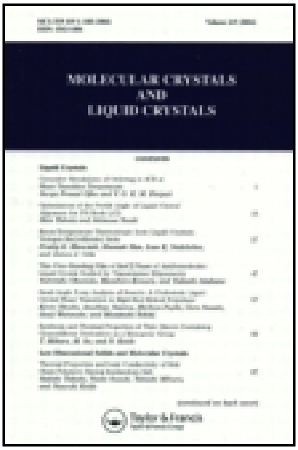


Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Characteristics of Organic El Device Using A Pppma Blue Light Emitting Polymer Doped with Fluorescent Dyes

Se Oh [a], Jung Ham [a], Chang Lee [a] & Hwan Oh [b]
[a] Department of Chemical & Biomolecular Engineering, Sogang University, Seoul, Korea
[b] Department of Electronics Engineering, Konkuk University, Seoul, Korea

Version of record first published: 18 Oct 2010

Mol. Cryst. Liq. Cryst., Vol. 424, pp. 127–134, 2004

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400490506018

CHARACTERISTICS OF ORGANIC EL DEVICE USING A PPPMA BLUE LIGHT EMITTING POLYMER DOPED WITH FLUORESCENT DYES

Se Young Oh, Jung Min Ham, and Chang Ho Lee
Department of Chemical & Biomolecular Engineering,
Sogang University,
Seoul, 121-742, Korea

Hwan Sool Oh
Department of Electronics Engineering, Konkuk University,
Seoul, 143-914, Korea

We have synthesized a novel blue light emitting poly(N-(p-perylene)phenylmethacrylamide) (PPPMA) polymer having a perylene moiety in the side chain. The prepared polymer was very soluble in most organic solvents such as monochlorobenzene, THF, chloroform and benzene. A single-layered organic electroluminescence (EL) device consisting of ITO/PPPMA polymer + fluorescent dye dopants (DCM or Coumarin 6)/Al was fabricated, and then the effect of dye doping on the EL characteristics was examined. The luminescence of the doped devices was significantly influenced by the amount and structure of fluorescent dye molecules. The EL devices emitted red light (597 nm) and green light (558 nm) corresponding to the fluorescent dye molecules. Especially, EL device containing a DCM of 3 wt% emitted a red light with the high brightness of 600 cd/m^2 at a DC 15 V.

Keywords: blue light-emitting PPPMA polymer; doping; fluorescent dye; luminescence; single-layered organic EL device

INTRODUCTION

Since Tang and VanSlyke have reported organic electroluminescence (EL) device with high brightness in 1987, the organic EL devices have been

Received 1 October 2003; accepted 13 January 2004.
This work was supported by grant No. R0I-2003-000-10493-0 from the Basic Research Program of the Korea Science & Engineering Foundation.
Address correspondence to Se Young Oh, Department of Chemical Engineering, Sogang University, Seoul, 121-742, Korea. Tel.: + 82-2-705-8681, Fax: + 82-2-714-3880, E-mail: syoh@sogang.ac.kr

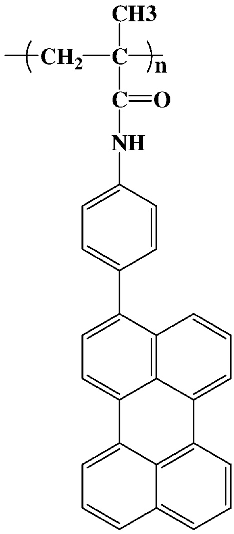
received a great deal of attention because of their potential for application in a flexible flat panel display [1,2]. Especially, polymer based EL device has a significant advantage such as the easy in device fabrication based on inkjet-printing technique [3]. Furthermore, many conjugated polymers such as mono-substituted poly(*p*-phenylenevinylene) and polythiophene which are able to emit the whole of visible range have been reported [4]. However, single-layered EL devices using the conjugated polymers have low efficiency and brightness due to the imbalance in carrier transport [5]. Therefore, multi-layered organic EL device using low molecular compounds such as Alq_3, DCM and DPVBi is often employed in order to attain high EL efficiency [6,7]. Recently, polymer based EL device using nonconjugated copolymers has been studied in order to improve the performance of single-layered EL device [8–10]. These copolymers can allow optimized carrier transport and radiation by controlling the functional unit.

In the present work, we have fabricated organic EL device using a nonconjugated blue light emitting PPPMA polymer blend mixed with fluorescent dyes, and then investigated the effects of dye dopants on EL characteristics.

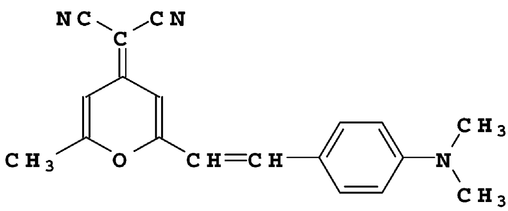
EXPERIMENTAL

N-(*p*-perylene)phenylmethacrylamide monomer was synthesised from the substitution reaction between (*p*-perylene)phenylamine and methacryloyl chloride. Poly(*N*-(*p*-perylene)phenylmethacrylamide) (PPPMA) polymer as a blue light emitting polymer was synthesized by the solution polymerization of *N*-(*p*-perylene)phenylmethacrylamide monomer with an AIBN initiator. The detailed synthesis and physical properties of the PPPMA polymer will be reported separately. DCM (4-(dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran) and Coumarin 6 used as fluorescent dyes and Al of high purity were purchased from Aldrich. The prepared PPPMA polymer was identified through elemental analysis and spectroscopic measurements such as UV-Visible (JASCO V570), FT-IR (Perkin Elmer 2000 FT-IR spectrometer) and ^{1}H-NMR (Varian Gemini FT-NMR).

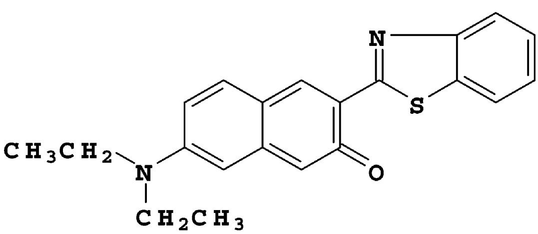
PPPMA polymer blend mixed with various concentration of dye dopants was spin-casted from a THF solution onto an ITO coated glass (16 Ω), at a spin casting speed of ca. 2500 rpm. The ITO substrate was cleaned in deionized water, and given an ultraviolet/ozone treatment prior to use. Al was deposited by using a vacuum deposition sublimator (ULVAC VPC-260F) at 10^{-6} mbar. Photoluminescence (PL) and electroluminescence (EL) spectra were obtained by using an Acton 300i spectrofluorometer. Current-voltage-luminance characteristics in air were determined using



(a)



(b)



(c)

FIGURE 1 Chemical structures of (a) PPPMA polymer, (b) DCM and (c) Coumarin 6.

a Kiethley 237 programmable electrometer and a Newport 1830-c photodiode. Figure 1 showed the chemical structures of PPPMA light emitting polymer and fluorescent dyes used in the present work.

RESULTS AND DISCUSSION

The EL mechanism of a single-layered organic EL device using a PPPMA blue light emitting polymer blend mixed with a fluorescent dye may be described by Forster energy transfer model caused due to the resonant dipole-dipole coupling. Figure 2 showed the change in EL spectra of EL devices using PPPMA polymer doped with DCM or Coumarin 6. The maximum EL peak of the PPPMA light emitting polymer appeared at 491 nm. For the devices doped with DCM and Coumarin 6 of 3 wt% and 5 wt%, respectively, the EL spectra represented the maximum peaks at 597 nm and 558 nm, respectively, which is characteristics to the emission originated from the fluorescent dye molecules. It can be concluded that sufficient energy transfer occurred at both EL spectra. By the way, as the dopant concentration increased, a slight red shift of the maximum EL peak and shoulder peak in the long wavelength at both cases was generated, which is mainly due to the formation of exciplex.

I-V characteristics of the dye doped PPPMA polymer blends were shown in Figure 3. As the amount of dye dopants increased, turn-on voltage of the devices increased, implying that the dye molecules behave as a hole-blocking material or reducing transport of majority carrier. Especially, it should be noted that the optimally doped EL devices (DCM 3 wt%) for EL efficiency showed low turn-on voltage of 7 V. For a further improvement of device performance, we are currently synthesizing a novel blue light emitting copolymer with a perylene moiety as emitting unit and a triazine moiety as electron transporting unit.

Finally, the external quantum efficiency of organic EL devices consisting of ITO/PPPMA polymer + fluorescent dye dopants (DCM or Coumarin 6)/Al was investigated. As shown in Figure 4, maximum EL quantum efficiency of the devices was achieved at a DCM content of 3 wt% and a Coumarin 6 content of 5 wt%, respectively. Especially, DCM doped EL device exhibited a high external quantum efficiency compared to the device doped with a Coumarin 6 because of the increase in recombination sites and the high quantum of DCM molecule.

A nonconjugated blue light emitting PPPMA polymer was synthesized, and then the organic EL device using the prepared PPPMA polymer blend mixed with fluorescent dye molecules was characterized. It can be found that the sufficient energy transfer from PPPMA polymer to fluorescent dye molecules with high fluorescence efficiency occurred in the present

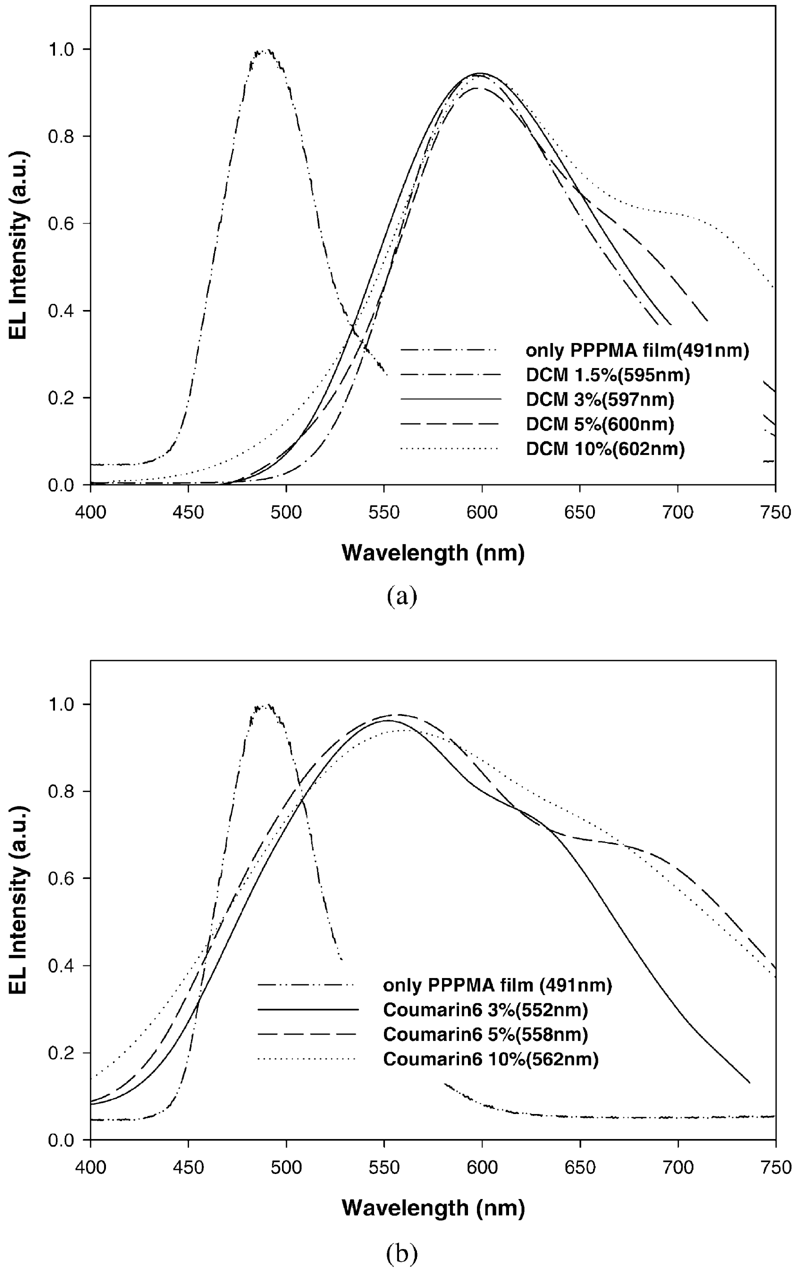
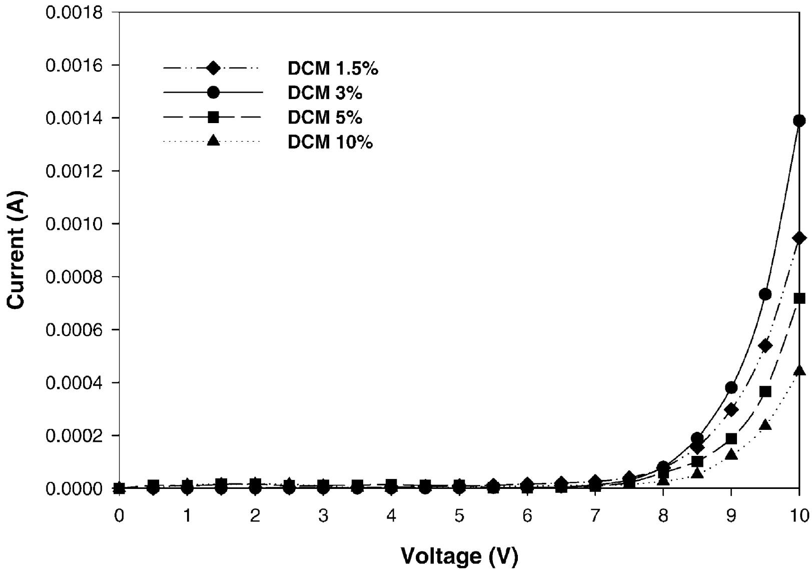
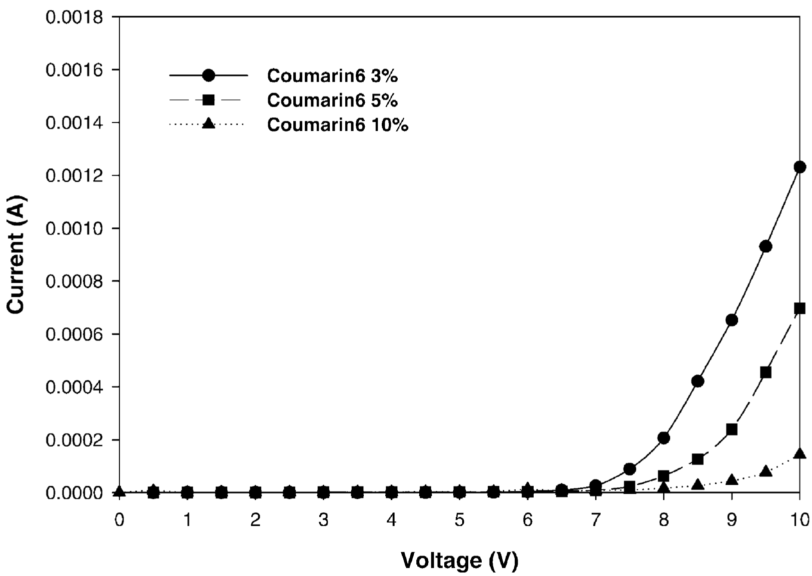


FIGURE 2 EL spectra of ITO/PPPMA + (a) DCM or (b) Coumarin 6/Al devices under various dopant contents.

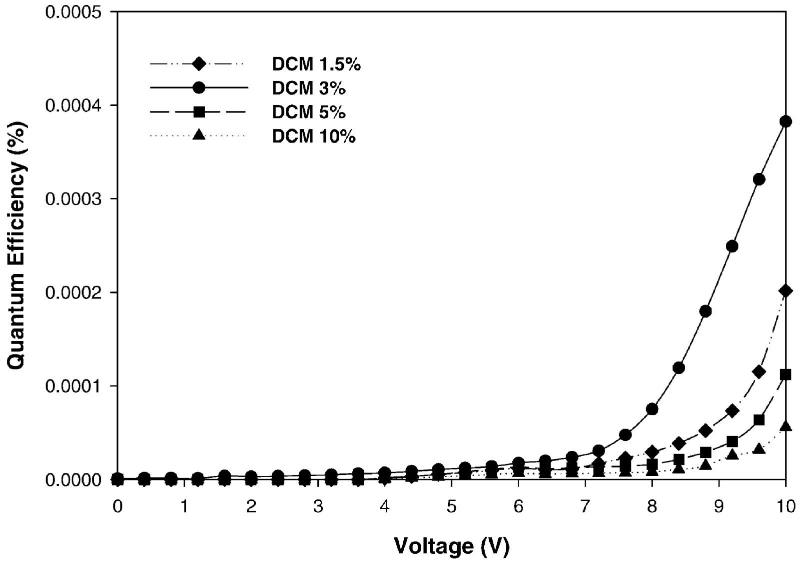


(a)

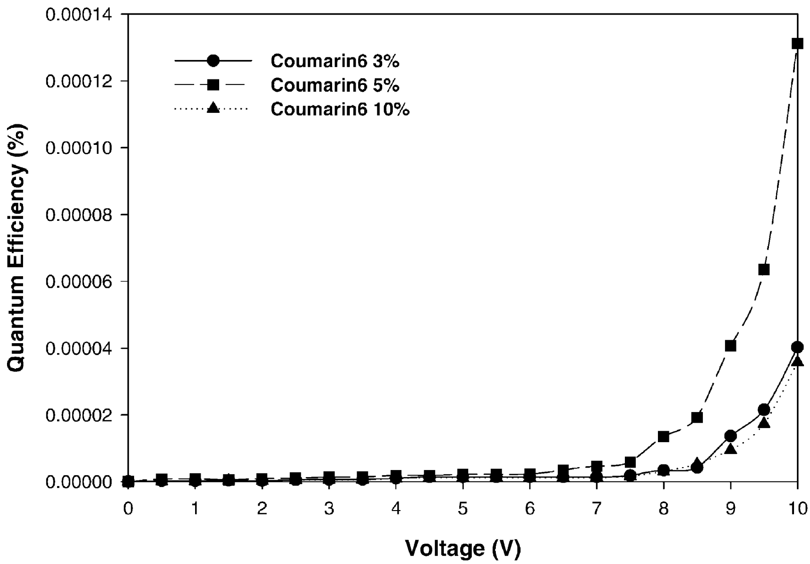


(b)

FIGURE 3 Current-voltage characteristics of ITO/PPPMA + (a) DCM or (b) Coumarin 6/Al devices under various dopant contents.



(a)



(b)

FIGURE 4 External quantum efficiency of ITO/PPPMA + (a) DCM or (b) Coumarin 6/Al devices under various dopant contents.

organic EL device. Thus, we concluded that the present single-layered polymer light emitting diode may be used to fabricate full color flexible polymer display panel *via* a straightforward process.

REFERENCES

[1] Tang, C. W. & VanSlyke, S. A. (1987). *Appl. Phys. Lett.*, *51*, 913.
[2] Tang, C. W., VanSlyke, S. A., & Chen, C. H. (1989). *J. Appl. Phys.*, *65*, 3610.
[3] S.-C. Chang, J. Liu, J. Bharathan, Y. Yang, J. Onohara, & J. Kido (1999). *Advanced Materials*, *11*, 734.
[4] Braun, D. & Heeger, A. J. (1991). *Appl. Phys. Lett.*, *58*, 1982.
[5] Kido, J., Kohda, M., & Nagai, K. (1992). *Appl. Phys. Lett.*, *61*, 761.
[6] Oh, S. Y., Lee, C. H., Jung, S., & Kim, E. (2001). *Mol. Cryst. Liq. Cryst.*, *371*, 265.
[7] Kusano, H., Shiraishi, N., Kawakami, S., Sugioka, K., Kitagawa, M., Ichino, K., Kobayashi, H., & Hosaka, S. (1997). *Synthetic Metals*, *91*, 337.
[8] Lee, C. H., Ryu, S. H., & Oh, S. Y. (2003). *J. Polymer Science*, Part B, in press.
[9] Lee, C. H., Kim, S. W., Bloom, F., Malliaras, G., & Oh, S. Y. (2002). *Mol. Cryst. Liq. Cryst.*, *377*, 77.
[10] Lee, C. H., Kim, S. W., & Oh S. Y. (2002). *Polymer* (Korea), *26*, 543.