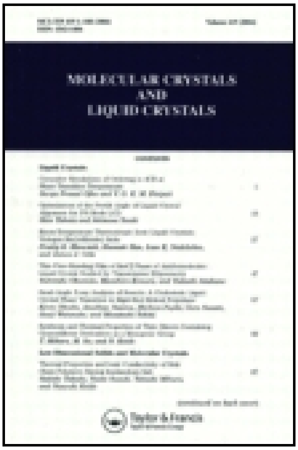

Molecular Crystals and Liquid Crystals

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

White Emission from an Immiscible Polymer Blend

Jong Park [a] & O. Park [a]

[a] Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology, Yuseong-gu, Daejeon, Korea

Version of record first published: 18 Oct 2010

Mol. Cryst. Liq. Cryst., Vol. 424, pp. 135–139, 2004

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400490506063

WHITE EMISSION FROM AN IMMISCIBLE POLYMER BLEND

Jong Hyeok Park and O. Ok Park
Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology, 373-1 Guseong-dong, Yuseong-gu, Daejeon 305-701, Korea

White light emission was obtained from a light-emitting diodes (LEDs) prepared from an immiscible polymer blend consisting of Poly(9,9′-di hexylfluorene-2,7-divinylene-m-phenylenevinylene-stat-p-phenylenevinylene) (CPDHFPV) and poly(2-methoxy-5-(2′-ethy-hexyloxy)-1,4-phenylenevinylene) (MEH-PPV). An inefficient energy transfer between CPDHFPV and MEH-PPV was observed because the blends are partially miscible. The phase separated structure was good advantage to obtain white emitting device. The incomplete energy transfer in the blend generated a pure white color and the emission color of this system showed a low sensitivity to the driving voltage.

Keywords: light-emitting diodes (LEDs); polymer blend; white emission

INTRODUCTION

The methods that have been proposed to produce white LEDs from polymers or organic small molecules can generally be classified into two categories. The first produces multi-layer devices composed of several different materials [1,2]. Kido *et al*. developed a device with three emitting layers, each layer emitting light in a different region of the visible spectrum to generate white light [3]. Xie *et al.* also reported white emission from organic multiple hetero-structure [2]. The second methods to obtain white emission are that red emitting material is co-deposited with blue and/or green emitting materials [4]. In polymer blend system, Kido *et al*. reported composites of emitting dyes and poly(vinylcarbazole) emitted white

Received 1 October 2003; accepted 7 January 2004.

Address correspondence to O. Ok Park, Department of Chemical and Biomolecular Engineering, Korea Advanced Institute of Science and Technology, 373-1 Guseong-dong, Yuseong-gu, Daejeon 305-701, Korea. Tel.: +82-42-869-3923; Fax: +82-42-869-3910, E-mail: ookpark@webmail.kaist.ac.kr

emission [5]. In both small molecules doped polymer and polymer blend systems usually needs very low level (10^{-3}%) doping controls due to the effective Förster energy transfer. Therefore, in this study, we tried to an immiscible polymer blend composed of two polymer components for white emission. Blend morphology, energy transfer and light emitting characteristics of LEDs using immiscible polymer blend were described.

EXPERIMENTAL

CPDHFPV (M_w: 32,000 and T_g: 125°C) was synthesized by employing the Heck reaction as reported elsewhere [6]. MEH-PPV (M_w: 120,000 and T_g: 65°C) purchased from H. W. Sands Co. and used without further purification. Chemical structures of the polymers are shown in inset of Figure 1. Poly(3,4-ethylene dioxythiophene)(PEDOT) on an O_2 plasma treated indium-tin-oxide (ITO)-coated glass substrate was used as the hole-injecting layer and then a 100 nm thick film of the immiscible polymer blend was spin-cast from the monochlorobenzene solution on it. Lithium fluoride (LiF) with 1 nm thickness was deposited on the top of the blend

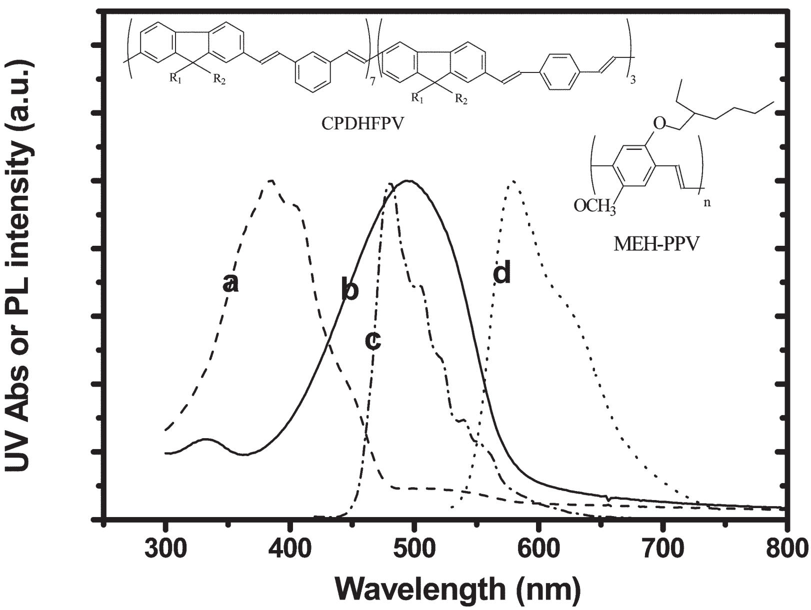

FIGURE 1 Normalized absorbance (Abs) and photoluminescence (PL) spectra of CPDHFPV and MEH-PPV. a: Abs of CPDHFPV, b: Abs of MEH-PPV, c: PL of CPDHFPV, d: PL of MEH-PPV. The inset shows the structures of CPDHFPV and MEH-PPV.

film and then aluminum was deposited under a high vacuum (5×10^{-5} torr). Electroluminescence (EL) as well as photoluminescence (PL) spectra were measured using an ISS PC1 Photon Counting Spectrofluorometer.

RESULTS AND DISCUSSION

Figure 1 shows the normalized absorption and PL spectra of CPDHFPV and MEH-PPV. We can clearly observe the spectral overlap between the emission of CPDHFPV and the absorption of MEH-PPV. The blend system, therefore, meets the necessary condition of Förster-type energy transfer that the emission of the donor and the absorption of the acceptor should spectrally overlap with each other. We can expect energy transfer from CPDHFPV to MEH-PPV when the polymers are molecularly intermixed within the Förster distance [7].

Figure 2 shows an atomic force microscope (AFM) images of CPDHFPV/MEH-PPV (2:1 by wt.) film which can characterize the film structure. Partially phase-separated morphology was observed. We can consider incomplete energy transfer originates from the partial miscibility between

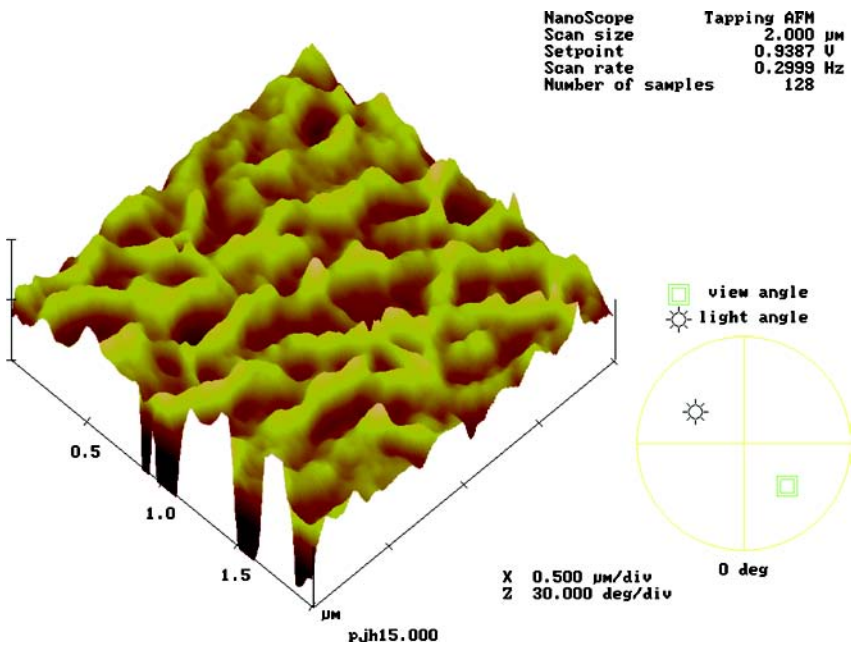

FIGURE 2 AFM image of CPDHFPV/MEH-PPV (33% MEH-PPV by wt.) film.

two components. The excitation energy transfer from CPDHFPV to MEH-PPV partially takes place across the phase boundary within Förster radius.

We examined the energy transfer from CPDHFPV to MEH-PPV while changing the blend ratio as shown in Figure 3. When the weight ratio of MEH-PPV in CPDHFPV/MEH-PPV blend was 0.5% we obtained the two colors emitted simultaneously from CPDHFPV as well as MEH-PPV: blue and orange red, respectively. Inset in Figure 3 shows the EL spectra of the ITO/(CPDHFPV/MEH-PPV(0.5% MEH-PPV by wt.)/LiF/Al device measured while applying various voltage. It has been reported that the EL spectrum of a polymer blend significantly changed when the blend emitted white color due to different bandgap energy of the each components [8]. However, the EL spectra of the immiscible polymer blend investigated in this work did not change remarkably with the driving voltage. It is noteworthy that MEH-PPV in the blend can emit orange red color by the partial excitation energy transfer from CPDHFPV as well as by the direct excitation, which makes the emission color of the blend insensitive to the drive

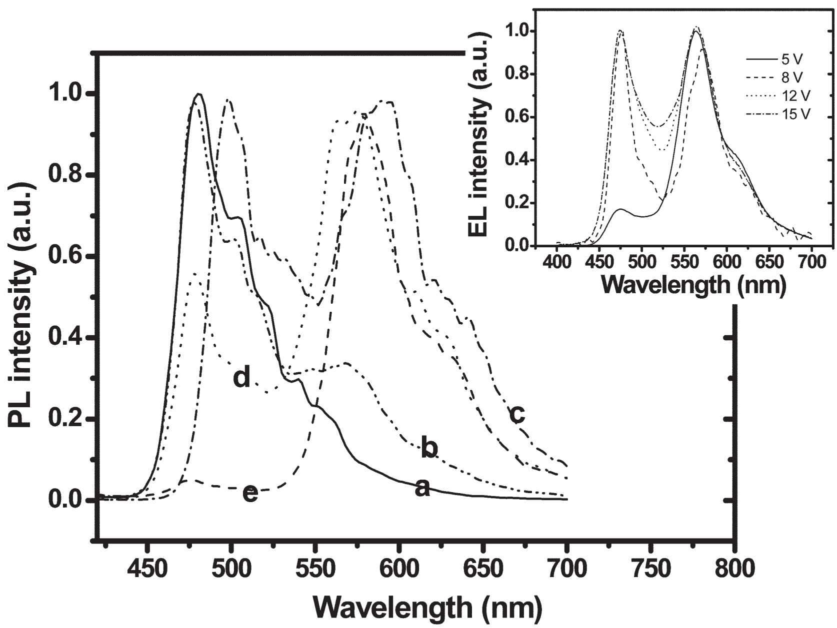

FIGURE 3 PL spectra of CPDHFPV/MEH-PPV immiscible blend films excited at 380 nm as increasing MEH-PPV content. a: 0% MEH-PPV by wt., b: 0.25% MEH-PPV by wt., c: 0.5% MEH-PPV by wt., d: 1.0% MEH-PPV by wt., e: 5.0% MEH-PPV by wt.. The inset shows the EL spectra of ITO/(CPDHFPV/MEH-PPV(0.5% MEH-PPV by wt.)/LiF/Al device.

voltage [9]. In addition, we obtained white light near CIE 1931 coordinate (0.33, 0.33) at the voltage less than 10 V.

CONCLUSIONS

White polymer EL devices from immiscible polymer blend composed of CPDHFPV and MEH-PPV were obtained. The study indicates that the simple blend method can be employed to obtain white polymer LED. The phase separation between CPDHFPV and MEH-PPV which induce incomplete energy transfer helps to produce the white emission with a small drive voltage dependence of the emission spectrum.

REFERENCES

[1] Kido, J., Kimura, M., & Nagai, K. (1995). *Science*, *267*, 1332.
[2] Deshpande, R. S., Bulovic, V., & Forrest, S. R. (1999). *Appl. Phys. Lett.*, *75*, 888.
[3] Xie, Z. Y., Liu, Y., Huang, J. S., Wang, Y., Li, C. N., Liu, S. Y., & Chen, J. C. (1999). *Synth. Met.*, *106*, 71.
[4] Shi, J. & Tang, C. W. (1997). *US patent* 5683823.
[5] Kido, J., Shionya, H., & Nagai, K. (1995). *Appl. Phys. Lett.*, *67*, 2281.
[6] Cho, H. N., Kim, J. K., Kim, D. Y., Kim, C. Y., Song, N. W., & Kim, D. (1999). *Macromolecules*, *32*, 1476.
[7] Shoustikov, A. A., You, Y., & Thomson, M. E. (1998). *IEEE J. Sel. Top. Quant. Elect.*, *4*, 3.
[8] Granstrom, M. & Inganas, O. (1996). *Appl. Phys. Lett.*, *68*, 147.
[9] Lee, T. W., Park, O. O., Cho, H. N., Hong, J. M., & Kim, Y. C. (2001). *Mol. Cryst. Liq. Cryst.*, *371*, 435.