Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl17

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Version of record first published: 22 Sep 2006.

To cite this article: B. Pura , J. Przedmojski , A. Rajewska , K. Wentowska , A. Jablonka & R. Dąbrowski (1990): The Phase Transitions and the X-Ray Critical Scattering in the Mixture of the Liquid Crystals $S_B + S_C$, Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics, 192:1, 25-29

To link to this article: http://dx.doi.org/10.1080/00268949008035601

Mol. Cryst. Liq. Cryst. 1990, Vol. 192, pp. 25-29
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Printed in the United States of America

THE PHASE TRANSITIONS AND THE X-RAY CRITICAL SCATTERING IN THE MIXTURE OF THE LIQUID CRYSTALS $S_B + S_C$.

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Abstract We have carried out a high-resolution X-ray critical scattering in a binary mixture of smectic B: 4-4-hexyl(bicyclo[2,2,2]octylphenyl) 4-octyloxybenzoate and smectic C: 1-[5-(4-hexylphenyl) pyrimidyl-2]-2-(4-hexylophenyl) ethane. Near the multicritical points NAC [1,2] and INA [3] the magnitudes of the critical exponents: $\nu_{\parallel}$, $\nu_{\perp}$ and τ for the N - S_A transition are extracted from our data. The critical exponent β was also calculated in the vicinity of the BAC and NAC points.

INTRODUCTION

The subject of our study was the binary mixtures of the liquid crystal compounds with the different smectic phases. The phase diagrams of these systems exhibit the appearance of different multicritical points in dependent on the composition of the mixture. The phase diagram of our binary mixture $S_B + S_C$ shown in Fig. 1 was obtained by means of the optical microscopy, scanning calorimetry and X-ray scattering. X-ray measurements were performed for different concentrations of smectic C in the mixture: x = 0, 0.3, 0.5, 0.6, 0.8, 1. The following sequences of the phases have been observed: S_B - S_A - I for x = 0, S_B -S_A-

- I for x = 0.3, S_B - S_C - S_A - N - I for x = 0.5; 0.6, S_B - S_C - N - I for x = 0.8 and S_C - N - I for x = 1.

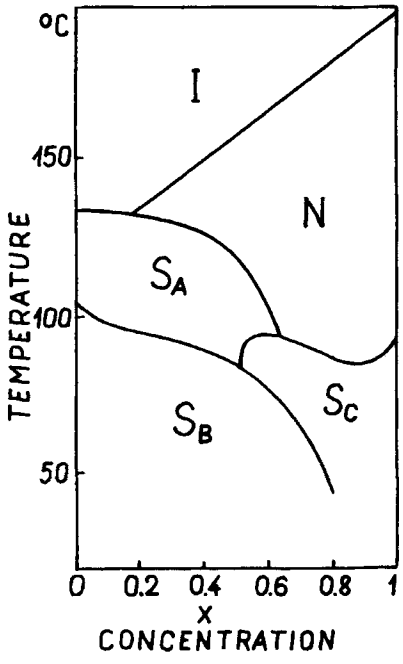

FIGURE 1. The phase diagram of the S_B + S_C binary mixture.

EXPERIMENT

The X-ray scattering measurements were performed on two-crystals spectrometer using the $Cu_{K\alpha}$ radiation monochromatized by two flat Ge single crystals. The instrumental resolution defined as the half-width at half maximum of the Bragg peak (HWHM) was $4 \cdot 10^{-3}$ Å^{-1} in-plane longitudinal direction (respectively to the long axes of the molecules), $8 \cdot 10^{-4}$ Å^{-1} in the in-plane transverse direction and $2 \cdot 10^{-2}$ Å^{-1} in the direction perpendicular to the scattering plane. The investigations have been carried out for the parameters of the primary beam: 40 kV and 30 mA. The liquid crystal

sample was ordered through the cooling from isotropic to smectic phases in the magnetic field 0.8 T. The temperature was controlled within ± 0.01 K.

EXPERIMENTAL RESULTS AND DISCUSSION

The X-ray critical scattering intensity was measured near the S_A - N phase transition ($T = T_{NA} + \Delta T$) above the smectic A - nematic transition line. Experimental data were analyzed by means of the expression for cross-section given by Als-Nielsen at all. [4]

$$\sigma(q) = \frac{\sigma_o(q_o)}{1 + (q_{\parallel} - q_{\perp})^2 \xi_{\parallel}^2 + q_{\perp}^2 \xi_{\perp}^2} .$$

The temperature dependences of the longitudinal $\xi_{\parallel}$ and transverse $\xi_{\perp}$ (respectively to the long axes of the molecules) correlation lengths and the static susceptibility were discussed. We observed that the $\xi_{\perp}$ changes with the concentration x. The results of our measurements are presented in Table I and in Fig. 2. The values of the $\xi_{\parallel}$, $\xi_{\perp}$ and $\xi_{\parallel}/\xi_{\perp}$ in the Table are given at $t = T/T_{NA} - 1 = 10^{-3}$.

TABLE I The values of the measured parameters for the smectic A - nematic phase transition.

x	$\nu_{\parallel}$	$\nu_{\perp}$	γ
0.3	0.70 ± 0.05	0.55 ± 0.04	1.35 ± 0.08
0.5	0.75 ± 0.06	0.58 ± 0.05	1.40 ± 0.07
0.6	0.78 ± 0.05	0.65 ± 0.04	1.50 ± 0.07

x	$\xi_{\parallel}$ (Å)	$\xi_{\perp}$ (Å)	$\xi_{\parallel}/\xi_{\perp}$	T_{NA} (K)
0.3	230	70	3	403.15
0.5	250	50	5	394.85
0.6	260	30	9	384.55

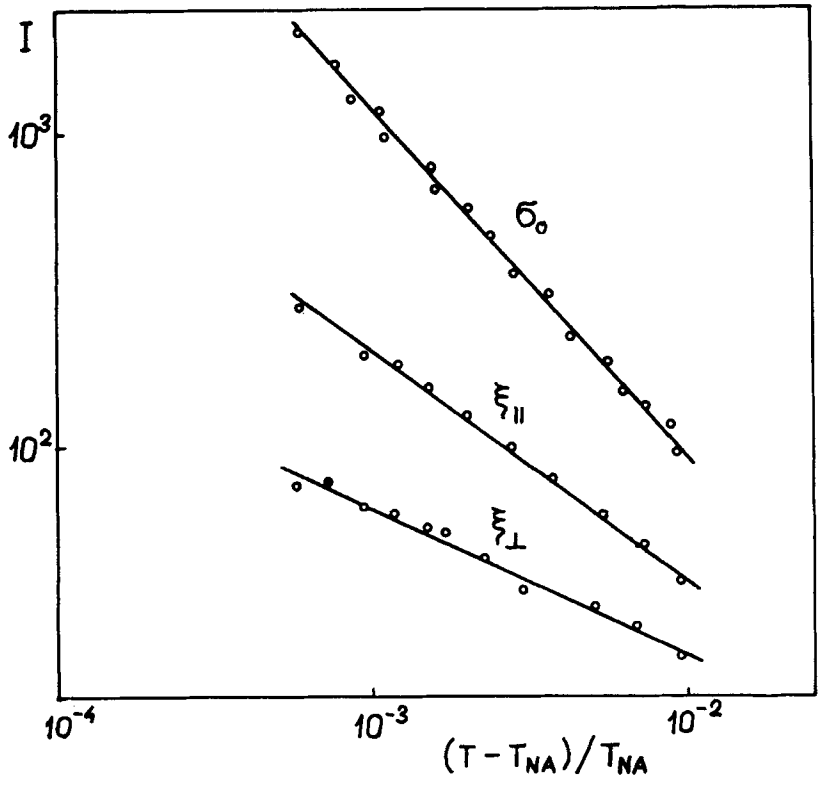

FIGURE 2. The correlation lengths: ξ_{II}, $\xi_\perp$ and the static susceptibility σ_o versus temperature for x = 0.3.

For the S_A - S_C phase transition the change with temperature of the tilt angle τ of smectic C was studied. This change was obtained from the expression:

$$\cos \tau = \left| \sin \Theta_A / \sin \Theta_C \right|,$$

where:

Θ_A - the Bragg angle of scattering for the smectic A phase

Θ_C - the Bragg angle of scattering for the smectic C phase for a fixed temperature.

With our experimental data for Θ_C and for the concentration x = 0.5 and x = 0.6 we obtained the change of the

angle τ as a function of the reduced temperature:

$$\tau \sim |(T_{AC} - T)/ T_{AC}|^{\beta}$$

as well as the exponent β. For the above compositions two multicritical points were observed: BCA and CAN. The maximal values of τ for different concentration are: 11.6° for $x = 0.5$, 13.2° for $x = 0.6$, 15.6° for $x = 0.8$ and 16.8° for $x = 1$. The calculated exponent β near these multicritical points has the folloving values: $\beta = 0.46 + 0.05$ for $x = 0.5$ BCA and $\beta = 0.50 + 0.05$ for $x = 0.60$ (CAN).

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