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ELECTROOPTICAL PROPERTIES OF LIQUID CRYSTAL CELLS IN TEMPERATURE RANGE NEAR SmA - SmC^x PHASE CHANGE

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Abstract Temperature dependences of optical transmission, response times, and tilt angle were measured in chiral SmC and SmA phases under homogeneous boundary conditions near the transition temperature t_c. A soft mode type behaviour was established in temperature range 1.5 K above t_c.

INTRODUCTION

Electrooptic properties of smectic mesophases formed with chiral compounds are interesting from both theoretical and practical standpoints. An attention was recently devoted especially to the electroclinic effect which shows the features of a soft mode[1,2,3].

In this paper we present results of some electrooptic studies on cells filled with a compound having SmC^x - SmA phase transition near room temperature under homogeneous boundary conditions at the ratio $d/p \gg 1$.

EXPERIMENTAL CONDITIONS

The FLC was sandwiched between glass plates with ITO electrodes coated with antiparallel rubbed polyimide layers (ZLI 2650). The plates were separated by 20 μm Mylar spacers. Orientation was carried by slow cooling in an AC electric field $\pm$ 150 V at frequency 20 Hz.

The cell was placed between crossed polarizers and the axis of the first polarizer was adjusted to make a field induced tilt angle Θ with the layer normal in a zero field. An ac square-wave voltage was applied and the depth of the modulation in the transmitted light intensity, A, was measured with a photomultiplier in connection with a digital storage oscilloscope.

The electrooptic response time, τ, is defined at application of a square-wave ac voltage as the time needed for the transmittance to change from 100 % to 10 % or from 0 % to 90 % after voltage polarity change. The electrooptic relaxation time, τ_{rel}, is defined as time needed for the transmittance to change from the A to the value of A/e after the voltage cut off.

The field-induced tilt angle, Θ, was directly measured on a rotating stage of a polarising microscope by finding the maximum of the value A under the ac field with a low frequency to minimize the effects associated with the dynamic response of the system.

The FLC material used in our measurements was the compound C_8H_{17}-O-C_6H_4-COO-C_6H_4-COO-CH_2-$C^xH(CH_3)$-C_2H_5 with phase sequence C 34 SmA 56 I (31 SmC^x). The spontaneous polarization in the SmC^x phase is about 5 nC/cm^2.

RESULTS AND DISCUSSION

Typical results of measurements of temperature dependences of electro-optic response and relaxation times, induced tilt angle, and optical amplitude are presented in Figure 1.

As can be seen the electro-optic switching is taking place in temperature range corresponding the SmA phase. The value of the apparent electric field induced

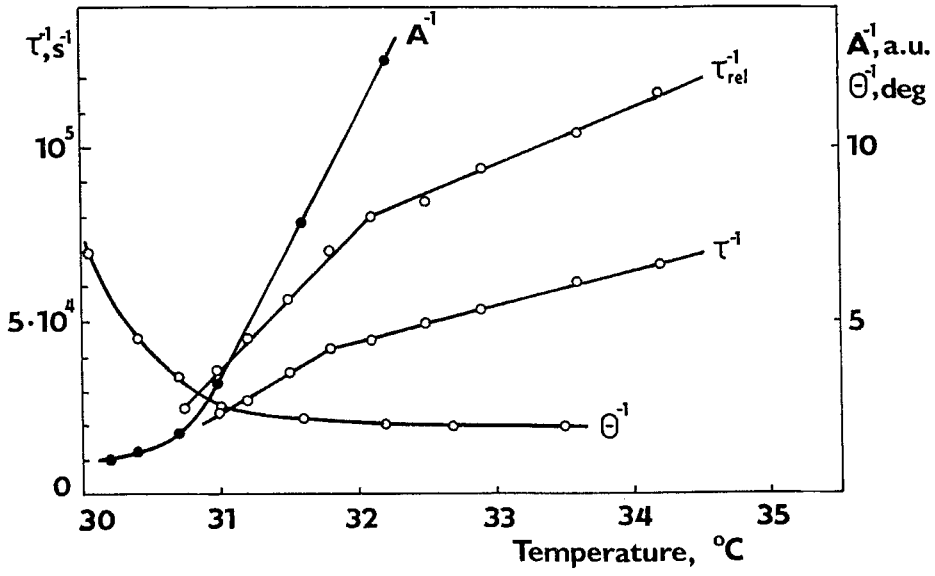

FIGURE 1 Temperature dependences of reciprocal electro-optic response time, $1/\tau$, reciprocal optical response amplitude, 1/A, and induced tilt angle, Θ, measured at application of an ac voltage 50 V, and reciprocal electrooptic relaxation time, $1/\tau_{rel}$, measured at application of a voltage step 50 to 0 V, to a 20 /um thick sample.

tilt angle is about 2^{o} and increases considerably on approaching the SmA-SmC^{x} transition from above. We find for the electroclinic coefficient[1] the values $e_c = 1.4 \cdot 10^{-8}$ rad.m.V^{-1} at 32 ^{o}C, and $e_c = 4.9 \cdot 10^{-8}$ rad.m.V^{-1} at 30 ^{o}C. A reciprocal value of the tilt angle varies linearly with temperature near the phase transition. Maximum value $\Theta = 17^{o}$ was found at 20 ^{o}C in supercooled SmC^{x}.

Switching and relaxation times increases also very considerably on approaching the phase transition and plots of their reciprocal values vs temperature are linear in a temperature range about 1.5 ^{o}C above t_c. Such behaviour is in accordance with theoretical predictions on the soft-mode contribution to the dielectric constant.

Above temperature 32 ^{o}C the soft-mode contribution vanishes[2] and plots τ^{-1} and τ_{rel}^{-1} vs temperature have lower slopes. Owing to complex character of the electro-optic response, relaxation frequencies determined as reciprocal values of the electrooptic relaxation times are different from relaxation frequencies f_R and f_S determined by the dielectric measurements[2].

In accordance with the theory, the electro-optic relaxation time was established as voltage independent in voltage range from 5 V to 50 V in SmA phase.

The cell under investigation shows also a diverging depth of light intensity modulation A in the SmA phase. The inverse of the A shows linear dependence on temperature.

In despite of low spontaneous polarization the switching times of about 20 μs was reached near a room temperature at electric field intensity of 2 V/μm.

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REFERENCES

1. G. Anderson, I. Dahl, W. Kuczynski, S.T. Lagerwall, K. Skarp, and B. Stebler, Ferroelectrics, 84, 285 (1988).
2. M. Glogarová, J. Pavel, R. Dabrowski, Ferroelectrics, 81, 413 (1988).
3. Ch. Bahr, G. Heppke, Liq. Cryst., 2, 825 (1987).