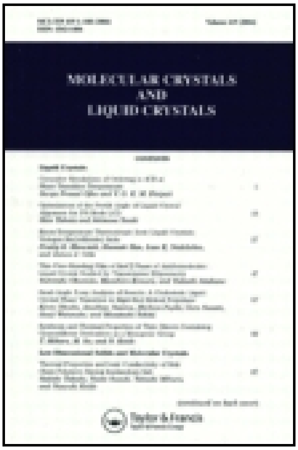

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Phase Diagram of Binary Mixture TM74A:E48 Liquid Crystals

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In this study, mixtures of two different commercially available liquid crystals (LC) were used to formulate a technologically viable LC operating at room temperature. Nematic E7 (BDH) and cholesteric TM74A were mixed at different weight ratios with 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 --cholesteric-nematic mesophase, smectic A phase and isotropic. For mixtures that are largely nematic (more than 50% E7), the smectic phase has vanished and the cholestric-nematic phase dominated from 30–60°C.

Keywords: phase diagram; smectic; binary mixture

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 difficulties are often experienced in achieving stable mesophases in a technologically useful temperature range. To overcome these difficulties, mixtures can be formulated.[1] In general, a binary mixture has transitions at temperatures between the transitions of the pure components.

It is also known that increasing the concentration of an optically active material in a nematic compound increases the pitch of the resulting mixture. Chiral-nematic mixtures can show the so-called "injected smectic phase"[3] although none of the compounds used is smectic. The smectic 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 Sm A → Ch at –32°C and Ch → I above 10°C.[4]

This paper aims to determine the mixture suitable for room temperature operations such as temperature sensors used in microchip production.

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 10μm-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 percent E7 while the rest of the samples only have a single transition. A typical thermogram of the samples is shown in Figure 1. The phase diagram shown in Figure. 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 (FIGURE 3b and 4a,4b). 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 (FIGURE 5) 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[6]. Furthermore, the stabilization of the smectic phase results from the deformation of the nematic phase due to the presence of a chiral dopant.[7] Other probable reasons are intermolecular forces, length of molecules, rate of heating, impurity content, surface alignment properties and elastic distortions.[3]

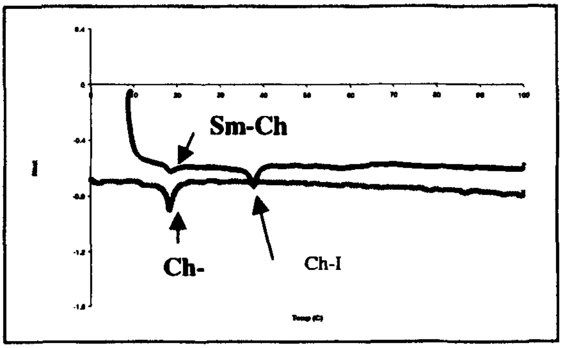


FIGURE 1 Typical temperature profile (heat vs temperature) of Sm-Ch, Ch-I (two peaks) transitions and the Ch-I only (one peak)

Another notable observation from Figure. 2 is the increasing cholesteric-nematic to isotropic transition as 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 cholestric-nematic phase is the dominant mesophase from 30-60°C.

Based from the above observations, E7:TM74A mixtures with high nematic concentrations is 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 function of temperature and molar concentration could also be made to understand the behavior of the system.

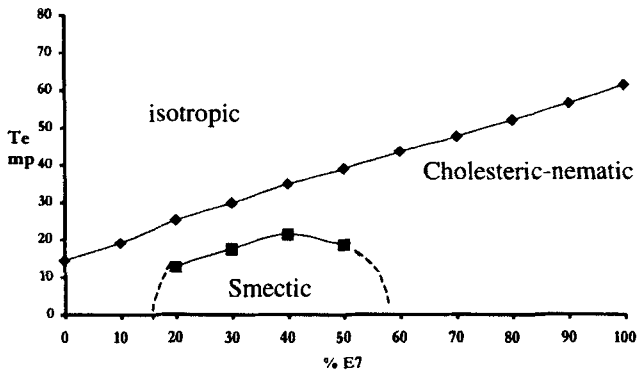
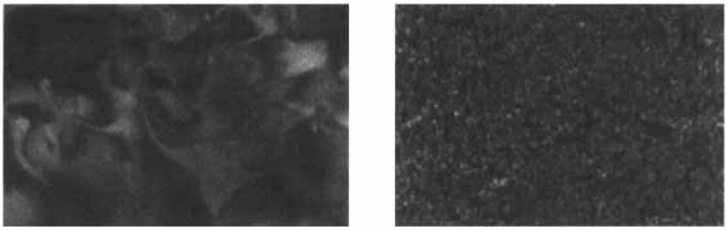
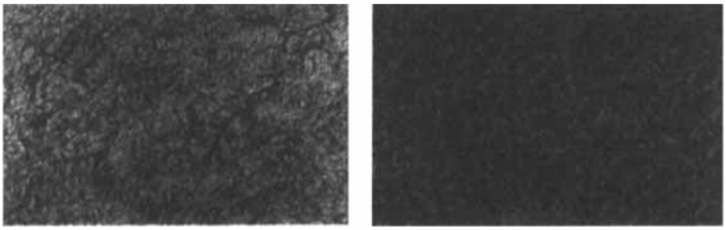


FIGURE 2 Phase diagram of the binary mixture E7: TM74A



(a) (b)

FIGURE 3 (a) Photomicrographs of ppure E7 and (b) a focal conic texture from E&:TM74AQ mixture 50:50 (right)



(a) (b)

FIGURE 4 Photomicrographs of cholesteric-nemtic phase at (a)90:10 and (b) 40:60 weight ratios of E7:TM74A

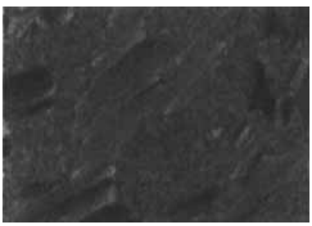


FIGURE 5 The enhanced Smectic phase in the mixture (30:70) at 12.6°C See Color Plate III at the back of this issue.

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