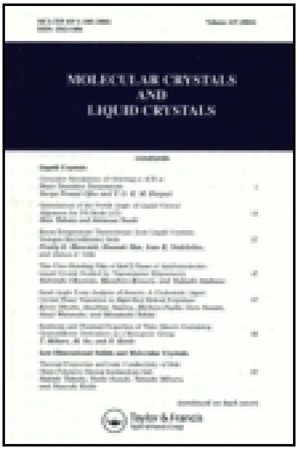

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X-RAY CRITICAL SCATTERING IN HEXATIC SMECTIC B - SMECTIC C BINARY MIXTURE

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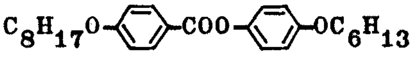
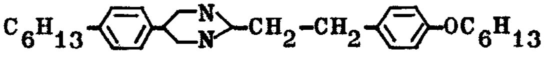
Abstract We present the results of high-resolution X-ray scattering measurements for a binary mixture of smectic C: 4-hexyloxyphenyl-4-octylbenzoate and hexatic smectic B: 1-[5-(4-hexylphenyl)pyramidyl-2]-2-(4-hexyloxyphenyl) ethane . The Bragg scattering intensity was measured as a function of temperature for several concentrations x of smectic B. The molecular arrangement in the existing phases were determined. The smectic A phase ($\bar{A}$) was observed which is strongly ordered by magnetic field and give very high diffraction peak. The smectic $\bar{A}$ - nematic phase transition was studied for concentrations $x \leqslant 0.3$ including the vicinity of the N$\bar{A}$C point. The temperature dependence of the correlation lengths: $\xi_{\parallel}$ - parallel to the long axes of the molecules and $\xi_{\perp}$ was discussed and critical indices: $\nu_{\parallel}$, $\nu_{\perp}$ and τ were calculated.

INTRODUCTION

We investigated the liquid-crystal binary mixture composed of smectic C: 4-hexyloxyphenyl-4-octylbenzoate



with the S_C - N - I phase sequence and hexatic smectic B:



1-[5-(4-hexylphenyl)pyramidyl-2]-2-(4-hexyloxyphenyl) ethane with the S_{Bhex} - S_A - I phase sequence. The (T,x) phase diagram (T - temperature, x - molar fraction of smectic B) obtained by optical microscopy, scanning calorymetry and X-ray scattering [1] is shown in Fig. 1. Smectic A phase denoted by $\bar{A}$ was identified by a change in the texture in comparizon to the usual S_A phase and is characterized by very high diffraction peak - the intensity of the Bragg scattering (at angle of $2\theta \simeq 2.5^{0}$) is two orders of magnitude larger than measured for other smectic phases: S_C, S_A, S_{Bhex}. This unexpected behaviour reflects very strong

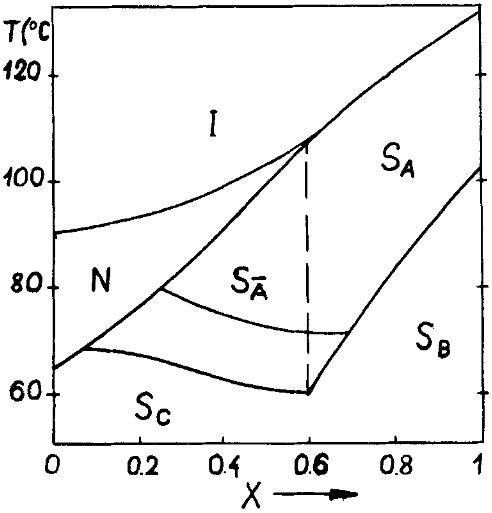


FIGURE 1 The (T,x) phase diagram for the studied smectic C and hexatic smectic B mixture. Dashed line delimits the region of the S_A phase with strong orientational properties; x - molar fraction of smectic B.

orientational properties of the smectic A phase and may by connected with the presence of the nematic phase in a wide range of temperature for low concentrations x.

The nature of the $S_{\bar{A}}$ phase is difficult to establish by the X-ray method. The analysis of the Bragg scattering intensity at high angle $2\theta \simeq 18^{0}$, as a function of temperature, leads to the conclusion that the molecular arrangement in this phase seems to be similar to the arrangement in the S_{Bhex} phase. The width of the peak (at half maximum) for the temperature corresponding to the maximum of intensity is similar to the width of the peak observed for the hexatic smectic B, but is spreading out with the increase of temperature - which is characteristic for the smectic A phase.

The measurements of X-ray scattering have been performed on a two-crystal spectrometer described elsewhere

[5]. The instrumental resolution expressed as half-width at half-maximum was $6\cdot10^{-3}$ Å^{-1} in the longitudinal in-plane direction, $4\cdot10^{-4}$ Å^{-1} in the transverse in-plane direction and $2\cdot10^{-2}$ Å^{-1} in the direction perpendicular to the scattering plane. The temperature was controlled within ± 0.01 K. The sample was orientated in a magnetic field of 0.8 T.

$S_{\bar{A}}$ - N PHASE TRANSITION

The intensity of the Bragg scattering (at angle $2\theta \simeq 2,5^0$) in the $S_{\bar{A}}$ phase depends on the composition of the mixture; the maximum of intensity increases with x in the concentration range $0.07 \leq x \leq 0.3$.

The X-ray diffuse scattering was measured for concentrations: x = 0.1, 0.15, 0.2, 0.3, above the smectic $\bar{A}$ - nematic transition line: $T = T_{N\bar{A}}(x) + \Delta T$, in the direction parallel to the long axes of molecules: $q_\perp = 0$, $q_\parallel$ varied and in the direction perpendicular to the director: $q_\parallel = q_0$, $q_\perp$ varied.

The analisis of the experimental results has been done using the cross-section expression [4]

$$\sigma(q) = \frac{\sigma_0(q_0)}{1 + (q_\parallel - q_0)^2 \xi_\parallel^2 + q_\perp^2 \xi_\perp^2}$$

The longitudinal $\xi_\parallel$ and the transverse $\xi_\perp$ correlation lengths have been calculated. Values of $\xi_\parallel$, $\xi_\perp$ and the ratio $\xi_\parallel/\xi_\perp$ for different concentrations x are given in Table 1 for the reduced temperature $t = \Delta T/T_{N\bar{A}} = 10^{-3}$. The longitudinal correlation length does not practically depend on the composition of the mixture while the transverse one decreases while approaching the N$\bar{A}$C point. The anisotropy parameter $\xi_\parallel/\xi_\perp$ changes from 0.9 for x = 0.3 to ≃ 9 for x = 0.1. Similar behaviour was observed for other binary mixtures near the NAC point [3] and near the INA point [5]. The temperature variations of the correlation lengths and the static susceptibility shown in Fig. 2 may be described

TABLE I The $\xi_\parallel$ and $\xi_\perp$ correlation lengths and the ratio $\xi_\parallel/\xi_\perp$ at reduced temperature $t = \Delta T/T_{N\bar{A}} = 10^{-3}$ for some values of x.

x	$\xi_\parallel$ (Å)	$\xi_\perp$ (Å)	$\xi_\parallel/\xi_\perp$	$T_{N\bar{A}}$ (K)
0.1	340	40	9	342.04
0.15	360	60	6	347.45
0.2	340	120	3	352.77
0.3	300	310	0.9	359.39

by the simple power-low expressions:

$$q_0\xi_\parallel = bt^{-\nu_\parallel},\quad q_0\xi_\perp = ct^{-\nu_\perp};\quad \sigma_0(q_0) = at^{-\gamma}.$$

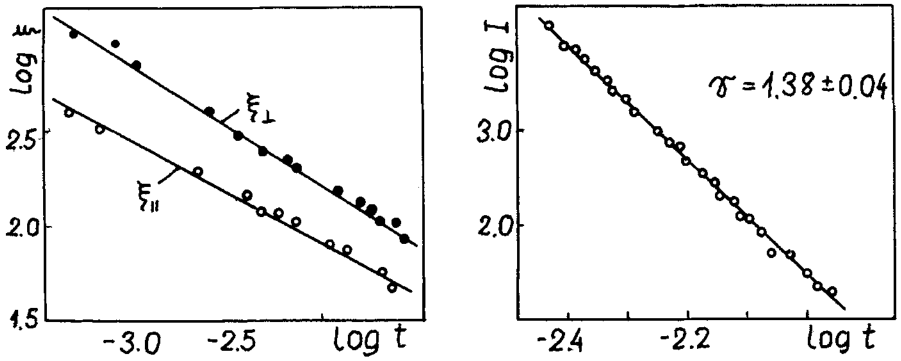


FIGURE 2 The longitudinal $\xi_\parallel$, transverse $\xi_\perp$ correlation lengths and the susceptibility as function of reduced temperatures for x = 0.2.

Values of the critical indices $\nu_\parallel$, $\nu_\perp$ and γ for different concentrations x are presented in Table II. While approaching the NĀC point exponent γ and $\nu_\parallel$ increase but $\nu_\perp$ does not practically change. It shows a tendency to decrease but the change is too small to give a definite answer. In the vicinity of the NĀC point the critical indices are close to those obtained by other authors [2] and are different from those postulated for the pure N – A transition from superconducting model analogy.

TABLE II Values of the critical exponents: $\nu_{\parallel}$, $\nu_{\perp}$ and τ for different concentrations x.

x	$\nu_{\parallel}$	$\nu_{\perp}$	τ
0.1	0.90 ± 0.04	0.65 ± 0.05	1.53 ± 0.02
0.15	0.88 ± 0.05	0.69 ± 0.06	1.34 ± 0.05
0.2	0.77 ± 0.03	0.71 ± 0.04	1.38 ± 0.04
0.3	0.73 ± 0.04	0.75 ± 0.04	1.18 ± 0.03

We were not be able to discuss the measurements concerning the S_C - $S_{\bar{A}}$ phase transition because of very small intensity of the X-ray scattering in the S_C phase.

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