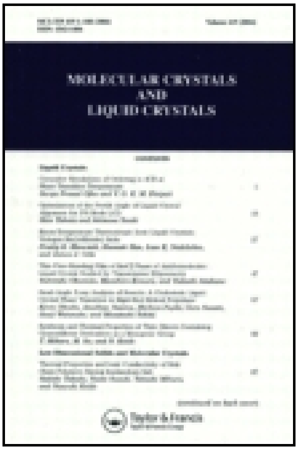

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Preliminary Results on UV and High Temperature Exposure Effects on the Electro-Optical Properties of Cellulose Derivatives Based PDLC Type Cells

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In this work we have studied, by light transmission, the effects of either UV or high temperature exposure on the electro-optical properties of cellulose derivatives based PDLC type cells prepared from hydroxypropylcellulose (HPC) and HPC cross-linked with 1,4 – diisocyanatobutane (BDI) (7,0 % w/w). The time evolution of the electro-optical properties of different cells, some under UV exposure, and others under high temperature (65 °C), was recorded for times up to 7 days. Two sets of cells were analysed, one with electric field off during exposure, the other with electric field on. The results obtained show that no significant changes of the electro-optical properties of the cells occurred under the studied conditions, meaning that these systems are very stable and so good candidates for industrial applications.

Keywords: Solid films of Cellulose Derivatives; PDLCs; Electro – Optical properties

INTRODUCTION

A cellulose derivative based polymeric matrix combined with a nematic liquid crystal [1-4] may form a very interesting type of composite material with application in PDLC type electro-optical cells. These systems differ from the usual PDLCs [5-7] in the distribution of the liquid crystal, which is not confined to droplets. The cellulose derivative based PDLC optical cells are composed of 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. These systems have shown relevant electro-optical properties along with good temporal stability and acceptable contrast ratios that may challenge usual PDLC systems for window applications. The studies carried on so far have focused mainly on the optimisation of the electro - optical properties of these cells [1-4]. To access the long-term stability of these systems under normal working conditions, studies of the evolution of the electro-optical properties under severe external conditions such as UV and high temperature exposure had to be performed. The preliminary results reported in this study refer to the influence of high temperature (65 °C) and UV radiation exposure for up to seven days on the electro-optical properties of cells made from either HPC or HPC+BDI solid films and the commercial nematic mixture E7.

EXPERIMENTAL

The solid films were prepared from solutions of hydroxypropylcellulose (HPC) (commercial reagent grade – Aldrich – M_W = 100000gmol^{-1}), with acetone (commercial reagent grade – Pronalab – without further purification) and 1,4-diisocyanatobutane (BDI) (Aldrich) was used as a cross–linking agent. Two kinds of films were made according to the procedure described previously [1]. The first kind was prepared with cross-linking agent, and the second without BDI. In both cases, the HPC percentage was 12% w/w.

The solid films were obtained from spreading the solutions on a flat parafilm by means of a calibrated ruler (0.5 mm), moving at a constant speed of 20 mm/s. The solvent was allowed to evaporate for 2 days in a laboratory atmosphere (25 °C), and the HPC and HPC cross-linked solid films were obtained. A commercial nematic mixture (E7-Merck) was used for cell preparation. The thickness of the liquid crystal layers was set by 10 μm spacers.

The voltage dependence of the light intensity transmission coefficient was measured using a x5 beam expander equipped helium-neon laser and an AC controllable generator. AC pulses of convenient duration and amplitude were applied to the samples, allowing the voltage dependence of the light intensity transmission coefficient and the turn on time to be measured.

In order to study the evolution of the electro-optical properties of the cellulose based PDLC type cells under UV and high temperature exposure, we have prepared two sets in a total of 12 cells, 6 from cross–linked HPC films and 6 from HPC films. Half of the cells of each set were submitted to UV and the other half to high temperature (65 °C) for up to a period of a week. In each subset one cell was also under an applied AC voltage close to its turn on voltage during the all exposure process. The UV light source used is equipped with a G8T5 8 Watts lamp, radiating in between 200 and 300 nm and was placed

10 cm away from the samples. Measurements of the electro-optical properties were then performed at regular time intervals.

RESULTS AND DISCUSSION

Table 1 lists the experimental conditions for the 12 cells studied. The time evolution of the light intensity transmission coefficient (maximum and minimum) and the turn on voltage is reported in figures 1 to 4 for cells number 1 to 8. Cells 9 to 12 were used in a 24 hour continuous measuring experiment of the light intensity transmission coefficient with $V \approx V_{on}$ and $V=0$ at $T=50$ °C and the results are reported in figure 5.

TABLE 1 Experimental conditions for the studied cells.

Sample number	BDI	Voltage during	Type of exposure	Film Thickness (μm)
1	Y	0	Temperature (65 °C)	25
2	N	0	Temperature (65 °C)	20
3	Y	$\approx V_{on}$	Temperature (65 °C)	27
4	N	$\approx V_{on}$	Temperature (65 °C)	22
5	Y	0	UV	24
6	N	0	UV	21
7	Y	$\approx V_{on}$	UV	25
8	N	$\approx V_{on}$	UV	22
9	Y	0	Temperature (50 °C)	24
10	N	0	Temperature (50 °C)	21
11	Y	$\approx V_{on}$	Temperature (50 °C)	26
12	N	$\approx V_{on}$	Temperature (50 °C)	20

The dashed lines in all graphics are only guides to the eye. V_{on} is the applied rms voltage necessary to reach 90% of the maximum transmission obtained in the sample. The transmission coefficient is defined as the ratio between the intensity of the transmitted light through the sample and the intensity of the incident light on the sample.

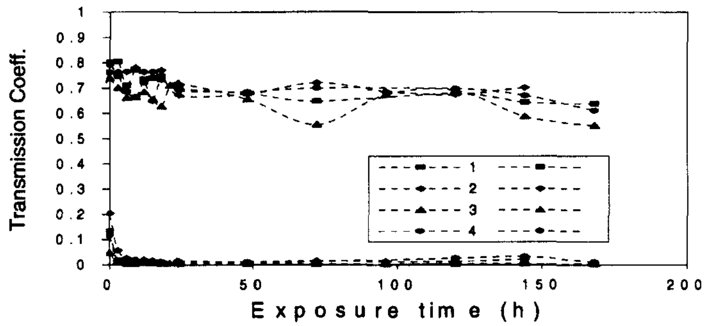

FIGURE 1: Maximum and minimum transmission coefficient vs time of exposure to high temperature (65 °C).

The data shown in figures 1 to 4 exhibits some oscillations that are more pronounced in the V_{on} curves. These oscillations are in part due to sample inhomogeneities since the measuring area in each sample was not rigorously the same for all the measurements performed in that sample. The light intensity transmission coefficient data reported in figures 1 and 2 shows that the maximum transmission has values around 0.7 and shows a slight average decrease with time. Strong differences between the different samples are not observed. The minimum transmission shows a significant decrease with time at early times in the high temperature exposed samples (1 to 4) leading to significant increases in the contrast values.

The V_{on} data reported in figures 3 and 4 shows in average larger values for the temperature exposed samples, further results need to be obtained to check this tendency for which a plausible explanation is still not available. In the UV exposed samples the cross-linked films show higher values of V_{on} what can in part be attributed to a higher constraint of the liquid crystal at the film surface.

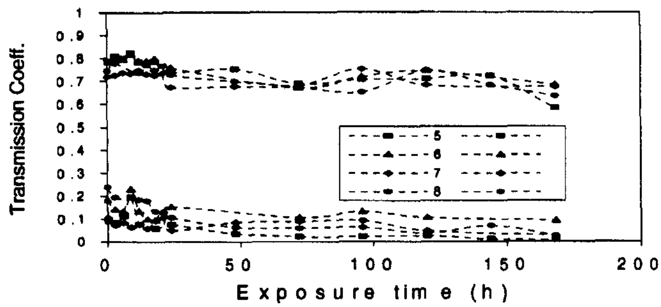

FIGURE 2: Maximum and minimum transmission coefficient vs time of exposure to UV radiation.

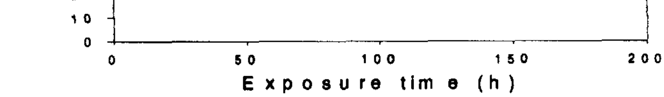

FIGURE 3: Voltage V_{on} vs time of exposure to high temperature (65 C).

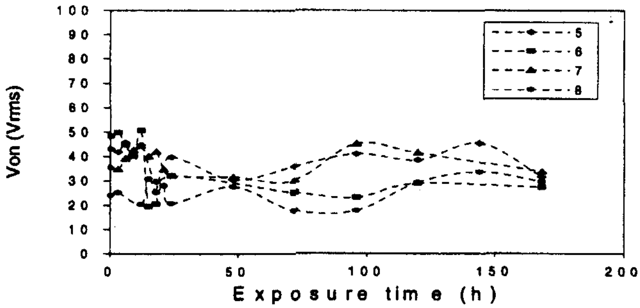

FIGURE 4: Voltage V_{on} vs time of exposure to UV radiation.

The contrast, defined as the ratio between the maximum transmission in the transparent state and the lowest transmission in the opaque state, exhibits lower values for the UV exposed samples (5-40) than in the high temperature exposed samples (50-250) and in those the cross-linked films produce larger contrasts. No specific time trends was detected in the contrast curves.

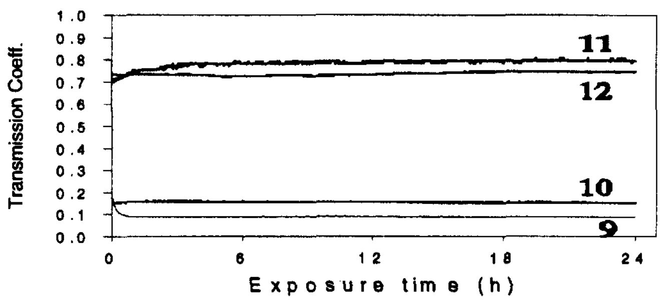

FIGURE 5: Transmission Coefficient with $V=V_{on}$ and $V=0$ vs time of exposure to high temperature (50 °C).

t_{on} , defined as the time spent on going from 10% to 90% of the maximum transmission for an excitation of amplitude V_{on} , is in between 5 and 10 ms for the samples studied, and shows no significant time trends.

No traces of sample ageing are visible in the data presented.

Figure 5 shows the time dependence of the light intensity transmission coefficient obtained in samples 9 to 12 over a 24 hours period. Only the cross-linked film cells show some variation in the early times, which may indicate some chemical reaction occurring in the sample at early times. In future work the solid films will be submitted to high temperature cycles prior to cell assembly, to establish the origin of these phenomena.

The results presented are a strong indication of the good temporal stability of the cellulose derivative based PDLC type cells. They also show that the initial exposure of the cells to high temperature may be beneficial to their electro-optical performance. Studies of the time evolution of the electro-optical properties over larger periods of time, in these systems, are now in progress.

Acknowledgements
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References

[1] M.H. Godinho, A.F. Martins, J.L. Figueirinhas, *Liquid Crystals*, **20**(3), 373 (1996).
[2] M.H. Godinho, J.L. Figueirinhas, A. Almeida, A.F. Martins, *Proc. of EUROMAT 97*, **2**-111 (1997).
[3] M.H. Godinho, A.F. Martins, J.L. Figueirinhas, *Optical Materials*, **9**, 226 (1998).
[4] M.H. Godinho, C. Costa, J.L. Figueirinhas, *Mol. Cryst. Liq. Cryst.*, **331**, 173 (1999).
[5] J.L. Fergason. SID *Int. Symp. Digest Tech. Papers*, **16**, 68 (1985).
[6] J.W. Doane, N.P.Vaz, B.-G. Wu, and S. Zumer, *Appl. Phys. Lett.* **48**, 269 (1986); J.W.Doane, *Liquid Crystals-Applications and Uses*, **Vol. 1** (W. S. P.), p. 361 (1990).
[7] H. S. Kitzerow, *Liquid Crystals*, **16**(1), 1 (1994).