Phase Diagram of Binary Mixture E7:TM74A Liquid Crystals

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ABSTRACT

Although there are many liquid crystalline materials, difficulty is often experienced in obtaining LCs that are stable and has a wide mesophase range. In this study, mixtures of two different LCs were used to formulate a technologically viable LC operating at room temperature. Nematic E7(BDH) and cholesteric TM74A were mixed at different weight ratios at 10 % increments. Transition temperatures were determined via Differential Scanning Calorimetry and phase identification was done using Optical Polarizing Microscopy. The phase diagram showed the existence of three different phases for the temperature range of 10-80°C. Mixtures with 0-20% E7 exhibit only the cholesteric-nematic mesophase, which could be due to the mixture's being largely TM74A and its behavior in the temperature range considered is similar to the behavior of pure TM74A. With an increase in the concentration of E7, the smectic phase of the pure cholesteric was enhanced, as seen from the increased transition to the cholesteric-nematic phase and a broader smectic range. The cholesteric-nematic to isotropic transition increased as the nematic concentration increases, following the behavior expected from LC mixtures. For mixtures that are largely nematic (more than 50% E7), the smectic phase has vanished and the cholesteric-nematic phase dominated from 30-60°C.

Keywords: liquid crystals, phase diagrams.

INTRODUCTION

For many applications of liquid crystal, some requirements and characteristics need to be satisfied, such as stability of mesophase range and the existence of the mesophase at the desired temperature of operation. Although there are many liquid crystalline materials, some difficulty is often experienced in achieving technologically useful temperature range for the existence of mesophase and response to external fields, as well as stability of the substance. To overcome this difficulty, mixtures can be used (Atkins, 1994). In general, a binary mixture has transitions at temperatures in between the transition temperature of the pure compounds.

It is also known that when a small concentration of an optically active material is mixed with a nematic compound, the pitch of the cholesteric increases. Cholesteric-nematic mixtures can show the so-called "injected smectic phase" (Das et al., 1995) although none of the compounds used is smectic. This smectic

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phase can be stabilized and its transition temperature increased. This results in an enhanced smectic phase for the mixture.

For this investigation, we used the nematic liquid crystal E7 and cholesteric TM74A due to their optical activity and availability. E7 is nematic at room temperature and isotropic above 60.5 °C while TM74A is known to exhibit smectic A below -32°C, isotropic above 10°C, and cholesteric mesophase in between (Barcale, 1997).

This paper aims to determine the mixture that uses the available cholesteric LC suitable for room temperature operations.

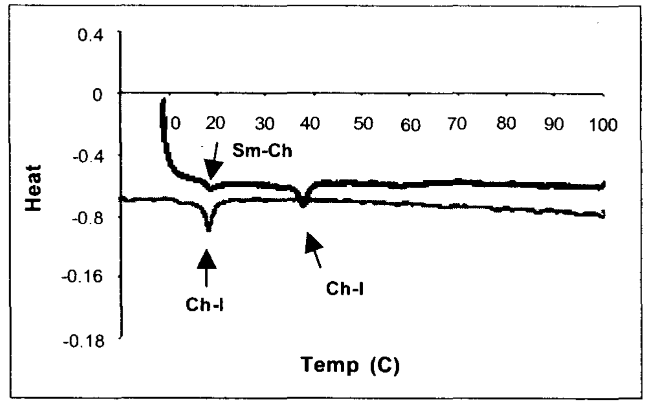

Fig. 1. Typical temperature profile (heat vs temperature) of Sm-Ch, Ch-I (two peaks) transitions and the Ch-I only (one peak)

METHODOLOGY

Commercially available liquid crystals E7 (Merck) and TM74A were mixed at different weight ratios from 0:100 (E7:TM74A) to 100:0 (E7:TM74A) with an increment of 10%. Mixtures were then sandwiched between ITO-coated glass plates separated by a 10mm-thick mylar spacer. Transition temperatures of each mixture were determined using the Differential Scanning Calorimetry by heating the samples at a constant rate of 5°C/min from 0°C to 80°C. The phases after each transition were then identified using Metler-Toledo FP82 Hot Stage under a polarizing microscope.

RESULTS AND DISCUSSION

Two transitions were observed for mixtures with 20 to 50% E7 while the rest of the samples only have a single transition. A typical thermogram of the samples is shown in Fig. 1. The phase diagram shown in Fig. 2 reveals the existence of three phases in the temperature range considered. These phases were identified as the isotropic, cholesteric-nematic, and smectic phase under the microscope.

Mixtures with 0-20% E7 exhibit only the cholesteric-nematic mesophase. This is because the mixture is largely TM74A, and its behavior in the temperature range considered is similar to the behavior of pure TM74A. The smectic phase was not observed because for pure TM74A this mesophase occurs at a temperature beyond the range being considered.

With an increase in the concentration of E7, the smectic phase of the pure cholesteric was enhanced, as seen from the higher transition to the cholesteric-nematic phase and a broader smectic range. A possible cause of the improvement in transition temperature is the interaction between molecules and the decrease in layer spacing, as reported by M.K. Das (1995). Furthermore, the stabilization of the smectic phase results from the deformation of the nematic phase due to the presence of a chiral dopant (Nagappa, 1995). Other probable reasons are intermolecular forces, length of molecules, rate of heating, impurity content, surface alignment properties, and elastic distortions (Nagappa, 1995).

Another notable observation from Fig. 2 is the increasing cholesteric-nematic to isotropic transition as

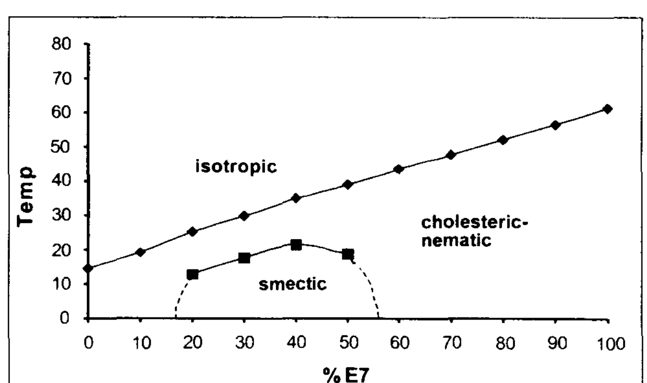

Figure 2: Phase diagram of the binary mixture E7: TM74A

the nematic concentration increases. This behavior follows the expected trend for LC mixtures.

For mixtures that are largely nematic (more than 50% E7), the smectic phase has vanished and the cholesteric-nematic phase is the dominant mesophase from 30-60°C.

Based on the above observations, E7:TM74A mixtures with high nematic concentrations are more suitable for applications such as liquid crystal displays.

Although the transition temperature was enhanced, the effects on other properties such as switching voltage, switching time, viewing angle, and contrast ratio have not been studied. Optical characterization could be done to check the above effects. Refractive index change as a function of temperature and molar concentration could also be made in order to understand the behavior of the system.

REFERENCES

Atkins, P.W., 1994. Physical Chemistry. 5th ed. Oxford University Press: 833-834 pp.

Bancale, A., 1997. BS Thesis. Opto-Optical Properties of A Dye-Doped Nematic Liquid Crystal. National Institute of Physics—UP Diliman: 44 pp.

Das, M.K. et al., 1995. Phase Transition and Physical Properties of a Binary Mixture Showing Enhanced Smectic Phase. Molecular Crystals and Liquid Crystals. 261: 95-106.

Davila, L., 1996. BS Thesis. Cholesteric-nematic Liquid Crystal Dispersions in the Visible Region. National Institute of Physics—UP Diliman: 19 pp.

Nagappa, J. et al., 1995. Induced Reentrant Smectic Phase in a Binary Mixture of Nematic and Cholesteric Compounds. *Mol. Crystal and Liquid Crystal.* 260: 547.