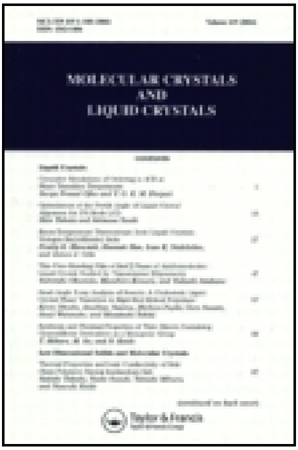

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Light Scattering Studies in Cellulose Derivative Based PDLC Type Cells

P. L. Almeida [a], M. T. Cidade [a], M. H. Godinho [a], A. C. Ribeiro [a b] & J. L. Figueirinhas [b c]

[a] Dept. Ciĕncia dos Materiais and CENIMAT, FCT/UNL, Quinta da Torre, 2825-114, Monte de Caparica, Portugal

[b] CFMC, Av. Professor Gama Pinto 2, 1649-003, Lisboa, Portugal

[c] Dept. Física, IST, Av. Rovisco Pais, 1049-001, Lisboa, Portugal

Version of record first published: 24 Sep 2006

Mol. Cryst. and Liq. Cryst., 2001, Vol. 359, pp. 79-88
Reprints available directly from the publisher
Photocopying permitted by license only

Light Scattering Studies in Cellulose Derivative Based PDLC Type Cells

P.L. ALMEIDA[a], M.T. CIDADE[a], M.H. GODINHO[a], A.C. RIBEIRO[bc] and J.L. FIGUEIRINHAS[bc]

[a]*Dept. Ciência dos Materiais and CENIMAT, FCT/UNL, Quinta da Torre 2825 – 114 Monte de Caparica, Portugal;,* [b]*CFMC, Av. Professor Gama Pinto 2, 1649 – 003 Lisboa, Portugal and* [c]*Dept. Física, IST, Av. Rovisco Pais, 1049 – 001 Lisboa, Portugal*

In this work we have analysed the light scattering pattern produced by the cellulose derivative based PDLC type cells [1–5] when illuminated at normal incidence by a laser light beam. The voltage dependence of the scattering pattern was obtained along with the voltage dependence of the cells' transmission coefficient. Two different types of cells were studied, one assembled with films of hydroxypropylcellulose (HPC), and the other assembled with films of HPC and cellulose acetate (CA) (9.1% w/w), both cross linked and not.

The presence of CA, which was seen to affect the films' surface increasing significantly its rugosity [6], is correlated with the scattering patterns obtained. The light scattering results are globally analysed in terms of their implications for the optimisation of electro-optical properties of these types of cells.

Keywords: Solid films of cross-linked cellulose derivatives; liquid crystals; PDLC; electro-optical properties; light scattering

INTRODUCTION

Composite materials where a nematic liquid crystal and a cellulose based polymeric matrix are put together in a particular fashion give rise to relevant systems for electro-optical applications exhibiting electro-optical properties similar to those of standard PDLC systems [1-4].

The cellulose derivative based PDLC like system (CPDLC) uses a liquid crystal distribution different from usual PDLCs, where the liquid crystal is confined to droplets. The CPDLC optical cell is constituted by a thin rugous polymeric film covered in both surfaces with a liquid crystal layer and placed in between two conducting transparent glass plates [5-8]. The electro-optical properties registered in these systems [5-8] challenge classical PDLCs for window applications.

In this study we report the light scattering pattern obtained in these systems when illuminated at normal incidence by a laser light beam. The voltage dependence of the scattering pattern was obtained as well as its dependence upon the types of polymeric films used in the cells. The presence of 9.1% w/w of cellulose acetate (CA) in the hydroxypropylcellulose (HPC) matrix and the effect of cross linking with 1,4-di-isocyanatobutane (BDI) (7.0%w/w) were analyzed.

This is the first light scattering study in CPDLC systems and it will help to clarify the role of the different types of the polymeric films used on the light scattering properties in these systems.

EXPERIMENTAL

The cellulose derivatives, HPC (Aldrich, Mw=100 000 gmol-1) and CA (Mw=12 000 gmol-1; acetyl content = 38.9% fractionated as in [9]) were dried in vacuum at 50°C for about 48 hours before use. Solutions of HPC and HPC/ AC in acetone were prepared (see ref. [5]).

Two sets of solid films were made. The first one was obtained from solutions of HPC (sample #1) and HPC/CA (9.1% w/w) (sample #3) in acetone. The second one was prepared by promoting the reaction of the cross linking agent 1,4-diisocyanatobutane (BDI) (7% w/w) with HPC (sample #2) and HPC/CA (9.1% w/w) (sample #4) according to the procedure described previously [5, 6].

The nematic liquid crystal mixture used was the commercially available E7 (Merck Ltd. UK). The thickness of the liquid crystal layers was maintained by 10 μm spacers.

The light scattering pattern was obtained with the help of a Helium-Neon laser (λ=0.6328 μm), a goniometer and an optical bench equipped with a photomultiplier light detector. An AC controllable generator was used to set the voltage applied to the samples. All measurements were performed at a room temperature of 24 °C.

RESULTS AND DISCUSSION

Scattering patterns were recorded by measuring the angular dependence of the scattered light for both parallel and perpendicular polarizations, for several levels of voltage excitation. Figures 1 to 4 report the results obtained with the four samples for parallel polarization. Each set of data points corresponds to a different applied voltage to the sample, the dotted lines are guides to the eye. Bellow 0.2° the recorded pattern is a mixture of scattered and transmitted light, for 0.2° and above a pure scattering pattern is obtained. The scattering patterns obtained in the different samples are similar, suggesting that the dominant light scattering mechanism is the same in all cells and thus not strongly dependent on the type of polymeric film used.

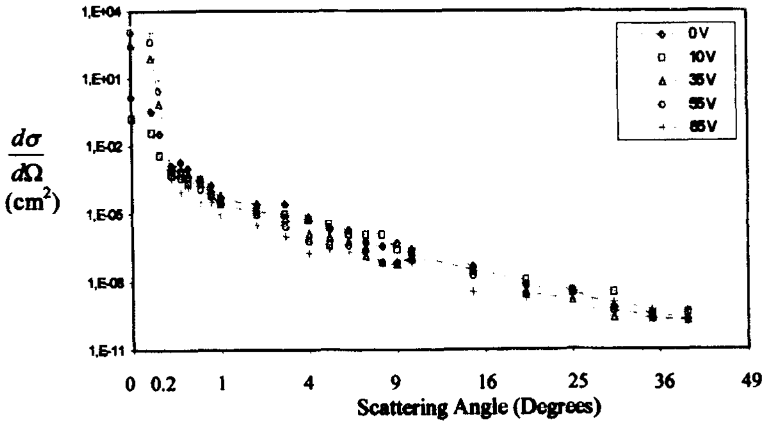

FIGURE 1 Angular dependence of the differential cross section for sample #1.

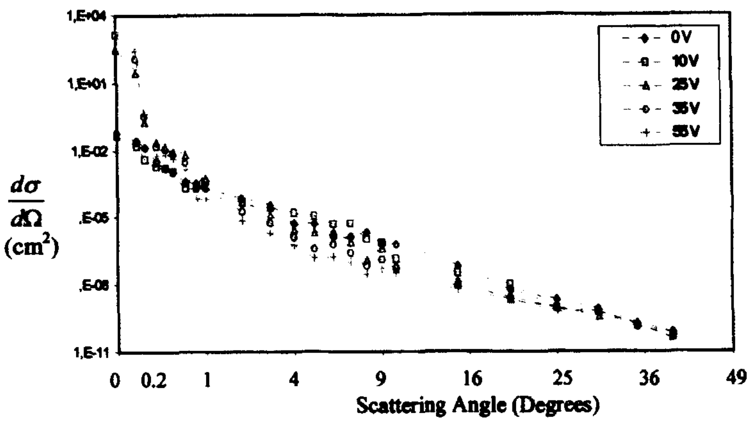

FIGURE 2 Angular dependence of the differential cross section for sample #2.

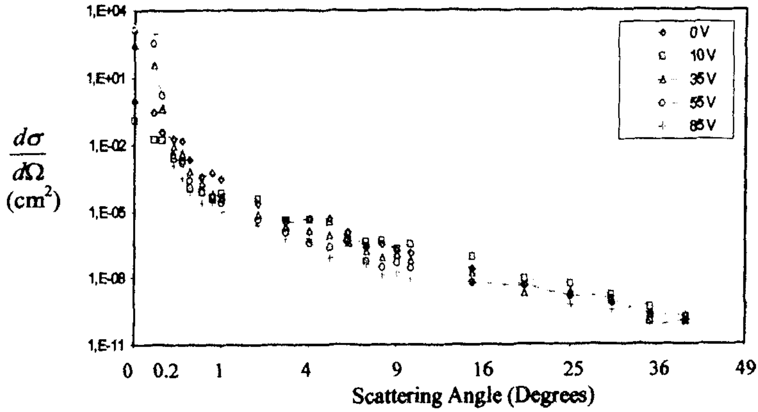

FIGURE 3 Angular dependence of the differential cross section for sample #3.

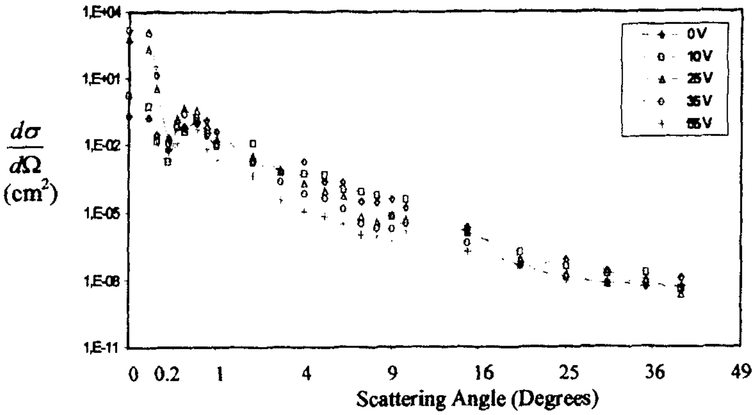

FIGURE 4 Angular dependence of the differential scattering cross section for sample #4. In this figure and the previous three, the three highest voltages correspond to transmission coefficients of respectively ¼, ½ and ¾ of the samples maximum transmission.

The data obtained in the four samples studied reveals that the scattered light is concentrated at small angles. This is compatible with a "scenario" where variations of the director over lengths larger than the wavelength of the laser light are the most efficient scatterers. As expected, for scattering angles larger than 1° the scattering is more efficient in the opaque state (V=0 volt) or at V=10 volt where the transmission coefficient is minimum. From the comparison of the results obtained with the four samples studied it can be seen that the most efficient scattering is obtained with sample #4. This result is in agreement with previous results [6] where it was shown that the presence of CA in a cross linked film significantly alters its morphology, increasing the films' rugosity as is shown in figures 3 and 4 of [6].

The cross linking of the polymeric film by its own is also a relevant factor for the scattering efficiency as samples #2 and #4 show, yielding better results than samples #1 and #3 respectively. The data for perpendicular polarization exhibits similar trends. Figure 5 shows the voltage dependence of the transmission coefficient obtained in the four studied samples. The samples prepared with the cross linked films exhibit the highest transmission coefficients.

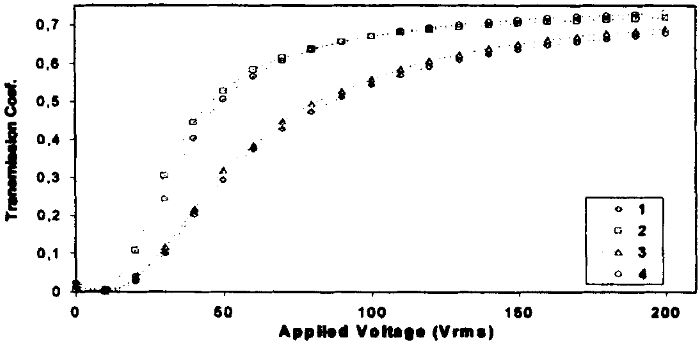

FIGURE 5 Voltage dependence of the transmission coefficient in samples #1 to #4.

Figure 6 shows the voltage dependence of the scattering pattern for specific angles obtained in sample #4. As it can be seen the scattering intensity variation with applied voltage decreases with

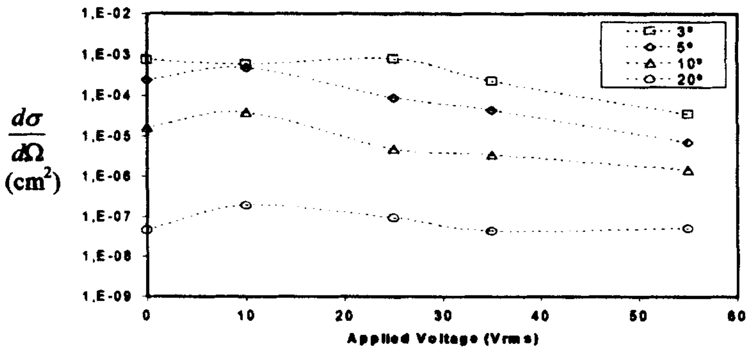

FIGURE 6 Voltage dependence of the differential scattering cross section for sample #4 at specific scattering angles.

increasing scattering angle. A similar behavior was detected for the other studied samples. This result seems to indicate that the large angle scattering is mainly produced by director field variations, that are only slightly affected by the applied electric field, as for instance those occurring close to the polymer and glass surfaces. For voltages higher than those corresponding to transmission coefficients of ¼ of the maximum transmission (25 Volts for sample #4), the scattering intensity for larger angles is almost independent of applied voltage. At this level of excitation the variation of transmission coefficient with applied voltage is only matched by opposite variations of the scattered intensity for very low scattering angles. This result is compatible with a mechanism where the transmission coefficient variations at this level of excitation are dominated by refractive index mismatches between the core of the nematic layers partially oriented by the field and their surfaces.

The light scattering results just presented point out sample #4 as the most efficient in the scattering of light in the opaque state, reinforcing the position of the cross linked HPC film with CA as the best material for these types of optical cells.

Acknowledgements

This work was partially supported by PRAXIS XXI, Portugal, under contract number 3/3.1/CEG/2620/95. P.L. Almeida wishes to thank partial support from the PRAXIS program grant no. PRAXIS XXI BD 17071/98.

References

[1] J.L. Fergason, SID *Int. Symp. Digest Tech. Papers,* **16,** 68 (1985).
[2] J.W. Doane, N.P.Vaz, B.-G. Wu, and S. Zumer, *Appl. Phys. Lett.* **48,** 269 (1986).
[3] J.W. Doane, *Liquid Crystals-Applications and Uses,* edited by B. Bahadur, Vol. 1 (World Scientific Publishing), p. 361 (1990).
[4] H. S. Kitzerow, *LiquidCrystals,* **16**(1), 1 (1994).
[5] M.H. Godinho, A.F. Martins, and J.L. Figueirinhas, *Liquid Crystals,* **20**(3), 373 (1996).
[6] M.H. Godinho, C. Costa, J.L. Figueirinhas, *Molecular Crystals and Liquid Crystals,* **331**, 173 (1999).

[7] M.H. Godinho, J.L. Figueirinhas, A. Almeida, A.F. Martins, *Proc. of EUROMAT 97,* **2**-111 (1997).
[8] M.H. Godinho, A.F. Martins and J.L. Figueirinhas, *Optical Materials,* **9,** 226 (1998).
[9] M.H. Godinho, PhD Thesis, FCT-UNL, Lisbon (1990).