# LIQUID-CRYSTAL 2-AROYLAMINOPYRIDINES

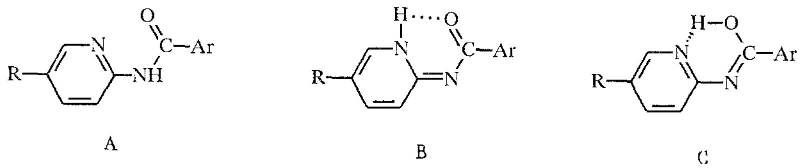
**B. M. Bolotin, V. N. Kokin, E. G. Sklyarova,**
**G. N. Rodionova, and V. A. Tafeenko**

*A number of 2-aroylaminopyridines that have mesogenic properties were synthesized. The relationship between the mesogenic character and the structure was traced on the basis of data from x-ray diffraction analysis and IR spectroscopy.*

It is known that 4,4′-disubstituted phenyl benzoates have mesogenic properties. In contrast to them, the corresponding benzanilides, with rare exceptions [1, 2], do not have such properties. This is probably associated with the tendency of the latter to form molecular associates in the condensed phase [3] due to intermolecular hydrogen bonds (intermolecular HB), which leads to a significant increase in the melting point of the solid crystal. As a rule, the increase in the melting point is so significant that it turns out to be substantially higher than the probable temperature of transition from the mesomorphic state to the isotropic liquid, and this latter temperature is not manifested.

The amido group of benzanilides is capable of existing in two tautomeric forms: —CO—NH— ⇄ —C(OH)=N—. We assumed that if the nitrogen atom of the amido group were bonded with the α atom of a heterocycle that contains a proton-acceptor atom, the amide-imide equilibrium would be shifted to the right due to the formation of an intramolecular hydrogen bond (intramolecular HB).

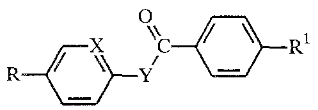
As subjects for our investigation we chose 2-aroylaminopyridines I:



I

It is known [4, 5] that the tautomeric equilibrium for N-benzoyl-2-aminopyridine is shifted markedly to favor tautomer A. At the same time, the introduction of electron-acceptor substituents into the 5 position of 2-aminopyridine shifts the azinylylidene equilibrium to favor the 2-pyridoneimine form [6, 7]. We assumed that the equilibrium could be shifted to the right to favor tautomers B and C by the introduction of an electron-acceptor substituent into the 5 position of the pyridine ring of N-benzoyl-2-aminopyridine. These forms will be stabilized by intramolecular HB. In addition, the structures formed will be stabilized due to additional orderliness in the meso phase, which should be characteristic for tautomers B and C when substituents that increase the geometrical anisotropy of the molecule are present.

To verify this assumption we synthesized a series of substituted benzoylaminopyridines Ia-g, and, for comparison, benzanilides IIa-g, phenyl benzoates IIIa-c, and pyridyl benzoates IVb-d:



I X=N, Y=NH; II X=CH, Y=NH; III X=CH, Y=O; IV X=N, Y=O; I—IVa R=Br, $R^1$=$C_7H_{15}$; b R=Br, $R^1$=$OC_6H_{13}$; c R=$NO_2$, $R^1$=$C_7H_{15}$; d R=$NO_2$, $R^1$=$OC_6H_{13}$; e R=CH, $R^1$=$C_7H_{15}$; f R=CN, $R^1$=$OC_6H_{13}$; g R=$R^1$=$OC_6H_{13}$; h R=$R^1$=$C_7H_{15}$; i R=$OC_6H_{13}$, $R^1$=$C_7H_{15}$

---

Scientific-Research Institute of Organic Intermediates and Dyes, Moscow 103787. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 8, pp. 1079-1082, August, 1992. Original article submitted February 12, 1990; revision submitted January 14, 1991.

TABLE 1. Characteristics of 2-Aroylaminopyridines and Related Compounds

| Compound | Empirical formula | Solvent | T of the phase transitions, °C |  | IR spectrum, ν, cm$^{-1}$ |  | Yield, % |
|---|---|---|---|---|---|---|---|
|  |  |  | C/I[*] | $S_a$/I[*] | NH in KCl (in $CCl_4$) | C=O in KCl (in $CCl_4$) |  |
| Ia | $C_{19}H_{23}N_2BrO$ | Hexane | 86 | — | 3230<br>(3440) | 1685<br>(1690) | 65 |
| Ib | $C_{18}H_{21}N_2BrO_2$ | Heptane | 114 | (103) | 3260<br>(3425) | 1675<br>(1685) | 83 |
| Ic | $C_{19}H_{23}N_3O_3$ | Heptane | 92 | 123 | 3360<br>(3440) | 1670<br>(1690) | 69 |
| Id | $C_{18}H_{21}N_3O_4$ | Ethanol | 138 | 163 | 3260<br>(3425) | 1680<br>(1690) | 85 |
| Ie | $C_{20}H_{23}N_3O$ | Heptane | 114 | 140 | 3260<br>(3420) | 1690<br>(1690) | 59 |
| If | $C_{19}H_{21}N_3O_2$ | Heptane | 126 | (124,5[*2]) | 3240<br>(3425) | 1680<br>(1690) | 59 |
| Ig | $C_{24}H_{34}N_2O_3$ | Ethanol | 80 | — | 3340<br>(3440) | 1640<br>(1675) | 78 |
| IIa | $C_{20}H_{24}NBrO$ | Heptane | 183 | — | 3330<br>(—[*3]) | 1650<br>(—[*3]) | 87 |
| IIb | $C_{19}H_{22}NBrO_2$ | Octane | 195 | — | 3320<br>(3440[*4]) | 1650<br>(1670[*4]) | 64 |
| IIc | $C_{20}H_{24}N_2O_3$ | Heptane | 123 | — | 3360<br>(3440) | 1670<br>(1690) | 46 |
| IId | $C_{19}H_{22}N_2O_3$ | Ethanol | 137 | — | 3340<br>(3420[*4]) | 1655<br>(1680[*4]) | 90 |
| IIg | $C_{25}H_{35}NO_3$ | Ethanol | 154 | — | 3320<br>(—[*3]) | 1640<br>(—[*3]) | 78 |
| IIh | $C_{27}H_{39}NO$ | Heptane | 127 | — | 3320<br>(3440) | 1650<br>(1680) | 58 |
| IIi | $C_{26}H_{37}NO$ | Heptane | 134 | — | 3320<br>(3450) | 1640<br>(1680) | 88 |
| IIIa | $C_{20}H_{23}BrO_2$ | Hexane | 52 | — | — | — | 28 |
| IIIb | $C_{19}H_{21}BrO_3$ | Hexane | 95 | — | — | — | 73 |
| IIIc[*5] | $C_{20}H_{23}NO_4$ | Heptane | 50 | — | — | — | 49 |
| IVb | $C_{18}H_{20}NBrO_3$ | Hexane | 79 | — | — | — | 23 |
| IVc | $C_{19}H_{22}N_2O_4$ | Hexane | 52 | — | — | — | 25 |
| IVd | $C_{18}H_{20}N_2O_5$ | Hexane | 77 | — | — | — | 61 |

---

[*] In C/I we present the upper limit of the temperature range of the solid-crystal phase and the lower limit of the temperature range of the isotropic phase; in $S_a$/I we present the upper limit of the temperature range of the smectic A phase and the lower limit of the temperature range of the isotropic phase.

[*2] For If T 128°C is the upper limit of the temperature range of the nematic phase and the lower limit of the temperature range of the isotropic phase.

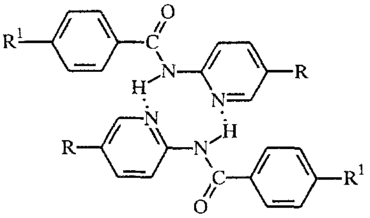
[*3] Insoluble.

[*4] In chloroform solution.

[*5] For IIId: C/I 65°C, N/I 58°C [8, p. 113]; for IIIe: C/I 44°C, N/I 56.5°C [8, p. 125]; for IIIf: C/I 70.5°C, N/I 81°C [8, p. 125]; for IIIg: C/I 64.5°C, N/I 90°C [9, p. 67]; for IIIi: C/I 46°C, N/I 64°C [9, p. 65].

It is apparent from Table 1 that all 2-aroylaminopyridines Ib-f, in contrast to benzanilides IIa-i, have mesogenic character, forming an $S_a$ phase on melting. However, it follows from the IR and PMR spectral data that the tautomer with an intramolecular HB is not detected in appreciable amounts in solution for Ia-g. It is impossible to explain the difference in the properties of amides I and II by the effect only of the pyridine fragment, since, when one compares the properties of the esters of the benzene (IIIa-i) and pyridine (IVb-d) series, which are close structural analogs of amides I and II, it is apparent that replacement of the benzene ring by a pyridine ring in the esters does not always promote the development of mesogenic character. Our x-ray diffraction analysis of a single crystal of N-(4-hexyloxybenzoyl)-5-bromo-2-aminopyridine (Ib) showed that the molecules exist in the form of tautomer A and are connected in pairs by means of an intermolecular HB in which the NH group of one molecule and the heterocyclic nitrogen atom of another molecule participate (Scheme 1).

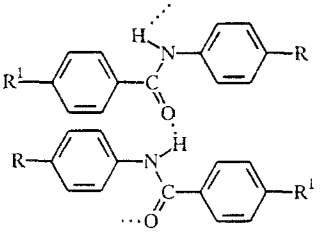
Scheme 1



The shortest distance between the unit crystal cells is observed along the "a" axis, i.e., the strongest intermolecular interaction occurs in this direction. It might be assumed that the interaction between the molecules along the "b" and "c" axes is primarily disrupted when the crystal melts and that the interaction along the "a" axis is retained. This results in the development of a layer, the thickness of which corresponds to the length of the associated pair connected by an intermolecular HB, while the long axis of the pair is perpendicular to the plane of the layer. This sort of orientation corresponds to the $S_a$ phase. A comparison of the IR spectra of Ia-g and IIa-i in the solid state and in dilute solutions shows that an intermolecular HB exists in the crystals between the NH group of one molecule and the heterocyclic nitrogen atom of another molecule for all 2-aroylaminopyridines Ia-f that have mesogenic character. The frequency of the C=O group does not change on passing from the solid state to solution, while in the case of benzanilides IIa-d, g-i, as well as 2-aroylaminopyridine Ig, which do not have mesogenic character, the formation of an intermolecular HB between the NH group of one molecule and the C=O group of the adjacent molecule is observed in the crystals (Scheme 2). The difference between 2-aroylaminopyridines Ia-f and benzanilides IIa-d, g-i with respect to their ability to form a meso phase can therefore be explained by the fact that the 2-aroylaminopyridine molecules in the solid state form, due to intermolecular HB, pairs in which the molecules are laid out as they are in a playing card "jack" (see Scheme 1).

Polymolecular associates with a lower (as compared with the dimers of 2-aroylaminopyridines Ia-f) degree of geometrical anisotropy are formed in the case of substituted benzanilides IIa-d, g-i in the solid state; it is known that this has a negative effect on the mesogenic character (see Scheme 2).

Scheme 2



## EXPERIMENTAL

The IR spectra of the compounds (KCl pellets or solutions in $CCl_4$) were recorded with a Perkin—Elmer 598 spectrometer. The purity of the compounds was monitored by TLC on Silufol UV-254 plates [elution with benzene—ethyl acetate (4:1), development in UV light or with iodine vapors].

Single crystals of Ib were investigated with a Enraf Nonius CAD-4 four-circle automatic diffractometer in Mo $K_\alpha$ emission with $\omega$ scanning. The principal crystallographic data were as follows: $a = 5.577(1)$, $b = 10.375(2)$, $c = 15.354(2)$ Å, $\alpha = 93.75(2)°$, $\beta = 94.49(2)°$, $\gamma = 97.90(2)°$, Fedorov group P-1, $z = 2$, $V = 874.7$ Å$^3$. In the range $\theta \leq 23°$ we detected 2099 nonzero reflections, of which the 1661 greater than $3\sigma$ were used to refine the positional and thermal parameters of the molecule, the motif of which was found using direct methods realized in the MULTAN program with the SDP complex. The refinement of the positional and thermal parameters of the nonhydrogen atoms was carried out within the anisotropic total-matrix approximation. The hydrogen atoms were localized from Fourier syntheses and were refined within the isotropic approximation. Allowance for the absorption was carried out by means of the Difabs program. Final divergence factor R = 4.6%.

The starting compounds were obtained by known methods: 2-amino-5-bromopyridine [10, 11], 2-amino-5-nitropyridine [12, 13], 2-amino-5-hexyloxypyridine [14], 2-amino-5-cyanopyridine [11], 2-hydroxy-5-bromopyridine [15], and 2-hydroxy-5-nitropyridine [16].

Compounds I-IV were synthesized by acylation of the corresponding amines or phenols with acid chlorides in pyridine.

The results of elementary analysis of the synthesized compounds for C, H, and N were in agreement with the calculated values.

**General Method for Obtaining I-IV.** A 0.012-mole sample of the corresponding p-substituted benzoyl chloride was added dropwise at room temperature to a solution of 0.01 mole of the 2-amino(or 2-hydroxy)-5-substituted pyridine or p-substituted aniline (phenol) in a tenfold (by weight) amount of anhydrous pyridine, and the resulting mixture was heated to the boiling point, cooled to room temperature, and poured into 50 ml of water. The aqueous mixture was extracted with benzene (3 × 50 ml), and the combined extracts were washed successively with 5% aqueous $Na_2CO_3$ solution, 5% HCl solution, and water until the wash water was neutral. The solvent was removed by distillation, and the residue was crystallized (see Table 1) until the temperatures of the phase transitions were constant.

## REFERENCES

1. E-Won Choe and R. Mininni, *Mol. Cryst. Liq. Cryst.*, **49**, 133 (1979).
2. B. Kohne, K. Praefke, G. Heppke, and E. J. Richter, *Israel J. Chem.*, **18**, 199 (1979).
3. D. Barton and U. D. Ollis (eds.), *General Organic Chemistry* [Russian translation], Vol. 4, Khimiya, Moscow (1983), p. 430.
4. R. A. Jones and A. R. Katritzky, *J. Chem. Soc.*, 1317 (1959).
5. A. R. Katritzky and R. A. Jones, *J. Chem. Soc.*, 2067 (1959).
6. O. P. Petrenko, V. V. Lapachev, and V. P. Mamaev, *Zh. Org. Khim.*, **24**, 1793 (1988).
7. O. P. Petrenko and V. V. Lapachev, *Zh. Org. Khim.*, **24**, 1806 (1988).
8. D. Demus and H. Zaschke, *Flüssige Kristalle in Tabellen*, Vol. 2, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig (1984).
9. D. Demus and H. Zaschke, *Flüssige Kristalle in Tabellen*, Vol. 1, VEB Deutscher Verlag für Grundstoffindustrie, Leipzig (1974).
10. A. I. Busev, *Synthesis of New Organic Reagents for Inorganic Analysis* [in Russian], Izd. Moskovsk. Gosudarstv. Univ., Moscow (1972), p. 69.
11. W. T. Caldwell, F. T. Tyson, and L. Lauer, *J. Am. Chem. Soc.*, **66**, 1479 (1944).
12. L. N. Pino and W. S. Zehrung, *J. Am. Chem. Soc.*, **77**, 3154 (1955).
13. B. A. Geller and L. S. Samosvat, *Zh. Obshch. Khim.*, **34**, 613 (1964).
14. R. Urban and O. Schnider, *Helv. Chim. Acta*, **47**, 363 (1964).
15. A. E. Chichibabin and V. S. Tyazheleva, *Zh. Russk. Fiz.-khim. Obshchestva*, **50**, 483 (1918).
16. A. E. Chichibabin, *Zh. Russk. Fiz.-khim. Obshchestva*, **46**, 1236 (1914).