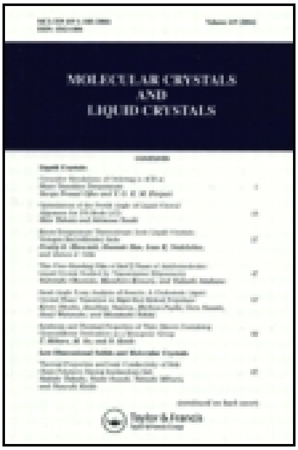

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ELECTRO-OPTIC CHARACTERIZATION OF E48:TM74A:PMMA PDCLCs

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Polymer dispersed cholesteric liquid crystal (PDCLC) films have been fabricated via the Polymerization-Induced Phase Separation (PIPS) technique. E48:TM74A:PMMA PDCLCs, with LC:PMMA ratio of 80:20 and varying E48:TM74A weight ratio, have been characterized for their electro-optic properties. The PDCLC films have been UV-cured ($\lambda = 365$ nm) at various curing times. Transmittance measurements, conducted using a linear optics set-up with a He-Ne laser ($\lambda = 632.8$ nm) as probe beam while subjected to varying voltage, showed that 10 μm-thick films UV-cured for 3 hours exhibited the best electro-optic response among all the samples. The use of cholesterics in PDCLCs resulted to a lower off-state transmittance and higher contrast ratio compared to purely nematic PDLCs. As a consequence, however, the threshold and driving voltages are increased for PDCLCs.

INTRODUCTION

Polymer dispersed liquid crystals (PDLC) are composed of nematic LC droplets dispersed in a polymer matrix sandwiched between two transparent, conducting electrodes.

Polymer dispersed cholesteric liquid crystal (PDCLC) films are PDLC films, which make use of cholesteric LCs instead of nematics. These, like PDLCs, can be switched from a scattering state to a transmitting state.

Without an applied external field, the LC-polymer boundary conditions determine the droplet configuration. The incident light is randomly scattered and only a very small amount is transmitted through the cell. Upon application of an electric field, the LC molecules are reoriented

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from the scattering texture to a planar helical alignment. With incident white light, nearly monochromatic but circularly polarized light is reflected [1]. Application of very high fields could result to the untwisting of the helix and thus, a highly transmitting PDCLC film [2].

PDCLCs may operate either in the normal mode or reverse mode. Normal mode refers to an opaque sample in its OFF state and a transparent sample without the application of an electric field. Reverse mode, on the other hand, exhibits a transparent sample at OFF state and an opaque sample at the ON state.

For PDCLCs to be effective for displays, these must exhibit high scattering in the OFF state and high transmittance in the ON state for a normal mode. For a reverse mode PDCLC, it must exhibit high transmittance in the OFF state and high scattering in the ON state. Both normal and reverse mode PDCLCs must have fast switching speeds and low threshold voltages.

These properties are dependent on the refractive indices of the LC and the polymer film thickness **d**, droplet radius and shape. These factors are dependent on the preparation parameters such as cooling rate, curing time, and curing temperature, among others.

This study aims to fabricate normal mode E48: TM74A: PMMA PDCLC films via Polymerization Induced Phase Separation (PIPS) technique; characterize the films through optical microscopy and transmittance measurements; and compare the electro-optic properties of PDCLC films with ordinary nematic PDLC films.

METHODOLOGY

E48: TM74A: PMMA PDCLC films were prepared using 80:20 E48: TM74A: PMMA weight ratio. The E48: TM74A LC mixtures were prepared with the following E48 concentrations: 85, 90, 95, and 100% wt. The 20% PMMA was actually composed of methyl methacrylate, EDMA and AIBN. The mixture was then sandwiched between two ITO-coated glass plates using mylar 10 μm mylar spacers to control the thickness of the film. The PDCLC cells were then UV-cured ($\lambda = 365$ nm) at the following curing times 30 mins, 1 hr, 2 hrs, and 3 hrs. The curing time was varied to investigate its effect on the microscope. To study the electro-optic response of the PDCLC films, a linear optics set-up was used, as shown in Figure 1. Transmittance measurements were conducted using a He-Ne laser ($\lambda = 632.8$ nm) as the probe beam. Measurements were conducted while subjecting the PDCLC samples to varying voltage.

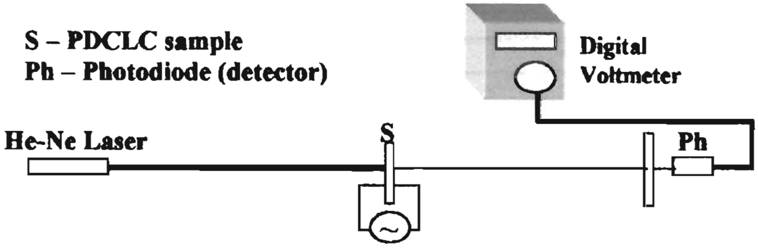

FIGURE 1 Linear optics set-up.

RESULTS AND DISCUSSION

The samples were viewed under a polarizing microscope and Figure 2 shows a representative photomicrograph.

Length of Curing Time Dependence

Figures 3, 4, 5 and 6 show the plots of voltages vs. transmittance profiles and it can be observed that although most of the samples switched on, the samples cured for 3 hours exhibited the highest on-state transmittance, in general.

This is consistent with the results of Chang *et al.* [3], wherein they observed that samples with longer curing time have higher optical transmission in the on-state. This was attributed to extent of polymerization in the sample. For the samples that were cured at shorter curing time (30 mins, 1 hr, 2 hrs), and thus not completely polymerized, some monomers will remain mixed with the LC. This would change the refractive

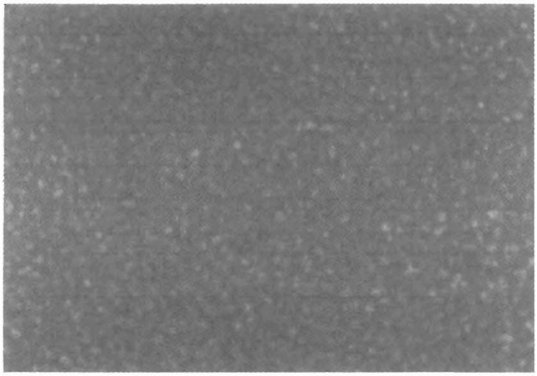

FIGURE 2 Droplet configuration observed in sample photomicrograph. 20x.

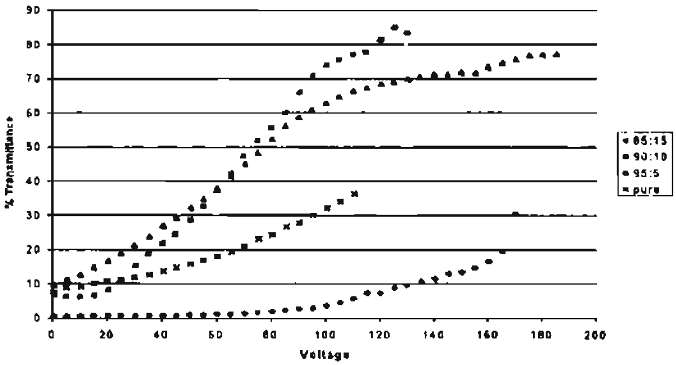

FIGURE 3 Voltage vs. Transmittance profile for PDCLC films polymerized for 30 minutes.

index of the LC-rich region (droplet). Since PDCLCs work on the index-matching concept of the LC and the polymer upon application of an external field, this change in the refractive index of the LC would result to lower on-state transmittance.

Formulations

Formulation, i.e., LC-polymer ratio, affects the electro-optic property of PDCLC films. In this study, the composition varied was the E48: TM74A ratio while the LC:polymer ratio remained 80 : 20.

Note that in Figure 6, it can be observed that the off-state transmittance increase with increasing TM74A concentration. The addition of cholesteric

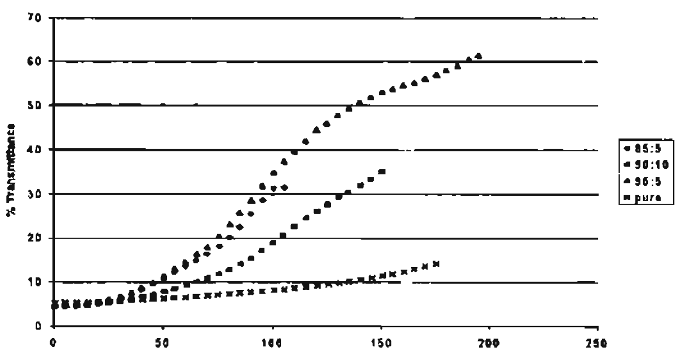

FIGURE 4 Voltage vs. Transmittance profile for PDCLC films polymerized for 1 hour.

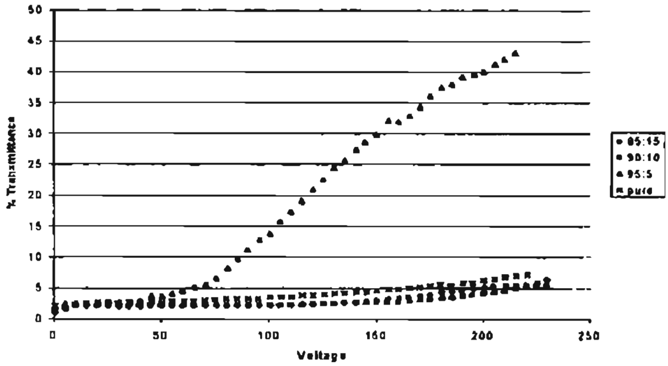

FIGURE 5 Voltage vs. Transmittance profile for PDCLC films polymerized for 2 hours.

TM74A to nematic E48 results in an induced chirality in the LC mixture. The presence of this chiral configuration affects the properties of the LC. Increasing the concentration of TM74A results in a more chiral LC, which results to a more scattering sample. And a more scattering sample result to a lower off-state transmittance.

In PDLCs, the opacity of the film at off-state is due to the refractive index mismatch between the LC and the polymer. The PDCLC films have a lower off-state transmittance compared to the purely nematic PDLC because of the additional factor of the LC component being a highly scattering medium itself.

Also it can be noted that the threshold voltage increases with increasing TM74A concentration. This is due to the fact that a more chiral LC needs a

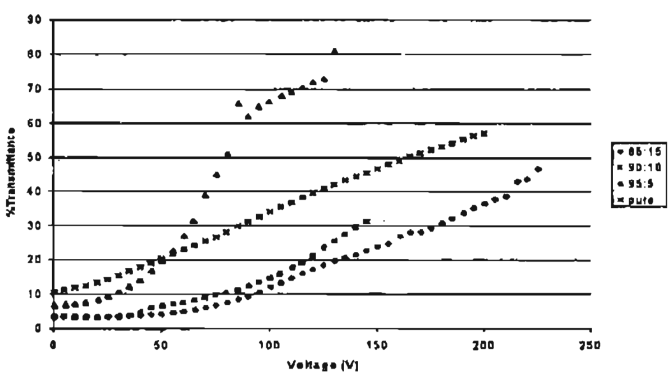

FIGURE 6 Voltage vs. Transmittance profile for PDCLC films polymerized for 3 hours.

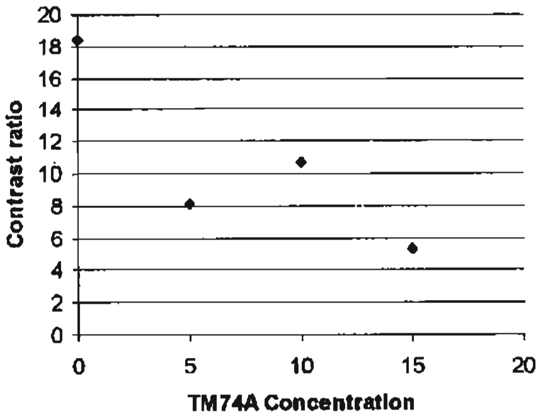

FIGURE 7 Contrast ratio of PDCLC samples.

greater electric field to be untwisted then realigned parallel to the electric field as compared to a purely nematic PDLC that only needs realignment.

Figure 7 shows the profile of the contrast ratio of the films. It is shown that the 95.5 sample has the highest contrast ratio and that the PDCLCs exhibited higher contrast ratios compared to the purely nematic PDLCs. This is because the PDCLC films have lower off-state transmittance.

CONCLUSION

The electro-optic response of PDLC and PDCLC films is affected by several factors such as the length of curing time and formulation. The length of curing time affects the electro-optic characteristics such that increasing the length of curing time yields samples with higher transmittance. The use of cholesterics in PDCLCs result in a low off-state transmittance, and a high contrast ratio compared with purely nematic PDLCs. As a consequence, however, PDCLCs require a higher threshold and driving voltage.

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