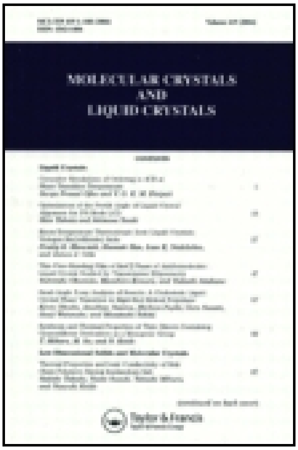

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

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

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Version of record first published: 04 Oct 2006

Mol. Cryst. Liq. Cryst., 1999, Vol. 331, pp. 173-179
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We have performed a preliminary study by light transmission of the electro-optical behaviour of several cells prepared either from hydroxypropylcellulose (HPC) or HPC with cellulose acetate (CA) (1% w/w) cross linked in both cases with 1,4-diisobutanocianate (BDI) (7%w/w) and different concentrations of a commercial nematic liquid crystal mixture with varying optical anisotropies. The optical response when the cells are subjected to a short ac electric pulse of variable intensity is presented and correlated with the use of CA and the optical anisotropy of liquid crystal mixture used in the cells. It was found that cells with CA exhibit much larger contrasts but also a small decrease of the maximum light transmission when compared with cells without CA. The anisotropy of the liquid crystal mixture is seen to have a strong influence on the electro-optical behaviour of the cells prepared with CA. From scanning electron microscopy (SEM), we found in the surface of the solid films prepared with CA some heterogeneities and porous (2μm) that can be responsible for the strong increase in the contrast observed.

Keywords: Solid films of crosslinked cellulose derivatives; liquid crystals; PDLC; electro-optical properties

INTRODUCTION

Composite materials formed by a liquid crystal and a polymeric matrix may give rise to relevant systems for electro-optical applications like the widely known PDLC systems [1-4]. In this work we studied a cellulose derivative based composite material in an electro-optical application [5,6]. The cellulose derivative based PDLC system differs from the usual PDLCs in the distribution of the liquid crystal, which is not confined to droplets as in usual PDLCs. The cellulose derivative based PDLC optical cells are constituted by a thin rugous polymeric film with both surfaces covered by a liquid crystal layer and the set placed in between two conducting transparent glass plates. The results so far obtained in these systems [5,6] show a high transparency in the on state without haze, a very weak angular dependence, a good temporal stability and acceptable contrast ratios which may challenge usual PDLC systems for window applications. The preliminary results reported in this study refer to the influence of the optical anisotropy of the nematic liquid crystal and the presence of 1.0% w/w of cellulose acetate (CA) in the polymeric matrix of hydroxypropylcellulose (HPC) cross linked with 1,4-diisobutanocianate (BDI) (7.0%w/w) on the electro-optical behaviour of the cells.

EXPERIMENTAL

HPC (commercial reagent grade-Aldrich Mw=100000 $gmol^{-1}$) and CA (Mw≈ 12.000 $gmol^{-1}$, acetyl content =38.9% fractionated as in [7]) powders were dried in vacuum at 50°C for about 48 hours. All solvents used were of commercial reagent grade and were used without further purification. Two kinds of solid films were prepared. The first type was obtained from solutions of HPC with the cross link agent 1,4-diisocyanatobutane (BDI) (Aldrich) and acetone (Pronalab) according to the procedure described previously [5]. The second type was prepared from a mixture of CA (1.0% w/w) and HPC stirred with a glass rod with acetone (10-20% w/w) for two days. The mixture was then stored in a refrigerator (T≈10°C) for two weeks. The reaction with BDI (7.0% w/w) was performed, under nitrogen atmosphere, for two hours. HPC/CA cross linked solid films were spread on a flat parafilm with the help of a calibrated ruler (0.5mm), and the solvent was allowed to evaporate for 4 days in a laboratory atmosphere (25 °C). The nematic mixtures used were the Merck E2100.000 (Δn=0.1367 at 20°C), E2100.100 (Δn=0.1713 at 20°C) and a 50% mixture by volume of those two. The voltage dependence of light intensity transmission coefficient was measured using a Helium-Neon laser equipped with a × 5 beam expander and an AC controllable generator. AC pulses of convenient duration and amplitude where applied to the samples allowing both the voltage dependence of the light transmission coefficient and the turn on and off times to be measured. The results reported were obtained for normal sample incidence at an ambient temperature of 25 °C. The use of the beam expander was required to decrease the effects of sample inhomogeneity.

RESULTS AND DISCUSSION

A total of 6 cells were studied. Three cells were assembled with the polymeric film containing HPC/CA cross linked and the other three from a normal film of HPC cross linked. The cells in each set differ in the optical anisotropy of the liquid crystal used.

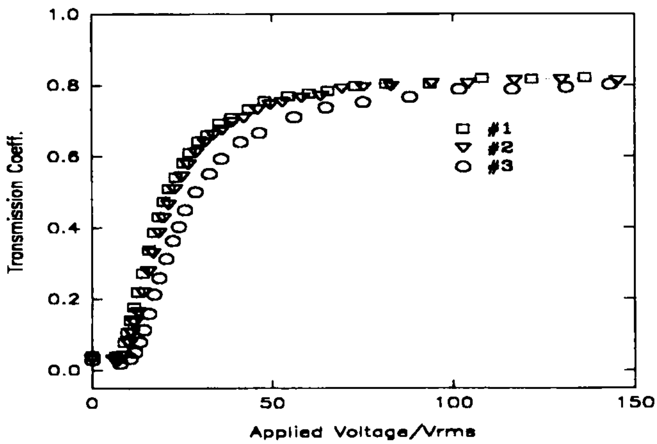

FIGURE 1 Voltage dependence of the light intensity transmission coefficient obtained in samples #1, #2 and #3.

In Fig. 1 the voltage dependence of the transmission coefficient for the three cells prepared from a standard film is presented. The three curves are similar and this indicates that the differences in the optical anisotropy of the mixtures used are not very important for the characteristics of the on state in these samples such as maximum transmission and turn-on voltage. The observed differences may partially have its origin in inhomogeneities present in the film used to prepare those three samples. A summary of the electro-optical properties of these three samples is found in table 1, different values in turn on voltage and turn on time are shown for sample 3 compared to 1 and 2 and this may have its origin partly in the active area of sample 3 which is twice as large as the other two areas. A tendency for the increase in contrast with the increase in optical anisotropy is also observed.

TABLE 1 Summary of the electro-optical properties of the samples studied. The contrast is defined as the ratio between the maximum transmission in the transparent state and the lowest transmission in the opaque state. Von is the applied rms voltage necessary to reach 95% of the maximum transmission. ton is the time spent on going from 10% to 90% of the maximum transmission for an excitation of amplitude Von, toff is the time spent on going from 90% to 10 % after removal of the excitation with amplitude Von.

Sample	CA	Δn (20°C)	Film thick. (μm)	Von (Vrms)	Max. Trans.	Contrast	ton (ms)	toff (ms)
#1	No	0.1367	34	57	0.81	19	5	20
#2	No	0.1542	33	59	0.81	23	4	17
#3	No	0.1713	34	71	0.79	27	31	15
#4	Yes	0.1367	15	43	0.75	34	8	20
#5	Yes	0.1542	21	56	0.80	86	13	12
#6	Yes	0.1713	20	73	0.70	170	21	8

Figure 2 shows the voltage dependence of the light transmission coefficient for the three samples prepared from the film HPC/CA cross linked. Discrepancies between the three curves are now more pronounced than in the previous case. The presence of CA increased the degree of film inhomogeneities and influenced its optical properties. Table 1 also presents the summary of the electro-optical properties of the three samples. The most significative feature is the large increase in contrast with increase in optical anisotropy of the liquid crystal.

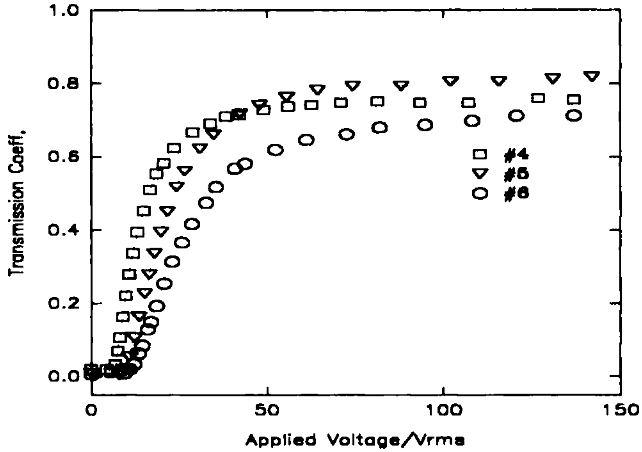

FIGURE 2 Voltage dependence of the light intensity transmission coefficient obtained in samples #4, #5 and #6.

The presence of CA in the polymeric film created a strong dependence of the contrast on the optical anisotropy of the mixture used and produced increases in contrast values when compared with cells prepared with films without CA. These results are not readily seen when comparing figures 1 and 2 since the linear scale used for the transmission doesn't differentiate well between the different low light transmission values in the cells' opaque state. The principal differences between the electro-optical behaviour of the cells with and without CA can only be fully appreciated in table 1. Figures 3 and 4 show scanning electron microscope (SEM) views of the free surfaces of the two types of films used, the presence of CA strongly altered the morphology of the films' free surface. The irregularities produced in the polymeric film surface by the presence of CA seem to be introducing larger variations in the nematic director orientation in the liquid crystal layers, increasing the scattering efficiency in the off state. An average decrease of the maximum transmission of the cells is also seen when CA is used but a fine tune of the percentage of CA in the polymeric film may attenuate this effect. The use of CA seems to be a root to improve the optical properties in these systems in particular the scattering efficiency in the off state and consequently allow an increase in the cells' contrast.

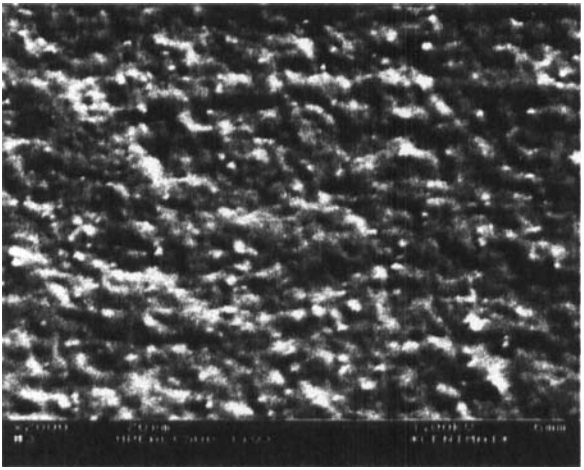

FIGURE 3 Scanning electron microscopy (SEM) photograph of the free surface of the film with CA.

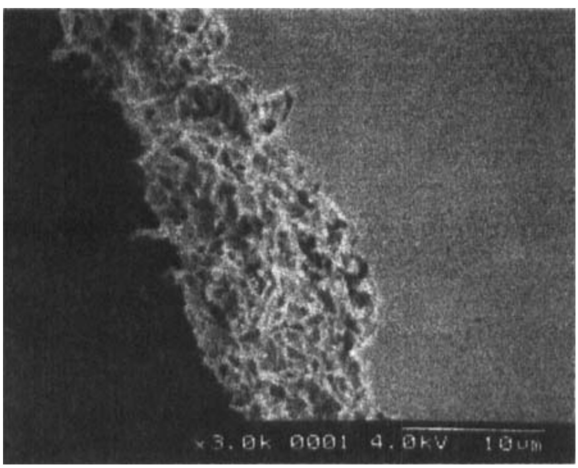

FIGURE 4 Scanning electron microscopy (SEM) photograph of the free surface of the film without CA.

Acknowledgements

This work was supported in part by PRAXIS XXI, Portugal, under contract number 3/3.1/CEG/2620/95.

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