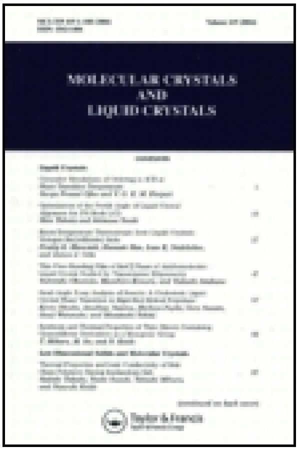

Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl17

Electrooptic Properties of Encapsulated Liquid Crystals

V. A. Zhujkov [a], V. F. Shabanov [a], G. M. Zharkova [a], A. N. Vtyurin [a] & L. V. Kirensky [a]
[a] Institute of Physics, Krasnoyarsk, 660036, USSR

Version of record first published: 22 Sep 2006.

To cite this article: V. A. Zhujkov , V. F. Shabanov , G. M. Zharkova , A. N. Vtyurin & L. V. Kirensky (1990): Electrooptic Properties of Encapsulated Liquid Crystals, Molecular Crystals and Liquid Crystals Incorporating Nonlinear Optics, 192:1, 149-153

To link to this article: http://dx.doi.org/10.1080/00268949008035622

Mol. Cryst. Liq. Cryst. 1990, Vol. 192, pp. 149–153
Reprints available directly from the publisher
Photocopying permitted by license only

Printed in the United States of America

ELECTROOPTIC PROPERTIES OF ENCAPSULATED LIQUID CRYSTALS

V.A.ZHUJKOV, V.F.SHABANOV, G.M.ZHARKOVA, A.N.VTYURIN
L.V.Kirensky Institute of Physics, Krasnoyarsk, 660036, USSR

Abstract Electrooptic phenomena in the encapsulated liquid crystals (ELC) under alternating electric field are studied. Their transparency nonlinear reaction is investigated experimentally and numerically simulated using proposed model. Dielectric parameters of the model (dielectric relaxation times) are determined from experimental data.

INTRODUCTION

Encapsulating of liquid crystals into thin polymer film has become a well known method of their protection from enviromental damage. Experimental investigations of ELC showed new ways to vary their characteristics changing their structure or chemical components[1]. Besides, new properties and interesting effects have been observed. In particular new essentially nonlinear effect of differential transparency reaction under pulsed electric field has been described recently[2], but it has not been explained numerically yet. For this purpose here we investigate ELC transparency reaction to sinusoidally alternating field and simulate this reaction using simple phenomenological model qualitatively described earlier[2].

EXPERIMENTAL RESULTS

Experimental measurements were done with 15 μ m film of 5CB liquid crystal (n_e=1.725, n_o=1.533) encapsulated in PVA (n=1.473). Film transparency was measured at λ =0.63 m (He-Ne laser) with calibrated photodiode as light detector. Obtained electric signal was registered with selective voltmeter and oscilloscope. ELC film was sandwiched between glass plates coated with indium-tin oxides mixture, where external alternating field of the frequency f was applied.

We observed clearly threshold character of transparency modulation effect. No reaction was obtained for the voltages below 30 V. Field increase resulted in the transparency modulation at the frequency 2f. The 4f Fourier component was registered as well. Only even harmonics were observed under strictly sinusoidal field. Frequency dependences of the first and second harmonics amplitudes of the optical signal are shown in the Figures 1 and 2, respectively. Both of them had well defined maxima, the second harmonic has lower frequency. Nearly 1 kHz electric field up to 70% modulation of film transparency can be easily obtained with reasonably small nonlinear distortions. Voltage increase resulted in nonlinearity growth, i.e. growth of the second harmonics amplitude as well as the constant (time independent) transparency component. Maximum of 2f component frequency dependence shifted higher and became flat. It saturated at 200 V voltages, where 4f component amplitude reached the 2f component order. It looked like effective energy transmission from the first (2f) to the second (4f) harmonics (Fig.1,2).

COMPUTER SIMULATION

To describe observed effects numerically let us consider in detail a simple model[2] of ELC reaction to applied electric field. In free film LC capsules are randomly oriented and considerable differences of n_e and n resulted in strong light scattering at polymer-capsule boundaries. Low (prethreshold) field can't reorient them, and going over threshold internal field E_t LC capsules orient along applied field. Therefore and due to $n_o \approx n$ light scattering drops considerably and film becomes nearly transparent. Equilibrium transparency dependence on the

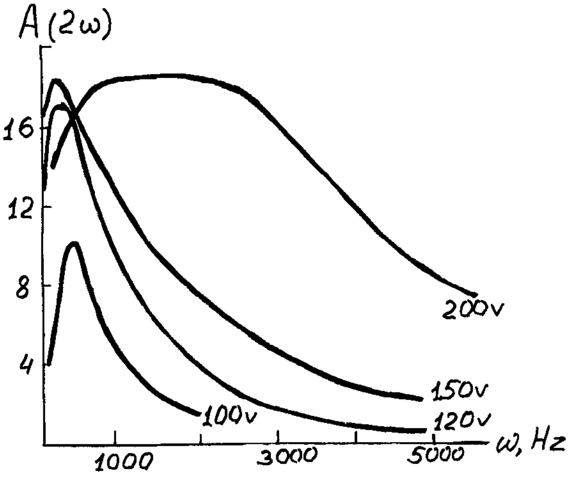

FIGURE 1 Frequency dependence of the first harmonic amplitude.

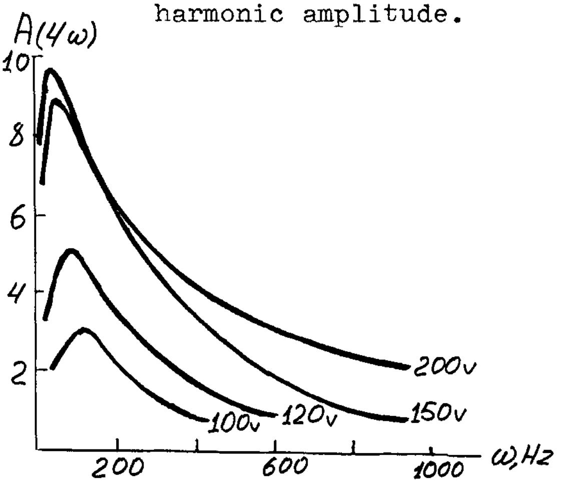

FIGURE 2 Frequency dependence of the second harmonic amplitude.

internal field E can be roughly modelled as:

$$T_\infty = \begin{cases} T_o, & E < E_t \\ T_s - (T_s - T_o)\, e^{-\alpha (E - E_t)^2}, & E > E_t , \end{cases} \quad (1)$$

where T_s - maximal (saturated) transparency of the film, α - constant, determined by LC molecules anchoring at the capsules boundaries and their interaction with orienting field (LC dielectric anisotropy). Naturally, anchoring effeciency depends on the droplet size.

Under alternating field inertial effects are to be taken into account, and time dependence of T is simulated by:

$$\frac{dT}{dt} = \frac{T_\infty - T}{\tau}, \quad (2)$$

where τ is the LC relaxation time. Internal field on the droplet under consideration can be easily calculated taking into account dielectric properties of polymer - its dielectric relaxation in particular:

$$\frac{dE}{dt} = \frac{E_\infty - E}{\tau_p}. \quad (3)$$

Here τ_p is the polymer dielectric relaxation time. So the polymer relaxation can decrease internal field below E_t and destroy LC orientation (provided $\tau_p > \tau$). So physical characteristics of the ELC may be connected with experimental frequency dependences of 2f and 4f harmonics amplitudes. We performed all these calculations, and obtained $\tau = 1.1 \cdot 10^{-3}$ s, $\tau_p = 1.5 \cdot 10^{-2}$ s both for 2f and 4f harmonics data from numerical calculations. Agreement factor R was decreased down 3% using standard optimization procedure . So the proposed simple model may be applied to simulate electrooptic properties of ELC films as well as to determine the characteristics of their components.

REFERENCES

1. Nuno A.Vaz, G.Paul Mongomery, Jr., J.Appl.Phys. 62 (8), 1987, p.p.3161-3172.
2. V.A.Zhuikov, V.F.Shabanov, G.M.Zharkova, V.M.Vladimirov, Mol.Cryst.Liq.Cryst. - to be published.