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New dyes for guest-host mode

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Abstract. New guest-host dyes of red and purple colour suitable for fabrication of ultrathin film polarizer from polymerizable liquid crystals are developed. When the absorption spectrum of dye matches the photopic curve, samples with total film thickness below 50 µm show good visual contrast.

Keywords: guest-host, polymerizable liquid crystal, thin film, polarizer.

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1. Introduction

One of the first electrooptical effects observed in liquid crystals (LC) was the 'guest-host' one [1, 2]. The 'guest-host' effect arises after introduction of anisotropic linear dye, the 'guest', into liquid-crystal 'host' matrix. The dye placed into the anisotropic medium of liquid crystal, orients its main absorption axis along the LC director field. Thus, performing the polarized light absorption measurements at the dye absorption peak wavelength the absorption dichroism can be registered.

Development of thin film polarizers [3] and utilization of the polarizer LC effects [4] allowed to obtain the higher values of image contrast, which has brought to the fall of the first wave of interests to the 'guest-host' effect by the mid of 80-ies of the past century.

2. Perspectives of 'guest-host' effect

Despite the effect is already known for about 40 years, the electrooptical properties of the 'guest-host' system are actual and in demand up to date. The series of contemporary applications and simple technical solutions give rise to the new wave of interest to the 'guest-host' effect. For instance, in displays on plastic substrates to achieve mechanical flexibility requires reduction of the thickness of the liquid-crystal element down to 0.3 mm [5]. If the thickness of each of two plastic substrates is about 100 µm, the remaining thickness budget in 100 µm is insufficient for application of the standard film polarizers with the thickness above 100 µm each, necessary for implementation of the two-polarizer electrooptical LC effect. One of the possible solutions is utilization of the 'guest-host' effect, where distribution of LC material controlled with electric field rotates the dye molecules and changes the transmission of LC elements [6].

The alternative solution is the development of ultrathin polarizers based on the 'guest-host' effect. Introduction of the dye into the polymerizable liquid-crystal matrix allows creation of the ultrathin anisotropic film with oriented dye molecules, which is suitable to fabricate a thin film polarizer with the total thickness less than 50 µm. Fabrication of the ultrathin polarizers based on the polymerizable liquid crystals put certain requirements for dye material. Thus, the dye should neither affect the LC phase of the polymerizable 'host' nor influence on the photopolymerization properties of the liquid crystal.

The perspective solution is implementation of dye with the absorption peak in the green spectral range. The absorption spectrum of this dye mostly corresponds to the sensitivity of the human eye with the spectral

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maximum of efficiency at 550 nm. Thus, to achieve the necessary photometric image contrast requires introduction of fewer amount of dye material into the LC matrix as compared to a dye or a set of dyes with equivalent extinction but with the absorption peak in other spectral region.

3. Dyes for 'guest-host' effect

We developed new dyes for the 'guest-host' effect with the absorption peaks in the green spectral range. To investigate optical properties of dyes, liquid-crystal polarizers were prepared. The LC polarizer is an antiparallel LC cell with 20 µm gap. The cells were filled with liquid crystal VIN9 doped with 0.5% of dye. Thus, the influence of the 'guest' dye absorption spectrum on the colour contrast and the visual image perception, when used is the polarizer based on a liquid crystal, was investigated. The dichroic ratio for all dyes in experiment is the same and equal to 4, while the dramatic difference in the photometric contract is observed in relation with the absorption spectra of the dye.

M8 dye

Polarized light absorption spectra of an optically rewritable LC cell [7, 8], with the top LC polarizer are based on the dye M8 (Fig. 1) that possesses the absorption peak at 518 nm, are shown in Fig. 2, and the photo of this cell is depicted in Fig. 3. In these conditions, the optical density in the peak of the absorption band is 1.67 (Fig. 2). The photometric contrast of this dye-based guest-host polymerizable liquid-crystal polarizer measured with a continuous light source is 1.9.

M5 dye

Polarized light absorption spectra of an optically rewritable LC cell, with the top LC polarizer based on the dye M5 (Fig. 4) that possesses the absorption peak at 540 nm, are shown in Fig. 5, and the photo of this cell is depicted in Fig. 6. In these conditions, the optical density in the peak of the absorption band is 1.48 (Fig. 5). The photometric contrast of this dye-based guest-host polymerizable liquid-crystal polarizer measured with a continuous light source is 2.3, due to the better match of the absorption peak to photopic than for M8 dye.

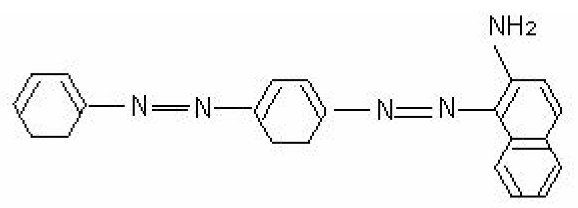

Fig. 1. Chemical structure of M8 dye.

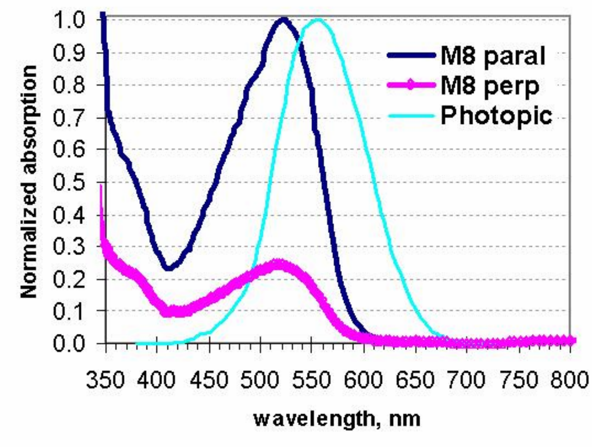

Fig. 2. Dichroic absorption spectra of LC cell filled with LC VIN9 doped with M8.

Fig. 3. Photo of patterned LC cell with top LC polarizer based on M8 dye.

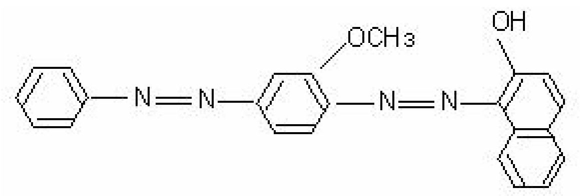

Fig. 4. Chemical structure of M5 dye.

M4 dye

Polarized light absorption spectra of an optically rewritable LC cell, with the top LC polarizer are based on the dye M4 (Fig. 7) that possesses the absorption peak at 555 nm, are shown in Fig. 8, and the photo of this cell is depicted in Fig. 9. In these conditions, the optical density in the peak of the absorption band is 1.48 (Fig. 8). The photometric contrast of this dye-based guest-host polymerizable liquid crystal polarizer measured with a continuous light source is 3.6 and is limited by the dichroic ratio due to the best fit of the absorption peak to photopic.

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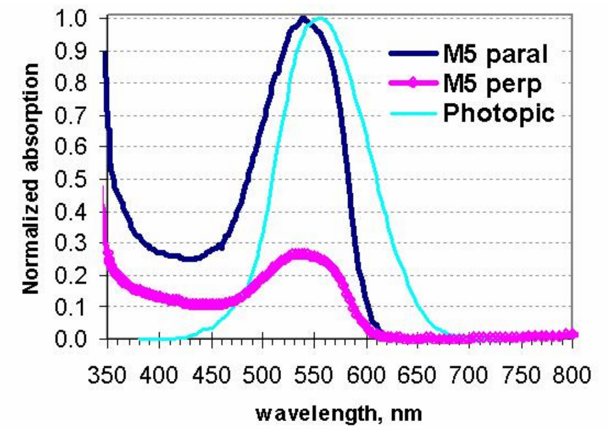

Fig. 5. Dichroic absorption spectra of LC cell filled with LC VIN9 doped with M5.

Fig. 6. Photo of patterned LC cell with top LC polarizer based on M5 dye.

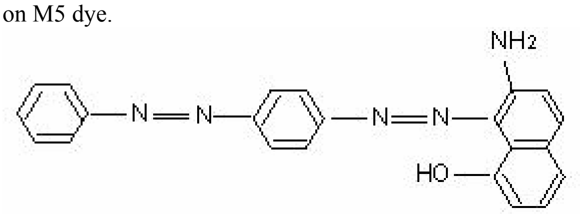

Fig. 7. Chemical structure of M4 dye.

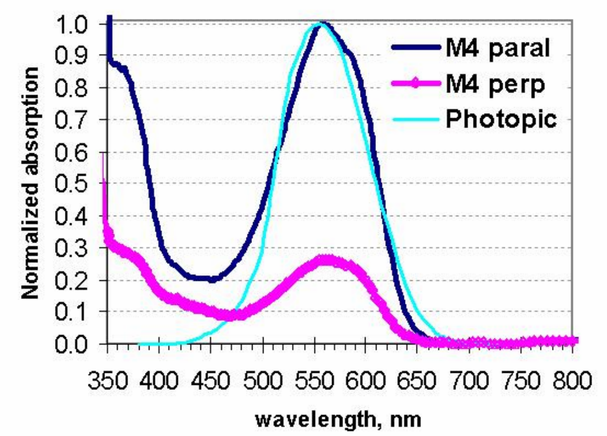

Fig. 8. Dichroic absorption spectra of LC cell filled with LC VIN9 doped with M4.

Fig. 9. Photo of patterned LC cell with top LC polarizer based on M4 dye.

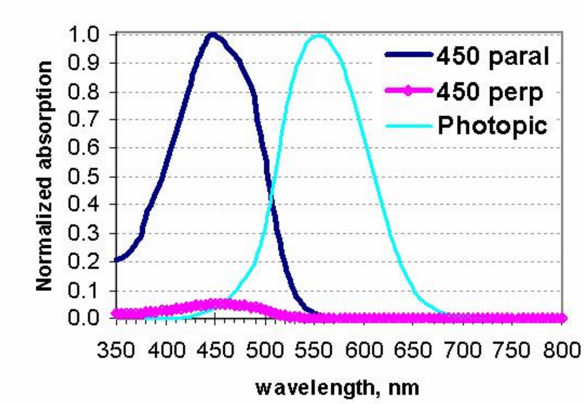

Fig. 10. Dichroic absorption spectra of model gye with dichroic ratio 20 but photopic mismatch.

4. Photopic mismatch

Consider the model when the dye spectral absorption peak is 450 nm (Fig. 10), but the dichroic ratio of the dye is 20. The dye absorption spectrum is located away from the photopic maximum and photopic mismatch takes place. The photometric contrast of this dye-based guest-host polymerizable liquid-crystal polarizer estimated for the gray light source is 1.3 only, which means a poor visual contrast.

5. Conclusions

Dyes M4, M5 and M8 are oriented in the liquid-crystal matrix and possess absorption spectra in the green spectral range. When the dye absorption spectrum matches the sensitivity of the human eye, LC polarizer samples demonstrate a good visual contrast, even when the optical density of the absorption band is below 1.5. New materials are perspective for fabrication of the ultrathin polarizers based on the polymerizable liquid crystals with the total film thickness below 50 μm. It was experimentally verified that, when selecting a dye for the

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polymerizable LC polarizer, the position of dye absorption spectra is more important than the dichroic ratio. As high values of photometric contrast can be obtained with the smaller amount of such dye, which is in demand to preserve the photopolymerization property of the polymerizable LC matrix.

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