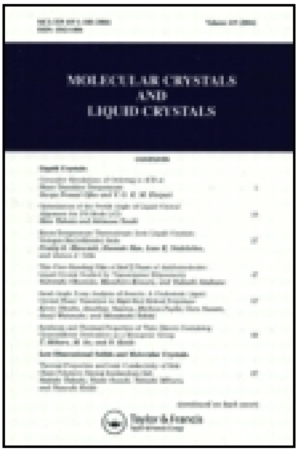

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Influence of Plasticizers on the Values of Operational Voltages of Microencapsulated Liquid Crystals

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INFLUENCE OF PLASTICIZERS ON THE VALUES OF OPERATIONAL VOLTAGES OF MICROENCAPSULATED LIQUID CRYSTALS

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Abstract The voltage-contrast dependencies for a number of microencapsulated liquid crystals were measured. It was shown that there exists a large number of plasticizers which significantly lower the operational values.

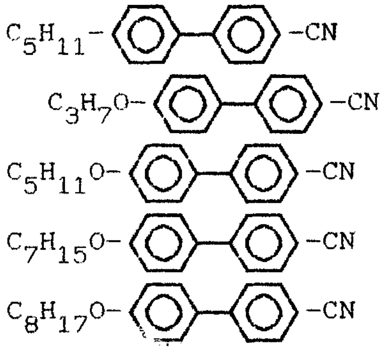
Keywords: liquid crystals, microcapsulated, plasticizers, polymeric films

INTRODUCTION

Thin polymeric films containing small droplets of micro-encapsulated nematic liquid crystals have been reported as new electrically switched light shutters [1]. Recently Ukrainian scientists [2] have reported the influence of the anchoring conditions at the inner surfaces of the micro-droplets on the switching times values; it was shown that normally anchored drops provide shorter response times than tangentially anchored ones. Here we will report about an influence of certain plasticizers on the values of the operational voltages of such polymeric films.

EXPERIMENTS

The model system[3] polyvinyl butyral – liquid crystal was used in this work. A cyanobiphenyl type nematic liquid crystalline mixture was used.



40.0% by weight

15.0%

13.9%

12.7%

18.4%

This material does not crystallize up to $-10^{\circ}C$ and becomes isotropic at $56^{\circ}C$. Its refractive indices (λ = 632,8 nm) $n_o = 1.524$, $n_e = 1.710$ at $20^{\circ}C$; low frequency (10 kHz) dielectric permittivities at the same temperature $\varepsilon_{\parallel} = 17.1$, $\varepsilon_{\perp} = 6.3$, $\Delta\varepsilon = +10.8$.

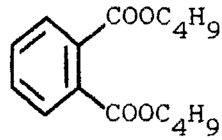
A procedure for preparing a polymeric film containing microencapsulated liquid crystals was the following. The components (typically, 1 part by weight of polyvinylbutyral, 2 parts of liquid crystal, 0.2 parts of a plasticizer) were mixed together thoroughly at room temperature. This mixture was put on a glass plate (3 cm^2) coated by indium/tin oxide (ITO) and heated at $150^{\circ}C$ till became transparent and homogeneous (0.5 h). Then two 20 μm Teflon spacers were put at both sides and the sample was covered by a second glass plate, coated by ITO. A weight (1 kG) was put on the upper glass plate and the whole system was cooled at a slow rate (0.5°/min). The sample prepared as mentioned above was placed into an electro-optical setup. The transmittance and its dynamics were measured using 0.63 μm He-Ne laser light. The beam of the laser was passed through the sample and recorded by the photometer with 1 mm aperture, so the scattered light was cut off.

The transmittance versus applied voltage was measured on 8 kHz sine-wave, because a frequency doubling effect was observed for such systems until 4 kHz. The response times were measured using 50 ms single pulses. On top of the

8 kHz sine-wave.

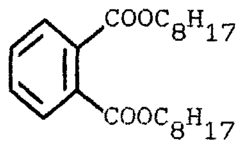
The following plasticizers were used in this work:

1. dibutylphtalate,



;

2. dioctylphtalate,



;

3. dioctylsuccinate, $n\text{-}H_{17}C_8OOC\text{-}CH_2CH_2\text{-}COOC_8H_{17}\text{-}n$;
4. diisooctylsuccinate, $H_{17}C_8OOC\text{-}CH_2CH_2\text{-}COOC_8H_{17}$;
5. dioctyladipate, $n\text{-}H_{17}C_8OOC\text{-}(CH_2)_4\text{-}COOC_8H_{17}\text{-}n$;
6. diisooctylsebacate, $H_{17}C_8OOC\text{-}(CH_2)_8\text{-}COOC_8H_{17}$;
7. polypropyleneglycol. $HO[\underset{CH_3}{\underset{|}{C}}HCH_2]_nOH$ (M.W.2000);
8. oleic acid, $CH_3(CH_2)_7\text{-}CH{=}CH\text{-}(CH_2)_7COOH$;
9. perfluorononylacrylate, $H_2C{=}CH\text{-}COOC_9F_{19}\text{-}n$.

RESULTS AND DISCUSSION

The transmittance versus applied voltage and turn-off times were measured for 9 different plasticizers (Fig 1, Table 1).

Mainly two types of transmittance-voltage(T-V) curves were observed. A T-V curve with linear increase was observed in a system without plasticizer and systems 6, 8, 9. It must be pointed out that hysteresis behavior was not observed in these systems. On the contrary, a sharp threshold and hysteresis were observed in systems 1-5, 7. It is clearly seen that the latter setup consists of compounds which have polar groups at both ends of the

Table 1. Threshold and saturation voltages, turn-off times and transmission in the bright state of the polymeric films.

System	Threshold voltage,V	Saturation voltage,V	Turn-off time,ms	Transmission in the bright state,%
model	14.7	64.0	10	50.9
1	3.8	18.0	150	67.3
2	3.2	16.0	200	56.4
3	5.4	20.5	40	69.1
4	3.7	19.7	300	65.5
5	2.6	35.0	300	70.9
6	13.3	57.5	30	49.2
7	10.0	28.0	40	66.7
8	8.6	57.2	30	57.1
9	16.0	65.3	30	39.3

molecule and therefore may act as the planar-aligning agents. On the contrary, the compounds 8, 9 have only one polar group and strongly hydrophobic alkyl either perfluoroalkyl group and therefore act as homeotropic - aligning agents. The compound 6 has small influence on electrooptic properties: though containing two polar groups it is branched too much for an effective interaction with liquid crystal molecules.This consideration may be confirmed by the results of the wetting angle measurements. When a drop of distilled water is put on a free surface of a film consisting of polyvinyl butyral and liquid crystals, the wetting angle is 66.5°. When the system contains additionally dioctylsuccinate (3)or perfluorononyl acrylate (9), this angle is 54.3° and 81°, accordingly.

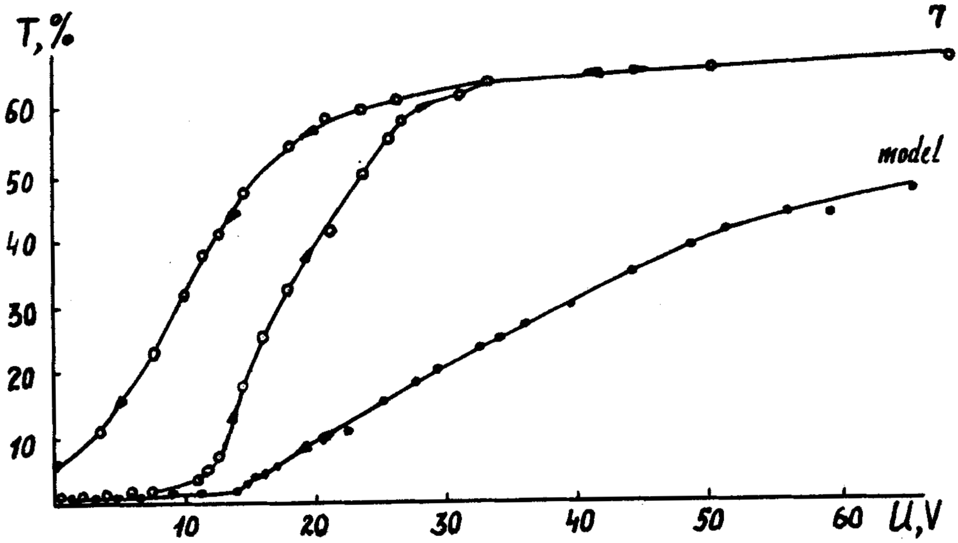


Figure 1 The transmittance vs voltage curves for systems 1,7 and model system.

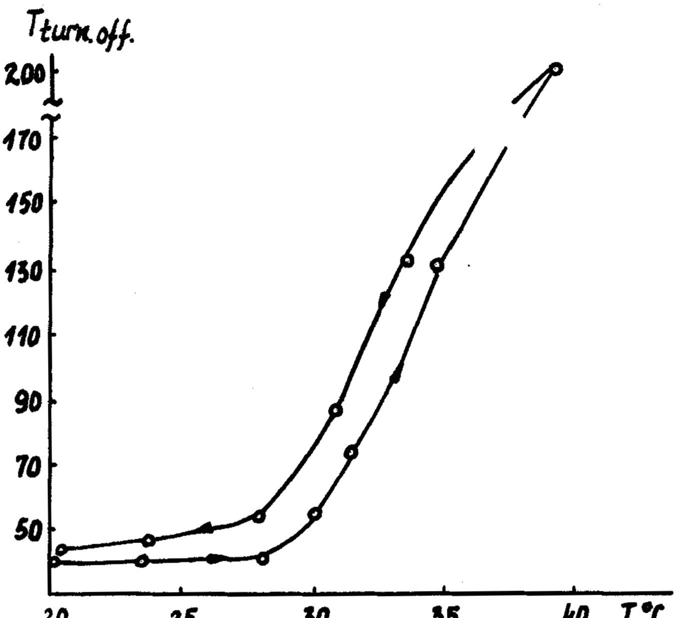


Figure 2 The turn-off time versus temperature for system 7.

The temperature dependence of turn-off time was also measured. When the temperature increases the turn-off time increases reaching the maximum value near the clearing point. Here the typical turn-off time versus temperature is shown. A small hysteresis is observed.

The threshold voltage, saturation voltage and turn-off time dependence on dioctyladipate (5) concentration are shown on Fig. 3, 4, 5.

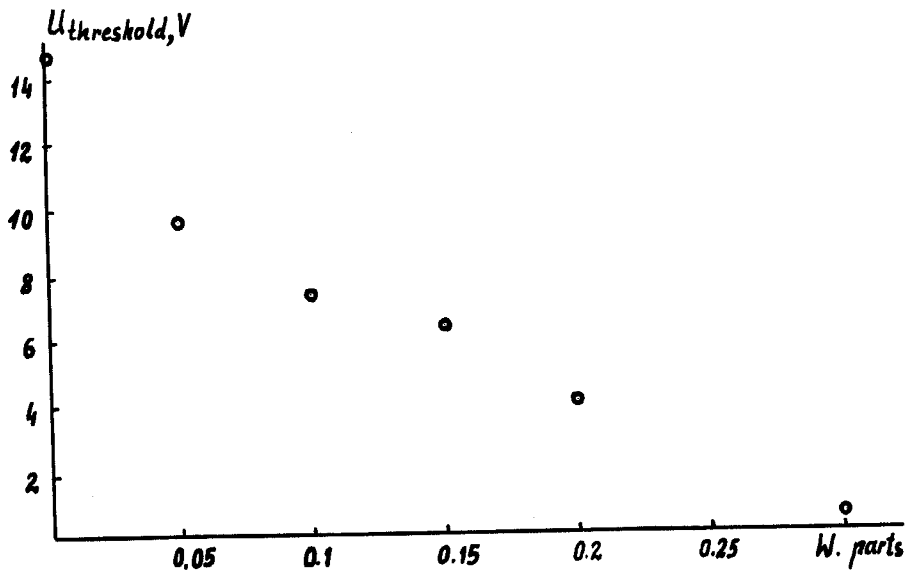


Figure 3 The threshold voltage's dependence on dioctyladipate (5) concentration.

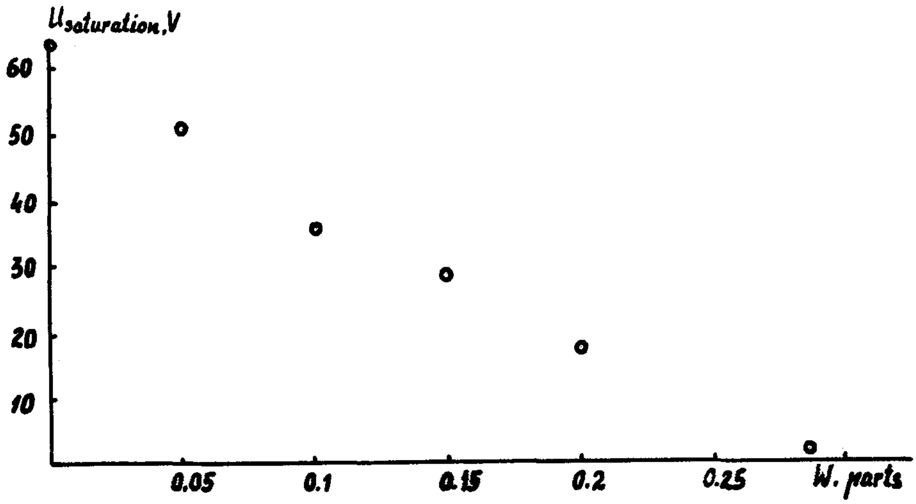


Figure 4 The saturation voltage dependence on dioctyladipate (5) concentration.

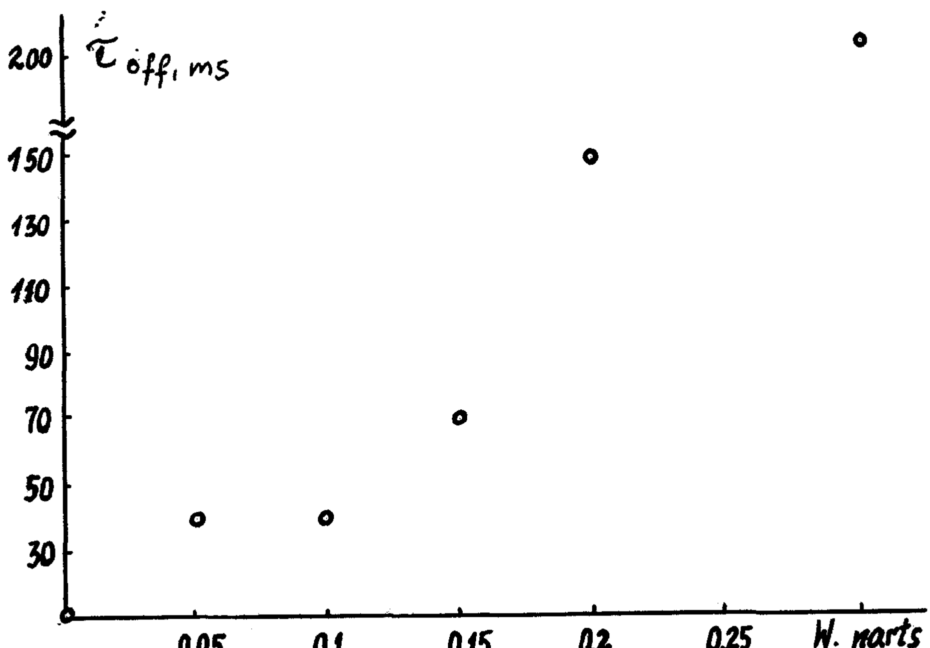


Figure 5 The turn-off time versus dioctyladipate (5) concentration.

It's well seen that both threshold and saturation voltages decreased, and the turn-off time increased smoothly when the concentration of the plasticizer was increased. This agrees with the conclusion [2] about an influence of surface properties on switching times.

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