THE EFFECT OF APPLIED ELECTRICAL FIELDS ON THE PHASE TRANSITIONS OF THE ANTIFERROELECTRIC LIQUID CRYSTAL AS618

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ABSTRACT

Phase transitions of antiferroelectric liquid crystals can be described by the Landau model. These phase transitions may be expressed in terms of the antiferroelectric and ferroelectric order parameters. They respectively are: $\xi_a = \frac{(\xi_1 + \xi_2)}{2}$ and $\xi_f = \frac{(\xi_1 - \xi_2)}{2}$, where $\xi_i = (n_{ix} n_{iz}, n_{iy} n_{iz})$ is a two-dimensional tilt order parameter.

The Landau free energy density is given by:

$$g(z) = \frac{1}{2}\alpha_a \xi_a^2 + \frac{1}{2}\alpha_f \xi_f^2 + \frac{1}{4}\beta_a \xi_a^4 + \frac{1}{4}\beta_f \xi_f^4 + \frac{1}{2}\gamma_1 \xi_a^2 \xi_f^2 + \frac{1}{2}\gamma_2 \left(\bar{\xi}_a \bullet \bar{\xi}_f\right)^2 +$$
$$\delta_a \left(\xi_{ax} \frac{\partial \xi_{ay}}{\partial_z} - \xi_{ay} \frac{\partial \xi_{ax}}{\partial_z} \right) + \delta_f \left(\xi_{fx} \frac{\partial \xi_{fy}}{\partial_z} - \xi_{fy} \frac{\partial \xi_{fx}}{\partial_z} \right) + \frac{1}{2} k_a \left(\frac{\partial \xi_a}{\partial_z} \right)^2 + \frac{1}{2} k_f \left(\frac{\partial \xi_f}{\partial_z} \right)^2$$

When investigating the directional relationship between ξ_a and ξ_f, the order parameters are expressed as:

$$\xi_a = (\theta_a \cos qz, \theta_a \sin qz) \text{ and } \xi_f = (\theta_f \cos qz, \theta_f \sin qz) \quad \textbf{(13)}$$

where q = 2Л/pitch is the wave vector of the helix. If the free energy is minimized with respect to Θ_a, Θ_f and q, four stable solutions exist. Namely,

$\Theta_a = 0, \Theta_f = 0$ SmA

$\Theta_a = 0, \Theta_f \neq 0$ SmC*

$\Theta_a \neq 0, \Theta_f = 0$ SmC^*_A

$\Theta_a \neq 0, \Theta_f \neq 0$ $S_mC^*_\gamma$ ($S_mC_{FI}^*$)

A rotating analyzer technique utilizing green light (543 nm) was used to monitor the temperature and field dependence of the optical activity of the ferroelectric, antiferroelectric and sub phases of AS618. For field-effect studies, voltages (23 Hz, a.c.) ranging from 100V to 750V (26.5 to 200 kV/m) were applied. Optical Activity versus Temperature; Electric field versus Temperature and Transmitted Intensity versus Temperature phase diagrams; were then constructed. Electrical fields above ~ 86 kVm induced an additional unknown the S_m? phase between the $S_mC^*_{FI}$ and $S_mC^*_A$ phases. An applied field of ~200 kV/m also produced measurable optical activities in the $S_mC^*_\alpha$ phase. The external electrical field stabilised both the unknown the S_m? induced phase and the $S_mC_{FI}^*$ phase at the expense of the S_mC^* and $S_mC^*_\alpha$ phases. The antiferroelectric $S_mC^*_A$ phase was basically unaffected by the external fields. The Optical Activity versus Temperature phase diagrams and Transmitted Intensity versus Temperature phase diagrams confirmed the ranges of the various phases [I-S_mA-$S_mC^*_\alpha$- S_mC^*-$S_mC^*_\gamma$ ($S_mC^*_{FI}$)-$S_mC^*_A$-crystal] under investigation.