# A NEW SERIES OF MESOGENIC DERIVATIVES OF PYRIMIDINE-SUBSTITUTED 2-(O-HYDROXYPHENYL)PYRIMIDINES

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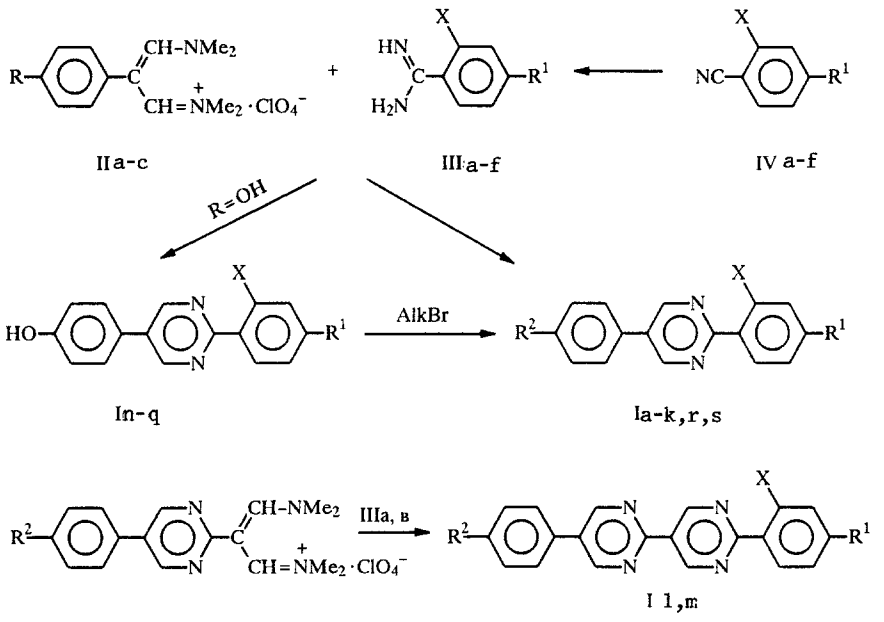
*Analogs of known mesogenic 2,5-diarylpyrimidines, 5-[p-alkyl(alkoxy)phenyl]-2-(o-hydroxy-p-alkoxyphenyl)pyrimidines (I), have been synthesized that have a wider mesogenic phase temperature range. Pyrimidines I show smectic C and A phases but not the nematic phase.*

The presence of hydroxyl groups in a molecule, leading to the formation of different kinds of hydrogen bonds, has a substantial influence on the mesogenic properties. This fact, however, has not been much investigated [1-3]. There are data on dimers with an intermolecular hydrogen bond [4, 5] and on alcohols [6, 7]. Compounds with an intramolecular hydrogen bond (IHB) have been studied to a greater extent. Among these are o-hydroxybenzenes [8] and, primarily, Schiff's bases, derivatives of salicylic aldehyde [9-12].

As a rule, the introduction of a sidechain into the rigid framework of a mesogenic molecule causes the temperature range of the mesophase to become narrower, and the effect of the substituent on the relative stability of the different kinds of mesophase is determined by the nature and arrangement of these substituents [13]. However, if the side chain, a hydroxyl group for example, participates in the formation of a chelate ring which increases the conjugation in the molecule, this has a favorable effect on the liquid crystalline properties of the compound [14].

Mesogenic compounds with an o-hydroxyphenyl group in a position $\alpha$ to an endocyclic nitrogen atom have not been described in the literature. In the present work, we have synthesized and studied 5-[p-alkyl(alkoxy)phenyl]-2-(o-hydroxy-p-alkoxyphenyl)pyrimidines (I), the o-hydroxy analogs of the well-studied liquid crystalline 2,5-diarylpyrimidines [15-17] (Table




IIc, R = OH; Ia, III, IVb, $R^1$ = H; Ic-f, I-o, r, III, IVa-c, $R^1 = OC_4H_9$; Ib, III, IVd, $R^1 = OC_5H_{11}$; Ik, i, p, III, IVe, $R^1 = OC_8H_{17}$; Ig, j, k, q, s, III, IVf, $R^1 = OC_9H_{19}$; Ia, b, l, p, IIa, R, $R^2 = C_4H_9$; Ic, d, g, IIb, R, $R^2 = C_5H_{11}$; Ih, $R^2 = OC_7H_{15}$ Ii, j, $R^2 = OC_8H_{17}$; Ii, j, $R^2 = OC_8H_{17}$; Ik, s, $R^2 = OC_{10}H_{21}$; Id, f, m, o, III, IVa, X = H; Ia-c, e, g-l, n, p. q, III, IVc-f, X = OH; Ir, X = $OC_5H_{11}$; Is, X = $OC_{10}H_{21}$

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TABLE 1. Liquid Crystalline Properties of Pyrimidines I

| Compound | Phase transition temperatures, °C | Molecular formula | Yield % |
|---|---|---|---|
| a | C 97 Sc 137 I | $C_{20}H_{20}N_2O$ | 90 |
| b | C 84 (Sc 83,6) $S_A$ 219 I | $C_{25}H_{30}N_2O_2$ | 50*;83** |
| c | C 86 Sc 231 I | $C_{25}H_{30}N_2O_2$ | 50 |
| d | C 93 Sc 194 $S_A$ 200 N 208 I | $C_{25}H_{30}N_2O$ | 50 |
| e | C 100,4 Sc 134 $S_A$ 249 I | $C_{25}H_{30}N_2O_3$ | 56 |
| f | C 143 Sc 183 $S_A$ 216 N 230 I | $C_{25}H_{30}N_2O_2$ | 66 |
| g | C 84,7 Sc 171 $S_A$ 213,3 I | $C_{30}H_{40}N_2O_2$ | 84 |
| h | C 73,2 Sc 182 $S_A$ 227,5 I | $C_{31}H_{42}N_2O_3$ | 43 |
| i | C 68,9 Sc 196 $S_A$ 225,3 I | $C_{32}H_{44}N_2O_3$ | 40 |
| j | C 80 Sc 185 $S_A$ 217 I | $C_{33}H_{46}N_2O_3$ | 28 |
| k | C 81 Sc 205 $S_A$ 212 I | $C_{35}H_{50}N_2O_3$ | 24 |
| l | C 229 Sc 370 I | $C_{28}H_{30}N_4O_2$ | 43 |
| m | C 249 Sc 345 $S_A$ 365 I | $C_{28}H_{30}N_4O$ | [18] |
| n | C 182...183 I | $C_{20}H_{20}N_2O_3$ | 75 |
| o | C 175...176 I | $C_{20}H_{20}N_2O_2$ | 99 |
| p | C 163...164 I | $C_{24}H_{28}N_2O_3$ | 76 |
| q | C 150...152 I | $C_{25}H_{30}N_2O_3$ | 86 |
| r | C 75...77 (N 56) I | $C_{30}H_{40}N_2O_3$ | 21 |
| s | C 79,5 (N 76) I | $C_{45}H_{70}N_2O_3$ | — |

Phases: C) crystalline; $S_A$) smectic A; $S_C$) smectic C; N) nematic; I) isotropic. The temperature to the left of the phase is the lower limit of its existence, that to its right is the upper limit. The monotropic transition temperatures, observed only on cooling are given in parentheses.

*In alcohol.

**In pyridine.

Recrystallized pyridines: Ia, b, n from methanol; Ic, i, p. q, s from alcohol; Id; Ie, n, o from methyl or ethyl cellosolve; Id from toluene; Ig from ethyl acetate; Ih from ligroin; Il, m from chloroform.

TABLE 2. Heats of Phase Transitions

| Compound | $\Delta H$, kcal/mole | | | |
|---|---|---|---|---|
| | C | $S_C$ | $S_A$ | I |
| Ia | 4,3 | — | 0,8 | |
| Ig | 12,5 | — | 2,1 | |
| Ij | 5,1 | — | 1,9 | |

1). Pyrimidines Ia-d, g, n-q were synthesized by the familiar procedure of condensing trimethine salts IIa-c with corresponding benzamidines IIIa-f obtained from nitriles IV. Pyrimidines Ie, f, h-k were prepared by alkylating 5-(p-hydroxyphenyl) derivatives In-q. Here, depending on conditions, trialkoxy substituted pyrimidines Ir, s, products of alkylation at the o-hydroxyl group were also evolved. 2,5′-Bipyrimidine derivatives Il were prepared by the method in [18].

A comparison of the liquid crystalline properties of even the first representative of the new series, pyrimidine Ia, with its analog containing no IHB (K 107.5°, $S_A$ 130.5° I [19]), revealed the basic trends associated with the o-hydroxyphenyl group: a broadening of the temperature range of the liquid crystalline phase and a tendency to form a smectic C phase. In this case, except for the $S_A$ phases, in which the molecules are "heaped up" in such a way that their long axes are perpendicular to the plane of the layer, lowering the temperature favors the $S_C$ phase in which the molecules are also "heaped up," but are shifted with respect to each other along the direction of the long axes and thus prove to be inclined to the plane of the layer. Further investigations showed that the angle of inclination of the molecules to the layer is 28-29°.

As to be expected, pyrimidine Ia has the smallest mesophase range of the compounds investigated, because of the lack of a terminal substituent to stabilize the mesophase. Usually, compounds lacking a terminal substituent do not have any tendency to show liquid crystalline properties. The remaining o-hydroxyphenylpyrimidines, Ib, c, e, h, l, have very broad mesophase ranges of more than 100°. Here, in comparison with the analogs that do not have OH groups, the melting points are lower (by ~40° in the case of Ie) and there is a concurrent increase in the isotropic transition temperature of about 10-20° (in the case of pyrimidines Ic, e). The range of the $S_C$ phase generally increases with an increase in the length of the alkyl chain of the terminal substituent — from 34° in the case of pyrimidine Ie up to 100° in the case of pyrimidines Ii-k.

Yet another characteristic difference between o-hydroxypyrimidines I and their analogs with no IHB is the absence of a nematic phase in the former. For example, pairs of compounds Ic, d and Ie, f, and also the 2,5-bis[p-alkyl(alkoxy)phenyl]pyrimidines that, unlike pyrimidines I do have a nematic mesophase [20, 21].

Trialkoxy substituted Ir, s do not display smectic properties and are monotropic nematic because of the effect of the long chain substituents [13, 22].

The heats of the crystal/smectic C and smectic/isotropic phase phase changes were measured for compounds Ia, g, j (Table 2).

## EXPERIMENTAL

The temperatures of the phase changes and the type of mesophase were determined on a miniature, Boethius-type stage with a visual, RNMK-0.5, attachment. The heats of the phase changes and exact temperatures were measured on a Setaram DSC-111 scanning microcalorimeter.

The perchlorates of 2-arylpropenes IIa-c were prepared according to [23]. The p-alkoxysalicylaldehydes were prepared according to [24], and substituted benzamidines IIIb-f were synthesized according to [25] and used without further purification

The elementary analyses of the synthesized compounds I and IV correspond to the calculated values.

**2-(o-Hydroxyphenyl)-5-(p-butylphenyl)pyrimidine (Ia).** Add a solution of 0.4 g (18 mmoles) of metallic Na in 7 ml of absolute methanol drop by drop with stirring to a hot solution of 5.38 g (15 mmoles) of salt IIa and 2.1 g (18 mmoles) of amide IIIb in 40 ml of anhydrous pyridine. Reflux the reaction mixture for 15 h, then cool it to 20°C, pour it into 75 ml of water, and stir. Filter off the precipitate of Ia that forms, wash it with water (2 × 20 ml), and recrystallize to obtain 4.2 g of pyrimidine Ia.

Pyrimidines Ib, g, l, n, p, q are prepared from amidines IIIc-f and salts IIa-c in a similar manner (Table 3).

**2-(o-Hydroxy-p-amyloxyphenyl)-5-(butylphenyl)pyrimidine (Ib).** Add a solution of 0.15 g (6.5 mmoles) of metallic Na in 5 ml of absolute methanol drop by drop with stirring to a boiling solution of 2.3 g (6.5 mmoles) of salt IIa and 2.g (9 mmoles) of amidine IIId in 25 ml of absolute alcohol. Reflux the reaction mixture for 4 h, then filter the hot solution and evaporate it down in a rotary evaporator. Wash the residue with water (2 × 10 ml), 5 ml of chloroform, and 5 ml of ethyl acetate. Recrystallize to obtain 1.27 g of pyrimidine Ib.

Pyrimidine Ic is prepared from salt IIb and amidine IIIc in similar manner.

**2-(p-Butyloxyphenyl)-5-(p-amylphenyl) (Id) and -5-(p-Hydroxyphenyl)pyrimidine (Im).** Pour 30 ml of absolute alcohol onto a mixture of 1.4 g (6.33 mmoles) of amidine IIIa hydrochloride [20] and 6.3 mmoles of salt IIb or IIc, respectively. Heat this to boiling and add a solution of 0.44 g (18.9 mmoles) of metallic Na in 10 ml of absolute methanol drop by drop with stirring. Reflux the mixture for 6 h, cool, and filter. Evaporate down the filtrate in a rotary evaporator, wash the residue with water (3 × 10 ml) and recrystallize.

TABLE 3. Characteristics of 2-Hydroxy-4-alkoxybenzonitriles IVc-f

| Compound | $T_{mp}$, °C | Molecular formula | Yield, % |
|---|---|---|---|
| IVc | 99,0...99,5 | $C_{11}H_{13}NO_2$ | 38* |
| IVd | 97,6...98 | $C_{12}H_{15}NO_2$ | 27* |
| IVe | 87,5...88 | $C_{15}H_{21}NO_2$ | 27*; 67** |
| IVf | 105,5...106 | $C_{16}H_{23}NO_2$ | 59* |

*By procedure A.

**By procedure B.

**Preparation of 5-(p-Alkoxyphenyl)pyrimidines Ie, f, g-k by the Alkylation of 5-(p-Hydroxyphenyl)pyrimidines In-q.** Add 0.28 (5 mmoles) of powdered KOH gradually to 30 ml of alcohol, then add 2 mmoles of pyrimidine In-q and 3 mmoles of the appropriate alkyl bromide. Reflux the reaction mixture for 8-16 h, and cool it to 20°C. Filter off the precipitated alkoxy derivative, wash with water (2 × 10 ml) and 10 ml of alcohol, and recrystallize.

**2-(o-Amyloxy-p-butyloxyphenyl)-5-(p-amyloxyphenyl)pyrimidine (Ir).** Add 0.5 g (9 mmoles) of powdered KOH and 0.8 ml (6 mmoles) of amyl iodide to a suspension of 1.38 g (4 mmoles) of dihydroxypyrimidine In in 25 ml of DMF. Heat the reaction mixture 4 h at 80°C, cool it to 20°C, filter, and evaporate down in a rotary evaporator. Filter off the precipitated needlelike crystals and recrystallize them to obtain 0.44 g of pyrimidine Ir.

**2-(o-Decyloxy-p-nonyloxyphenyl)-5-(p-decyloxyphenyl)pyrimidine (Is).** Add 0.25 g (4.5 mmoles) of powdered KOH and 0.5 g (2.2 mmoles) of decyl bromide to a suspension of 0.7 g (1.7 mmoles) of pyrimidine Iq in 25 ml of alcohol. Reflux the mixture for 10 h, cool to 20°C, and filter off the 0.05 g of precipitate of Is. Evaporate down the filtrate and treat the residue with ligroin to recover 0.5 g of the starting pyrimidine Iq.

**2-Hydroxy-4-alkoxybenzonitriles (IVa-f). Preparation of p-Alkoxysalicylal Aldoximes.** Dissolve 0.24 mole of the appropriate p-alkoxysalicylic aldehyde in 400 ml of alcohol and add a solution of 0.36 mole of hydroxylamine hydrochloride in 150 ml of water and a solution of 0.48 mole of sodium carbonate in 450 ml of water. Hold the mixture at 20°C for 24 h and acidify it with dilute HCl (1:1) to pH 3-4. Extract the oil formed with ether (5 × 40 ml), wash the ethereal extract with water, dry it over $Na_2SO_4$, and distil off the ether in a rotary evaporator to obtain the corresponding oxime in a 60-70% yield for further use. Recrystallize the oxime from 50% alcohol if necessary.

**Preparation of Nitriles IVc-f. A.** Reflux a mixture of 0.15 mole of the appropriate oxime and 100 ml of acetic anhydride for 3 h, cool it to 20°C, pour into 500 ml of water, and allow to stand overnight. Filter off the precipitate that forms, place it in a flask with 250 ml of an 8% solution of NaOH, and reflux for 5 h. Cool the reaction mixture to 20°C, acidify with dilute (1:5) $H_2SO_4$ to pH 4, and filter off the nitrile. Wash it with water, dry it, and recrystallize it from a 1:1 benzene/heptane mixture.

**B.** Reflux a mixture of 21.8 g (0.08 mole) of p-octyloxysalicylal aldoxime in 100 ml of acetic anhydride for 5 h. Distil off the acetic anhydride under the vacuum of a water aspirator add 100 ml of an 8% solution of NaOH to the residue, and reflux the mixture for 1 h. Cool to 20°C, filter off the precipitate that forms, wash it with 50 ml of water, acidify with conc. HCl to pH 6, filter off the nitrile, and wash it with water (2 × 25 ml) and ligroin (2 × 30 ml) to obtain 13.6 g of nitrile IVe.

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