Molecular Crystals and Liquid Crystals

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

Dependency of Ionization Potentials of Photoconductive Polymers on Photorefractive Response Time

Chil-Sung Choi [a], In Kyu Moon [a], Jin-Woo Oh [a] & Nakjoong Kim [a]

[a] Department of Chemistry, Hanyang University, Seoul, Korea

Version of record first published: 22 Sep 2010

To cite this article: Chil-Sung Choi, In Kyu Moon, Jin-Woo Oh & Nakjoong Kim (2007): Dependency of Ionization Potentials of Photoconductive Polymers on Photorefractive Response Time, Molecular Crystals and Liquid Crystals, 472:1, 11/[401]-15/[405]

To link to this article: http://dx.doi.org/10.1080/15421400701544752

Mol. Cryst. Liq. Cryst., Vol. 472, pp. 11/[401]–15/[405], 2007

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400701544752

Taylor & Francis
Taylor & Francis Group

Dependency of Ionization Potentials of Photoconductive Polymers on Photorefractive Response Time

Chil-Sung Choi
In Kyu Moon
Jin-Woo Oh
Nakjoong Kim
Department of Chemistry, Hanyang University, Seoul, Korea

Photorefractive response time has been an important issue to be improved. We investigate the dependency of photorefractive speed against ionization potentials of the photoconductive polymers. The composite with the lowest ionization potential gives the highest photoconductivity. Fast component of the response time is found to be strongly dependent of photoconductivity of the composite.

Keywords: photoconducting polymer; photorefractive effect; response time

INTRODUCTION

Photorefractive (PR) effect refers to a spatial modulation of refractive index of material upon illumination of non-uniform beam through photoconductivity and electro-optic property [1,2]. As two coherent beams intersect a photorefractive material, the internal space-charge field is formed due to redistribution of photo-generated charge carriers, which subsequently modulate the refractive index via electro-optic effect [3–7].

In this work, we investigate the relationship of photorefractive speed against I_p (ionization potential) of the photoconductive polymers. Figure 1 shows the chemical structures of the polymers containing electron-donating groups with different ionization potential. The ionization potentials of PSX-DB[a,g]Cz, PSX-DB[a,i]Cz, PSX-B[a]Cz calculated

The financial support of Creative Research Initiatives is gratefully acknowledged.
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

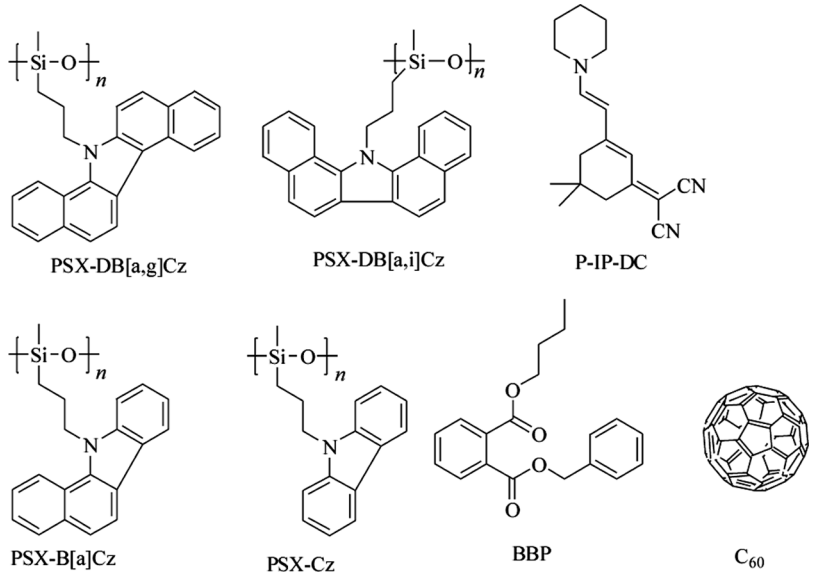

FIGURE 1 Chemical structure of the components studied.

using the semi-empirical method, Material Studio (acccelrys co.) with PM3 approximation method, for geometry optimization are 7.79, 8.01, 8.08 respectively, which are less than that of PSX-Cz (8.26 eV).

EXPERIMENTAL

Preparation of Photorefractive Devices

Photorefractive composites are prepared by mixing photoconducting matrix, electro-optic chromophores, and photosensitizer. Table 1 shows compositions of components in photorefractive composites. Four

TABLE 1 Composition of Photorefractive Composites Studied (wt. %)

		C1	C2	C3	C4
Chromophore	P-IP-DC	30	30	30	30
Polymer	PSX-DB[a,g]Cz	54			
	PSX-DB[a,i]Cz		54		
	PSX-B[a]Cz			54	
	PSX-Cz				64
Plasticizer	BBP	15	15	15	5
Sensitizer	C_{60}	1	1	1	1

different photoconducting polymers were employed to change their charge generation efficiency. To obtain homogeneous samples all components were dissolved in toluene followed by evaporation of solvent. The devices were prepared by sandwiching the heat-softened composites between two ITO coated glass plates [8]. The thickness of active layer was 50 μm. The glass transition temperature (T_g) of the composite was determined by differential scanning calorimetry (TA DSC Q100).

Measurement

The photoconductivity of the device was measured with a He–Ne laser (632.8 nm, $I = 13\,mW/cm^2$) by photocurrent method [8,9]. The dark and photoconductivity were calculated according to:

$$\sigma = iL/(VS) \tag{1}$$

Diffraction efficiency of the photorefractive material was determined by the conventional degenerated four wave mixing method using He–Ne laser [3,10]. 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 $0.06\,mW/cm^2$. The internal diffraction efficiency η_{int} was calculated according to:

$$\eta_{int} = I_{R,diffr}/(I_{R,diffr} + I_{R,transm}) \tag{2}$$

RESULTS AND DISCUSSION

I_p dependency of the photoconductivity and PR response time of the samples C1–C4 were summarized in Table 2. PR response times were determined from curve fitting of $\eta = a_1\ (1\text{-exp}\ (-x/\tau_1)) + a_2\ (1\text{-exp}(-x/\tau_2)$ measured in the generate four-wave mixing experiment at 632.8 nm. Table 2 shows that as I_p of the photoconducting matrices

TABLE 2 Photorefractive Properties of Composites C1–C4

Composite	40 V/μm σ_{ph} (pS/cm)	40 V/μm τ_1	T_g (°C)
C1	1.85	0.32	32
C2	0.77	0.91	30
C3	0.57	1.52	30
C4	0.152	5.53	28

Photoconductivity σ_{ph}, fast components of PR response time τ_1.

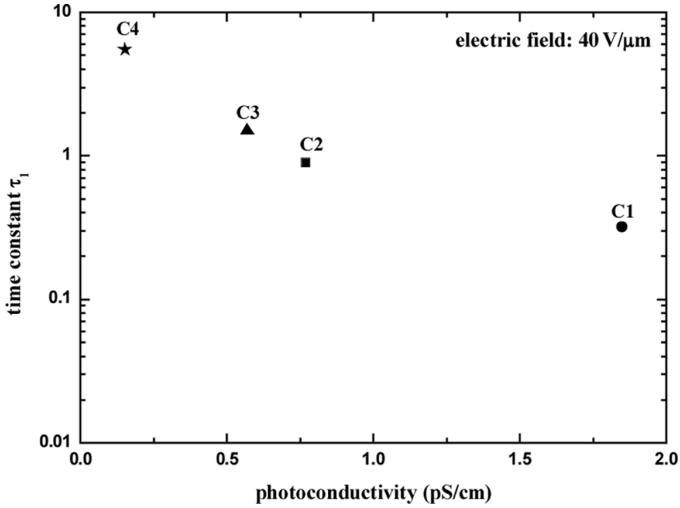

FIGURE 2 Photorefractive response time as a function of photoconductivity C1 (circles), C2 (squares), C3 (triangles), C4 (stars).

decrease, photoconductivity of the PR composites increase due to their efficiencies of photo-charge generation. PR effect is a combined feature of space-charge build-up process and electro-optic process. Space-charge field build-up process includes photo-charge generation process charge trapping process. If this space-charge build-up process is a limiting, one determining PR response time, then the photoconductivity would strongly affect the PR response time [11].

Figure 2 cleanly shows that fast component of response time strongly depends on the photoconductivity but slow component does not. It means that fast component is closely related to the space-charge build-up process.‘

CONCLUSION

In this work, we investigate the dependence of photorefractive speed on I_p of the photoconductive polymers. The composite with the highest ionization potential shows the lowest photoconductivity. Also, fast components of PR response time strongly depend on photoconductivity of the composites. From this result, we could conclude that limiting factor of fast response time might be a space-chare build-up process which could be accelerated by improving the photo-charge generation efficiency.

REFERENCES

[1] Günter, P. & Huignard, J.-P. (1988). *Photorefractive Materials and Their Applications,* Springer-Verlag: Berlin, vol. I, 7.
[2] Moerner, W. E. & Silence, S. M. (1994). *Chem. Rev.*, *94*, 127.
[3] Joo, W.-J., Kim, N.-J., Chun, H., Moon, I. K., Kim, N., & Oh, C. H. (2002). *J. Appl. Phys.*, *91*, 6471.
[4] Hwang Ui-Jung, Choi Chil-Sung, Vuong Nguyen Quoc, & Kim Nakjoong (2005). *J. Chem. Phys.*, *123*, 244905.
[5] Joo, W.-J., Kim, N.-J., Chun, H., Moon, I. K., & Kim, N. (2001). *Polymer*, *43*, 9863.
[6] Joo, Won J., Choi Chil-Sung, Moon, In K., & Kim Nakjoong (2002). *Proc. SPIE.*, *4802*, 122.
[7] Joo Won-Jae & Kim Nakjoong (2004). *The Society of Polymer Science, Japan*, *36*, 674.
[8] Chun, H., Moon, I. K., Shin, D.-H., Song, S., & Kim. (2002). *J. Mater. Chem.*, *12*, 858.
[9] Zhang, Y., Wada, T., Wang, L., & Sasabe, H. (1997). *Chem. Mater.*, *9*, 2798.
[10] Bittner, R., Daubler, T. K., Neher, D., & Meerholz, K. (1999). *Adv. Mater.*, *11*, 123.
[11] Wright, D., Diaz-Garcia, M. A., Casperson, J. D., DeClue, M., & Twieg, R. J. (1998). *Appl. Phys. Lett.*, *73*, 1490.