Effect of light properties on nonlinear molecular reorientation of polymer-stabilized dye-doped liquid crystals

Kohsuke Matsumoto,[a] Atsushi Shishido[b]
[a]*Institute for Molecular Science, National Institutes of Natural Sciences, E-mail: kmatsumoto@ims.ac.jp*
[b] *Laboratory for Chemistry and Life Science, Institute of Innovative Research, Tokyo Institute of Technology, E-mail: ashishid@res.titech.ac.jp*

Liquid crystals (LCs) have both properties of conventional liquids and crystals and exhibit fluidity and optical anisotropy simultaneously. These properties help us control their molecular orientation by application of external stimuli such as an electric field and a laser beam. In particular, adding a small amount of dye to the LCs enhances the sensitivity of their molecular reorientation by irradiation with a linearly polarized laser beam [1]. Such molecular reorientation induces diffraction caused by changing their refractive index. The diffraction occurs by the spatial distribution of the incident light intensity, which is recognized as a typical nonlinear optical effect. Recently, we found that the nonlinear optical response of the oligothiophene dye-doped LCs could be successfully sensitized by adding low-concentration polymers (Polymer-stabilized dye-doped liquid crystals, PSLCs) [2-4]. For applying PSLCs to functional optical devices, it is important to understand the optical response of PSLCs to laser beams with various properties, such as large-beam diameter and different polarization states. In this study, we irradiated the PSLCs with various laser beams. We evaluated the sensitivity of the molecular reorientation and the shape of the diffraction in order to investigate the effect of these incident beam properties on the photoresponsive behavior of PSLCs [5].

A host LC (5CB), acrylate monomer (A4CB), guest dye (TR5), and photopolymerization initiator (Irgacure 651) were mixed and injected into a 100-μm-thick glass cell treated with a silane coupling reagent. The monomers in the glass cell were photopolymerized by irradiation with ultraviolet (UV) light at 365 nm. Polarized optical microscopy and polarized UV-visible absorption spectroscopy revealed that the LC and dye molecule in the cell were homeotropically aligned. We irradiated the PSLCs with a DPSS laser beam at a wavelength of 488 nm and investigated the photoinduced molecular reorientation of PSLCs.

As a result, the irradiation with the large-diameter laser beam decreased the threshold intensity of the molecular reorientation. This enhancement could be explained in terms of the balance of torque; the torque of the bulk elasticity of LCs decreased by the large-area irradiation with the laser beam. Moreover, we revealed that an elliptical diffraction beam appeared on the screen by irradiating the PSLCs with the linearly polarized beam. The torque balance also explains this elliptical diffraction; the addition of polymer increased the anisotropy of the elastic constants of LCs, resulting in the deformation of diffraction.

References

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