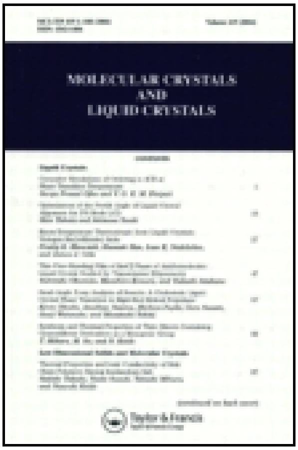


Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Chromophore Concentration Effect on Photorefractive Performance of Organic Photorefractive Composites

Jin-Woo Oh [a] & Nakjoong Kim [a]
[a] Department of Chemistry, Hanyang University, Seoul, Korea

Version of record first published: 22 Sep 2010

Mol. Cryst. Liq. Cryst., Vol. 491, pp. 53–57, 2008

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400802328873

Chromophore Concentration Effect on Photorefractive Performance of Organic Photorefractive Composites

Jin-Woo Oh and Nakjoong Kim
Department of Chemistry, Hanyang University, Seoul, Korea

We investigated the effect of chromophore (DB-IP-DC) on the photorefractive performance in organic photorefractive composites. We prepared several photorefractive composites; PSX-Cz:TNF:DB-IP-DC:BBP = 69:1:x:(30 − x) wt% and measured photocurrent and PR grating build-up time. The photocurrent was measured by the competition between the hole trapping and detrapping rates from DB-IP-DC and PSX-Cz. The PR grating build-up rate increased with the increment of photocurrent.

Keywords: chromophore; photocurrent; PR grating build-up time; trap

1. INTRODUCTION

Organic photorefractive (PR) composites are considered today to be highly promising materials for holographic applications [1–4]. The photorefractive phenomenon requires photo-charge generation, hole transporting, and hole trapping, together with nonlinear electro-optic effect [5]. Photoconductivity in polymer materials has been quite well explored due to its employment in xerography. The electro-optic effect in polymers has also been a subject of intense research interest, due to the potential exploitation of the polymers in the light modulators and switches [6].

To perform highly efficient and highly response PR property, many researchers have studied the structure-property relationship of different photoconducting polymer, NLO chromophores, plasticizer, and sensitizers in organic photorefractive materials; however, few studies have been reported on the effect of trap density, which is crucial in the

Address correspondence to Nakjoong Kim, Center for Organic Photorefractive Materials, Department of Chemistry, Hanyang University, 17 Haendang-Dong, Seongdong-Gu, Seoul, 133-791, Korea. E-mail: kimnj@hanyang.ac.kr

space charge field formation. By definition, hole trapping takes place at the hopping sites that require energy substantially higher than average to release the charge carriers. Thus, in a hole transporting polymer, the addition of chromophore whose ionization potential is lower than the hopping sites is expected to give rise to trapping [6,7].

In this work, we investigated the chromophore concentration effect on the PR performance in several PR samples, especially PR grating build-up time. The chromophore is expected to act as a trap for hole transport in the matrix. We measured the photocurrent and PR grating build-up time, and discussed the chromophore concentration dependence of them.

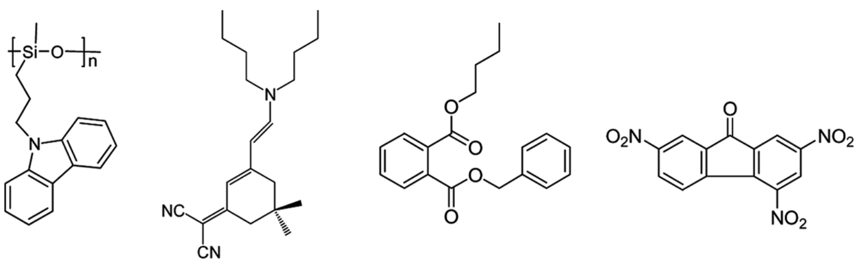
2. EXPERIMENTAL

2.1. Materials and Sample Fabrications

We prepared several photorefractive composites:poly[methyl-3-(9-carbazoly) propylsiloxane] (PSX-Cz, IP = 8.334 eV): 2,4,7-trinitro-9-fluorene (TNF, IP = 10.930 eV): 2-{3-[(*E*)-2-(dibutylamino)-1-ethenyl]-5,5-dimethyl-2-cyclohexenyliden} malononitrile (DB-IP-DC, IP = 8.110 eV): benzyl butyl phthalate (BBP, IP = 9.634 eV) = 69:1:x:(30 − x) wt%. The ionization potential of the materials was calculated by using VAMP-AM1 method in the material studio 4.1 program. Figure 1 shows the chemical structure of the materials used in this study. The sample was prepared by sandwiching of the softened composite between two ITO coated glass plates. The thickness of active layer was 100 μm.

2.2. Measurements

The photoconductivity was measured using He-Ne laser with intensity of 20 mW/cm^2 while applying bias field of 50 V/μm. The PR grating



(A) (B) (C) (D)

FIGURE 1 Chemical structure of components of photorefractive composite: (A) PSX-Cz, (B) DB-IP-DC, (C) BBP, and (D) TNF.

build-up time of the photorefractive composites was obtained from the degenerated four-wave mixing (DFWM) measurement using He-Ne laser [8]. The intensity of *s*-polarized writing beams was 30 mW/cm^2. The incident angles of two writing beams were 30° and 60° from the sample normal. The intensity of *p*-polarized reading beam was 0.06 mW/cm^2.

3. RESULTS AND DISCUSSION

Polymeric composite systems with T_g around room temperature exhibit excellent photorefractive properties due to reorientation of the optically anisotropic chromophore molecules under the spatially modulated space charge field [9]. Figure 2 shows the photocurrent of the samples plotted against the chromophore concentration. Below 3 wt% of chromophore concentration, the photocurrent decreased with increasing the chromophore concentration. This is due to the trap-effect of chromophore DB-IP-DC (8.110 eV) having lower ionization potential compared with the hole transporting polymer PSX-Cz (8.334 eV). However, above 3 wt% of chromophore concentration, the photocurrent increased as the chromophore concentration increased. Since the difference of ionization potential between PSX-Cz and DB-IP-DC is small as 0.224 eV, the DB-IP-DC serves as a shallow trap. The increment of the shallow trap density increases the number

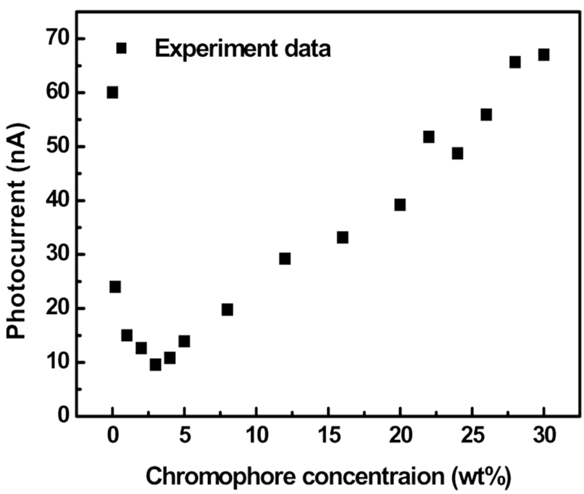


FIGURE 2 Photocurrent dependence on the chromophore concentration for all samples.

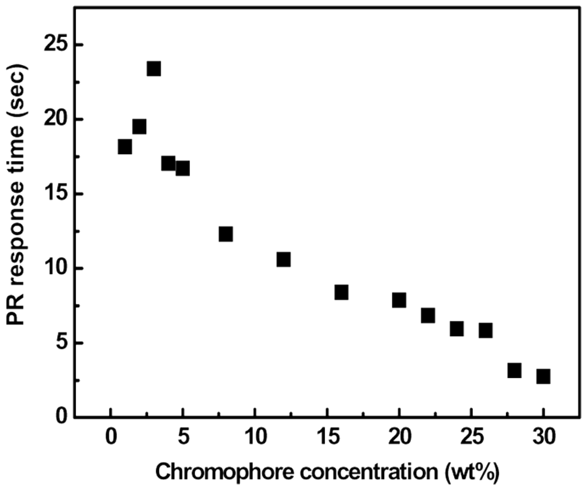


FIGURE 3 PR grating build-up time dependence on the chromophore concentration for all samples.

density of trapped hole and also increases the probability of hole detrapping, resulting in larger photocurrent.

Figure 3 shows the photorefractive grating build-up time (τ_1) of the samples plotted against the chromophore concentration. The PR grating build-up time was calculated by fitting the diffraction gain, g(t) of the

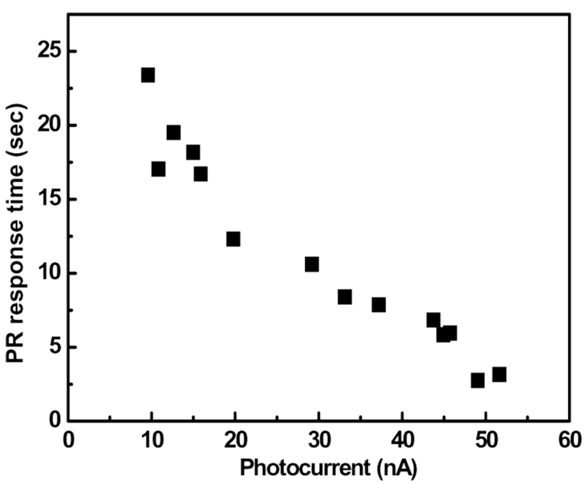


FIGURE 4 PR grating build-up time dependence on the photocurrent for all samples.

DFWM measurement, with the following biexponential function, [10]

$$g(t) = a_1\{1 - \exp(-t/\tau_1)\} + a_2\{1 - \exp(-t/\tau_2)\} \quad (1)$$

where τ_1 and τ_2 are the fast and slow time constants, respectively. The PR grating build-up time has a maximum at 3 wt% of chromophore concentration where the photocurrent reaches its minimum value. As shown Figure 4, the sample with higher photocurrent had the faster PR grating build-up time. From this result, we can indicate that the PR grating build-up speed related to the magnitude of photocurrent, which is effected by chromophore concentration.

4. CONCLUSION

We investigated the chromophore concentration effect on the PR performance in several photorefractive samples; PSX-Cz:TNF:DB-IP-DC:BBP = 69:1:x:(30 − x) wt%. The photocurrents were measured by competition between the hole trapping and detrapping rates from DB-IP-DC and PSX-Cz. Below 3 wt% of chromophore concentration, the photocurrent decreased with increasing the chromophore concentration due to the trap-effect of chromophore DB-IP-DC (8.110 eV) having lower IP compared with the hole transporting matrix PSX-Cz (8.334 eV). However, above 3 wt% of chromophore concentration, the photocurrent is considerably increased due to the increment of the hole detrapping. The PR grating build-up time was found to be related to the photocurrent of the PR samples. At the same electric field, the PR grating build-up speed increased with the photocurrent which is effected by chromophore concentration.

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