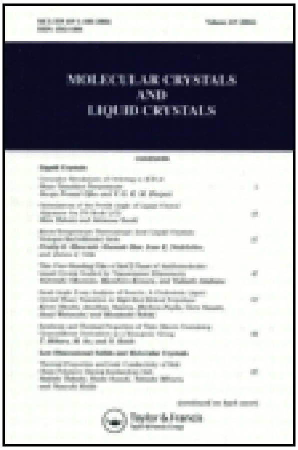

Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

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Version of record first published: 18 Oct 2010

Mol. Cryst. Liq. Cryst., Vol. 412, pp. 513/[2123]–517/[2127], 2004

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400490432308

INVESTIGATION OF MEMORY EFFECT IN DICHROIC DYES BASED PDLC FILMS

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Polymer dispersed liquid crystals (PDLC) films doped by dichroic dyes (DD) with "polymer ball" morphology have been obtained. It has been shown that they possess a "memory effect". The optical characteristics of PDLC films with the "memory effect" have been investigated. The possibility to use this effect for recording and storing an information has been established.

Keywords: dichroic dye; memory effect; morphology; PDLC films

INTRODUCTION

PDLC films attracted the attention as new class of materials suitable for light valves and displays [1–4]. PDLCs are composite materials made from polymers and liquid crystals (LC). Micron-sized droplets of nematic LC (NLC) are distributed inside a transparent polymer film and typically possess a highly scattering "off-state". PDLCs can be switched from the opaque ("off-state") to the transparent ("on-state") by the application of an external electric field. After removal of the applied voltage, the film returns to its original opaque state. Usually PDLC devices do not exhibit any significant hysteresis. PDLC films with dichroic dye (DD) dissolved in the liquid crystal (dichroic-dye-based PDLC) possess a controllable absorbance and a controllable scattering as well. This combination can be used to produce high contrast displays [5].

The work was supported by European Community in the frame of the INCO Copernicus Concerted Action "Photocom", under Contract No. IC15-CT98-0806. One of the author (T.S.I.) is very grateful to the Organizing Committee of 19-th ILCC for the financial support.

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Three methods of PDLC films preparation are described in the literature: the first one consists in filling the polymer micropores with a liquid crystal [6], the second one involves the formation of PDLC films from an aqueous emulsion [1], the third way to prepare these films is the polymerization-induced phase separation (PIPS), which occurs when a homogeneous mixture of monomers/oligomers and LC is polymerized [3,4]. The initiator for PIPS method is either UV-light or temperature.

As it is known from the literature [7,8], there are present two types of PDLC morphology: "Swiss cheese" and "polymer ball". The last one possesses the so-called "memory effect". The mechanism of polymerization with PIPS method initiated by UV light is the radical one. It is possible to choose the desirable morphology, using the special substances for regulation of the chain growing. A chain polymerization provides the "polymer ball" morphology, whereas a step mechanism leads to "Swiss cheese".

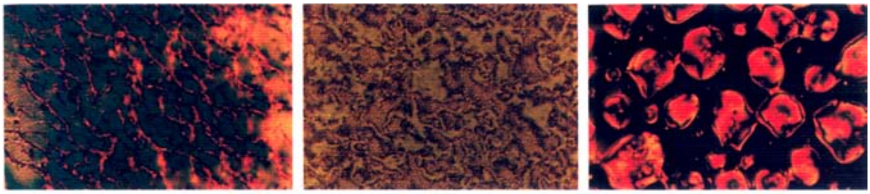
In our previous works [9,10] we have prepared and investigated dichroic dyes based PDLC films with "polymer ball", "Swiss cheese" and "mixed" morphologies (Fig. 1). We have shown that in the presence of DD only PDLC films with "polymer ball" morphology possess a "memory effect", whereas without DD also films with "mixed" morphology exhibit this effect.

In recent years, PDLC films have also been identified as suitable media for optical storage [11,12].

The aim of the present work is to investigate the optical characteristics of PDLC films with the "memory effect" and to understand the possibility to use this effect for recording and storing an information.

EXPERIMENTAL

In our work we used PIPS method with UV initiation for the preparation of the dichroic-dye-based PDLC films [9]. As NLC material we used ZhKM-1289. As dichroic-dye-guest in LC material KD-184 was used. Both are commercial products of NIOPIK. The solution was placed in the cell, made



a b c

FIGURE 1 PDLC films with different morphologies shown by polarizing microscopy: a – "polymer ball" morphology; b – "mixed" morphology; c – "Swiss cheese" morphology. (See COLOR PLATE VIII)

TABLE Transmittance vs. Applied Voltage for PDLC Films

Sample	T_0%	T_{75}%	T_{75}-m%	T_{150}%	T_{150}-m%
A	0.06	30	4	45	10
B	0.07	46	7	57	20

T_0 is the transmittance of PDLC film at 0 voltage; T_{75} and T_{150} are the transmittances of PDLC film at 75 V and 150 V respectively; T_{75}-m and T_{150}-m are the transmittances in the "memory state" after application of 75 V and 150 V.

with two glass plates covered by ITO. The conductive layer was made as three separated stripes. The first stripe was used as a reference and the voltage was not applied to it. To the second ITO stripe it was applied a voltage equal to 75 V, to the third one –150 V.

The electro-optical properties were measured using a He-Ne laser (632.8 nm, 1 mW) and a silicon photodiode. The laser beam was transmitted through the PDLC sample and directed with normal incidence with respect to the sample. The PDLC cell was driven by a sinusoidal voltage with frequency equal to 1 kHz.

The results of the measurements are presented in the Table and on the Figures 2 and 3.

RESULTS AND DISCUSSION

The optical characteristics of PDLC films with- and without DD are presented in the table. For the sake of simplicity we will call sample A – the PDLC films without DD, and sample B – the PDLC films doped by KD-184.

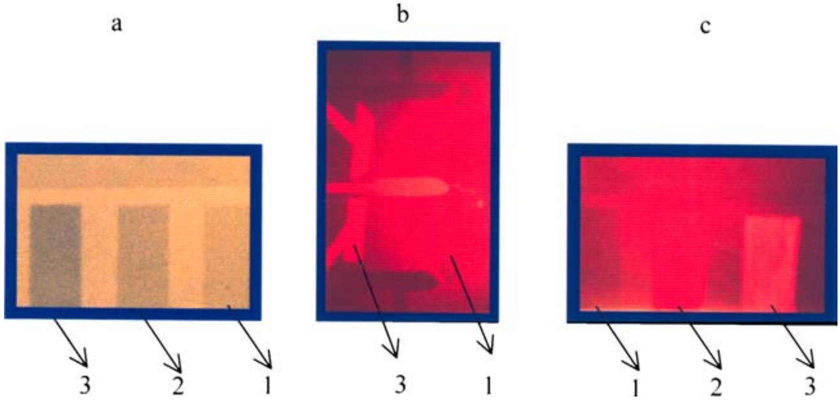


FIGURE 2 "Memory effect" in PDLC films. a – sample A; b, c – samples B; 1 - without application of the voltage; 2 – after application of 75 V; 3 – after application of 150 V. (See COLOR PLATE IX)

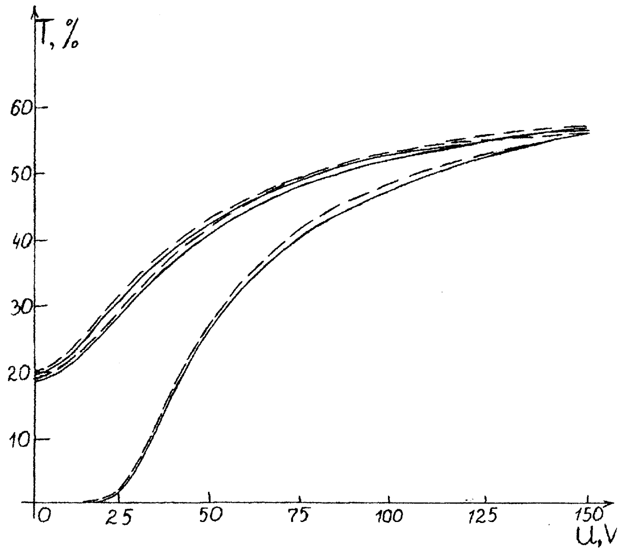


FIGURE 3 Transmittance *vs.* applied voltage for sample B. Multiply repetition of the heating and voltage application. Solid lines denote to the sample after 1 min of heating, dotted lines denote to the sample after 20 min of heating.

As it is evident from the table, the transmittance for both samples is higher after application of 150 V in the "on-state" as well as in the "memory-state". The fact that the transmittance for the sample B is higher than for sample A was unexpected. The explanation of this fact can be the following: the optical properties of the samples were measured using He-Ne laser (632.8 nm) and the dye doesn't absorb at this wavelength. At the same time, the dye possibly is playing the role of sensibilisator in the polymerization process, what increases the polymerization rate and leads to PDLC films with less scattering.

The possibility to store the information by using the "memory effect" is shown on the Figure 2.

In order to use the "memory effect" for recording the information, it was chosen 150 V as a working voltage. We have applied this voltage to the samples during 1 s, 5 s, 20 s and 600 s. After 5 s it was the maximum transmittance of the "on-state" and of the "memory state" as well.

The transmittance of the films was decreased after removing the voltage from "on-state" to "memory state" during 45s from 45% to 10% for sample A and from 57% to 20% for sample B.

The transmittance of both samples was permanently measured in "memory state" during seven months.

The maximum change for the sample B was from 20% to 18%, and for the sample A from 10% to 9%. So, we can conclude that the storage of information with the help of "memory effect" is very promising.

Our next step was the investigation of the possibility to erase the stored information and to rewrite it again. In order to erase the information the samples were heated to 80°C (clearing point of ZhK-1289 = 62°C) from 30 s to 20 min. We realized that it is enough 1 min for the complete erasing of the information. The optical characteristics of the sample after heating are completely equal to the initial "off-state". After the second application of the voltage (150 V) we obtained the same transmittance of the sample B "on-state" (57%) and for the "memory state" (20%). The multiple repetition (8 times) of the heating and the voltage application does not change the optical characteristics of the samples (Fig. 3). This is valid for both samples A and B.

In order to increase the transmittance both in "on-state" and in "memory-state" we varied the polymerisation conditions. The best transmittance what we obtained for B-type samples was 70% in "on-state" and 48% in "memory-state". The transmittance optimization will be the subject of our further research.

CONCLUSIONS

The optical characteristics of PDLC films with "memory effect" were investigated. It was shown that this effect could be very useful for the information storage. It is possible to erase and to restore many times the information without any change of optical characteristics of PDLC films.

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