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SYNTHESIS AND SPECTRAL PROPERTIES OF COUMARONYL-SUBSTITUTED BENZO[f]QUINOLINES

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Condensation of arylidene-2-naphthylamines with 2-acetylbenzofuran (2-acetylcoumarone) was used for the first time to synthesize 1-(2-coumaronyl)-3-arylbenzo[f]quinolines containing two different heteroatoms — N and O — in the molecule. The IR, UV, ESR and mass spectra of the compounds obtained were studied.

Among heteroaromatic derivatives of benzo[f]quinoline, the so-called polycyclic heterocycles [1], the best known are benzo[f]quinolines, which contain a nitrogen-containing substituent—pyridyl [2], quinolyl [3], or indolyl [4]. Practically no studies have been made of benzo[f]quinolines with oxygen-containing heterocyclic substituents. In [5], we described the synthesis of several 1-(2-furyl)-2-carbethoxy-3-arylbenzo[f]quinolines in the reaction of arylidene-2-naphthylamines with furoylacetic ester. No benzofuran derivatives of benzo[f]quinoline have been obtained thus far. Yet the synthesis of such compounds is of interest from the standpoint of preparation of biologically active substances and study of the influence of various heteroatoms on the spectral properties of a polyheterocyclic system.

To obtain benzofuryl- or coumaronyl-substituted benzo[f]quinolines, we carried out for the first time the condensation of arylidene-2-naphthylamines (Ia-m) with 2-acetylbenzofuran (2-acetylcoumarone) (II). The reaction was carried out by boiling a solution of the reactants in ethanol in the presence of catalytic amounts of conc. HCl.

We found previously [1-3, 5] that condensation of azomethines with CH acids goes through several successive stages: formation of an amino ketone — a product of addition of a CH acid to the C=N bond of azomethine, cyclization of the amino ketone to a hydroxy derivative of 1,2,3,4-tetrahydrobenzo[f]quinoline, dehydration of the hydroxy derivative to 3,4-dihydrobenzo[f]quinoline, and dehydrogenation of the latter to the completely aromatic benzo[f]quinoline. Depending on the condensation conditions and structure of the reactants, the reaction forms various intermediates or the final product. (See scheme on following page.)

In the studied condensation of arylidene-2-naphthylamines (Ia-m) with 2-acetylcoumarone (II) under the conditions indicated above, not a single intermediate was detected. As a result of the reaction, pure 1-(2-coumaronyl)-3-arylbenzo[f]quinolines (IIIa-m) were selectively obtained in 17-52% yield (Table 1). When the reaction was carried out under milder conditions (20-50°C), both in the presence and in the absence of HCl, the initial arylidene-2-naphthylamines were isolated. We postulate that the bulky benzofuran substituent in the 2-acetylcoumarone molecule produces steric hindrance in the reaction, resulting in the necessity of heating for a fairly long time and using a catalyst to activate the CH acid at the stage of its addition to the azomethine molecule and completion of cyclization of the intermediate β-arylamino ketone. The steric effects apparently also affect the formation of the end product of the reaction as the thermodynamically most favored, completely conjugated aromatic system. The substituent in the aldehyde part of the azomethine has no significant effect on the yield of the target products of the reaction (Table 1). As expected, the electron-acceptor substituent caused a certain increase in yield of benzo[f]quinolines (compounds IIIb-e, j), while the electron-donor substituents lower it (compounds IIIf-h, k), this being due to a change in polarization of the azomethine bond and correspondingly, an increase or decrease in its reactivity [1, 6]. A decrease in yield of the reaction product (IIIm) is also observed in the case of the sterically hindered quinolyl-substituted azomethine (Im).

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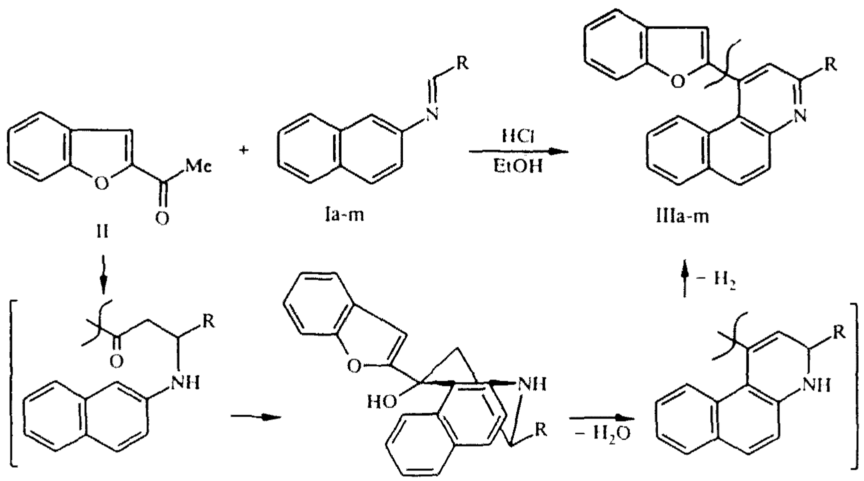
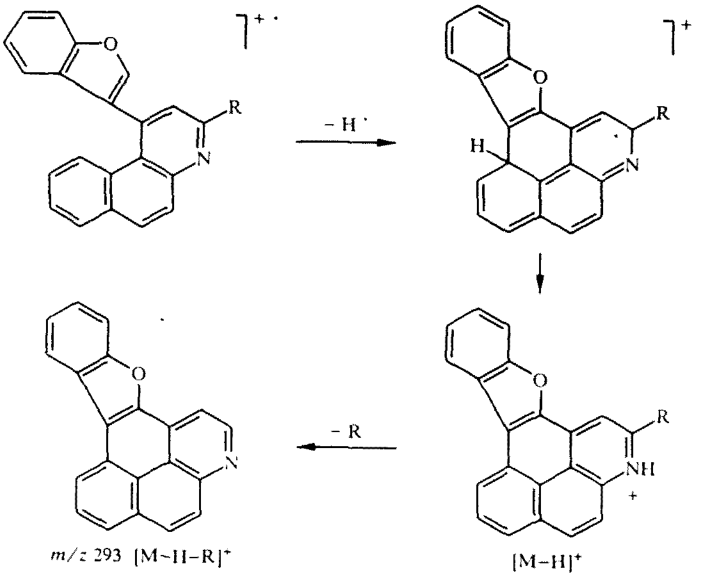


I—III a R = C_6H_5, b *p*-FC_6H_4, c *p*-ClC_6H_4, d *p*-BrC_6H_4, e *m*-BrC_6H_4,
f *p*-OHC_6H_4, g *o*-OHC_6H_4, h *p*-$OCH_3C_6H_4$, i *p*-$NO_2C_6H_4$, j *m*-$NO_2C_6H_4$, k 3,4-$OCH_2OC_6H_3$,
l 3- pyridyl m 2- quinoline

The IR spectra of benzo[f]quinolines (IIIa-m) show absorption bands at 3080-3030 cm^{-1} (ν_{C-H}) and 875-865, 840-835, 770-755 cm^{-1} (δ_{C-H}). The group of medium-strength bands at 1610-1455 cm^{-1} is characteristic of the stretching vibrations of a heteroaromatic ring ($\nu_{C=C}$) [2]. The C−O−C bond of the benzofuran ring shows up in the spectra as a medium-strength band at 1110 cm^{-1} and a fairly strong band at 1270-1260 cm^{-1}; in the spectra of compounds IIIh,k, the latter band splits in two owing to the presence of OCH_3 and $O-CH_2-O$ groups. The nitro group in the spectra of compounds IIIi, j gives two characteristic strong bands at 1535-1530 cm^{-1} and 1360-1355 cm^{-1}.

A characteristic feature of the mass spectra of benzo[f]quinolines IIIa-m is the small number of fragment ions. The peak of the molecular ion (M^+) is the strongest in the spectra; there are also peaks of $[M-H]^+$ ions and peaks of low and medium strength (5-25%), m/z 293 and 369, corresponding to $[M-H-R]^+$ ions, where R is a fragment of the R substituent, in particular, Hal for IIIb-e, OH for IIIf, g, OCH_3 for IIIh, NO_2 for IIIi, j. It should be noted that in the spectra of benzo[f]quinolines IIIa-m, no splitting off of the coumaronyl substituent from the 1 position is observed, as was noted in the case of quinolyl-substituted benzo[f]quinolines [7]. One can therefore postulate that in the series of the studied compounds IIIa-m, the formation of an even-electron ion $[M-H]^+$ will be associated with cyclization of the molecular ion to an energetically stable system of oxaindeno[2,3-*l*]azapyrene, from which the substituents R^1 and R are subsequently eliminated.



In the ESR spectra of compounds of IIIa-m, the signals of aromatic protons are in the range 6.95-8.58 ppm. The protons of the OCH_3 group in the spectrum of IIIh give a singlet at 3.86 ppm. The signal of the protons of $O-CH_2-O$ com-

TABLE 1. Characteristics of 1-(2-Coumaronyl)-3-arylbenzo[f]quinolines (IIIa-m)

Com. pound	Empirical formula	Found, %			Calculated, %			mp, °C	UV spectrum, λ_{max}, nm (log ε)	Yield, %
		C	H	N	C	H	N			
IIIa	$C_{27}H_{17}NO$	87,09	4,77	3,64	87,29	4,62	3,77	213...214	248 (4,41), 290 (4,56), 337 (4,12), 356 (4,00), 373 (3,96), 399 (3,44)	25
IIIb	$C_{27}H_{16}FNO$	–	–	3,52	–	–	3,60	219...220	251 (4,60), 290 (4,75), 337 (4,20), 355 (4,18), 371 (4,05), 401 (3,60)	32
IIIc*	$C_{27}H_{16}ClNO$	79,40	4,01	3,12	79,89	3,98	3,45	236...238	253 (4,48), 291 (4,68), 340 (4,08), 356 (4,08), 375 (3,93), 398 (3,65)	37
IIId*	$C_{27}H_{16}BrNO$	71,58	3,44	2,98	72,01	3,59	3,11	199...200	248 (4,60), 285 (4,39), 294 (4,36), 344 (4,08), 3,58 (3,78), 376 (3,58), 397 (3,30)	52
IIIe*	$C_{27}H_{16}BrNO$	72,13	3,68	3,02	72,01	3,59	3,11	217...218	253 (4,68), 287 (4,77), 337 (4,40), 354 (4,17), 372 (4,05), 400 (3,60)	31
IIIf	$C_{27}H_{17}NO_2$	83,42	4,64	3,21	83,69	4,43	3,62	238...240	253 (4,22), 291 (4,41), 337 (4,10), 3,63 (3,98), 385 (3,94), 397 (3,88)	24
IIIg	$C_{27}H_{17}NO_2$	83,24	4,18	3,74	83,69	4,43	3,62	254...255	258 (4,14), 291 (4,30), 337 (4,08), 365 (3,92), 383 (3,90)	22
IIIh	$C_{28}H_{19}NO_2$	83,48	4,86	3,13	83,76	4,78	3,49	205...206	250 (4,54), 297 (4,70), 339 (4,20), 356 (3,85), 3,76 (3,76), 397 (3,49)	18
IIIi	$C_{27}H_{16}N_2O_3$	77,44	3,64	6,38	77,87	3,88	6,73	279...280	239 (4,53), 293 (4,50), 326 (4,34), 351 m. (4,02), 369 m. (3,99)	45
IIIj	$C_{27}H_{16}N_2O_3$	77,69	3,49	7,08	77,87	3,88	6,73	149...150	249 (4,55), 283 (4,56), 354 m. (4,01), 365 m. (3,92)	44
IIIk	$C_{28}H_{17}NO_3$	80,74	4,48	3,12	80,94	4,13	3,37	264...266	236 (4,11), 291 (4,08), 330 (3,88), 357 (3,78), 376 (3,75), 397 (3,67)	25
III*l*	$C_{26}H_{16}N_2O$	83,61	4,11	7,09	83,84	4,34	7,52	228...230	247 (4,47), 289 (4,55), 337 (4,10), 355 (3,98), 373 (3,90), 398 (3,42)	26
IIIm	$C_{29}H_{18}N_2O$	84,53	4,59	6,28	84,85	4,43	6,83	234...236	260(4,70), 281 (4,69), 329 (4,54), 343 (4,45), 376 (4,06), 406 (3,98)	17

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*Found, %: Cl 8.55 (IIIc), Br 17.41 (IIId), Br 18.04 (IIIe). Calculated, %: Cl 8.73 (IIIc), Br 17.74 (IIId, e).

pound IIIk) is located at 6.15 ppm. Such a marked shift of this signal to the weak-field region as compared to the usual location of the signals of aliphatic protons [8] is, in our view, due to the anisotropic effect of the two oxygen atoms; we observed it previously for 3-(3',4'-methylenedioxy)phenylbenzo[f]quinoline [6], annelated in the 1,2 position by a carbon ring.

The absorption spectra of compounds IIIa-m (Table 1) at 235-400 nm are characterized by a structure typical of benzo[f]quinolines [9]. The long-wavelength band (330-406 nm) is interpreted as an α band ($'L_b$ after Platt). Compared to the spectra of 1,3-diarylbenzo[f]quinolines [9], this band undergoes a substantial bathochromic shift and an intensification of the vibrational structure, apparently beause of an enlargement of the conjugation chain as a result of the introduction of the benzofuran substituent. The shorter-wavelength bands, located at 281-297 nm and 236-260 nm, are the p and β bands ($'L_a$ and $'B_b$), respectively. As a rule, the p band is stronger than the β band, this being characteristic of compounds of angular structure—phenanathrene [10], benzo[f]- and benzo[h]quinolines [9, 11], and 4,7-phenanthrolines [12]. The introduction of halogens and of the OCH_3 group into the phenyl ring increases the strength of the p band, while the hydroxyl group and the $O-CH_2-O$ fragment decrease it. The introduction of a nitro group into the phenyl ring leads to an equalization of the strengths of the p and β bands and a leveling of the vibrational structure of the α band.

EXPERIMENTAL

The IR spectra were taken with a UR-20 instrument in KBr pellets. The mass spectra were recorded with an MX-1320 instrument. The UV spectra were taken with a Specord UV-vis instrument for $1 \cdot 10^{-4}$ mole/liter solutions of the compounds in ethanol. The ESR spectra were obtained on a Tesla 567A (100 MHz) instrument in $CDCl_3$ for compounds IIIb, i, c and in $(CD_3)_2SO$ for IIIa, c-h, j-m. The internal standard was TMS.

1-(2-Coumaronyl)-3-arylbenzo[f]quinolines (IIIa-m). A solution of 0.01 mole of azomethine (Ia, m), 0.0125 mole of 2-acetylcoumarone (II), and 6 drops of conc. HCl in 40 ml of ethanol are heated for 10-12 h at 80°C. The precipitated reaction product is filtered off, then treated with an alcohol solution of NH_4OH, water, and ethanol. Compound IIIg is crystallized from a 1:1 isopropanol—toluene mixture.

REFERENCES

1. N. S. Kozlov, 5,6-Benzoquinolines [in Russian], Nauka i Tekhnika, Minsk (1970).
2. N. S. Kozlov, S. V. Mikhalevskaya, V. A. Serzhanina, and R. D. Sauts, Dokl. Akad. Nauk BSSR, **28**, No. 9, 810 (1984).
3. K. N. Gusak, V. A. Serzhanina, N. G. Kozlov, and V. V. Gren', Khim. Geterotsikl. Soedin., No. 10, 1406 (1994).
4. G. P. Korotyshova and N. S. Kozlov, Izv. Akad. Nauk BSSR, Ser. Khim. Nauk, No. 4, 48 (1990).
5. N. S. Kozlov, V. A. Serzhanina, N. A. Krot, K. N. Kovalevich, I. P. Mikhailova, and R. D. Sauts, Khim. Geterotsikl. Soedin., No. 2, 169 (1979).
6. N. G. Kozlov, K. N. Gusak, and S. A. Makhnach, Khim. Geterotsikl. Soedin., No. 1, 34 (1996).
7. N. S. Kozlov, G. S. Shmanai, V. P. Suboch, and V. I. Vil'chinskaya, Khim. Geterotsikl. Soedin., No. 4, 520 (1979).
8. D. R. Dyer, Applications of Absorption Spectroscopy [Russian translation], Khimiya, Moscow (1970), p. 100.
9. N. S. Kozlov, L. F. Gladchenko, V. A. Serzhanina, G. V. Vorob'eva, O. D. Zhikhareva, G. S. Shmanai, and R. D. Sauts, Khim. Geterotsikl. Soedin., No. 9, 1237 (1977).
10. C. Brown and B. J. Sikkel, J. Chem. Soc. Perkin Trans. I, No. 12, 3007 (1982).
11. N. S. Prostakov, A. V. Varlamov, and T. N. Borisova, Khim. Geterotsikl. Soedin., No. 5, 648 (1984).
12. N. S. Kozlov, K. N. Gusak, V. A. Serzhanina, L. V. Gladchenko, and N. A. Krot, Khim. Geterotsikl. Soedin., No. 12, 1651 (1987).