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The influence of photochromic phenomenon on the arrangement state of the liquid crystal and polymer systems

ABSTRACT

In this dissertation the results of the research on photochromic properties of low molecular liquid crystals (from the series of 4-alkyl-4-alkoxyazobenzenes) and amorphous polymer systems containing azobenzene derivatives were presented. The main purpose of the study was to determine the ability of molecular rearrangements and the formation of spatially modulated periodic structure in the form of a diffraction grating. This structure can find application in optical information recording and processing, in photonic devices for construction of optical diffraction elements, optical filters and in micro/nano fabrication technologies.

The dissertation begins with a brief introduction and specifying research goals. The general information about the classification, chemical structure and properties of azobenzene derivatives has been included in the theoretical part of the dissertation. The light-induced effects observed in these materials have been reported, including photoinduced cis-trans isomerization, photo-orientation, photoinduced phase transition and photoinduced mass transport. Theoretical bases of holographic techniques in the investigation of the molecular arrangements were also discussed. The experimental part contains the characteristics of the analyzed group of photochromic materials and description of the applied methods and techniques (absorption spectroscopy, degenerated two-wave mixing technique, polarization microscopy). The most extensive part of the elaboration is discussion of results. The dissertation is concluded with a short summary.

The studies of the liquid-crystalline azobenzene derivatives were focused on the investigation of the process of the diffraction grating formation as a result of the isotropic-to nematic (I-N) phase transition. Studies have revealed a comparable diffraction efficiencies in molecular systems exhibiting different chemical structures. However, a response time of the material is different for various molecular systems indicating differences in the mechanism of the grating formation. Additionally, the reaction rate of thermal relaxation was investigated by using spectroscopic measurements.

Studies performed in order to increase the efficiency of the recording process in photochromic polymers were carried out by using bifotonic (two-colour) holographic recording. In this approach the additional light source of the wavelength coming from the same spectral range as the recording light was applied. As a result, the azo molecules were simultaneously excited by light of two different wavelengths (from the same range), which led to a substantial increase in the diffraction efficiency of the recording process. The study revealed also higher amplitudes of the reliefs obtained during biphotonic recording than in the case of the structure obtained in classical monophotonic (one-colour) recording.

An important objective of the present study was to demonstrate a periodic structure formation on the surface of a supramolecular polymer-azobenzene complex films, as a result of illumination of the material by a single linearly polarized laser beam. It is worth noticing that relatively high amplitude of the structures can be obtained (even 400 nm), which is extremely hard to obtain in multiple-beam-interference methods. It has been shown that the period and amplitude of the periodic structure depend on the wavelength of recording light, thickness of the polymer layer and the inscription temperature. Additionally, it was observed that there is no influence of the content of azobenzene chromophore and the incidence angle of the recording beam on the formation of the structure with a given period. The research has shown that the appropriate selection of recording conditions makes a possibility to optimize the period and amplitude of the periodic structure. Furthermore, some attempts have been made to explain the mechanism of this peculiar photopatterning process.

The results of the research performed during realization of the doctoral study were published in 6 scientific papers (5 of them were published in journals indexed in the *Journal Citation Reports* database), presented on the national and international scientific conferences and have become the object of the one patent application.