REACTION OF N-(2-NAPHTHYL)-2-FORMIMIDOYLPYRIDINE WITH SUBSTITUTED ACETOPHENONES

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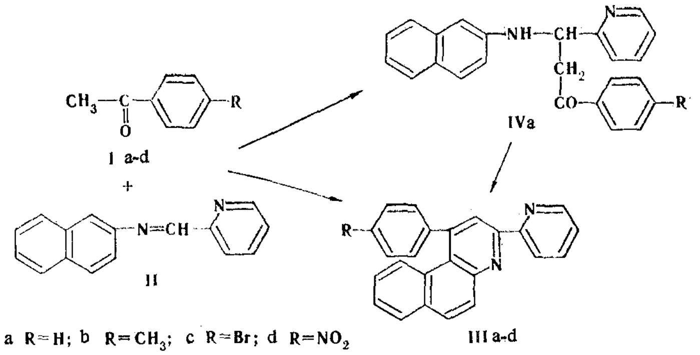
The reaction of N-(2-naphthyl)-2-formimidoylpyridine with substituted acetophenones leads to the formation of 1,3-disubstituted benzo[f]quinolines with a pyridine ring in the 3 position. 1-Phenyl-3-(2-pyridyl)-3-(2-naphthylamino)-propan-1-one was isolated in the case of acetophenone. The IR, UV, and mass spectra of the synthesized compounds are discussed.

It is known that the reaction of arylidene-2-naphthylamines with methyl ketones with various structures leads to the production of 1,3-disubstituted benzo[f]quinolines. The formation of a benzo[f]quinoline ring is a complex process and proceeds through a number of intermediate steps [1].

In order to obtain new data on the mechanism of this reaction we carried out the condensation of N-(2-naphthyl)-2-formimidoylpyridine (II) — an azomethine that contains 2-formylpyridine as the aldehyde component* — with aliphatic aromatic ketones $CH_3COC_6H_4R$ (I).



As a result of the condensation we obtained new 1,3-disubstituted benzo[f]quinolines IIIa-d, which contain a 2-pyridyl substituent in the 3 position. The reaction under conditions that are customary for the synthesis of benzo[f]quinoline derivatives (by refluxing the starting reagents at 70-80°C in the presence of a catalyst and an oxidizing agent [1]) proceeds with pronounced resinification of the reaction mass and leads to the desired products in low yields. We therefore accomplished the condensation by maintaining the reaction mixture at room temperature for a long time.

The structure of the synthesized benzo[f]quinoline bases was confirmed by the results of elementary analysis and IR, UV, and mass spectroscopy, and their characteristics are presented in Table 1.

The IR spectra of IIIa-d contain bands at 3030-3060 cm^{-1}, which are due to C—H stretching vibrations, bands at 1580-1590, 1485-1490, and 1450-1460 cm^{-1}, which are due to benzo[f]quinoline ring C—C stretching vibrations, and bands at 755, 837, and 860-870 cm^{-1}, which are characteristic for C—H out-of-plane deformation vibrations; they were correlated

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*Compound II was synthesized from 2-naphthylamine and 2-formylpyridine.

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with the number of adjacent hydrogen atoms in the ring and serve to establish the type of substitution [2]. The spectrum of IIId contains bands at 1528 and 1355 cm^{-1}, which are related to, respectively, the asymmetrical and symmetrical vibrations of the NO_2 group.

The UV spectra of IIIa-d consist of a system of three electronic absorption bands: β 242-250 nm (log ε 4.38-4.49), p 284-286 nm (log ε 4.57-4.85), and α 350-369 nm (log ε 3.63-3.97) (the latter has a clearly expressed vibrational structure). The form of the spectra is characteristic for benzo[f]quinoline derivatives [3]. Substituents in the para position of the 1-phenyl ring have virtually no effect on the positions of the bands but increase the intensities of the p and α bands. In comparing the UV spectrum of IIIa with the spectrum of 1,3-diphenylbenzo[f]quinoline [β 260 nm (log ε 4.61); p 282 nm (log ε 4.69); α 347, 369 nm (log ε 3.70, 3.72)] one's attention is drawn to the fact that replacement of the phenyl ring in the 3 position by a 2-pyridyl group gives rise to a hypsochromic shift of the β band with almost no change in the positions of the remaining absorption bands.

The principal peak in the mass spectra of IIIa-d is the peak of $[M - H]^+$ ions; the intensity of the molecular-ion peak (M^+) is lower than the intensity of this peak. The high intensity of the $[M - H]^+$ ion peak is possibly explained by loss of a hydrogen atom from the 10 position and the formation of the energetically favorable phenanthro[9,10,11-d,e,f]quinoline system [4,5]. The successive elimination of hydrogen atoms by the $[M - H]^+$ ions leads to the formation of $[M - 2H]^+$, $[M - 3H]^+$, and $[M - 4H]^+$ ions. This sort of fragmentation is characteristic for phenyl-substituted pyridines [6]. The principal pathway of the fragmentation of benzo[f]quinolines that contain substituent R is detachment of this substituent from the $[M - H]^+$ ion. The appearance of an $[M - H, - CH_3]^+$ ion peak in the spectrum of IIIb constitutes evidence for the presence of a methyl group in the molecule. The presence of bromine in IIIc is confirmed by the presence of an isotopic peak of $[M + 2]^+$ ions and an intense peak of $[M - H, - Br]^+$ ions. Peaks of $[M - H, - NO]^+$ and $[M - H, - NO_2]^+$ ions, which indicate the presence of a nitro group, are present in the spectrum of IIId. Ejection of neutral HCN and CH_3CN molecules in different stages of the fragmentation is also observed in the fragmentation of benzo[f]quinoline bases.

It must be noted that we were able to isolate a reaction intermediate, viz., noncyclic 1-phenyl-3-(2-pyridyl)-3-(2-naphthylamino)propan-1-one (IV), only in the case of acetophenone. The IR spectrum of the amino ketone contains bands of stretching and deformation vibrations of C=O (νC=O 1700, δC—CO—C 1218 cm^{-1}) and NH (νNH 3418, δNH 1555 cm^{-1}) groups. The UV spectrum of IV is similar to the spectrum of 2-naphthylamine and contains absorption bands associated with local excitation of the phenyl chromophore [7]. The mass spectrum of amino ketone IV contains, in addition to a molecular ion peak, a rather intense $[M - H]^+$ ion peak. The presence of a large number of peaks indicates the instability of the amino ketone with respect to the action of electron impact. The fragmentation of the substance is primarily associated with elimination of fragments that contain a carbonyl group, viz., $[M - H, - C_6H_5CO]^+$ and $[M - H, - C_6H_5COCH_2]^+$ ions, and these fragment ions undergo further fragmentation.

EXPERIMENTAL

The IR spectra of KBr pellets of the synthesized compounds were recorded with a UR-20 spectrometer. The UV spectra of solutions of the compounds in ethanol (c 10^{-4} mole/liter) were recorded with a Specord UV-vis spectrophotometer. The mass spectra were recorded with a Varian MAT-311A spectrometer with direct introduction of the substances into the ion source at an ionizing-electron energy of 70 eV; the substances were vaporized at 130-180°C. The course of the reaction was monitored, and the individuality of the compounds was determined by thin-layer chromatography (TLC) on Silufol UV-254 plates [elution with carbon tetrachloride—ethanol—acetic acid (8:1:1) and development in UV light].

2-Formylpyridine was obtained by treatment of 2-pyridylhydroxymethane-sulfonic acid with aqueous sodium hydroxide solution [8].

N-(2-naphthyl)-2-formimidoylpyridine was obtained by the method in [9].

1-Phenyl-3-(2-pyridyl)benzo[f]quinoline (IIIa). A mixture of 2.32 g (0.01 mole) of II, 1.32 g (0.011 mole) of acetophenone, 20 ml of isopropyl alcohol, and 16-20 drops of concentrated HCl was maintained at room temperature for 14 days with periodic stirring.

TABLE 1. Characteristics of 1-R-Aryl-3-(2-pyridyl)benzo[f]quinolines

Compound	R	mp, °C	UV spectrum, λ_{max}, nm (log ε)	Found, %			Empirical formula	Calc., %			Yield, %
				C	H	N		C	H	N	
IIIa	H	183—185[a]	250 (4,33), 284 (4,57), 350 (3,63), 365 (3,63)	86,7	4,9	8,5	$C_{24}H_{16}N_2$	86,7	4,9	8,4	24
IIIb	CH_3	168—169[a]	242 (4,38), 285 (4,64), 350 (3,69), 368 (3,69)	86,7	5,4	8,0	$C_{25}H_{18}N_2$	86,7	5,2	8,1	23
IIIc	Br	197—198[b]	252 (4,49), 286 (4,73), 351 (3,74), 369 (3,74)	70,2	4,1	6,3	$C_{24}H_{15}BrN_2$[c]	70,1	3,7	6,8	22
IIId	NO_2	220—221[b]	284 (4,85), 351 (3,97)	76,3	4,4	11,0	$C_{24}H_{20}N_3O_2$	76,4	4,0	11,1	25

[a] From a mixture of isopropyl alcohol with toluene. [b] From a mixture of ethanol with toluene. [c] Found: Br 19.0%. Calculated: Br 19.4%.

The resulting precipitate was removed by filtration, neutralized with 25% ammonium hydroxide, washed with water until the wash liquid was neutral, and crystallized from isopropyl alcohol—toluene (4:1).

Benzo[f]quinolines IIIb-d were similarly obtained.

1-Phenyl-3-(2-pyridyl)-3-(2-naphthylamino)propan-1-one (IV). A mixture of 2.32 g (0.01 mole) of N-(2-naphthyl)-2-formimidoylpyridine (II), 2.4 g (0.02 mole) of acetophenone, 20 ml of butanol, and two drops of concentrated HCl was heated at 40°C for 1.5-2 h, after which the solution was evaporated to dryness, and the residue was treated with 50 ml of ether to remove the resinous substances, neutralized with 25% ammonium hydroxide, washed with water until the wash liquid was neutral, and crystallized three times from toluene to give 0.63 g (18%) of IV with mp 161-163°C. IR spectrum: 3418 (νNH), 1555 (δNH), 1700 (νC=O), and 1218 cm^{-1} (δC—CO—C). UV spectrum, λ_{max} (log ε): 245 (4.40), 282 (3.87), 294 (3.77), and 345 nm (3.25). Found: C 82.1; H 6.2; N 8.1%. $C_{24}H_{20}N_2O$. Calculated: C 81.8; H 5.7; N 8.0%.

Cyclization of 1-Phenyl-3-(2-pyridyl)-3-(2-naphthylamino)propan-1-one (IV). A mixture of 1.76 g (0.005 mole) of IV, 20 ml of isopropyl alcohol, 16-20 drops of concentrated HCl, and 20-25 drops of nitrobenzene was heated on a boiling-water bath for 1 h, after which it was cooled, and the resulting precipitate was removed by filtration, neutralized with 25% ammonium hydroxide, and washed with water until the wash liquid was neutral to give 1 g (74.5%) of IIIa [from isopropyl alcohol—toluene (4:1)].

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