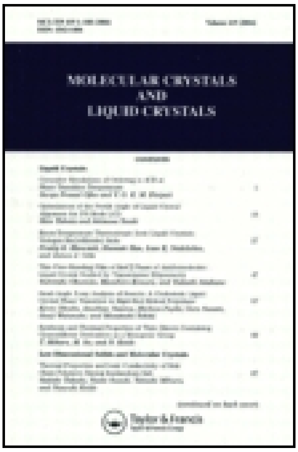

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Induced Cholesteric Liquid Crystal Polymer as a New Medium for Optical Data Storage

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INDUCED CHOLESTERIC LIQUID CRYSTAL POLYMER AS A NEW MEDIUM FOR OPTICAL DATA STORAGE

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Abstract Induced cholesteric LCP material is suggested for optical data storage and its main parameters are measured.

INTRODUCTION

A possibility of the application of nematic and smectic liquid crystal polymers (LCP) for optical data storage was discussed last decade[1]. Fabrication of a scattering spot by local laser heating of a transparent smectic sample followed by cooling is a widespread mechanism of markers formation in these media. Usually dye molecules are inserted into the polymer matrix or are bonded to the polymer chains for making the LCP sensitive to the visible light region. Laser induced variation of the refractive index in LC co-polymers caused by the photoisomerization of chain fragments or dopant molecules is the second way of optical recording in LCP. There are some efforts to use the analogous mechanism of information recording in cholecteric LCP [2,3].

In this paper the laser induced unwinding of a cholesteric pitch due to the photochemical changes of the twisting power of the dopant is proposed for optical recording.

EXPERIMENTAL SECTION

1.Material and sample preparation.

A side chain liquid crystal polymer of acryl units with methoxyphenylbenzoate mesogenic groups was used as a nematic matrix. A light sensitive chiral dopant of 2-arylyden-p-menthane-3-on type was inserted in it to induce a cholesteric phase. This matrix demonstrated a nematic behaviour in the 35^{0}-125^{0}C temperature range. At the temperatures below 35^{0}C a glass state was induced and the orientation of the side chains was stored. An addition of the chiral dopant into the matrix induced cholesteric helix. The mixture has transition temperatures similar to those of the nematic matrix. Some decrease of the mesophase region with increasing dopant concentration was observed. Cooling into the glass state stored the side chain orientation, as in the case of the nematic matrix. 10-20 μm thick cells of induced cholesteric LCP were prepared at 80^{0}-100^{0}C temperature, when the viscosity of the material was sufficiently low and the mobility of the chain fragments was high. Planar orientation of the side chain groups was achieved by shifting the substrates in the mesogenic phase followed by cooling to the room temperature. The Bragg band maximum position reversely depended on dopant concentration.The trasmittance specrta of induced cholesteric LCP samples with different dopant concentration are presented in fig.1. The transmittance minimum on the curve corresponds to the maximum of the reflectance. The material had a weak and reversible temperature dependence of the cholesteric pitch: $d\lambda/dT$ = 1nm/deg. The halfwidth of the Bragg reflectance peak increased when the temperature increased. The material and the LCP cells did not change their properties during 1 year when they were stored in the glass state.

Special processing of the glass subsrate permitted to receive a free surface of the cholesteric films with uniform orientation on glass subtsrates. The films were stable in the case of high material purity and storage under the glass temperature.

2. Experimental procedure and results.

Irreversible optical recording of different colour spots (square dimensions 1-100 mm^2) was obtained by nitride (λ_{ex}= 0.3 μm) and He-Cd (λ_{ex}= 0.4 μm) laser irradiation. A recording power density was varied from 15 to 0.1 mW/mm^2 and time exposure was from 1 - 30 min.

Two methods of optical recording had been used. During laser irradiation a wavelength shift of the selective reflectance was observed in the samples kept at the temperature of 80°C. The illuminated areas possessed changed colour with respect to the neighbouring ones. This colour was stored after cooling the samples to the room temperature.

Another way of laser recording was the irradiation in the glass state. The following heating of the sample into the mesophase temperature range led to the change of the colour of the sample in the illuminated areas.

The typical time of LCP transition into the new colour state was near 1 minute when the irradiated sample was placed in the oven at the temperature of 80°C. We did not note the dependence of the unwinding time on the chemical structure or concentration of the dopant. In the case of slow heating of the sample (dT/dt = 1 deg/min) the changed colour spots arose at the temperature near 50°C. The new material state was stable in time for both methods of optical recording. The spots can disappear only in the case of mixture destruction caused by the dopant falling out of the macromolecular matrix.

The transmittance spectra measured in nonpolarised light illumination are presented in fig.2. The spectral position of the Bragg band maximum corresponds to the the position of the transmittance minimum on the curve.The sensitivities of the material with 11% of the dopant to the

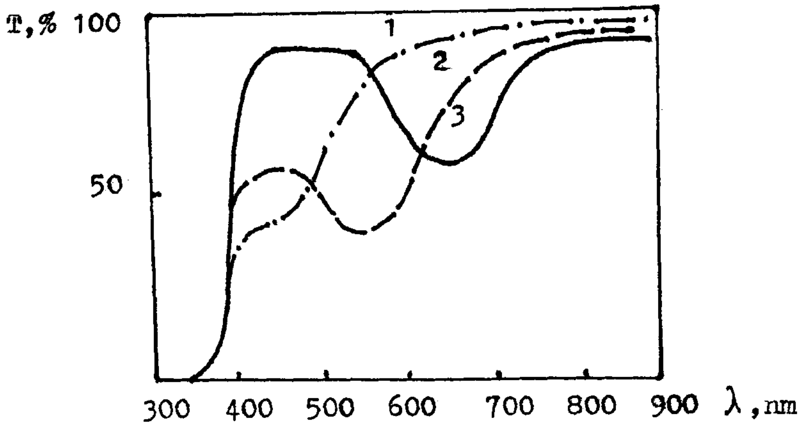
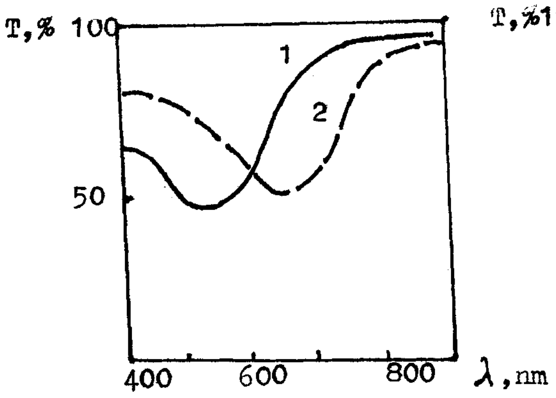


Fig.1.Transmittance spectra of induced cholesteric LCP samples with different dopant concentration:
1 - 13%; 2 - 11%; 3 - 10%.



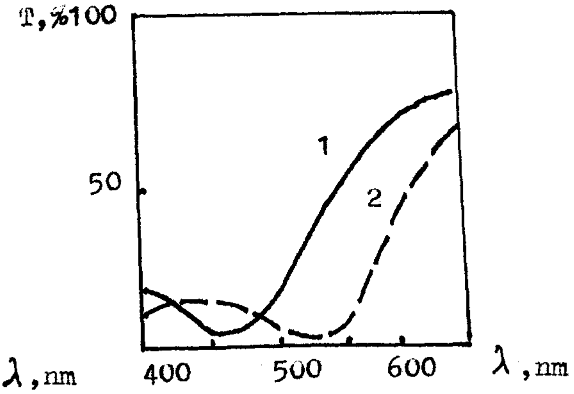


Fig.2. Transmittance spectra of LCP samples: 1-before and 2-after the irradiation.

Fig.3. Transmittance spectra of LCP samples measured in circularly polarized light:
1-before and 2-after the irradiation.

light irradiation of blue (λ_{ex}=0.4μm) and near UV (λ=0.3μm) regions was approximately the same and near 2 J/cm^2. In this case the Bragg band maximum shifts from green to red spectral region by 100 nm. The same results were obtained for free surface samples.

The contrast ratio of the optical recording was determined from transmittance spectra wich were measured by means of circularly polarised light (fig.3). We examined the blue sample with 13% dopant concentration which demonstrated the Bragg band shift into green spectrum region after laser irradiation. The ratio between the transmittance coefficients of the nonirradiated sample and the irradiated one for λ=550 nm was taken as a contrast ratio. The measurements demonstrated that it was near 10.

3. Discussion.

On the contrary to traditional systems a variation of the material colour is produced instead of changes in the scattering ability. The position of the Bragg band maximum depends on chiral dopant concentration. These optically active dopants included C=C chemical bonds which determined their laser induced *trans-cis*-isomerization. The twisting power of the *cis*-isomers is lower than for the *trans*-ones.The *cis*-isomers of such a dopant were isolated and it was shown that the *trans-cis*-isomerization led to decrease of the twisting power: from 40 μm^{-1}mol^{-1} to 1μm^{-1}mol^{-1}in the nematic 5CB matrix[4].

The similar process could be expected for the LCP. Clearly the same mechanism of Bragg band shift had to take place in the considered medium. It was shown that the spectral position of the Bragg band maximum depended on the concentration of the chiral dopant c and the twisting power of the dopant β : λ_{max}= n/βc.[5] To evaluate which part of the *trans*-isomers was converted into the *cis*-form it was supposed that the twisting power for the *cis*-isomers is much lower than for the *trans*-ones: $\beta_{cis} \ll \beta_{trans}$. In this case the shift of the Bragg band maximum is:

$$\Delta\lambda_{max} = \frac{n}{\beta_{trans}} \cdot \frac{C_{cis}}{C_{trans}(C_{trans} + C_{cis})}$$

For I= 2 J/cm^2 the $\Delta\lambda_{max}$=0.1 μm. As the twisting power was β_{trans}= 26 μm^{-1}and n = 1.6 it means that only one tenth part of the chiral dopant was changed. Thus, the range of displacement of the Bragg band maximum position can be extended considerably.

To apply the induced cholesteric media with the photoinduced shift of the Bragg band maximum for optical data storage, the following problems have to be solved:

- A high quality, homogeneous planar texture of samples with one free surface must be obtained. To do this, chiral dopant molecules have to be bonded to the polymer matrix chain and a perfect technology of LCP alignment and removing of one sample substrate have to be developed.
- The improvement of the light sensitivity of the material at least up to 0.1 J/cm^2 is required. We consider, that the insertion of triplet sensibilizators into the matrix is a reasonable way for this aim.

REFERENCES

1. C.Bowry and P.Bonnett, Optical Computing and Processing, 1, 13 (1991).
2. J.Pinsl, Chr.Brauchle and F.Kreuzer, J.Molec.Electron., 3, 9 (1987).
3. V.Vinogradov, A.Khizhnyak, L.Kutulya, Yu.Reznikov and V.Reshetnyak, Mol.Cryst.and Liquid Cryst., 192, 273, (1992).
4. S.N.Yarmolenko, L.A.Kutulya, V.V.Vaschenko and L.V.Chepeleva, Mol.Cryst.and Liquid Cryst.,- to be published.
5. L.A.Kutulya, I.B.Nemchenok and T.V. Khadrimailova , Kristallografiya, 35, 1234 (1990).