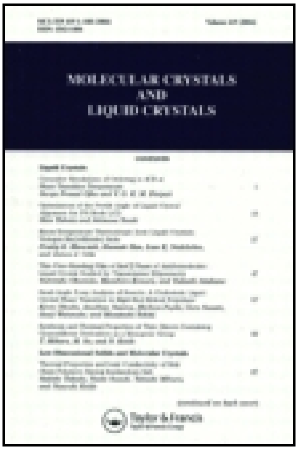

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Light Scattering Characteristics of Newly Designed Polymer Dispersed Liquid Crystals Films

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Light Scattering Characteristics of Newly Designed Polymer Dispersed Liquid Crystals Films

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Polymer Dispersed Liquid Crystal (PDLC) films were prepared by the phase separation method using the liquid crystal (TL205) and a prepolymer. This work investigated the characteristics of scattering angle – light transmittance. In this work, it was found that at a narrow scattering angle incident lights was only weakly scattered and retained polarization, as the scattering angle increased the scattered light became increasingly depolarized.

Keywords: electro-optic properties; flexible display; PDLC; prepolymer; scattering angle

INTRODUCTION

Devices using Polymer Dispersed Liquid Crystals (PDLCs) have been widely studied given the wide variety of potential applications. Some possible applications include smart windows, microdisplays, optical shutters, diffractive optics, photorefractive systems, e-paper and flexible displays [1–5].

PDLCs are state-of-the-art whereby micro-droplets of liquid crystal are dispersed into the polymer matrix [6]. The transparency of PDLCs can be altered by external electric fields, which can control the extent of the mismatch of refractive indices between the liquid crystal and the polymer matrix [7]. The detailed scattering properties of PDLC

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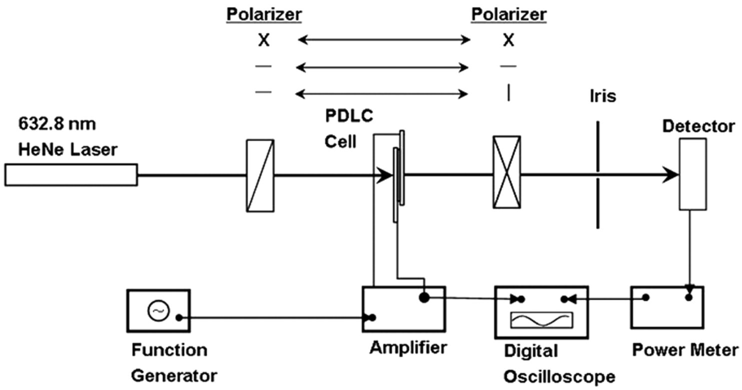


FIGURE 1 Electro-optic measurement system.

films mainly depend on the chemical nature of the polymer and LC, and on preparation conditions, which result in different interface environments between LC and the polymer. In this work, the scattering angle-dependent transmittance intensity profiles formed by a newly designed prepolymer have been investigated.

EXPERIMENTAL

The PDLC systems were prepared by the polymerization-induced phase separation process. The prepolymer consisted of a monomer, a crosslinker, a photo initiator and resin. 2-ethylhexyl acrylate (EHA) was used as monomer, Darocur4265 (Ciba, Inc.) was used as a photo initiator, and 1,6-hexanediol diacrylate (HDDA) was used as a crosslinker. The LC was a eutectic mixture of liquid crystals, commercially available as TL205 (Merck, Ltd.). The newly developed PDLC formulation was prepared by mixing TL205 (80 wt%) with the prepolymer (20 wt%) homogeneously. The mixture was injected into two ITO coated glasses spaced at 7 μm and cured by UV irradiation of 365 nm. Scattering angle-transmittance intensity was measured in the circumvolving sample using the electro-optic measurement system (Fig. 1) in conditions with no polarizer, with parallel polarizers (HH scattering) and with crossed polarizers (HV scattering).

RESULTS AND DISCUSSION

Figure 2 shows the voltage-transmittance curve and polarized microscopic images according to the applied voltages of PDLC film.

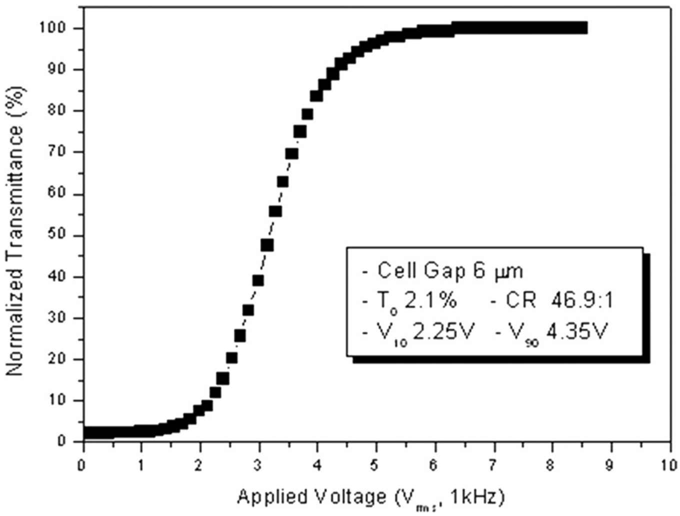
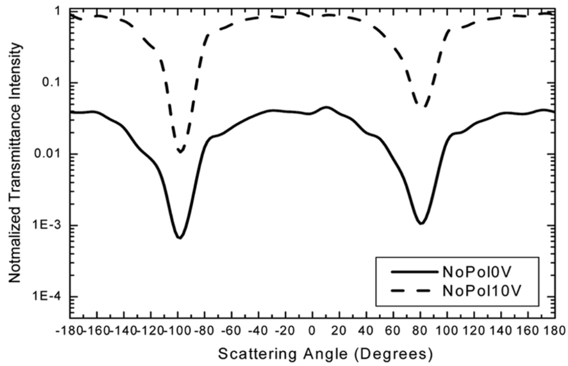


FIGURE 2 The Voltage-Transmittance characteristic of PDLC film.

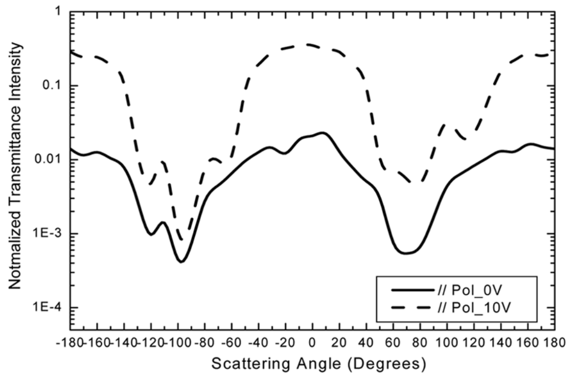
The electro-optic characteristics showed a relatively low V_{on} (0.725 V/μm), V_{th} (0.375 V/μm) and a high contrast ratio (46.9:1).

Scattering angle-transmittance intensity profiles for PDLC films have been published by Montgomery [8]. Figure 3 shows the polarization-dependent scattering profiles for PDLC film. The polarizer arrangement can influence the intensity of scattering angle-transmittance. The scattering angle-transmittance depends not only on the angular distribution of the scattered light within the PDLC film, but also on internal reflection and refraction of the light at the PDLC film-ITO film, PET film and air interface. Light scattered by the PDLC film into large angles suffers higher internal reflection at the PDLC film-ITO film, PET film and air interface. This light is reinjected into the PDLC film and does not contribute to forward scattering at high angles. At 10 V, the transmittance intensity is increased.

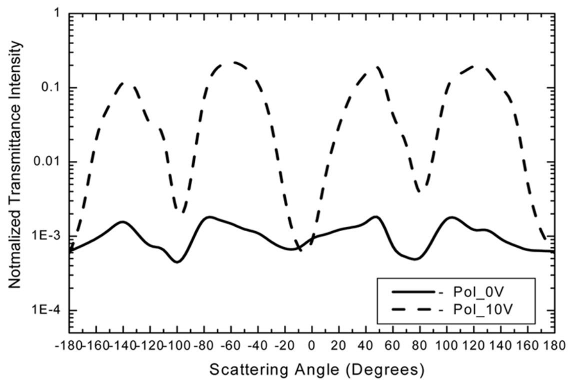
Figure 4 shows that schematize scattered lights by polarizers. Scattered light showed stable transmittance intensity over broad scattering angles in no polarizer conditions. In narrow scattering angles, incident light was scattered by PDLC droplets. As the scattering angle increases, the transmittance intensity of incident light decreased as a result of increases in internal reflection of PET, ITO film and PDLC droplets. Transmittance intensity decreased to a scattering angle of 80 degrees as the scattering angle increased, transmittance intensity also increased because the effects of internal reflection decreased.



(a)



(b)



(c)

FIGURE 3 Scattering profiles for PDLC films at zero V and at 10 V. (a) No polarizer, (b) parallel polarizers, and (c) crossed polarizers.

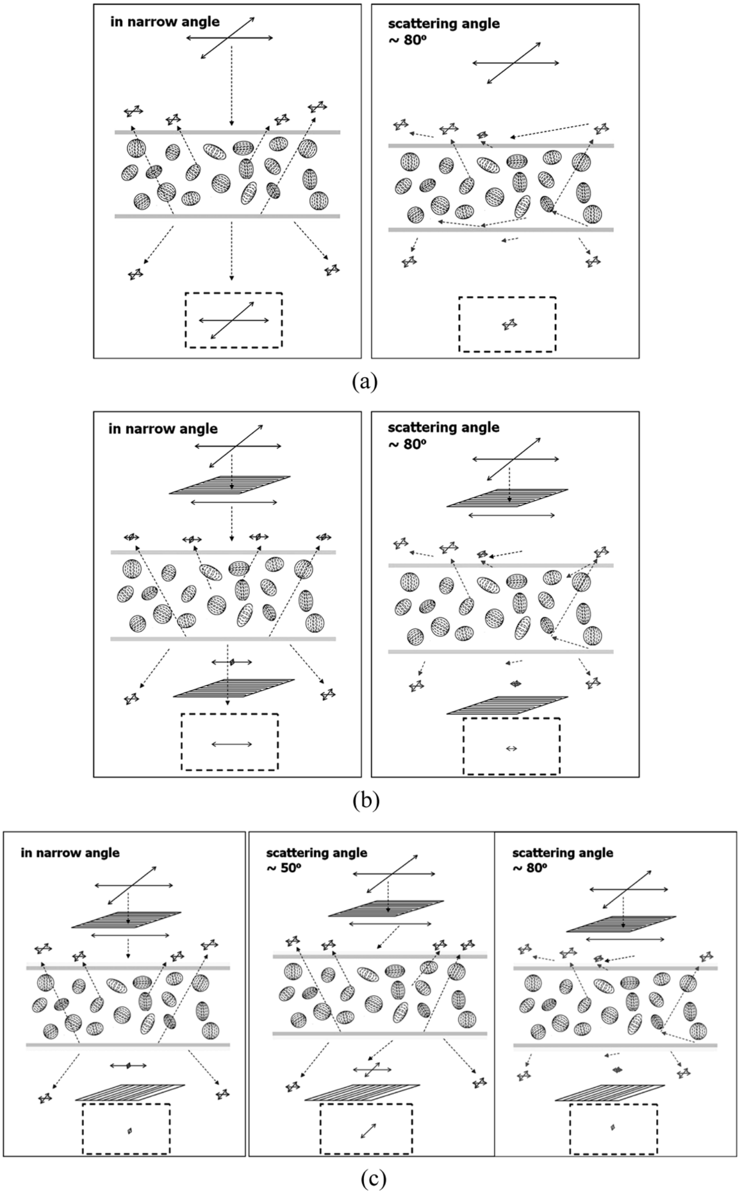


FIGURE 4 The scheme of scattered light by polarizers. (a) No polarizer, (b) parallel polarizers, and (c) crossed polarizers.

These characteristics were equally apparent in conditions with parallel polarizers. In incidences with narrow scattering angles, light stays polarized, but as the scattering angle increases, the light becomes depolarized. In conditions with crossed polarizers, a narrow scattering angle gave rise to a decrease in transmittance intensity as light that passed the first H polarizer then passed the second V polarizer. So in these angle ranges, incident light was weakly scattered, and

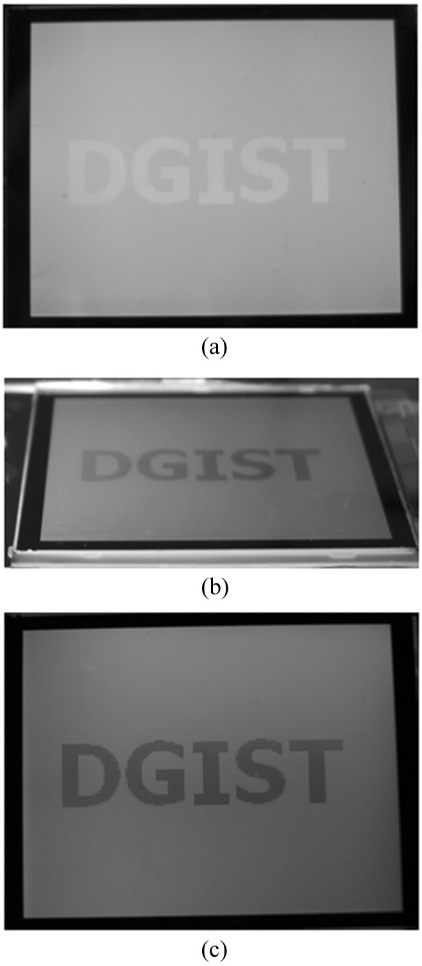


FIGURE 5 PDLC display showing a DGIST image. (a) The image at an on-axis angle without polarizer, (b) the image at an off-axis angle, and (c) the image at an on-axis angle with crossed polarizers.

for the most part, retained the polarization. As the scattering angle increased, intensity increased because incident light passing the PDLC film was depolarized and the intensity passing the crossed polarizers increased.

Figure 5 shows the PDLC display showing a DGIST image. A commercial BLU is located behind the display, providing normally incident light. Figure 5(a) is the image at an on-axis angle without a polarizer, (b) is the image at an off-axis angle and (c) is the image at an on-axis angle with crossed polarizers.

CONCLUSIONS

Polymer Dispersed Liquid Crystal (PDLC) films were prepared using the phase separation method with the liquid crystal (TL205) and the prepolymer. As the scattering angle increases, transmittance intensity decreased due to an increase in multiple scattering processes and the scattered light became increasing depolarized. The scattering angle dependence of the transmittance intensity relies not only upon the angular distribution of the scattered light within the PDLC film, but also on the internal multiple scattering process.

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