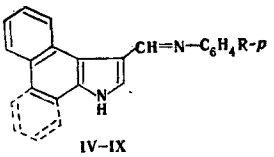
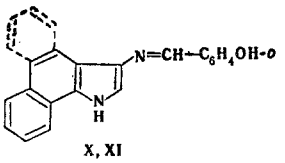
Schiff bases in the angular benzindole series that were obtained from 3-formyl[4, 5]- and -[6,7]benzindoles and aromatic amines, on the one hand, and 3-amino[4,5]- and -[6,7]benzindoles and salicylaldehyde, on the other, are described. It is shown that the conformations in each of the [6,7] and [4,5] isomers are identical and are independent of the substituent; this is a consequence of their nonplanar structures.

The very small amount of data on Schiff bases in the indole series pertains primarily to skatolideneaniline, which was used in the synthesis of the indole analog cephalosporin [2]. An attempt to use it for the preparation of tryptophan and its N-substituted analogs has been described [3].

The aim of the present research was to study the effect of the type of fusion of the second benzene ring with the indole molecule in angular 3-formylbenzindoles on the reactivity of the formyl group in condensation reactions with aromatic amines and to compare the spectral characteristics of the compounds obtained with the data for azomethines synthesized from 3-amino[4,6]- and -[6,7]benzindoles with salicylaldehyde.



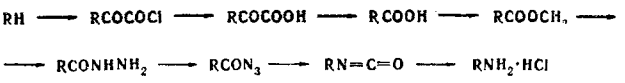
IV–IX



X, XI

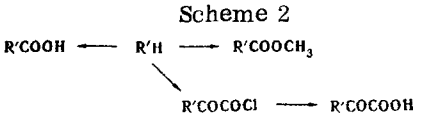
For the synthesis of the latter we tested two methods: 1) conversion of the hydrazines of 3-carboxylic acid through the azides with subsequent rearrangement to the isocyanates and conversion to 3-amino[4,5]- and -[6,7]benzindoles and 2) reduction of the 3-nitroso derivatives obtained by nitrosation of the benzindoles.

Scheme 1



[6,7]Benzindole-3-carboxylic acid was obtained by decarbonylation of [6,7]benzindol-3-ylglyoxylic acid with hydrogen peroxide (Scheme 1). [4,5]Benzindole-3-carboxylic acid is not formed under these conditions, and we resorted to the Grignard reaction (Scheme 2) for its preparation; this procedure with methyl chlorocarbonate gives the corresponding ester in 58% yield;

Scheme 2



R = [6,7]benzindol-3-yl; R' = [4,5]benzindol-3-yl

* See [1] for communication 18.

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TABLE 1. Conditions for the Preparation of the Schiff Bases and Their Constants

Compound	Formylindole	Aromatic amine	Time, h (method)	mp, °C (from alcohol)	Found, %			Empirical formula	Calc., %			Yield, % (method)
					C	H	N		C	H	N	
I	3-Formylindole	Aniline	39 (A)	127—128				$C_{15}H_{11}N_2$				88 (A)
II		p-Anisidine	20 (A)	125—126				$C_{16}H_{14}N_2O$				90 (A)
III		p-Chloroaniline	39 (A)	131—132				$C_{15}H_{11}ClN_2$				92 (A)
IV	3-Formyl[4,5]benzindole	Aniline	35 (A)	201—202	85,5	5,4	10,3	$C_{19}H_{14}N_2$	84,4	5,2	10,3	83 (A)
												96 (B)
V		p-Anisidine	10 (A)	180—182	80,0	5,8	9,3	$C_{20}H_{16}N_2O$	79,9	5,5	9,3	100 (A)
VI		p-Chloroaniline	35 (A)	208—210	74,5	4,1	9,0	$C_{19}H_{13}ClN_2$ a	74,9	4,3	9,1	86 (A)
VII	3-Formyl[6,7]benzindole	Aniline	8 (A), 6 (C)	224—225	84,0	5,4	10,3	$C_{19}H_{14}N_2$	84,4	5,2	10,3	94 (A)
												69 (C)
VIII		p-Anisidine	3 (A)	230—232	80,2	5,7	9,6	$C_{20}H_{16}N_2O$	79,9	5,5	9,3	98 (B)
			2 (C)									100 (A)
IX		p-Chloroaniline	11 (A)	220—223	75,0	4,4	10,1	$C_{19}H_{13}ClN_2$ b	74,9	4,3	9,1	69 (C)
			15 (C)									
X	o-Hydroxybenzylidene[4,5]benzindole-3-ylamine		1	276—278	79,4	4,7	9,7	$C_{19}H_{14}N_2O$	79,7	4,9	9,8	13
XI	o-Hydroxybenzylidene[6,7]benzindole-3-ylamine		1	222—223	79,4	4,7	9,6	$C_{19}H_{14}N_2O$	79,7	4,9	9,8	13

[a] Found: Cl 11.3%. Calculated: Cl 11.6%. [b] Found: Cl 9.8%. Calculated: Cl 11.6%.

TABLE 2. Spectral Characteristics of the Schiff Bases

Compound	Indole	R	IR Spectrum, cm^{-1}			UV Spectrum (in ethanol), λ_{max}, nm ($\varepsilon \cdot 10^3$)
			KBr pellets	Mineral oil	$CHCl_3$	
I	Indole	H		1620, 3185 w, 1625, 3440		224 (22,8), 270 (10,7), 335 (17,6), 221 (23,6), 269 (11,5), 330 (20,0)
II		OCH_3				
III		Cl		1610, 3170		
IV	[4,5] benzindole	H	1615, 1600, 2700—3200 br, 1615, 2700, 3200 br	1615, 3100	1650, 3380	222 (35,7), 249 i (16,5), 2,79 (17,2), 315 (10,7), 347 (6,3)
V		OCH_3		1618, 3080	1645	222 (42,0), 286 (19,5), 323 (18,5), 345 (15,5)
VI		Cl		1615, 3110	1650	
VII	[6,7]benzindole	H	1625, 3385	1625, 3330		215,5 (28,4), 263 (32), 285 i (20,6), 319 (20,0), 328 (20,0), 343 (16,2)
VIII		OCH_3	1623, 3425, 3450 i	1615, 3430		206 (27,4), 217 i (25,3), 265 (28,7), 332 (22,0), 343 i (21,0)
IX		Cl	1615, 2800—3200 br	1615, 3110	1625, 3480	207,5 (28,7), 218 i (23,0), 253 (24,8), 280 i (17,8), 319 i (18,4), 328 (18,7), 343 i (17,3)
X	o-Hydroxybenzylidene-[4,5]benzindol-3-yl-amine		1625, 1640 sh, 3240 w, 3380 sh 3420, 3480, 3560	3450—3200 br, 3060, 1625		
XI	o-Hydroxybenzylidene-[6,7]benzindol-3-yl-amine		1610, 1625 int, 1640, 3240, 3380, 3415, 3480, 3565	3400, 1610	1615, 1625, 3465	

however, the reaction gives the product in only 9% yield with dry ice. Fusion of [4,5]- and [6,7]benzindoles with sodium ethylcarbonate gave positive results only in the case of [6,7]benzindole; the yield of benzindole-3-carboxylic acid was 31%, while [4,5]benzindole was recovered unchanged from the reaction mixture.

The hydrazides of the benzindolecarboxylic acids were obtained by heating the esters with excess hydrazine hydrate at 145°C. However, methyl [4,5]benzindole-3-carboxylate does not form a hydrazide under these conditions and is recovered from the reaction mixture. Under the same conditions [4,5]- and [6,7]benzindole-2-carboxylic acid esters were converted to the hydrazides in 50% yields.

The subsequent conversion of [6,7]benzindole-3-carboxylic acid hydrazide to the azide and isocyanate proceeds quite smoothly. The Curtius rearrangement is accompanied by considerable resinification, and 3-amino[6,7]benzindole was isolated in the hydrochloride form. The aminobenzindoles obtained by the second method by reduction of 3-nitrosobenzindoles with bisulfite are also characterized by exceptional instability, and they were therefore subjected to condensation with salicylaldehyde without additional purification.

The condensation of 3-formyl[4,5]- and -[6,7]benzindoles with aromatic amines was carried out under different conditions (Table 1). As expected, the reaction with p-anisidine proceeds most readily, and 3-formyl-[6,7]benzindole is more active in condensation reactions with aromatic amines than the [4,5] isomer. This may be associated with the effect of steric factors that hinder nucleophilic addition to the carbonyl group in 3-formyl[4,5]benzindole, while this sort of effect of the second benzene ring is excluded for the [6,7] isomer.

The band of the vibrations of the C = N bond is found at 1610-1640 cm^{-1} in the IR spectra of the Schiff bases obtained, including o-hydroxybenzylidene[4,5]- and -[6,7]benzindol-3-ylamines (Table 2, X and XI). The change in the frequencies of the NR group in the solid state in the IR spectra of these compounds as compared with the spectra of solutions depends on the crystal packing and indicates the formation of different types of intermolecular hydrogen bonds: In the case of a considerable decrease in the frequency of the NH group (to 3100-3200 cm^{-1}, Table 2, IV-VI and IX) one can assume the formation of a hydrogen bond between the proton of the NH group and the nitrogen atom of the C = N bond. The small changes in ν_{NH} ($\Delta \sim 50$-80 cm^{-1}, Table 2, VII and VIII) indicate interaction of the NH group with the π system of the aromatic part of the molecule.

The UV spectra of the azomethines, viz., 3-formyl[6,7]benzindole derivatives, contain intense bands at 205, 265, and 330 nm. The intense band at 265 nm is evidently related to the benzindole part of the molecule [4]. The long-wave absorption band that characterizes interaction of the double bonds is located at rather high frequencies for all of the compounds of the indicated series if one takes into account the overall length of the conjugated π system. In addition, the spectra remain virtually unchanged when electron-acceptor groups are introduced in the para position of the benzene ring, i.e., the effect of the substituents is transmitted weakly through the conjugated chain (Table 2, IV and VI). All of these facts can be explained by disruption of the coplanarity of the molecule similar to that which occurs in the case of benzalaniline [5-7]. At the same time, in the case of [6,7]benzindol-3-ylaza-p-chlorobenzene, which is isoelectronic with respect to IX and, according to the data from the UV spectrum, has a planar structure [8], the long-wave absorption band is found at 435 nm (ε 25,000).

TABLE 3. Parameters of the PMR Spectra of Azomethines IV-XI in DMSO

Compound	Chemical shifts of the protons, δ, ppm relative to hexamethyldisiloxane							Spin coupling constants, J, Hz
[4,5] Isomer	N—H	2-H	8-H	6-H, 7-H	=C—H	2′-H, 6′-H	3′-H, 5′-H	
IV	12,18	8,10	10,02	7,63	8,81			$J_{1,2}=3,2$
V	12,17	8,06	10,10	7,65	8,86	7,26	6,92	$J_{1,2}=0,5$; $J_{2',3'}=8,8$
						$\delta_{OCH_3}=3,69$		
VI	12,20	8,11	10,00	7,64	8,82	7,29	7,37	$J_{1,2}=0,5$; $J_{2',3'}=8,8$ $J_{6,7}=9,0$
[6,7] Isomer	N—H	2-H	4-H	5-H	=C—H	2′-H, 6′-H;	3′-H, 5′-H	
VII	12,57	8,01	8,46	7,60	8,75			$J_{1,2}=2,6$; $J_{4,5}=8,4$
VIII	12,49	7,96	8,45	7,57	8,73	7,19	6,89	$J_{1,2}=2,6$; $J_{4,5}=8,4$; $J_{2',3'}=8,8$
						$\delta_{OCH_3}=3,72$		
IX	12,61	8,03	8,46	7,59	8,73	7,20	7,37	$J_{1,2}=1,7$; $J_{4,5}=8,4$; $J_{2',3'}=8,7$

A similar situation was observed for the [4,5] isomers of azomethines: The presence of a substituent in the para position of the benzene ring leads to a certain increase in the intensity but to only a slight shift of the long-wave band (Table 2, IV-VI). Thus, judging from the UV spectra, the conformations in each of the two series of compounds obtained are identical and do not depend on the substituent.

A comparison of the chemical shifts in the PMR spectra of each of the triads of [4,5]- and [6,7]benzindole derivatives (Table 3) confirms this conclusion. In the case of the [4,5]benzindole derivatives the chemical shifts of the benzindole 2-H and 8-H protons and the =C−H proton of the substituent are the most characteristic and sensitive to the conformation. The significant deshielding of the 2-H and 8-H protons in azomethines of [4,5]benzindole evidently may be the result of their nonplanar structure, in which the nitrogen atom of the substituent is in the immediate proximity of the 8-H atom. In this case the 2-H proton may be located in the plane of the phenyl ring of the amine and experience the deshielding effect of its ring π current.

The UV spectrum of [6,7] derivative XI, in which the benzindole component acts as an amino component, is similar to the spectrum of Schiff base VIII; however, the spectrum of o-hydroxybenzylidene[4,5]benzindol-3-ylamine (X) has qualitatively different character: The introduction of an OH group in the ortho position of the benzene ring leads to a rigid coplanar structure, evidently creating better conditions for interaction of the unshared pair of electrons of the nitrogen atom of the N= C bond with the system of π electrons. As a result, the neighboring band of the $\pi-\pi$ transition is shifted to 390-420 nm, and weak absorption at 470-500 nm, which can be assigned to an $n-\pi$ transition, appears.

EXPERIMENTAL

The IR spectra of mineral oil suspensions of the compounds (in other cases the solvent is specially indicated) were recorded with a UR-10 spectrometer. The UV spectra of solutions in ethanol were obtained with a Shimadzu MPS-50 spectrophotometer.

[4,5]Benzindol-3-ylglyoxyl Chloride. A 1.9-g (0.012 mole) sample of oxalyl chloride was added dropwise with cooling to a conical flask containing a solution of 2 g (0.012 mole) of [4,5]benzindole in 60 ml of absolute ether, after which the flask was sealed with a calcium chloride tube and allowed to stand in a refrigerator overnight. The resulting precipitate was removed by filtration and washed on the filter with ether to give 1.85 g (66%) of product. IR spectrum: 3370, 3320, 1795, and 1640 cm^{-1}. Found: C 65.6; H 3.5; N 5.3%. $C_{14}H_8ClNO_2$. Calculated: C 65.2; H 3.1; N 5.4%.

[6,7]Benzindol-3-ylglyoxyl Chloride. This compound was similarly obtained and had mp 178°C (mp 178-180°C [9]). IR spectrum: 3340, 1780, and 1640 cm^{-1}.

[6,7]Benzindol-3-ylglyoxylic Acid. A mixture of 2.5 g (0.01 mole) of [6,7]benzindol-3-ylglyoxylic acid chloride, 0.8 g (0.015 mole) of sodium hydroxide, and 50 ml of water was refluxed for 1 h, after which the mixture was filtered, and the filtrate was acidified with dilute hydrochloric acid. The precipitate was separated, washed with water, and dried to give 1.77 g (65%) with mp 200-201°C. IR spectrum: 3360, 1720, and 1640-1650 cm^{-1}. Found: C 65.8; H 4.4; N 5.3%. $C_{14}H_9NO_3 \cdot H_2O$. Calculated: C 65.4; H 4.3; N 5.4%.

[4,5]Benzindol-3-ylglyoxylic Acid. Hydrolysis of 3.4 g of [4,5]benzindol-3-ylglyoxyl chloride gave 0.75 g (24%) of the acid with mp 193-195°C. IR spectrum: 3240, 1720, and a doublet at 1620-1640 cm^{-1}. Found: C 70.6; H 4.1; N 5.7%. $C_{14}H_9NO_3$. Calculated: C 70.3; H 3.9; N 5.8%.

[6,7]Benzindole-3-carboxylic Acid. A) A 2.1-g (0.01 mole) sample of [6,7]benzindol-3-ylglyoxylic acid was heated in 40 ml of 30% hydrogen peroxide for 3 h, during which foaming and a change in the color of the precipitate from yellow to gray were observed. The precipitate was removed by filtration and dissolved in sodium carbonate solution, and the solution was acidified with dilute hydrochloric acid. Workup and purification gave 1.2 g (40%) of a product with mp 290-291°C. IR spectrum: 3300 and 1630 cm^{-1}. Found: C 67.7; H 4.5; N 6.0%. $C_{13}H_9NO_2 \cdot H_2O$. Calculated: C 68.1; H 4.8; N 6.1%.

B) A mixture of 1.6 g (0.01 mole) of [6,7]benzindole and 11.2 g (0.1 mole) of sodium ethylcarbonate was fused on a metal bath at 220°C in a flask equipped with a Wurtz trap and a descending condenser. The start of the reaction was determined from the liberation of alcohol. The fusion was carried out for 20 h, after which 60 ml of water was added, and the resulting solution was washed with ether and acidified with dilute hydrochloric acid. The precipitate was removed by filtration and purified by reprecipitation from sodium carbonate solution to give 0.68 g (31%) of a product with 290-291°C that was chromatographically identical to the compound obtained by method A (chromatography on Silufol with elution with ether).

[4,5]Benzindole-3-carboxylic Acid. A solution of 1 g (0.006 mole) of [4,5]benzindole in 15 ml of absolute ether was added to methylmagnesium iodide obtained from 0.2 g of Mg and 0.85 ml of methyl iodide in 10 ml of absolute ether, and the mixture was maintained at room temperature for 30 min, after which it was cooled to 0°C. Dry ice was then added slowly with stirring. When CO_2 evolution was complete, 20 ml of water was added carefully in the cold, and the mixture was acidified with dilute acetic acid. The ether layer was separated and washed with sodium carbonate solution, which was then acidified. The resulting white precipitate was removed by filtration and dried to give 0.23 g (9%) of a product with mp 158-160°C (from water). IR spectrum: 3170 and 1700 cm^{-1}. Found: C 73.7; H 4.1; N 6.7%. $C_{13}H_9NO_2$. Calculated: C 73.9; H 4.3; N 6.6%.

Methyl [4,5]Benzindole-3-carboxylate. A solution of 1.66 g (0.01 mole) of [4,5]benzindole in 5 ml of absolute ether was added dropwise in the cold to a Grignard reagent obtained from 0.48 g (0.02 mole) of Mg and 2.83 g (0.02 mole) of methyl iodide in the presence of a catalytic amount of iodine, and the mixture was stirred at room temperature for 30 min. A 1.4-g (0.015 mole) sample of methyl chlorocarbonate was then added, and the mixture was maintained at room temperature for 30 min. It was then decomposed cautiously with dilute acetic acid, and the ether layer was separated, washed with sodium carbonate solution, and dried over sodium sulfate. The solvent was removed by evaporation to give 2.24 g (58%) of 3-carbomethoxy[4,5]benzindole with mp 189-190°C. IR spectrum: 3320 and 1700 cm^{-1}. Found: C 75.5; H 5.3; N 6.3%. $C_{14}H_{11}NO_2$. Calculated: C 74.7; H 4.9; N 6.2%.

[4,5]Benzindole-2-carboxylic Acid Hydrazide. A solution of 0.5 g (0.5 mmole) of 2-carbomethoxy[4,5]-benzindole in 20 ml of hydrazine hydrate was refluxed for 20 h, after which it was cooled, and the precipitate was separated, washed with alcohol, and dried to give 0.25 g (50%) of a product with mp > 300°C. Found: C 68.8; H 4.9; N 18.7%. $C_{13}H_{11}N_3O$. Calculated: C 69.3; H 4.9; N 18.7%.

[6,7]Benzindole-2-carboxylic Acid Hydrazide. Similarly, 0.5 g (50%) of [6,7]benzindole-2-carboxylic acid hydrazide, with mp > 290°C, was obtained by refluxing a solution of 1 g (0.004 mole) of 2-carbomethoxy-[6,7]benzindole in 25 ml of hydrazine hydrate for 20 h. Found: C 68.7; H 5.0; N 18.4%. $C_{13}H_{11}N_3O$. Calculated: C 69.3; H 4.9; N 18.7%.

[6,7]Benzindole-3-carboxylic Acid Hydrazide. A 0.25-g (0.001 mole) sample of methyl [6,7]benzidole-3-carboxylate was heated in 20 ml of hydrazine hydrate at 145°C for 4 h, after which the mixture was cooled, and the resulting precipitate was removed by filtration and crystallized from alcohol to give 0.13 g (52%) of a product with mp 272-273°C. IR spectrum: 3380 and 1680 cm^{-1}. Found: C 69.3; H 4.9; N 18.6%. $C_{13}H_{11}N_3O$. Calculated: C 69.3; H 4.9; N 18.7%.

[6,7]Benzindole-3-carboxylic Acid Azide. A solution of 0.7 g (0.003 mole) sample of the hydrazide in 30 ml of glacial acetic acid was cooled to 0°C, and 0.21 g (0.003 mole) of sodium nitrite in 2 ml of water was added with vigorous stirring. The resulting precipitate was rapidly removed by filtration, washed with water, and dried in vacuo to give 0.65 g (88%) of a product with mp 154-155°C. IR spectrum: 3320, 2150, and 1660 cm^{-1}. Found: C 65.5; H 3.5; N 23.7%. $C_{13}H_8N_4O$. Calculated: C 66.1; H 3.5; N 23.7%.

3-Isocyanato[6,7]benzindole. A solution of 0.6 g (0.002 mole) of [6,7]benzindole-3-carboxylic acid azide in 30 ml of absolute benzene was heated on a water bath for 4 h, after which the benzene was evaporated in

vacuo at 40°C to give 0.45 g (79%) of a product with mp 125-126°C. IR spectrum: 3420 and 2300 cm^{-1}. Found: N 14.4%. $C_{13}H_8N_2O$. Calculated: N 13.5%.

3-Amino[6,7]benzindole Hydrochloride. A solution 0.45 g of the isocyanato[6,7]benzidole in 10 ml of tetrahydrofuran (THF) was heated with 2 ml of concentrated HCl for 30 min, after which the solvent was removed by distillation, and the residue was diluted with water. The aqueous mixture was extracted with ether, the water was removed by vacuum distillation, and the precipitate was washed with ether, dried, and purified by reprecipitation from a solution in alcohol by the addition of methylene chloride to give 0.2 g (43%) of a product that decomposed at 160°C. Found: C 66.0; H 5.0; Cl 16.7; N 12.8%. $C_{12}H_{10}N_2 \cdot HCl$. Calculated: C 65.9; H 5.1; Cl 16.2; N 12.8%.

3-Amino[6,7]benzindole. A 1.16-g (0.0069 mole) sample of [6,7]benzindole was added to a solution of sodium ethoxide prepared from 0.6 g of sodium and 10 ml of absolute alcohol, after which the mixture was cooled to 0°C, and 4 ml of freshly prepared isoamyl nitrite was added. The mixture was allowed to stand in a refrigerator overnight, after which it was diluted with 50 ml of water, and the amyl alcohol and unchanged [6,7]benzindole were extracted with ether. The aqueous solution of the sodium salt of isonitroso[6,7]benzindole was mixed gradually with a saturated solution of sodium hydrosulfite (a four- to fivefold excess with respect to the amount of [6,7]benzindole used) until the solution became colorless. It was then cooled to give a finely dispersed white precipitate of 3-amino[6,7]benzindole, which turned green during isolation. The mixture was extracted with chloroform, the chloroform was removed by distillation at 30°C, and the precipitate was dried in vacuo to give 0.34 g (38% based on the converted [6,7]benzindole) with mp 146-147°C. Found: N 14.9%. $C_{12}H_{10}N_2$. Calculated: N 15.4%.

3-Amino[4,5]benzindole. This compound, with mp 145-146°C, was similarly obtained from 1.66 g (0.01 mole) of [4,5]benzindole. The yield was 0.37 g (20%). Found: N 14.7%. $C_{12}H_{10}N_2$. Calculated: N 15.3%.

Preparation of Azomethines. A) A mixture of 0.01 mole of 3-formyl[4,5]- or -[6,7]benzindole[10] with 0.011 mole of the corresponding aromatic amine in alcohol was heated in a flask equipped with a reflux condenser. The end of the reaction was determined from the disappearance of the spot of the starting aldehyde [thin-layer chromatography (TLC)]. The Schiff base was removed by filtration after the mixture was cooled. The reaction conditions and the characteristics of the azomethines are presented in Table 1, and the spectral data are presented in Table 2.

B) A thoroughly stirred homogeneous mixture of 3-formyl[4,5]- or -[6,7]benzindole with a twofold excess of aniline was allowed to stand overnight, and the resulting precipitate was removed by filtration and crystallized from alcohol. The yields were quantitative (Table 1).

C) A mixture of 0.01 mole of 3-formyl[4,5]- or -[6,7]benzindole with 0.011 mole of the corresponding aromatic amine in 50 ml of absolute xylene (or toluene) was heated in the presence of one drop of formic acid with removal of the water by azeotropic distillation. The precipitate was separated at the end of the reaction. The yields and melting points of the azomethines obtained are presented in Table 1.

o-Hydroxybenzylidene[4,5]benzindol-3-ylamine (X). Without additional purification, 0.1 g (0.0005 mole) of 3-amino[4,5]benzindole was dissolved in 15 ml of absolute alcohol, and the solution was refluxed with 0.6 g (0.005 mole) of freshly distilled salicylaldehyde for 1 h. Reddish crystals of azomethine X separated after cooling. Workup gave 0.02 g (13%) of a product with mp 276-278°C. Found: C 79.4; H 4.7; N 9.7%. $C_{19}H_{14}N_2O$. Calculated: C 79.7; H 4.9; N 9.8%.

o-Hydroxybenzylidene[6,7]benzindol-3-ylamine (XI). Similarly, 0.02 g (13%) of azomethine XI, with mp 222-223°C, was obtained from 0.1 g (0.0005 mole) of 3-amino[6,7]benzindole. Found: C 79.4; H 4.7; N 9.6%. $C_{19}H_{14}N_2O$. Calculated: C 79.7; H 4.9; N 9.8%.

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KETO ACIDS IN THE PYRROLE SERIES

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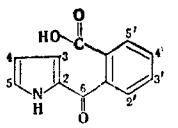
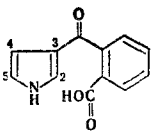
The spectral properties of o-(2-pyrrolylketo)benzoic acid and its N-methyl and N-benzyl analogs were investigated in order to detect ring-chain tautomerism. It is shown that the investigated acids exist in the open keto form. The corresponding derivatives involving the carbonyl group were obtained. The preparation of derivatives of the cyclic lactol form of the 2-pyrrolylketobenzoic acids is described.

The previously described [1] o-(2-pyrrolylketo)benzoic acid is of interest as a model for the study of various types of tautomeric transformations [2-4]. We have used it for the study of ring-chain tautomerism, in analogy with acetophenone-o-carboxylic acid [3, 4].

Keto acid I was obtained by reaction of pyrrolylmagnesium iodide with phthalic anhydride in anisole [1]. However, the reaction was complicated by considerable resinification and the production of cyclic lactam II; this was evidently a consequence of carrying out the reaction at high temperature. The yield of acid I was only 30%. We found that the yield can be increased to 63% if the reaction is terminated immediately after the addition of a hot solution of phthalic anhydride to the pyrrolylmagnesium iodide; in this case the presence of lactam II is not detected even by chromatography. Nevertheless, the reaction product has a melting point that is 40°C lower than that of pure acid I and, according to chromatography, is a mixture of two compounds. To separate them we used column chromatography on silica gel. The principal reaction product is actually acid I, which was isolated in a ratio of 9:1 relative to the second compound, which also has acid character (Ia). On the basis of an examination of the UV (Fig. 1) and IR spectra we assumed that we are dealing with structural



I



Ia

isomers: It was shown by mass spectrometry that the molecular ion at m/e 215 is the maximum peak in the spectra of both compounds and that the fragmentation pathways of the two substances coincide. An analysis of the PMR spectra (Table 2), which we will discuss below, confirms the assumption made above.

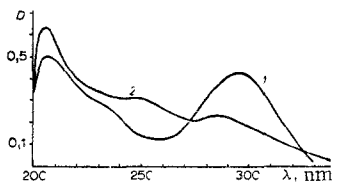


Fig. 1. UV spectra of 2-pyrrolylketo- and 3-pyrrolylketobenzoic acids: 1) o-(2-pyrrolylketo)benzoic acid (I); 2) o-(3-pyrrolylketo)benzoic acid (Ia).

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