Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

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Version of record first published: 24 Sep 2006

To cite this article: Suck Hoon Ahn, Tae Kyung Ahn, Shin Ho Han & Haiwon Lee (2000): Improvement of Quantum Efficiency of Polythiophene Derivatives by Controlling the Band Gap, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 349:1, 459-462

To link to this article: http://dx.doi.org/10.1080/10587250008024961

Mol. Cryst. and Liq. Cryst., 2000, Vol. 349, pp. 459-462
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Improvement of Quantum Efficiency of Polythiophene Derivatives by Controlling the Band Gap

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The external efficiency of poly(3-(2-(5-chlorobenzotriazolo)ethyl)thiophene) (PCBET) containing electron transporting moiety was 1.2×10^{-4} %. To enhance the efficiency of PCBET, we have synthesized polythiophene derivatives by introducing an alkoxy group which raises the HOMO and decreases the band gap due to the electron-donating nature of the oxygen.

Keywords: polythiophene; band gap; LEDs; electroluminescence

INTRODUCTION

We have reported the EL charateristics of PCBET containing an electron transporting moiety to lower the LUMO level[1]. The quantum efficiency of PCBET was 1.2 x 10^{-4} %. The structure modification of PCBET becomes necessary to improve the external quantum efficiency by decreasing the band gap. So, poly(3-(2-(5-chlorobenzotriazolo)ethyl) thiophene-co-3-methoxythiophene) (P(CBET-co-MOT)) was synthesized because alkoxy group leads to a decreased band gap[2] and we have investigated electronic properties of P(CBET-co-MOT).

EXPERIMENTAL

PCBET and P(CBET-co-MOT) were synthesized by chemical oxidation using $FeCl_3$. The structures of polymers are shown in Figure 1. Polymer films were spin-coated onto glass at 3000 rpm for 30 sec from 1,1,2,2-tetrachloroethane solution (0.04 g / mL) yielding a film with thickness of 100-120 nm. To investigate EL characteristics, polymer films were spin-coated onto ITO glass in the same manner. On top of these films, a 120 nm thick Al layer was evaporated at pressure below 10^{-5} torr. All processing steps for EL characteristic measurements were carried out in air and at room temperature.

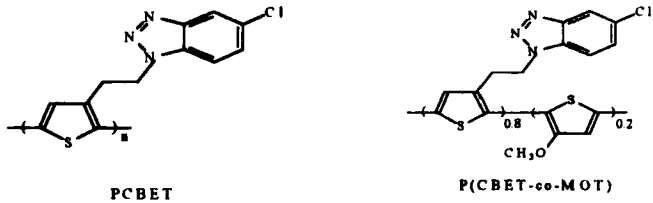

FIGURE 1. Structures of polymers

RESULTS AND DISCUSSION

As shown Figure 2 (a), the absorption maxima of PCBET and P(CBET-co-MOT) were 444 nm and 462 nm. The UV band edges of PCBET and P(CBET-co-MOT) were 570 nm and 640 nm, respectively. The band gap calculated from UV band edge of P(CBET-co-MOT) was decreased about 0.24 eV respect to that of PCBET because alkoxy group raises the HOMO level and decreases the band gap due to the electron-donating nature of the oxygen. The EL emission spectra of the device of ITO /

polymer / Al are shown in Figure 2 (b). The maximum emission peaks of PCBET and P(CBET-co-MOT) appeared at 590 nm and 664 nm, respectively. It is also interesting to note that the EL spectrum of P(CBET-co-MOT) is noticeably broader than that of PCBET.

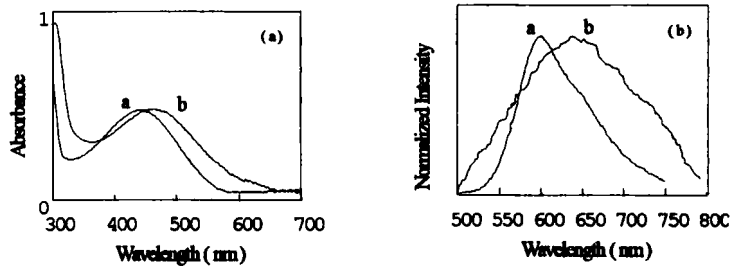

FIGURE 2. (a) UV-vis absorption spectra of spin-coated films. (b) EL emission spectra of ITO/ polymer / Al devices. (a: PCBET, b: P(CBET-co-MOT))

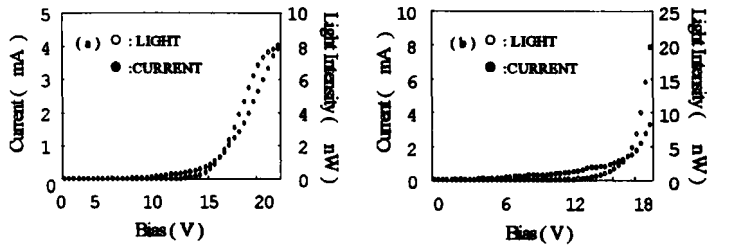

FIGURE 3. (a) I-V-L curve of ITO/ PCBET /Al device. (b) I-V-L curve of ITO/ P(CBET-co-MOT) /Al device

Figure 3 shows the current-bias-luminance (I-V-L) characteristics of the ITO/polymer/Al devices. Turn-on voltages of PCBET and P(CBET-

co-MOT) were 11 V and 10 V, respectively. The external efficiency of PCBET and P(CBET-co-MOT) were 1.2 x 10^{-4} % and 2.3 x 10^{-4} %. Despite of broad EL emission of P(CBET-co-MOT), the external efficiency was 2 times higher than that of PCBET due to small band gap respect to that of PCBET. The external efficiency of copolymer is 20 times higher than that of poly(3-hexylthiophene) because of electron transporting moiety and decreased band gap[3].

CONCLUSION

The P(CBET-co-MOT) was synthesized by decreasing the band gap respect to that of PCBET. The external efficiency of P(CBET-co-MOT) was 2 times higher than that of PCBET and 20 times higher than that of poly(3-hexylthiophene).

Acknowledgements

The authors wish to acknowledge the finacial support of Hanyang University, Korea, made in the program year of 1999.

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