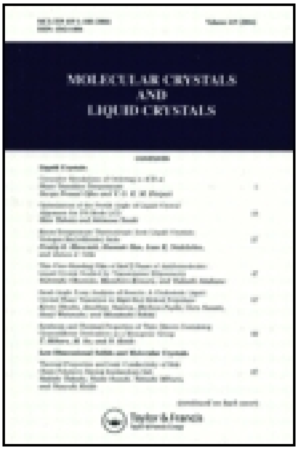

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Effect of Polymer Concentration on the Structure of Cholesteric Liquid Crystal Composites and their Scattering Properties

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Effect of Polymer Concentration on the Structure of Cholesteric Liquid Crystal Composites and their Scattering Properties

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The paper describes an experimental study of the field-controlled light transmittance of composites containing a cholesteric liquid crystal and a crosslinked polymer. Depending on the polymer concentration, a two- or three-stage reorientation process was observed. The influence of polymer concentration on the angular dependence of light transmittance of the LC composites was studied.

Keywords: PDLC; PSCT; polarizing microscope texture

INTRODUCTION

The progress in liquid crystal application for information display has attracted considerable interest to studying liquid crystal (LC) composites with controlled light scattering. Among the variety of LC materials, two types of them proved to be most promising for practical applications: films containing droplets of low-molecular liquid crystals (nematic, cholesteric or smectic) dispersed in a solid polymer matrix (with polymer concentration of 40-60 wt%) - PDLC[1-3], and composites containing a small amount of polymer (2-10 wt%) dispersed in a liquid crystal - PSCT[4-6]. The photopolymerization technique is most frequently used for preparation of such composites. In the present paper, results of an experimental study of LC systems prepared by using the SIPS process and consisting of a cholesteric LC and a cross-linked polymer are reported. Most attention has been concentrated on the effect of cross-linked polymer concentration on the angular dependences of light transmittance for planar and focal conic textures.

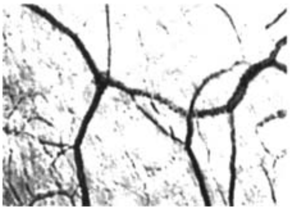
EXPERIMENTAL

Composites and their preparation

The PSCT composite and the PDLC one were formed by the SIPS process[7,8]. A solution of polymer polyvinylpyrrolidone (PVP) in ethanol was used. PVP has a refractive index being close to the ordinary refractive index of LC mixture. A small amount of polymer (2, 6 wt%) was used to form the polymer network in the PSCT composite and 50 % of polymer were used to form the polymer matrix in the PDLC material. A nematic mixture of cyanobiphenyls and oxyalkylcyanobiphenyls ($\Delta\varepsilon>0$) with an optically active chiral dopant 6OFBM[9] (8 wt% of LC) that twisted the structure was used as the cholesteric liquid crystal. The thickness of the LC composites under study was 15 microns. The pitch of the LC composites as determined from its reflection peak was 453 nm.

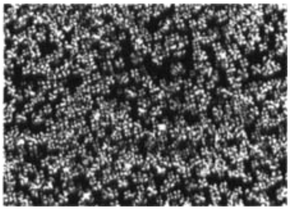
The morphology of the LC composites has been studied by means of polarizing microscopy.

Introduction of 2-6 % of polymer favors the formation of a multidomain system characterized by imperfect planar texture. In the absence of an electric field, the PSCT composites are in a transparent state (Fig.1). When an electric field is applied to the initially transparent planar texture, a transition to a focal conic texture with strong light scattering takes place[10]. As the applied voltage is increased further, the focal conic texture transforms into an electrically induced homeotropic nematic one, and we can visually observe the transition from strong scattering to a transparent state. The threshold voltages depend on the polymer content in the composite. The transition into the focal conic texture for the composite with 2 wt% of polymer takes place at 20 V, while the transition into the electrically induced homeotropic nematic texture at 60 V. The corresponding transitions for the composite with 6 wt% of polymer take place at 35 and 80 V, respectively. An increase in polymer content up to 50 wt% in the composite results in the formation of PDLC. A system of concentrical spherical LC layers in droplets is observed (Fig. 2.). Such composites are characterized by the presence of two states: the light-scattering one (without electric field) and the transparent one (in high field) corresponding to a non-twisted structure. An increase in polymer concentration results in stronger interaction between the cholesteric LC and the polymer. The latter provides an explanation for the occurrence of one reorientation transition and for the increase in the threshold voltage (120 V) for the transition from one state into the other.



100 μm

FIGURE 1 The initial planar texture of the LC composite with 6 wt % of polymer. Crossed polarizers.



100 μm

FIGURE 2 The zero-field texture of the PDLC droplets. 50 wt %. of polymer. Crossed polarizers.

Electro-optical measurements

A schematic representation of the transmitted light measurements is shown in Fig. 3. The experimental setup used for electro-optical measurements has been described elsewhere[8]. A He-Ne laser with λ=632.8 nm was used as a light source. All measurements were performed for normal incidence of light onto the sample, without analyzer in the detection system (mean intensity), the data being normalized to the incident light intensity.

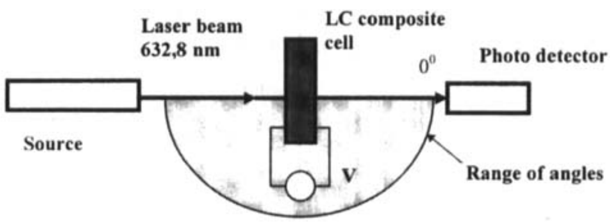


FIGURE 3 Schematic representation of the transmitted light measurements.

Since the light scattering is symmetrical in space about the normal to the sample, all parameters are plotted in one half-plane. The measurements in the range of angles of 170^0 to 180^0 were not taken, since the incident light was screened by the detection system. The transition from the transparent to the scattering state was performed by applying a driving voltage from a regulated power supply.

RESULTS AND DISCUSSION

Figures 4-6 show the angular dependences of the transmittance of PSCT composites with different polymer content (2 and 6 %) for three states of the composite: the initial transparent state with imperfect planar texture, the light scattering state with focal conic texture, and another transparent state with electrically induced homeotropic nematic texture. The angular dependences of the transmitted light intensity for the above three states lie close together, the observed slight difference in the intensity of the transmitted light for composite with 6% of polymer being attributable to higher density of the network. In the composites under consideration, the polymer network exerts a twofold influence. First, with growing polymer content, the number of light-scattering centers increases, thus decreasing the intensity of transmitted light. On the other hand, more dense network should result in more stable planar texture for isolated domain and, consequently, in enhanced light transmission. For the samples studied, an increased transmission has been observed for higher polymer concentrations, which is indicative of the dominating orienting influence of the polymer network at the polymer concentrations under study.

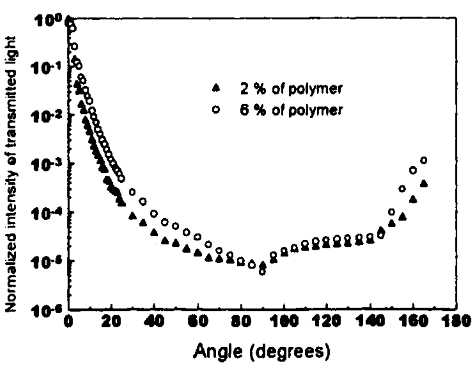


FIGURE 4 Angular dependences of transmitted light intensity of PSCT composites. Initial planar texture.

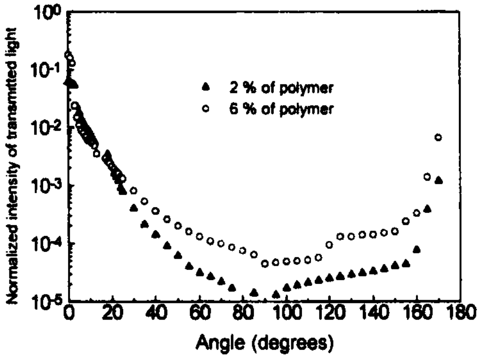


FIGURE 5 Angular dependences of transmitted light intensity of PSCT composites in electric field. The focal conic texture.

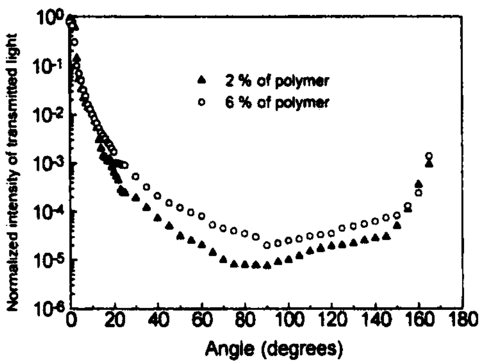


FIGURE 6 Angular dependences of transmitted light intensity of PSCT composites in electric field. The field induced homeotropic nematic texture.

At high polymer concentrations (PDLC), the LC turns out to be enclosed by curvilinear surfaces, which results in multiple scattering of light by droplet boundaries. Owing to the later, the intensity of the transmitted light falls down to 45% of that in the initial state (Fig. 7). For such a composite, the transmittance decreases markedly as the angle varies from 0° to 3°. Sufficiently high transmittance exhibited by the composite in the initial state is apparantly due to the orienting influence of the polymer on the LC texture in the droplets.

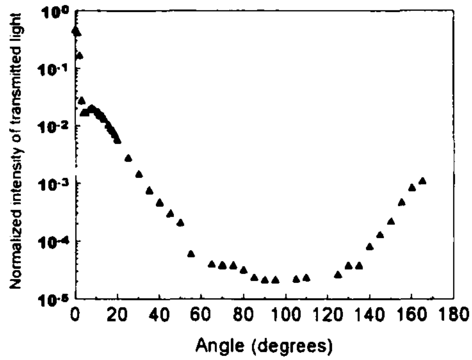


FIGURE 7 Angular dependence of transmitted light intensity of LC composite based on PDLC.

CONCLUSIONS

LC composites consisting of a cross-linked polymer and a cholesteric LC and obtained with the SIPS process were studied, with the emphasis placed on the effect of polymer concentration on the angular dependences of light transmission. The polymer under study is shown to exert a twofolf influence: the light-scattering and the orienting one. For the PSCT composites, the orienting influence of the polymer turned out to be the prevailing one, which results in an increased intensity of the transmitted light as the polymer concentration increases from 2 up to 6 wt%. In the composite with high polymer concentration, the strong orienting action of the polymer matrix brings about a single reorientation transition. On the other hand, the intensity of the transmitted light falls because of strong light scattering from droplet boundaries. Angular dependences of light transmission for the composites studied with different polymer content and different textures lie close together.

Acknowledgments

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