Weigert-effect in the Recording Media on the Base of the Polarization-sensitive Compositions

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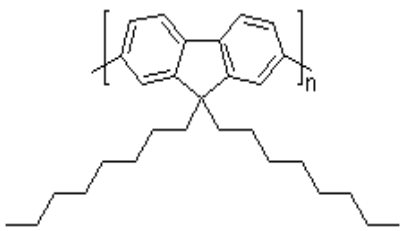
Abstract— The paper discusses the polarization properties of the compositions of the photosensitive media. The compositions have been developed — the transparent polymer in which activators were added: photo anisotropy, chiral and fluorescent impurities. Activators photo anisotropy were based on the organic dyes of different classes. Optical schemes have been created, which allows us to explore the polarized luminescence, and conduct the ellipsometric measurements of the photo anisotropic parameters obtained compositions. For polarized radiation were used standard lasers with wavelengths: ($\lambda = 405$; 441.6; 532) nm.

1. INTRODUCTION

At the beginning of the last century, F. Weigert discovered the appearance of dichroic properties under radiation of the emulsions by polarized light and a variety of solid solutions of organic dyes [1, 2]. F. Weigert also discovered the phenomenon of occurrence of partial polarization of the luminescence radiation emitted by an isotropic body when it was excited with polarized light [3]. These phenomena were called collectively Weigert effect. The possibility to display the polarization of the summary field of the object and reference source of radiation by the polarization-sensitive recording medium, provided the basis for the establishment in the middle of last century, by Georgian scientist Kakichashvili — the new direction in holography — polarization holography [3]. At present this direction was further developed. Weigert-effect expands the scope of application; are created polarization-sensitive medium having new properties, allowing noticeably to increase the use of Weigert effect in various types of optical studies [4, 5]. The phenomenon of light-induced anisotropy can generally be explained by photochemical or photophysical impacts of polarized light. In the compositions presented in this paper the predominant are photochemical processes.

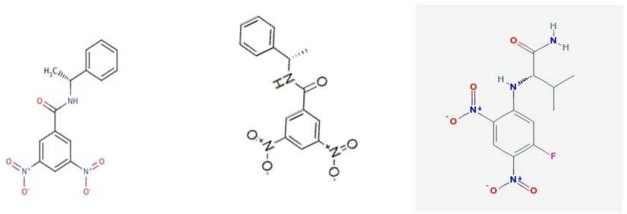
2. EXPERIMENTAL PART AND FORMULATIONS

The aim of this study was to create and develop new photo anisotropic-gyrotropic (Weigert-sensitive) recording media, the study of their properties. Determination of the possibility of their use for the needs of the polarization holography and the creation of optical elements with predetermined properties. The objects of study in this paper, were photosensitive compositions created by us. That are transparent polymer films, in which for giving them functional properties − activators of photo anisotropic, fluorescent and chiral dopants were introduced. The homogeneous solution: activator + polymer were poured on glass substrates. The thicknesses of the poured layers were about 10 microns. The polymer matrix for the created media were: polycarbonate (PC), polystyrene (PS), polymethyl methacrylaterylate (PMMC). As activators of the photo anisotropy organic dyes of different classes were selected, including Dimethyl Yellow(DY) dye and its analog Dimethyl Red (DmR), Cationic Orange 5K(CO) and also fluorescent Phthalocyanine (PhC) dye. As additive-Poly (9,9-di-n- octylfluorenyl-2,7-diyl) light-emitting polymer was used.



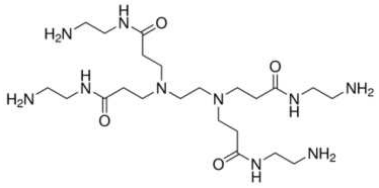
#1

To give the photosensitive samples the chiral properties we used dopants such as:



#1 #2 #3

Besides when creating the compositions PAMAM Dendrimer (DR) was used.

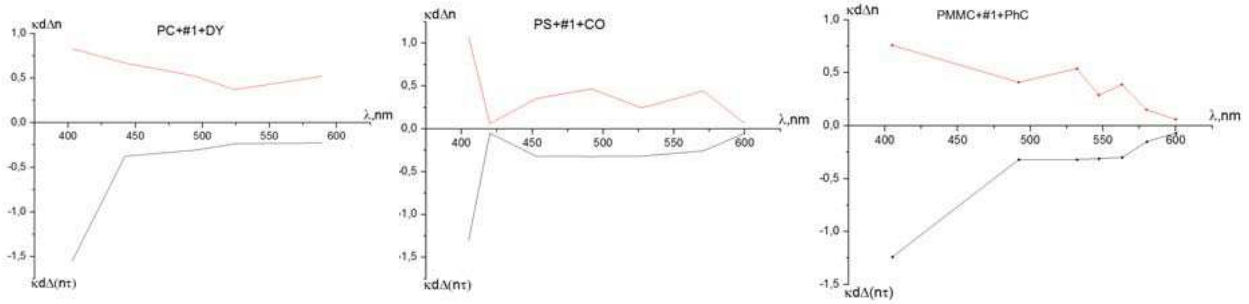


To investigate the fluorescent properties of the created compositions, the method of the polarized luminescence was used. Quantitative measurements were made on the optical scheme created by us, that allows the polarization state of the activating radiation to be changed. The samples were illuminated both polarized irradiation of laser wavelengths: (λ = 405; 441.6; 532) nm and unpolarized irradiation of the same wave lengths. The calculation formulas enable quantitative values of the coefficient of the anisotropic radiation $\kappa d\Delta\,(n\tau)$ and light-induced birefringence $\kappa d\Delta n$ to be obtained from measurements of the radiation intensity of the luminescence of the samples, oriented at angles of 0°, 45°, 90° to the plane of polarization of the activating radiation [6].

The degree of anisotropy of the radiation $?r = (I_{II} - I_{\perp})/(I_{II} + 2I_{\perp})$, and the angles between the dipoles of radiation and absorption $?\alpha$ was also measured $?\cos^2(2\alpha) = (1 + 5r)/15r$.

Photoinduced anisotropy can be described by an effective photo anisotropy A_{eff} obtained from a single measurement. It is numerically equal to the transmission of an anisotropic medium placed between crossed polarizers with an angle between the anisotropy axis and the axis of one of the polarizers 45°.

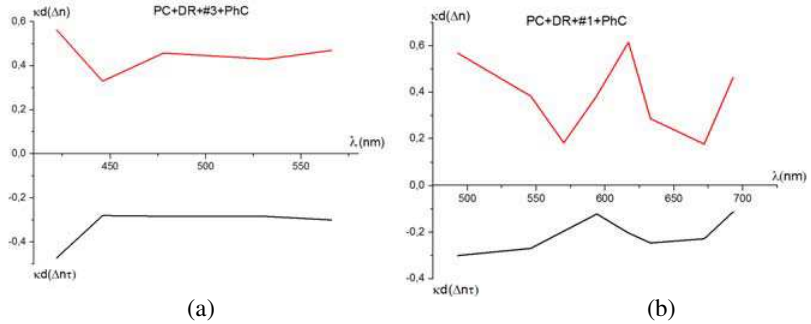
The use of this characteristics gives the possibility of obtaining the kinetic curves of photo anisotropy and to evaluate the influence of different components on photo anisotropy of the samples under investigation.



(a) (b) (c)

Figure 1: The spectral dependence of the anisotropic radiation coefficient for composition: matrix + fluorescent label + azo dye. Activation of the luminescence was carried out with a laser (λ = 405 nm). (a) PC + Dimethyl Yellow. (b) PS + Cationic Orange. (c) PMMC + Dimethyl Red.

For the estimation of the spatial distribution of molecules and investigation of hypothetical interactions or possibilities for bond formation between them, quantum-chemical calculations of the compositions and their components were carried out (MM2-energy minimization method, Chem3D Ultra; Total Steric Energy (TSE) as a main evaluation criterion). The most stable conformers for



(a) (b)

Figure 2: The spectral dependence of the coefficient anisotropic radiation for the composition: (a) PC + Dendrimer + Phthalocyanine dye + chiral dopant #3. (b) PC + Dendrimer + Phthalocyanine dye + dopant #1.

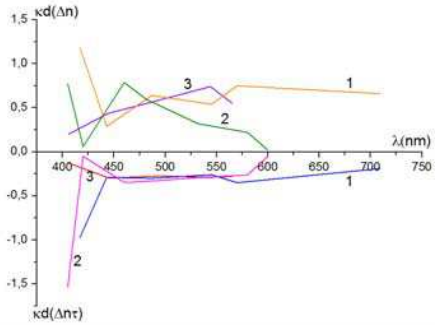
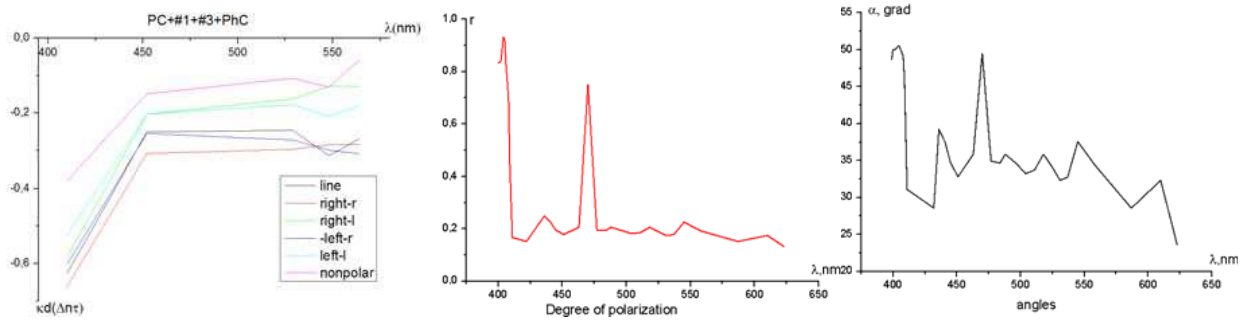


Figure 3: The spectral dependence of the coefficient of anisotropic radiation for the compositions: PC + Phthalocyanine dye + Fluorescent additive with different chiral dopants. Curve 1? #2; curve 2? #3; curve 3? #4.



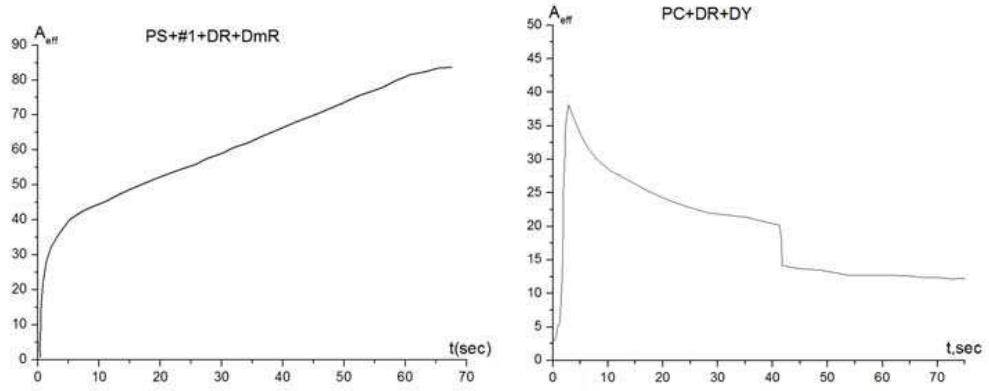
(a) (b) (c)

Figure 4: The spectral dependence of the coefficient of anisotropic radiation for the same composition: PC + Phthalocyanine dye + Fluorescent additive + chiral dopant. (a) With different polarization of a probing beam. (b) The spectral curve of the degree of anisotropy of the radiation. (c) The spectral curve of the angles between the dipoles of irradiation and absorption ?α.

each molecule were found and the models of molecules arrangement in compositions were simulated [TSE (PC) = 26.47; TSE (#3) = −17.6992; TSE (#1) = 15.69; TSE (PhC) = 28.01; TSE (PC + #3 + #1 + PhC) = 33.12]. [TSE (PC) = 26.47; TSE (#1) = 15.69; TSE (PhC) = 13.88; TSE (PC + #1 + PhC + DR) = 31.70]. According to calculations, molecules tend to move away - disperse in compositions and there are no bonds between them. We assume that arrangement of molecules in compositions in this way shouldn't influence on their photophysical properties negatively and shouldn't cause any significant changes in their photoactivity.

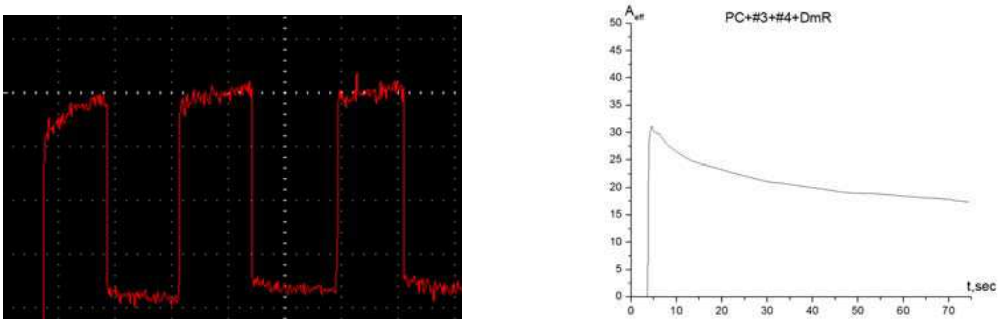
In order to determine the dynamic characteristics of the produced compositions the measurements photo anizotropy in real time, we used the optical scheme, which enables to be determined. The results of these studies are presented in Figs. 5(a) and 5(b).

As it is seen from the Figs. 6(a) and 6(b) anisotropy is induced only at the moment when actinic light is switched on. Thus, the data of the medium can be used as optical shutters.



(a) (b)

Figure 5: The kinetic curves of the effective photo anisotropy of the compositions. (a) PS + #1 + Dendrimer + Dimethyl Red. (b) PC + Dendrimer + Dimethyl Yellow.



(a) (b)

Figure 6: The kinetic curves of the effective photo anisotropy of the compositions. (a) The oscillogram of the compositions: PC + Dendrimer + Dimethyl Yellow. (b) The The kinetic curves of the effective photo anisotropy of the compositions. PC + #3 + #4 + Dimethyl Red.

3. CONCLUSION

Photosensitive compositions were created acquiring under the influence of polarized light the photo anisotropy properties (Weigert-effect), both absorption and emission (photoluminescence). In the compositions was included one of the film-forming polymers fluorescent label, photo anisotropic and chiral dopants. Dendrimer was included in the individual compositions. On the created optical scheme, by the method of polarized luminescence were obtained the spectral curves of the coefficients of anisotropic emission of the investigated compositions. The quantum mechanical calculations for a number of compositions are made. The scheme was created that enables kinetic curves of the effective photo anisotropy to be obtained. The kinetic curves for a number of anisotropy compositions are given. The oscillograms of the compositions which can be used as optical shutters are given.

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3. ??????
4. ??????
5. Kawatsuki N., A. Yamashita, M. Kondo, T. Matsumoto, T. Shioda, A. Emoto, and H. Ono, "Photoinduced reorientation and polarization holography in photo-cross-linkable liquid crystalline polymer films with large birefringence," *Polymer*, Vol. 51, 2849–2856, 2010.
6. ??????