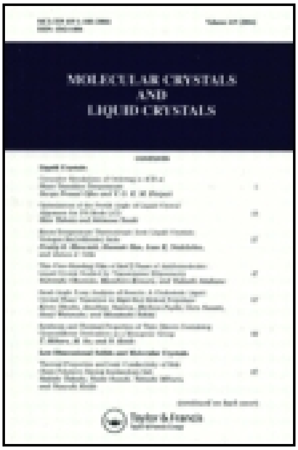

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Orientational photorefractive gratings in nematic liquid crystals (NLCs) on a poly(*N*-vinylcarbazole) film dispersed with 5,10,15,20-tetra-phenylporphyrinatozinc across poly(vinyl alcohol) film were observed. The maximum diffraction efficiency of 0.3–0.5% was measured.

Keywords: nematic liquid crystals; porphyrin; diffraction efficiency; poly(*N*-vinylcarbazole)

INTRODUCTION

Nematic liquid crystals (NLCs) have been found to exhibit extremely large laser induced refractive index change [1]. Since NLCs have large refractive index anisotropy, it is expected that the large index modulation can be generated by the reorientation of the NLC molecules. Photorefractivity arises from the effect of simultaneous photoconductivity and electro-optic response in a material. The electro-optic response in NLC's originates in the reorientation of NLC molecule. Khoo and his coworkers presented a detailed discussion of all the contributing processes of space-charge field formation, the resulting torques, the axis reorientation direction and optical wave mixing effects of NLC's [2]. Ono and Kawasaki reported orientational photorefractive gratings in NLCs on a photoconductive polymer film (PVK) across an insulated polymer film (PVA) and discussed the photorefractive-like grating formation mechanism [3].

In this work we observed and investigated photorefractive grating formation in a liquid crystal (LC) panel with PVK layer dispersed with 5,10,15,20-tetraphenylporphyrinatozinc. NLCs sandwiched between the photoconductive polymer layers across the insulated polymers with porphyrin has not been reported. We show the applied electric field dependent diffraction properties and electrically or optically rewritable processes of the panel.

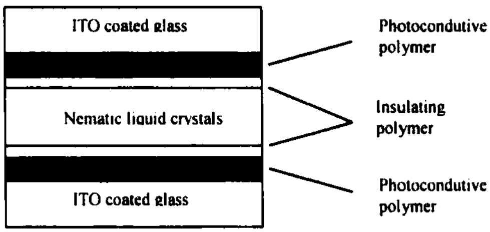

FIGURE 1 Structure of the cell with photoconductive polymer, nematic liquid crystal and insulating polymer.

EXPERIMENTAL

The panel under investigation consisted of layered structures: glass substrate, indium tin oxide electrode/ photoconductive polymer film (PVK) with porphyrin dye/ insulating polymer film (PVA)/ NLCs/ insulating polymer film/ photoconductive polymer film with porphyrin dye/ indium tin oxide electrode/ glass substrate(Figure 1). 5,10,15,20-tetraphenylporphyrinatozinc (ZnTPP), poly(*N*-vinylcarbazole) (PVK) (Mw=63,000) and poly(vinyl alcohol) (PVA) (Mw=50,000) were purchased from Aldrich. A nematic liquid crystal, E44 was purchased from Merck. PVK (0.2 g) was dissolved as a photoconductor in tetrachloroethane (4.8 g), then ZnTPP (0.01 g) was added to the polymer solution. The solution was passed through a 0.2 μm filter and then spin coated at 1000 rpm on ITO glass substrate. After spin coating, polymer film (100 nm) was dried at 50 ℃ for 12 h. PVA as an insulating polymer was dissolved in water at about 80 ℃ to prepare 6 wt% solution. The PVA aqueous solution was also passed through a 0.2 μm filter and then spin coated at 1000 rpm on the PVK coated ITO glass. The resulting layered polymer films (100 nm) were dried at 80 ℃ for 24 h. E44 was sandwiched between two layers. The thickness of the film was controlled with 25 μm.

A linearly polarized beam from a continuous Ar laser (514 nm) was divided into two beams of equal intensity (4.5 mW) by a polarized beam splitter. The resulting two beams were superposed onto the sample on the same 500 μm diameter spot. Polarization directions of two beams were controlled by two half-wave plates. Two coherent s-polarized writing beams inresect in the sample cell at incident angle, 3°, and create an intensity grating. The spacing Λ of the intensity grating was set to between 12 μm by controlling the incident angle between the two writing beams. The applied electric DC field was controlled. The diffraction efficiency (η) is defined as the intensity ratio of the zero order (I_0) and the first order (I_1) diffraction beams in the absence of one side of the two beams.

RESULTS AND DISCUSSION

The grating generation and extinction dynamics with a 300 V of applied DC field are shown in Figure 2. The grating constant was 12 μm. One of the two writing beams was turned on by using the mechanical shutter and the diffraction efficiency grew. One of the two writing beams was turned off and decay of the gratings was observed. This grating generation and extinction behaviors were reversible. Because the NLC molecules were reoriented in a few ms in the presence of the electric-field, we obtained the conclusion that the photocharge generation, transportation, and trapping processes were dominant in grating generation and trapping processes.

In the absence of applied electric field the NLCs molecules are randomly aligned on the PVA surface. Once a DC electric field is applied across the NLCs layers, the director of the NLCs is aligned parallel to the field. Under the optical standing wave pattern of intensity that is produced by two intersecting coherent writing beams, photocarriers are generated in the photoconductive polymer layer in response to the spatially varying illumination.

The photocharges in the photoconductive layers are transported to the insulating polymer layer. The mobile photocharges from the photoconductive polymer are eventually trapped in the insulating polymer. The role of the insulating polymer is to improve the surface charge density. The space-charge field is estimated via the Poisson equation of electrostatics which relates the gradient of the electric field to the space charge density distribution. The resulting space-charge field is shifted in space by $\pi/2$ relative to the space-charge density distribution. Electro-optic response is needed in order to modulate the refractive index with respect to the space-charge field. The electro-optic response in our cell is due to the reorientation of the NLC molecules by the space-charge field.

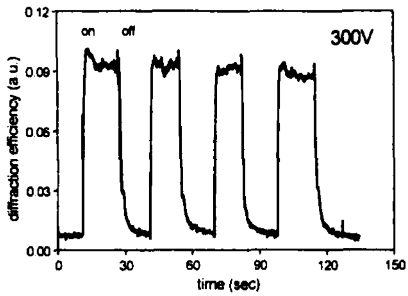

FIGURE 2 Diffraction efficiency vs time in the orientational photorefractive cell. Applied voltage was 300V.

The incident light beam is split, after interacting with the grating, into several beams corresponding to different orders of diffraction. The maximum diffraction efficiency of 0.3-0.5% was measured in the samples.

Acknowledgments
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