by filtration to give 6.5 g (94%) of a substance that was insoluble in water and petroleum ether, only slightly soluble in benzene and toluene, and more readily soluble in alcohol and glacial acetic acids. Recrystallization from alcohol gave prisms with mp 234-235%. Found: C 77.2; H 5.4%. $C_{22}H_{18}N_2O_2$. Calculated: C 77.2; H 5.3%.

Compounds II-XIX were similarly obtained.

Reduction of I. A solution of 1 g of I in 60 ml of alcohol was gently refluxed with 25 g of freshly prepared Raney nickel for 3 h, after which the mixture was filtered, and the filtrate was evaporated. The residue was crystallized from benzene to give prisms with mp 225-226° (in agreement with the melting point reported for 3,3-diphenyloxindole [5]). No melting-point depression was observed for a mixture of this product with a genuine sample. The IR spectra of the two substances were also identical.

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ACETYLATION OF PYRIDAZINO[4,5-b]INDOLES AND THEIR DIHYDRO AND TETRAHYDRO DERIVATIVES. III*

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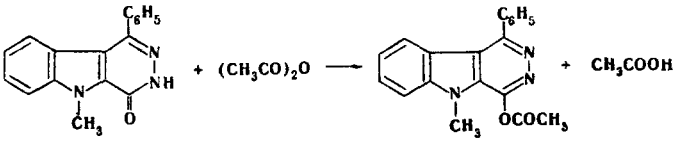
UDC 547.759.3'852:542.951

Acetylation of pyridazino[4,5-b]indol-4-ones with acetic anhydride gives the O-acetyl derivatives, and acetylation of 1,2-dihydropyridazino[4,5-b]indol-4-ones leads to the 2-acetyl and 2,4-diacetyl derivatives. Tetrahydropyridazino[4,5-b]-indoles, obtained by reduction of the dihydro derivatives, undergo substitution by an acetyl group at the 2 position.

Pyridazino[4,5-b]indoles [1, 2] are capable, as we have observed, of readily undergoing acetylation. It has been reported [3] that the acylation of pyridazino[4,5-b]indol-4-ones with benzoyl chloride leads to 3,5-dibenzoyl derivatives. In the case of 5-methylpyridazino[4,5-b]indole (A) we have observed that the introduction of an acetyl group is accompanied by the appearance of a single absorption band at 1770 cm^{-1}, which is characteristic for the ester group.



A I

*See [1] for communication II.

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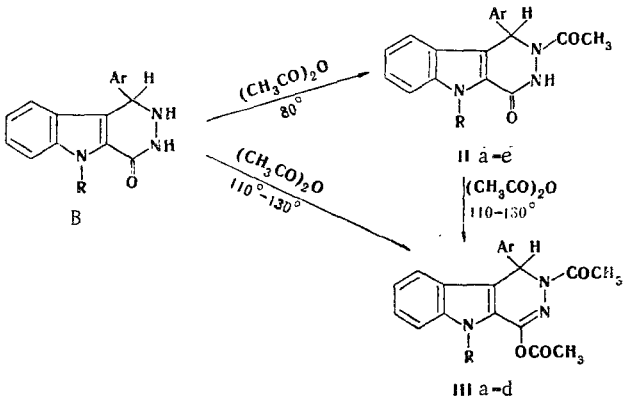
TABLE 1. Spectral Characteristics of Pyridazino-, Dihydropyridazino-, and Tetrahydropyridazino [4-5]indole Derivatives

Compound	$\nu_{C=O}$, cm^{-1}	λ_{max}, nm (lg ε)	PMR spectra, ppm
I	1770	234 (4,65), 253 (4,48), 295 (3,97), 325 (4,03)	7,6—7,2 (9H, aromatic protons) 4,42 (3H, $N_{(5)}CH_3$) 2,74 (3H, CH_3COO)
IIa	1648, 1685	302 (4,21)	—
IIIa	1710, 1725	315 (4,32)	—
IIIb	1708, 1723	315 (4,31)	—
IIIc	1705, 1728	315 (4,34)	7,4—7,2 (9H, aromatic protons) 4,73 (3H, $N_{(5)}CH_3$) 2,23 (3H, $N_{(2)}COCH_3$) 2,00 (3H, $OCOCH_3$)
IIId	1712	315 (4,34)	7,5—6,6 (8H, aromatic protons) 4,17 (3H, $N_{(5)}$—CH_3) 3,76 (3H—OCH_3) 2,27 (3H—$N_{(2)}$—$COCH_3$) 2,02 (3H—O—$COCH_3$)
VIa	Absent	285 (4,20)	7,5—7,2 (9H, aromatic protons) 4,18 (1H, benzyl proton) 3,55 (3H, $N_{(5)}$—CH_3) 2,22 (2H, methylene protons)
VII	1685	285 (4,21)	7,5—7,2 (9H, aromatic protons) 6,0 (1H, benzyl proton) 3,55 (3H, $N_{(5)}$—CH_3) 2,22 (2H, CH_2) 1,22 (3H, CH_3CO)

The formation of an aromatic structure — the aza analog of carboline — shows up in the increase in the intensity of the maximum at 325 nm (log ε 3.93) in the spectrum of the starting compound to log ε 4.03 in the spectrum of acetyl derivative I. The decrease in the melting point as compared with the melting point of the starting compound from 269° to 212°C indicates a decrease in the polarity of the structures. Acid hydrolysis of I regenerates the starting compound. Thus O-acylation seems more likely to us than acylation of the amide nitrogen atom (the 3 position) proposed in [3].

The 1,2-dihydropyridazino[4,5-b]indoles (B) contain amino and amido groups, and incorporation of an acetyl residue both in the 2 and 3 (N-acetylation) positions, as well as in the 4 position (O-acetylation), could be expected for them. In fact, we observed that 2-acetyl (IIa-e) derivatives are formed under mild conditions, whereas 2,4-diacetyl derivatives (IIIa-d) are formed under more severe conditions. The UV spectra of II do not change as compared with the UV spectra of the starting compounds, whereas an additional band of carbonyl absorption at 1675-1685 cm^{-1} (Table 1) with retention of the position of the band of the carbonyl group of the pyridazine ring (1635-1650 cm^{-1}) is observed in the IR spectra.



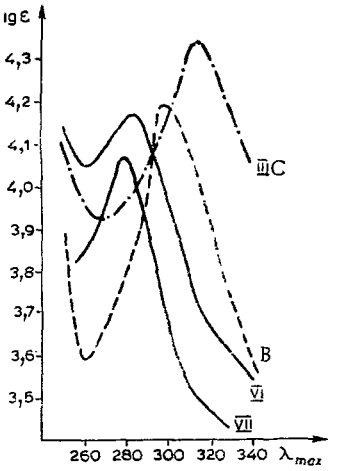
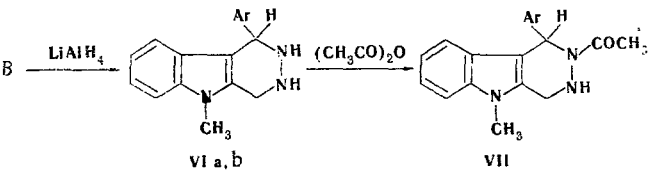


Fig. 1. UV spectra of B (R = CH_3, Ar = C_6H_5), IIIc (R = CH_3, Ar = C_6H_5), VI (Ar = C_6H_5), and VII (Ar = C_6H_5) in ethanol ($0.3 \cdot 10^{-4}$ g-mole/liter).

The PMR spectra of IIIa-d contain two signals of methyl groups belonging to acetyl residues; for example, for IIId, $N_{(2)}$—$COCH_3$ 2.27 ppm, $C_{(4)}$—$OCOCH_3$ 2.02 ppm; they are readily distinguished from the $N_{(5)}$—CH_3 and OCH_3 groups, which are found at weaker fields. Diacetyl derivatives IIIa-d differ from monoacetyl derivatives II with respect to their lower melting points. We note that the dihydropyridazino[4,5-b]indol-4-ones (B) are cyclic hydrazides and permit an analogy with phthalhydrazide, for which the O-acetyl derivatives also have lower melting points than the N-acetyl derivatives [4]. The carbonyl bands in the IR spectra of IIIa-d lie at 1705 cm^{-1} (amide carbonyl groups) and 1725 cm^{-1} (—COO). In this case substitution of the $N_{(5)}$ atom does not affect the position of the frequencies, and this indicates the absence of a hydrogen bond between the oxygen atom of the ester group and the hydrogen atom of the imino group of the pyrrole ring. The C=N bond formed as a result of O-acetylation is represented in the IR spectra of IIIa-d by a band at 1660-1680 cm^{-1}. The UV spectra of the diacetyl derivatives undergo a certain bathochromic shift from 300 to 315 nm. In conformity with [3], for 5-unsubstituted diacetyl derivatives we have previously proposed [5] a 2,5-diacetyl derivative structure, which should now be acknowledged to be incorrect. In addition to the data set forth above, the formation of diacetyl derivatives from $N_{(5)}$-methylated dihydropyridazino[4,5-b]indolones (B) serves as a convincing proof of this.



We obtained tetrahydropyridazino[4,5-d]indoles (IVa, b) by reduction of dihydropyridazino[4,5-b]indol-4-ones with lithium aluminum hydride in refluxing dioxane [6]. Monitoring of the reduction from the change in the UV spectrum of the reaction mixture showed that the optimum reaction time is 4 h. Bases VIa, b are low-melting compounds that give crystalline hydrochlorides. We were unable to obtain the hydrochloride of VIb in pure form for analysis. The compositions of the hydrochloride and adipate of VIa provided evidence that the compounds obtained in this study are monoacidic bases. Absorption in the region of C=O stretching vibrations was absent in the IR spectra of VIa, and a hypsochromic shift from 300 nm in the spectrum of dihydropyridazino[4,5-b]indol-4-one to 285 nm in the spectrum of tetrahydropyridazino[4,5-b]indole (Fig. 1) was observed in the UV spectra because of shortening of the conjugation chain. A new signal with an intensity of two proton units appears at 2.22 ppm (methylene group) and a singlet of a benzyl proton (1H) appears at 4.18 ppm in the PMR spectrum of VIa. After treatment of VIa with acetic hydride, the PMR spectrum of the acetylation product contained the singlet of a methyl group at 1.22 ppm, and the singlet of the benzyl compound was shifted to weak field at 6.0 ppm. This shift could have occurred in the case of incorporation of an acetyl group at the nearer nitrogen atom (2 position), which gave rise to a decrease in the electron density in the vicinity of the benzyl proton and, consequently, to a decrease in its deshielding. This is confirmed by the unchanged position of the singlet of the methylene group (2H, 2.27 ppm) in the spectrum of VII.

EXPERIMENTAL

The UV spectra of $0.2\text{-}0.3 \cdot 10^{-4}$ M solutions of the compounds in ethanol were recorded with an SF-16 spectrophotometer. The IR spectra of mineral oil suspensions were recorded with a UR-22 spectrometer. The PMR spectra of carbon tetrachloride solutions were obtained with a Varian EM-360 spectrometer (60 MHz). The purity of the isolated products was verified by thin-layer chromatography (TLC) on Silufol with a luminophore coating in a cyclohexane–ethyl acetate system (3:1).

1-Phenyl-4-acetoxy-5-methylpyridazino[4,5-b]indole (I). A solution of 2.75 g (0.01 mole) of 1-phenyl-5-methylpyridazino[4,5-b]indol-4-one in 15 ml of acetic anhydride was refluxed for 2 h, after which it was cooled, and the resulting precipitate was removed by filtration and purified by crystallization from ethanol to give 2.6 g (82%) of I with mp 212°. Found: C 71.5; H 5.0; N 13.4%. $C_{19}H_{16}N_3O_2$. Calculated: C 71.7; H 5.0; N 13.2%.

Compounds IIa (R = H, Ar = C_6H_5), IIb(R = CH_3, Ar = C_6H_5), IIc (R = H, Ar = p-$OCH_3C_6H_4$), IId (R = CH_3, Ar = p-$CH_3OC_6H_4$), and IIe (R = H, Ar = p-ClC_6H_4) were described in [7]. Compound IIb (R = CH_3, Ar = C_6H_5) was also described in [1].

1-Phenyl-2-acetyl-4-acetoxy-1,2-dihydropyridazino[4,5-b]indole (IIIa). This compound, with mp 190–192°, was obtained in 46% yield from 1-phenyl-1,2-dihydropyridazino[4,5-b]indol-4-one by heating in excess acetic anhydride at 110° for 2 h [7]. Found: C 69.3; H 4.9; N 12.1%. $C_{20}H_{17}N_3O_3$. Calculated: C 69.2; H 4.9; N 12.1%. Compounds IIIb, IIIc, and IIId were similarly obtained.

1-(p-Methoxyphenyl)-2-acetyl-4-acetoxy-1,2-dihydropyridazino[4,5-b]indole (IIIb). This compound, with mp 214-216°, was obtained in 46% yield. Found: C 66.7; H 5.0; N 11.0%. $C_{21}H_{19}N_3O_4$. Calculated: C 66.8; H 5.0; N 11.1%.

1-Phenyl-2-acetyl-4-acetoxy-5-methyl-1,2-dihydropyridazino[4,5-b]indole (IIIc). This compound, with mp 163°, was obtained in 85% yield. Found: C 70.4; H 5.3; N 11.9%. $C_{21}H_{19}N_3O_3$. Calculated: C 69.8; H 5.3; N 11.6%.

1-(p-Methoxyphenyl)-2-acetyl-4-acetoxy-5-methyl-1,2-dihydropyridazino[4,5-b]indole (IIId). This compound, with mp 142–144°, was obtained in 80% yield. Found: C 68.0; H 5.4; N 10.9%. $C_{22}H_{21}N_3O_4$. Calculated: C 67.5; H 5.4; N 10.7%.

1-Phenyl-5-methyltetrahydropyridazino[4,5-b]indole (VIa). A solution of 4 g (0.014 mole) of 1-phenyl-5-methyldihydropyridazino[4,5-b]indol-4-one in 25 ml of anhydrous dioxane was added dropwise to a suspension of 1.55 g (0.042 mole) of $LiAlH_4$ in 15 ml of ether, after which the ether was removed by distillation with simultaneous addition of dioxane to the reaction mixture until the vapor temperature reached 95–100°. The mixture was heated at the same temperature for 4 h, after which it was cooled, and the excess $LiAlH_4$ was decomposed with the minimum volume of water. The solution was decanted from the precipitate, and the precipitate was washed with dioxane. The dioxane solutions were combined, dried with Na_2SO_4, and filtered. An ether solution (0.5-1.0 ml) saturated with HCl was added carefully to the filtrate, and the precipitated hydrochloride of VIa was removed by filtration, washed with dioxane, and dried to give 0.93 g (25%) of a product with mp 256°. Found: N 13.8; Cl 11.7%. $C_{17}H_{16}N_3 \cdot HCl$. Calculated: N 14.0; Cl 11.9%.

Base VIa was obtained by treatment of an aqueous solution (5 ml) of the hydrochloride with 0.3 g (1 mmole) of a saturated Na_2CO_3 solution. The oil that separated immediately crystallized to give 0.2 g (77%) of a product with mp 112°. Found: N 16.0%. $C_{17}H_{16}N_3$. Calculated: N 16.0%. The adipate of VIa was obtained by mixing a saturated solution of adipic acid in 5 ml of ether with a solution of 0.2 g (0.77 mmole) of base VIa in 5 ml of dioxane. The precipitated salt was removed by filtration to give 0.13 g (50%) of a product with mp 180°. Found: N 12.3%. $C_{17}H_{16}N_3 \cdot {}^1/_2C_6H_{10}O_4$. Calculated: N 12.5%.

1-(p-Chlorophenyl)-5-methyltetrahydropyridazino[4,5-b]indole (VIb). The reduction of the starting 1-(p-chlorophenyl)-5-methyl-1,2-dihydropyridazine[4,5-b]indol-4-one was carried out as described above for VIa. The dioxane filtrates were diluted with water prior to separation of the oil, which was crystallized from methanol to give acicular crystals, with mp 132°, in 15% yield. Found: N 13.6; Cl 11.7%. $C_{17}H_{15}N_3Cl$. Calculated: N 14.2; Cl 11.9%.

An uncrystallizable dark-red oil separated when the dioxane solution of VIb was treated with an ether solution of HCl.

1-Phenyl-2-acetyl-5-methyltetrahydropyridazino[4,5-b]indole (VII). A 2.63 g (0.01 mole) sample of base VIa was refluxed in 50 ml of acetic anhydride for 20 min, after which it was cooled, and the precipitated crystals of VII were purified by crystallization from ethanol to give 2.38 g (78%) of a product with mp 218°. Found: N 13.7%. $C_{20}H_{17}N_3O_2$. Calculated: N 13.8%.

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1-ETHYL- AND 1,2-DIMETHYL-3-(p-METHOXYPHENYL)BENZO[f]QUINOLINES AND THEIR TRANSFORMATIONS

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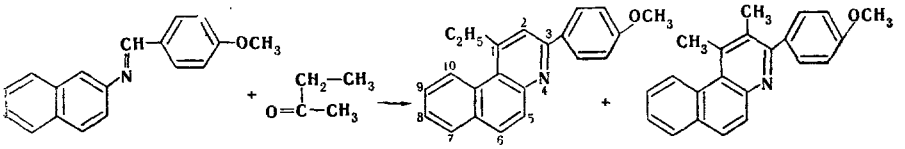
Condensation of p-methoxybenzylidene-2-naphthylamine with methyl ethyl ketone leads to a mixture of 1-ethyl- and 1,2-dimethyl-3-(p-methoxyphenyl)benzo[f]quinolines, for which protic and quaternary salts were obtained. Cyanine dyes were synthesized from 1,2-dimethyl-3-(p-methoxyphenyl)benzo[f]quinoline methiodide.

The condensation of p-methoxybenzylidene-2-naphthylamine with methyl ethyl ketone in acidic media proceeds simultaneously in two directions — at the methyl and methylene groups to give I and II.



I II

The PMR spectra demonstrated that the products contain both isomers in approximately equal ratios. The separation of I and II was based on the different solubilities of their hydrochlorides in ethanol. In addition to I and II, we also isolated the dihydro derivative of benzo[f]quinoline, the IR spectrum of which contains the characteristic band of the NH group at 3450 (in CCl_4) and 3410 cm^{-1} (KBr). This band is absent in the IR spectra of I and II.

Substituents in the benzo[f]quinoline ring and steric factors to a considerable degree determine the character of the absorption in the UV spectra of I and II, which contain absorption bands characteristic for benzo[f]quinolines with respect to the form, number, and position of the maxima [1-3]. A hypsochromic shift of the p and α bands as compared with

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