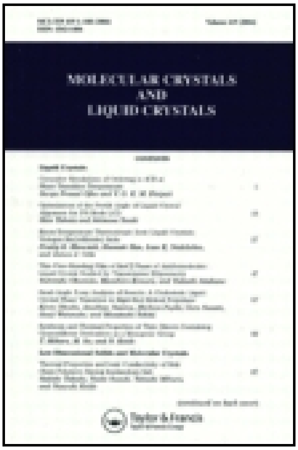

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Electro-Optical Characterization of E48:PVP Polymer Dispersed Liquid Crystals

Cheryll Lei E. Mahinay [a], Claire M. Macale [a], Fairland F. Amos [a], Zenaida B. Domingo [a] & Leonorina G. Cada [b]

[a] Liquid Crystal Laboratory, National Institute of Physics University of the Philippines, Diliman, Quezon City, 1101

[b] Liquid Crystal Laboratory, Institute of Chemistry University of the Philippines, Diliman, Quezon City, 1101

Version of record first published: 27 Oct 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 365, pp. 305-311
Reprints available directly from the publisher
Photocopying permitted by license only

Electro-Optical Characterization of E48:PVP Polymer Dispersed Liquid Crystals

CHERYLL LEI E. MAHINAY[a], CLAIRE M. MACALE[a], FAIRLAND F. AMOS[a], ZENAIDA B. DOMINGO[a] and LEONORINA G. CADA[b]

[a]*Liquid Crystal Laboratory, National Institute of Physics University of the Philippines, Diliman, Quezon City 1101 and* [b]*Liquid Crystal Laboratory, Institute of Chemistry University of the Philippines, Diliman, Quezon City 1101*

Transmittance behavior of nematic E48:polyvinylpyrrolidone (PVP) polymer dispersed liquid crystals (PDLC) is investigated in relation to the liquid crystals to polymer ratio. Five E48:PVP concentration mixtures are prepared: 75:25, 77.5:22.5, 80:20, 82.5:17.5, and 85:15. Solvent Induced Phase Separation and Thermally Induced Phase Separation techniques are used. Droplet sizes are measured using a polarizing microscope, and the 80:20 mixture prepared by slow cooling is determined to have the largest droplets. The liquid crystal cells prepared by fast cooling needed a higher switching voltage (ranging from 7V-35V) while the switching voltage of slow-cooled samples varied from 6V-47V, with most of the samples having switching voltages close to 10V. The transmittance behavior and contrast ratio of PDLC's are then investigated with a 660–680 nm light source. It is observed that fast-cooled samples had higher contrast ratios compared to slow cooled samples. Photographs of each sample are acquired to determine their respective textures.

INTRODUCTION

In polymer dispersed liquid crystals, LC droplets are dispersed in a polymer matrix. The size, concentration, and birefringence of the LC droplets would determine the intensity of the off-state scattering[1].

Liquid crystal droplets form in the polymer matrix, thus several factors influence the size and shape of the droplets, namely: solvent, temperature, and polymer.

Solvent Induced Phase Separation (SIPS) involves the evaporation of the solvent after dissolving the liquid crystal into the polymer. The solvent is evaporated at a controlled rate to begin phase separation. The droplets start forming as the polymer and liquid crystal come out of solution and stops when all of the solvent has been removed.

Thermally Induced Phase Separation (TIPS) is the process wherein the liquid crystal and polymer mixture is initially at a high temperature where they are isotropic then cooled to room temperature[2].

E48 is a nematic liquid crystal at room temperature. It has a whitish color. Polyvinylpyrrolidone (PVP) is widely used commercially because of its low toxicity, film-forming ability, adhesive characteristics, relative inert behavior towards salts, acids and thermal degradation in solution, and complexing ability. Its single most attractive property is its binding capability. Small quantities of PVP stabilize aqueous emulsions and suspensions apparently by its absorption as a thin layer on the surface of individual colloidal properties[3].

Polymer Dispersed Liquid Crystal films scatter light when light passes through considering there is no applied electric field. The directors of the droplets are oriented randomly so minimum transmittance is observed. When an electric field is applied, the directors align themselves in the direction of the field. As light passes through the film, optimum transmittance is noticed[4].

Contrast ratio is the ratio between the intensity of the on-state and off-state of the PDLC[5].

$$C = \frac{I_{on}}{I_{off}}$$

For PDLC's, high contrast ratio values are preferred, especially for applications in the development and research of PDLC shutters.

Droplet size in PDLC's are controlled by several factors like the type of liquid crystal and polymer used, the concentration of the solution, the solvent, the rate of solvent evaporation, the preparation temperature, the cooling rates, and the rate of polymerization. Slow cooling rates yield larger droplets than droplets formed by fast cooling.

This study aims to observe the transmittance behavior and contrast ratio of PDLC's in relation to the droplet size and cooling rate. This study also aims to determine if a memory effect can be observed in the PDLC. The absence of a memory effect is preferred since optical switches should have fast switching times.

METHODOLOGY

The liquid crystal used for the experiment is nematic E48, Polyvinnylpyrolidone, PVP was used as a polymer binder. Five different mixtures of E48:PVP were prepared: 75:25, 77.5:22.5, 80:20, 82.5:17.5, and 85:15. The spacers used were 20μm plastic spacers. The mixtures were dissolved in chloroform. Each mixture was prepared by using two phase separation methods: SIPS and TIPS. The mixture was placed evenly on the ITO coated glass plates. The solvent was allowed to evaporate. Obtaining a white film suggests that the chloroform evaporated. The second phase separation process was TIPS. The PDLC films were heated to 90°C on a hotplate. Then, one set of mixtures with varying ratio was removed from the hotplate. This set of samples was prepared under fast cooling. Another set was cooled with the same rate of cooling as the hotplate. The size of the liquid crystal droplets was measured under the polarizing microscope. Photographs of the samples were also acquired. Optical behavior of the PDLC films was analyzed in their off- and on-state. Reference intensity was taken without the PDLC and then intensity was measured with the sample present. Data were taken with varying voltages. The effect of the duration of on-state on the memory parameter was observed. The samples were switched on for 30 seconds then were switched off, while the transmittance was being measured. The process was repeated with initial switch-on time of 60 seconds.

RESULTS AND DISCUSSION

1. Droplet Size of Samples

Figure 1 shows the droplet size of the different sample ratio mixtures. These were measured using the micrometer scale of a polarizing microscope.

Larger droplets were formed for cells prepared by slow cooling while fast cooling formed smaller ones. This occurs because at a slower cooling rate, there is enough time for larger droplets to form[6]. It was also observed that at high LC concentrations, particularly at 90% LC concentration, there were no droplets formed.

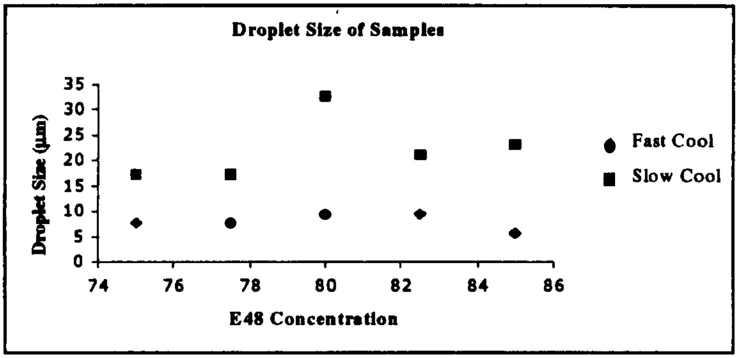

FIGURE 1. Relationship of droplet size and E48 concentration with a magnification of 50x and using a calibration constant of 1.92×10^{-3}mm/div See Color Plate XIV at the back of this issue.

2. Application of Electric Field using VARIAC

Based on figures 2 and 3, it can be observed that for samples prepared by fast cooling, the switching voltages ranged from 7V to 35V with most of the samples having switching voltages higher than 10V. For slow-cooled samples, the switching voltages ranged from 7V to 47V with most of the samples having a switching voltage close to 10V.

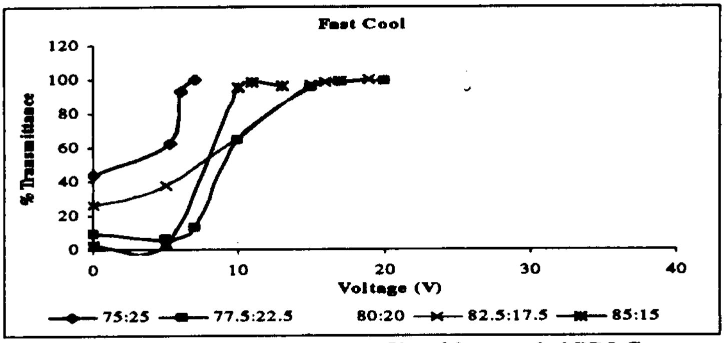

FIGURE 2. Transmittance profile of fast-cooled PDLC samples See Color Plate XV at the back of this issue.

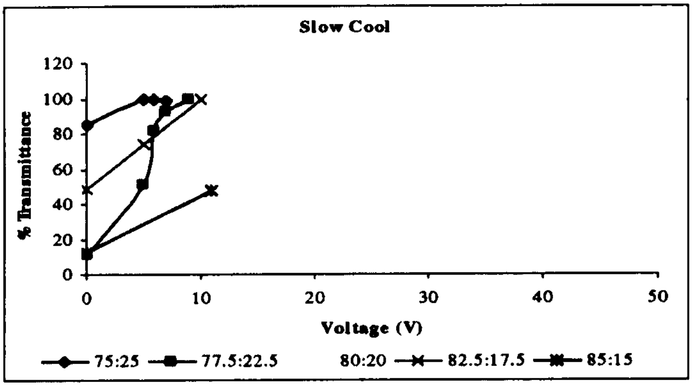

FIGURE 3. Transmittance profile of slow-cooled PDLC samples See Color Plate XVI at the back of this issue.

3. Contrast Ratio

For LC displays, a higher contrast ratio would be ideal in order to get good displays. As observed in figure 4, the contrast ratio of fast-cooled samples were higher than the slow cooled samples. This was expected because faster cooling rates yield smaller droplets, hence, more droplets are formed, resulting in the presence of more light scatterers in the PDLC film. This yields a low off state intensity.

This ratio is determined by the equation:

$$\text{ContrastRatio} = \frac{I_{On}}{I_{Off}}$$

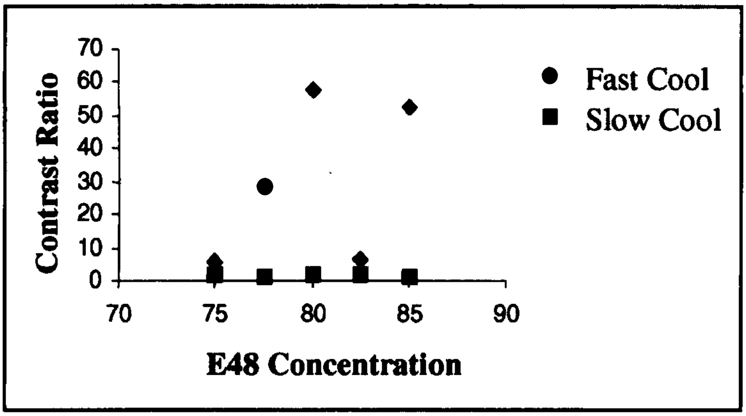

FIGURE 4. Contrast ratio for fast- and slow-cooled samples
See Color Plate XVII at the back of this issue.

CONCLUSION

Upon experimentation, it was observed that the rate of cooling has an effect on the size of the droplets formed. The rate of cooling has an inverse proportionality to droplet size. Cells prepared by slow cooling had larger droplet sizes compared to those prepared by fast cooling.

It was also determined that the droplet size has an effect on the switching voltage. As the droplet size is increased, the switching voltage decreases.

Samples with fast cooling rate attained higher contrast ratios compared to cells prepared by slow cooling. Although the samples at slow cooling rate needed a lower switching voltage, the samples at fast cooling rate had high values for the contrast ratio.

Further studies have to be made to determine the relation between the concentration of E48 LC's to the droplet size and also between the LC concentration and the contrast ratio.

Acknowledgments

The authors would like to thank Dr. Carlo Mar Blanca for the additional insights he has provided during the analysis of the data as well as for allowing the use of the electro-optic set-up in the Advanced Physics Laboratory. The laboratory is based at the National Institute of Physics, University of the Philippines, Diliman, Quezon City.

References

[1] I. Khoo. *Liquid Crystals: Physical Properties and Nonlinear Phenomena.*
[2] L. M. Blinov & V.G. Chigrinov. *Electrooptic Effects in Liquid Crystal Materials.*
[3] Z. B. Domingo. *Polymer Dispersed Liquid crystal Infrared Shutter.*
[4] Ibid.
[5] G.W. Gray. *Molecular Structure and Properties of Liquid Crystals.*
[6] L.M. Blinov and V.G. Chigrinov *Electrooptic Effects in Liquid Crystal Materials.*