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Photogeneration of Surface Relief Gratings in Azobenzene Polymer/Liquid Crystal Hybrid Films

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Photogeneration of Surface Relief Gratings in Azobenzene Polymer/Liquid Crystal Hybrid Films

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Surface relief gratings (SRGs) formed on the azobenzene containing polymer film via the irradiation with an interference pattern of coherent light have recently been demonstrated. In this presentation, we will show our new proposal that the nano-hybrid film composed of azobenzene polymer and liquid crystal provides an interesting SRG system. SRGs are formed on the film at room temperature at very low laser intensities in a few seconds. Details on our approach using the binary component host-guest system in the SRG process will be reported by changing the combination of materials.

Keywords: Photogenerated surface relief gratings; Nano-hybrid film; Azobenzene polymer; Liquid crystal

INTRODUCTION

During the past several years, it has been shown that thin films of azobenzene functionalized polymers (azo polymers) form regular surface modification under the irradiation with an interference pattern of coherent light [1-3]. Such photogeneration of surface relief gratings (SRGs) on azo polymers has attracted much attention not only from academic interest but also from a viewpoint of practical use for optical

device applications.

Recently, we have shown our new proposal that the nano-hybrid film composed of azo polymer and liquid crystal provides an interesting SRG system [4]. The present system comprises two materials, azo polymer (6Az10-PVA, host polymer) and 4'-pentyl-4-cyanobiphenyl (5CB, guest molecule) (FIGURE 1). SRGs are formed in the hybrid film at room temperature at low laser intensities (~50 mW / cm^{-2}) in a few seconds. Due to the cooperative nature involved in this binary molecular system, this may be dubbed a host-guest supramolecular SRG material.

In this report, details on our approach using the binary component host-guest system in the SRG process are presented by changing the combination of materials. As shown in FIGURE 1, various azo polymers (mAzn-PVA) having different tails and spacers were prepared to investigate the influences on the chemical structure of the host polymer. In addition, 6Az10-CB10-PVA having the CB mesogen connected via a covalent bond was examined (FIGURE 1).

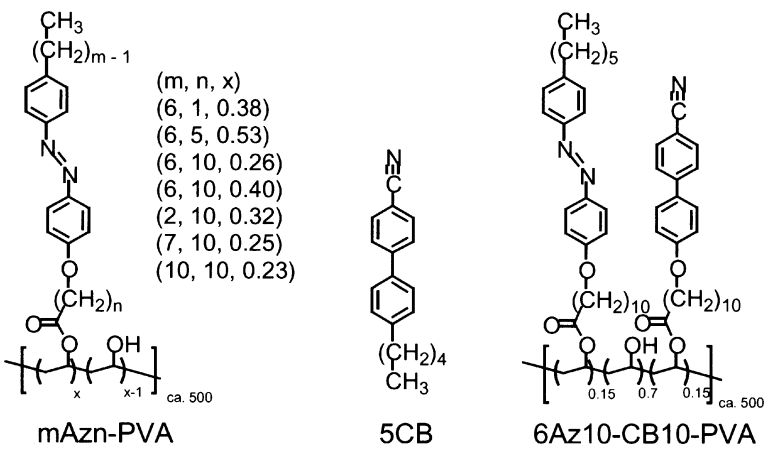

FIGURE 1 Chemical structures of material used.

EXPERIMENTAL

The azo polymers, mAzn-PVA and 6Az10-CB10-PVA, m and n being the tail and spacer carbon length, respectively, were synthesized in similar manners as described in the literature [5]. The hybrid films were prepared on a glass substrate by spin coating from mixed solution dissolving azo polymer and equimolar 5CB. Holographic set up and method of photofabricating SRGs were described in reference [4]. SRG formation was examined by the intensity of the first-order diffraction of He-Ne laser beam and atomic force microscopy (Seiko SPA300-SPI3700) in a cyclic contact mode.

RESULTS AND DISCUSSION

Generated diffraction efficiency and the depth of the surface modulation in the various hybrid films are summarized in TABLE 1. The difference in the length of spacer (n), which connects the azo unit and PVA backbone, influenced the efficiency of SRG formation. Hybrid films for 6Azn-PVA having the shorter spacer, especially n = 1, exhibited only a slight diffraction efficiency, which may be related to the inferior miscibility with 5CB [6]. On the other hand, the difference in the length of tail (m) hardly influenced the efficiency of the SRG formation.

Instead of addition of 5CB molecule, a 6Az10-CB10-PVA film having the CB mesogen connected via a covalent bond was examined. In this case the diffraction efficiency was not detected at all. These facts imply that it is important to add low-molecular-weight molecule for the efficient SRG generation, indicating that 5CB acts as a plasticizer and depresses the bulk viscosity substantially.

TABLE 1 Diffraction efficiency (η) and surface modulation depth (Δh) of SRGs fabricated with an interfering Ar^+ laser (ca. 0.5 J cm^{-2}) in the equimolar mAzn-PVA/5CB hybrid films.

mAzn-PVA				
m	n	x	η / %	Δh / nm
6	1	0.38	0.04	10-15
6	5	0.53	0.49	25-30
6	10	0.40	0.67	50-60
2	10	0.32	0.87	65-75
7	10	0.25	0.57	25-30
10	10	0.23	1.06	60-65
6Az10-CB10-PVA[a]			0.00	1-2

[a] Pure 6Az10-CB10-PVA film was prepared instead of addtion of 5CB molecule.

In summary, highly sensitive SRG formation was attained in the hybrid films composed of 5CB and various kinds of azo polymer (mAzn-PVA) except for 6Az1-PVA having the shortest spacer length. On the other hand, no SRG formation was observed in the 6Az10-CB10-PVA film, indicating that addition of low-molecular-weight molecule is essential for the efficient SRGs generation.

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