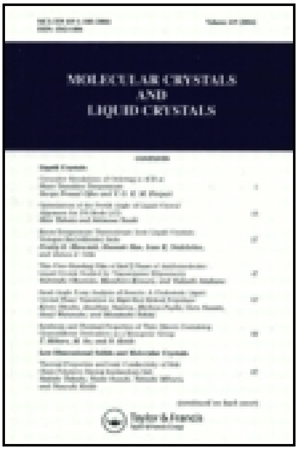

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CONTROL OF OPTICAL RADIATION ON THE BASIS OF NEMATIC LIQUID CRYSTALS WITH TWO-FREQUENCY CONTROL

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Abstract. We report on the possibility of using nematic liquid crystals which change sign of dielectric anisotropy to control the light beam cross-section, light polarization and filtration.

Nematic liquid crystals (NLC) are important for application in display devices. The method of control of liquid-crystal diaphragm on the basis of NLC is described in[1]. Electrically controlled polarizer on the basis of cholesteric LC is considered in[2]. The LC application for data optical processing is described in detail elsewhere[3].

This paper deals with the application of NLC which changes sign of dielectric anisotropy (ε_a) for the optical radiation control.

Light diaphragming, polarization and filtration were carried out in an electrooptic cell shown in Fig.1a. The cell consists of two transmitant electrodes (1) with the NLC layer (2) with sign inversion ε_a placed between them. The thickness δ and the shape of the layer was controlled by the spacer (3).

The LC-999 was used with critical frequency f_c, the sign inversion of which is 14 kHz at t_k=25°C and LC-1000 with f_c=10 kHz at t_k=20°C. Control voltage U for LC-999 is 10-40V and f_c can change in the range of 15-30 kHz for LC-1000, U=40-60 V, f=10-20 kHz.

The diameter of circular insulating spacer was D=30 mm and δ =20-30 μm. NLC was doped by 0.5 weight % of two dichroic dyes with positive dichroism (S_{DX}) KD-7 with S_{DX}=0.52 at wavelength of maximum absorption λ_{max}=434 nm and D-35 with S_{DX}=0.67, λ_{max}=554 nm and was controlled by LF(f=4 kHz) and HF (f=30 kHz) at U=60 V.

A film dichroic polaroid between two glass plates was used as an analyzer.

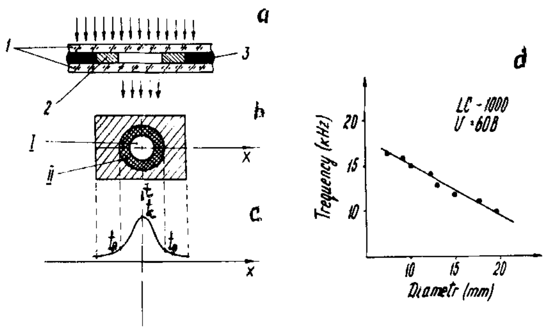

FIGURE 1. Electrooptic cells and diaphragming of light

1. The HF electrohydrodynamic (EHD) instability is observed in NLC with sign inversion ε_a[4]. By increasing the voltage on electrode (1)(Fig.1a) the instability transfers in the highly light scattering mode which exists in the narrow frequency range near f_c. At specific values of U and f applied on the layer the temperature (t) is distributed uniformly due to heat removal to the periphery of the cell. t and f_c in the centre of the cell are,hence,higher than those on the periphery (Fig.1b).Since the molecules in this part of the layer are homeotropically oriented, circular transmitant window is formed (Fig.1bI) and the light goes through this part of the cell without attenuation. Over the periphery of the cell where t is lower and f_c is,hence,lower than the frequency of the control voltage,the molecules of layer (2) form light scattering texture and this part becomes opaque to light (Fig.1b,II). By changing control voltage frequency we can adjust the dimension of the transmitent part and adjust the light beam dimension (diaphragming).By increasing the frequency the dimension of the transmitant part is increased and v.v.[5]. By applying 30V and f=15-20 kHz on the LC-999 cell, the NLC layer forms a circular diaphragm highly scattering light with transmitant central part (Fig.1b).By chan-

ging f from 15 to 20 kHz at t_k=26^oC a dimension of transmitant part changes from D=30mm to zero and v.v. In polarizing the dependence D on f is shown in Fig.1(d) for the LC-1000 cell by applying U=60V with f=10-17 kHz at t_k= 21^oC.

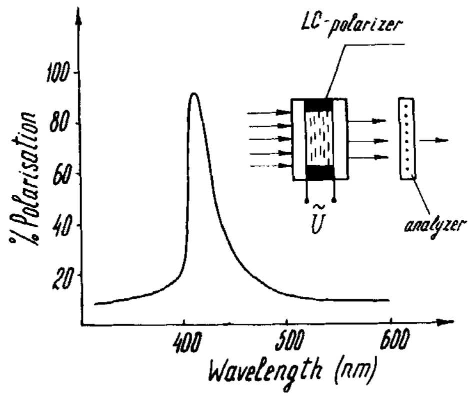

FIGURE 2. The dependence of polarization on wavelength

2. The absorption anisotropy (dichroism) is observed in the NLC with two frequency control under the electric field in the self-absorption band edge[6]. It is known that dichroism can be used to obtain polarized light from the natural[7]. To produce the polarized light the HF field is applyed on layer (2) (Fig.1a) and the planar orientation is obtained. From the natural light incident on the cell the directions of electric vector which are parallel to the NLC director will be absorbed due to high dichroism. The directions which are perpendicular to the director will absorb more weakly. As a result the light passed through the LC planar oriented layer is highly polarized in the spectral band of maximum dichroism. In homeotropic orientation obtained by applying HF field the ability of light polarization in the NLC layer is lost and the light which passes through the cell is non-polarized or slightly polarized owing to near-surface layers. So, by changing the frequency of applied field we can polarize and depolarize the passing light in the dichroism band. Fig.2 shows the dependence of the order of polarization (P) on wavelength

(λ) of the incident light at planar orientation of LC-999 molecules at 40 kHz and 10V.P is maximum at λ =420 nm and exceeds 90%, For λ =408-435 nm P exceeds 50%.

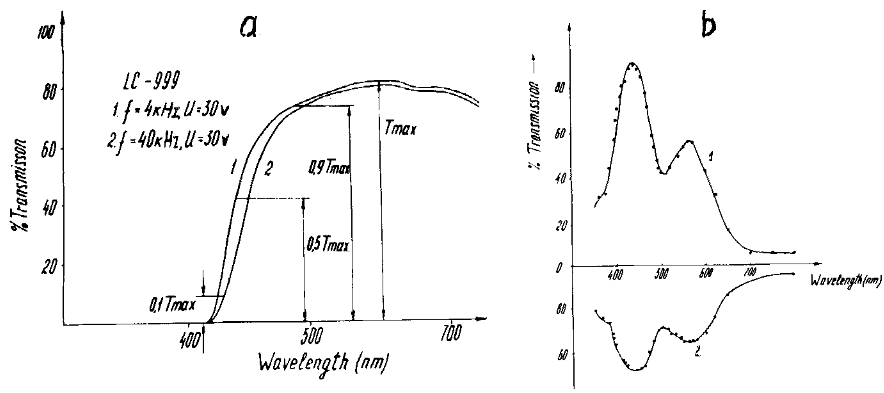

FIGURE 3. The dependence of transmission on wavelength

3. Under the electric field the absorption edge of the NLC is shifted in the self-anisotropy absorption band[8]. Using this effect we can realize a selective filter which operates as short-wavelength cutoff filter. Fig.3a displays the dependence of the absolute transmission versus λ for LC-999. Curve 1 is plotted at $f<f_c$ at homeotropic molecule orientation, curve 2 corresponds to $f>f_c$ when molecules have planar orientation. As it is seen there is an emission of light in the narrow spectral band of the absorption edge of 410-425 nm. From the figure it also follows that filter transmits long-wavelength light and, hence, it can be used as short-wavelength cutoff filter with the following parameters: the maximal transmission coefficient in the transmission band T_{max}=0.82; the rate of short-wavelength frontof the transmission curve $\mathcal{R}$ =0.86, the wavelength specifying the position of transmission cut-off for which the filtration is one-half of the maximal absorption edge λ_{cutoff} =434 nm. If dichroic dyes are inserted in the NLC with two frequency control and in order to control the molecule orientation in NLC dyes, one can obtain electrically controlled bandpass filter. Fig.3b shows the

transmission dependence on wavelength for LC-1000 doped by 0.5 weight % of dyes KD-7 and D-35. Curve 1 is plotted at f=4 kHz, U=60V, and curve 2 is plotted at f=30 kHz. As it is seen from the figure there are 2 transmission bands at λ_1=435 nm and λ_2=565 nm with maximum absorption T_1=91.5% and T_2=56.5%, respectively.

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