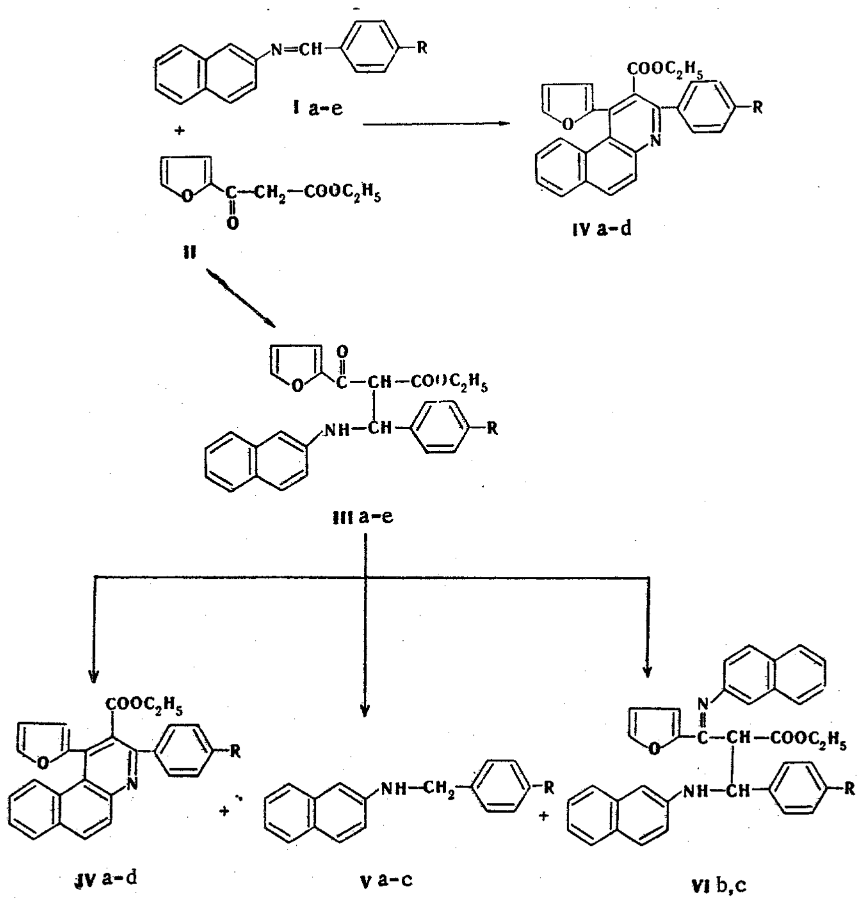
# REACTION OF ARYLIDENE-2-NAPHTHYLAMINES WITH ETHYL FUROYLACETATE

N. S. Kozlov, V. A. Serzhanina,
N. A. Krot, K. N. Kovalevich,
I. P. Mikhailova, and R. D. Sauts

UDC 547.836.3'725:543.422.25.4

The reaction of arylidene-2-naphthylamines with ethyl furoylacetate was studied. It is shown that noncyclic amino keto esters are formed when the reaction is carried out without a catalyst and that esters of the benzo[f]quinoline series are formed when the reaction is carried out in the presence of a catalyst and an oxidizing agent. Esters of the benzo[f]quinoline series are also formed in the cyclization of the amino keto esters. The structures of the reaction products were confirmed by the results of elementary analysis and the IR, UV, NMR, and mass spectroscopic data.

To ascertain the effect of substituents attached to the carbonyl group of the keto ester on the course of the reaction of azomethines with C—H acids [1] we carried out the condensation of arylidene-2-naphthylamines with ethyl furoylacetate (Scheme 1).



a R=H; b R=Br; c R=F; d $R=NO_2$; e $R=OCH_3$

Scheme 1

---

Institute of Physical Organic Chemistry, Academy of Sciences of the Belorussian SSR, Minsk 220603. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 2, pp. 169-172, February, 1979. Original article submitted April 10, 1978.

TABLE 1. Characteristics of Ethyl α-Furoyl-β-aryl-β-(2-naphthylamino)propionates

| Compound | R | mp, °C | Found, % |  |  | Empirical formula | Calc., % |  |  | Yield, % |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | C | H | N |  | C | H | N |  |
| IIIa | H | 108 | 75,6 | 5,9 | 3,2 | $C_{26}H_{23}NO_4$ | 75,5 | 5,6 | 3,4 | 88 |
| IIIb | Br | 103—104 | 63,3 | 5,0 | 3,0 | $C_{26}H_{22}NBrO_4$* | 63,4 | 4,5 | 2,8 | 68 |
| IIIc | F | 93—94 | — | — | 3,3 | $C_{26}H_{22}NFO_4$ | — | — | 3,3 | 83 |
| IIId | $NO_2$ | 92—93 | 68,6 | 5,1 | 6,4 | $C_{26}H_{22}N_2O_6$ | 68,1 | 4,8 | 6,1 | 94 |
| IIIe | $OCH_3$ | 92 | 73,5 | 6,0 | 3,2 | $C_{27}H_{25}NO_5$ | 73,1 | 5,7 | 3,2 | 78 |

---

*Found: Br 15.8%. Calculated: Br 16.2%.

TABLE 2. Physicochemical Characteristics of Ethyl 1-Furyl-3-arylbenzo[f]quinoline-2-carboxylates

| Compound | R | mp, °C | UV spectrum (ethanol), $\lambda_{max}$, nm ($\varepsilon \cdot 10^{-4}$) | Found, % |  |  | Empirical formula | Calc., % |  |  | Yield, % |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | C | H | N |  | C | H | N |  |
| IVa | H | 112 | 284 (3,98); 348 (0,66); 365 (0,66) | 78,9 | 5,1 | 3,2 | $C_{26}H_{19}NO_3$ | 79,4 | 4,9 | 3,5 | 22 |
| IVb | Br | 143—144 | 284 (4,13); 348 (0,63); 367 (0,59) | 66,5 | 3,9 | 2,6 | $C_{26}H_{18}NBrO_3$* | 66,1 | 3,9 | 3,0 | 56 |
| IVc | F | 96—98 | 286 (4,24); 349 (0,68); 367 (0,59) | — | — | 3,4 | $C_{26}H_{18}NFO_3$ | — | — | 3,4 | 30 |
| IVd | $NO_2$ | 188—190 | 290 (4,40); 348 (0,90); 366 (0,68) | 70,8 | 3,9 | 6,4 | $C_{26}H_{18}N_2O_5$ | 71,2 | 4,1 | 6,4 | 38 |

---

*Found: Br 17.0%. Calculated: Br 16.9%.

A study of this reaction showed that the products under mild conditions (when I and II are refluxed without a catalyst) are noncyclic amino keto esters — ethyl α-furoyl-β-aryl-β-(2-naphthylamino)propionates (III), the empirical composition of which was confirmed by the results of elementary analysis, and the structure of which was confirmed by IR and PMR spectroscopic data (Table 1).

The IR spectra of III contain a $\nu_{NH}$ band at 3375-3385 cm$^{-1}$. An ester $\nu_{C=O}$ band and a $\nu_{C=O}$ band of the carbonyl group attached to the furan ring are found at 1725-1735 and 1654-1663 cm$^{-1}$, respectively [2]. A certain shift of these bands to the low-frequency region is observed in the spectra of amino keto esters III as compared with ethyl furoylacetate; this is due to the stronger intermolecular bonds (the spectrum of a 0.1 mole/liter solution of IIIa in dioxane contains an ester $\nu_{C=O}$ band at 1739 cm$^{-1}$ and a carbonyl $\nu_{C=O}$ band at 1680 cm$^{-1}$).

Resonance signals at 1.06 ($CH_3$) and 4.01 ppm ($CH_2$) of an ethyl group and a diffuse singlet at ∿ 5.43 ppm (NH), which vanishes when $D_2O$ is added, are present in the PMR spectra. The signals of the central methylidyne protons (doublets with J = 10 Hz) lie at 5.47 and 4.81 ppm (IIIa) and 5.40 and 4.92 ppm (IIIb, c). Their paramagnetic shift is due to the location of these protons near the nitrogen atom and the aromatic ring and the anisotropic effect of the carbonyl groups. The mulitplet at 6.45-8.01 ppm (14H) can be assigned to aromatic and furan protons.

When the reaction is carried out under more severe conditions (in the presence of a catalyst and an oxidizing agent), it leads to the formation of benzo[f]quinoline derivatives — ethyl 1-furyl-3-arylbenzo[f]quinoline-2-carboxylates (IV) (Table 2). We also obtained IV by cyclization of amino keto esters III. The fact of the cyclization of III to IV is confirmed by the absence in the IR spectra of IV of characteristic absorption bands of NH stretching vibrations and a C = O group attached to the furan ring, as well as by the appearance in the region of skeletal stretching vibrations of bands characteristic for benzoquinoline structures (1618, 1605, 1580, 1490, 1480, and 1438 cm$^{-1}$) [3]. The location of the $\nu_{C=O}$ band of an ester group in the spectrum of IV (1719-1720 cm$^{-1}$) confirms conjugation of the ester grouping with the aromatic ring.

The signals at 5.47 and 4.81 ppm vanish in the PMR spectra of IV, but the triplet (1.05 ppm) and quartet (4.7 ppm) with J = 8 Hz of an ethyl group and a multiplet of aromatic and furan protons at 6.77-8.18 ppm remain.

Two principal bands — one at 348-366 nm, which has a vibrational structure, and the other at 280-290 nm, which we interpreted as α and p bands, respectively — can be isolated in the UV spectra of IV. These bands are characteristic for the benzo[f]quinoline derivatives that we previously studied in [4]. The introduction of substituents in the para position of the 3-phenyl ring has virtually no effect on the position of the bands but increases the intensity of the p band somewhat.

It should be pointed out that amino keto esters III are unstable compounds and, in addition to cyclization to IV, undergo cleavage at the CH—CH bond, evidently due to the effect of the electron-acceptor $COO_2H_5$ and C = 0 groups. The cleavage evidently proceeds through the formation of a carbonium ion, the recombination of which with simultaneous disproportionation leads to the formation of an azomethine molecule.

The formation of azomethines from amino keto esters III is also confirmed by the mass-spectrometric data. The mass spectra of IIIa-e do not contain molecular-ion peaks equal to the molecular masses of amino keto esters III but contain only fragment peaks corresponding to Ia-e and II. The azomethines formed in the cleavage of amino keto esters III undergo subsequent hydrolysis in acidic media to the corresponding aldehydes and 2-naphthylamine, which adds to the carbonyl group of III to give VI. The empirical composition of VI was confirmed by the results of elementary analysis, and the structure was confirmed by the IR and mass spectra. The IR spectra contain $\nu_{NH}$ (3364 $cm^{-1}$) and ester $\nu_{C=O}$ (1714 $cm^{-1}$) bands.

The principal peak in the mass spectra of VI is the molecular-ion peak. The next most intense peak corresponds to removal of 2-naphthylamine from the molecular ion. To establish the elementary composition of the molecular ions we recorded the high-resolution spectra. The molecular weight and empirical composition of VI determined by mass spectrometry are in agreement with the calculated values.

Our studies showed that the direction of cyclization depends on the electronic nature of substituent R. If R is an electron-acceptor substituent ($NO_2$, Br, F), the rate of formation of the cyclic product evidently exceeds the rate of cleavage of the amino keto ester. The electron-donor $OCH_3$ group shifts the process to favor cleavage of III, so that one cannot obtain the cyclic product at all. In this case the only reaction product is azomethine Ie.

Compounds V also are formed along with cyclic products IV; this confirms our previous assumption [1] that the hydrogen evolved in the formation of the benzo[f]quinoline ring goes into the reduction of the azomethines. The structure of V was confirmed by the results of elementary analysis and data from the IR and PMR spectra. Absorption bands at 3400-3410 $cm^{-1}$ $\nu_{(NH)}$) are observed in the IR spectra. A singlet at 4.3 ppm (2H) from the methylene group is present in the PMR spectrum; the aromatic protons give a resonance signal at 6.72-7.76 ppm (12H) and a broad singlet at 8.2 ppm (NH), which vanishes when $D_2O$ is added.

## EXPERIMENTAL

The $^1H$ NMR spectra of 10% solutions of the compounds in $d_7$-dimethylformamide were obtained with a JNM PS-100 spectrometer (JEOL, Japan) with hexamethyldisiloxane as the internal standard. The chemical shifts are given on the δ scale, and the J values are given in hertz. The IR spectra of KBr pellets of the compounds were recorded with a UR-20 spectrometer. The UV spectra of solutions of the compounds in ethanol were recorded with a Specord UV-vis spectrophotometer. The mass spectra were recorded with a Varian MAT-311 spectrometer with direct introduction of the compounds into the ion source at an ionizing-radiation energy of 70 eV. The vaporization temperature of the samples was 100°C. Ethyl α-furoylacetate was obtained by the method in [5].

Ethyl α-Furoyl-β-aryl-β-(2-naphthylamino)propionates (III). A mixture of 0.01 mole of arylidene-2-naphthylamine (I), 0.02 mole of ethyl α-furoylacetate (II), and 30 ml of ethanol was heated on a boiling-water bath for 1 h, after which it was cooled, and the precipitated III was removed by filtration and washed with ether. Compound IIIa was crystallized from ethanol.

Ethyl 1-(α-Furyl)-3-arylbenzo[f]quinoline-2-carboxylates (IV). A mixture of 0.01 mole of I, 0.02 mole of II, 30 ml of ethanol, 10 drops of concentrated HCl, and 12 drops of nitrobenzene was heated on a boiling-water bath for 2 h, after which it was cooled and neutralized with ammonium hydroxide. The precipitated IVa-d were removed by filtration and crystallized from isopropyl alcohol (IVa-c) or nitromethane (IVd).

Cyclization of III. An alcohol solution of 0.01 mole of III, 10 drops of concentrated HCl, and 12 drops of nitrobenzene was heated on a boiling-water bath for 2 h, after which it was cooled and filtered to remove the resinous precipitate, which was refluxed with ammonium hydroxide and triturated with water to give Va-c: R = H, mp 66-67°C (isopropyl alcohol) [1]; R = Br, mp 110-111°C (isopropyl alcohol). Found: C 65.7; H 4.6; Br 26.0; N 4.6%. $C_{17}H_{14}BrN$. Calculated: C 65.4; H 4.5; Br 25.6; N 4.5%; 65.4; R = F, mp 86-87°C (isopropyl alcohol). Found: N 5.1%. $C_{17}H_{14}FN$. Calculated: N 5.6%. Compounds Va-c were obtained in 15-20% yields. The mother liquor was evaporated to dryness, and the residue was treated with ammonium hydroxide and water. The solid material was dissolved in hot isopropyl alcohol, and the insoluble residue (VIb, c) was removed by filtration and crystallized from nitromethane to give VIb, c: R = Br, mp 227-228°C. Found: C 70.0; H 4.7; Br 12.9; N 4.6%. $C_{36}H_{29}BrN_2O_3$. Calculated: C 70.0; H 4.7; Br 12.9; N 4.5%. R = F, mp 270-271°C. Found: N 4.7%. $C_{36}H_{29}FN_2O_3$. Calculated: N 5.0%. Compounds VIb, c were obtained in ∿ 5-7% yields. The cooled isopropyl alcohol solutions were worked up to give IVa-d in 25-30% yields. Traces of 2-naphthylamine were removed by washing the precipitates with hot water.

## LITERATURE CITED

1. N. S. Kozlov, V. A. Serzhanina, and R. D. Sauts, Khim Geterotsikl. Soedin., No. 8, 1082 (1973).
2. L. Bellamy, New Data on the IR Spectra of Complex Molecules [Russian translation], Mir, Mosocw (1971), p. 318.
3. V. A. Koptyug (editor), Atlas of the Spectra of Aromatic and Heterocyclic Compounds, Vol. 2; IR and UV Absorption Spectra of Naphthalene Derivatives [in Russian], Nauka, Novosibirsk (1971), p. 127.
4. N. S. Kozlov, L. F. Gladchenko, V. A. Serzhanina, G. V. Vorob'eva, O. D. Zhikareva, G. S. Shmanai, and R. D. Sauts, Khim. Geterotsikl. Soedin., No. 9, 1237 (1977).
5. N. S. Vul'fson and V. E. Kolchin, Zh. Obshch. Khim., 29, 3760 (1959).

---

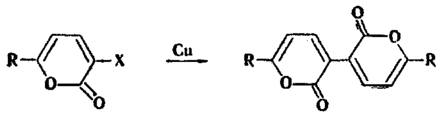
# HALO-2-PYRONES IN THE ULLMANN REACTION. 1.

S. V. Sokolovskaya and L. K. Moldovanova

UDC 547.812.5'813:542.944.1

The Ullmann reaction was used for the first time for the synthesis of poly-2-pyrones. 3-Halo-2-pyrones were obtained by halogenation of the corresponding 6-aryl-2-pyrones. The Ullmann reaction was carried out by heating a mixture of the 3-halo-2-pyrone with activated copper in a stream of an inert gas. The reaction products were the previously undescribed bis-2-pyrones, in which the α-pyrone rings are interlinked by means of the 3-C atoms.

Continuing our search [1] for new biologically active substances in the pyrone series we obtained bis-2-pyrones that are directly interlinked in the 3 position. The Ullmann reaction, which consists in the reaction of a halo derivative of the pyrone with copper, was used for the first time for the synthesis of poly-2-pyrones.



I-V, VII X-XIII

---

Moscow Technological Institute of the Meat and Dairy Industry, Moscow 109029. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 2, pp. 173-176, February, 1979. Original article submitted April 6, 1978.

0009-3122/79/1502-0142$07.50