

Polymer Light-Emitting Diodes with Efficient Energy Transfer in Fluorene-Based Copolymer Systems

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Abstract

We report photo- (PL), and electroluminescence (EL) realized via intrachain and interchain energy transfer in poly[9,9-(2'-octyl)fluorene-2,7-vinylene]-co-poly[2-methoxy,5-(2'-ethyl-hexyloxy)-1,4-phenylenevinylene] (PFV-co-MEH-PPV) copolymer systems. Energy transfer begins even at the device using 5 % MEH-PPV copolymer, and shows the best device performance for the 10 % MEH-PPV copolymer.

1. Objectives and Background

Recently semiconducting polymers draw a considerable attention as promising materials for light-emitting displays because of several advantages, such as ease processibility, wide spectral range, low cost, and flexibility. Although a variety of semiconducting polymer materials has been investigated for improving quantum efficiency and life-time of polymer light-emitting diode (PLED),^{1,2} ideal candidate materials for actual commercialization have not emerged yet. In such a case, it is frequently pointed out that the unique processibility of polymeric materials might provide alternative approaches for improving device performance.

One of the examples is to use the compatibility of semiconducting polymers. When blending two different luminescent polymers each with a different π - π^* gap, one expects that efficient energy transfer occurs for injected charges from larger π - π^* gap material to the smaller gap polymer, resulting in enhancement of device efficiency.³ In fact, Liu et al. recently reported that PLEDs using blends of poly[2-

methoxy,5-(2'-ethyl-hexyloxy)-1,4-phenylenevinylene] (MEH-PPV) with poly(alkylfluorene) (PF) exhibited an enhanced device performance.⁴ They attributed those observations to the energy transfer between the two polymers.

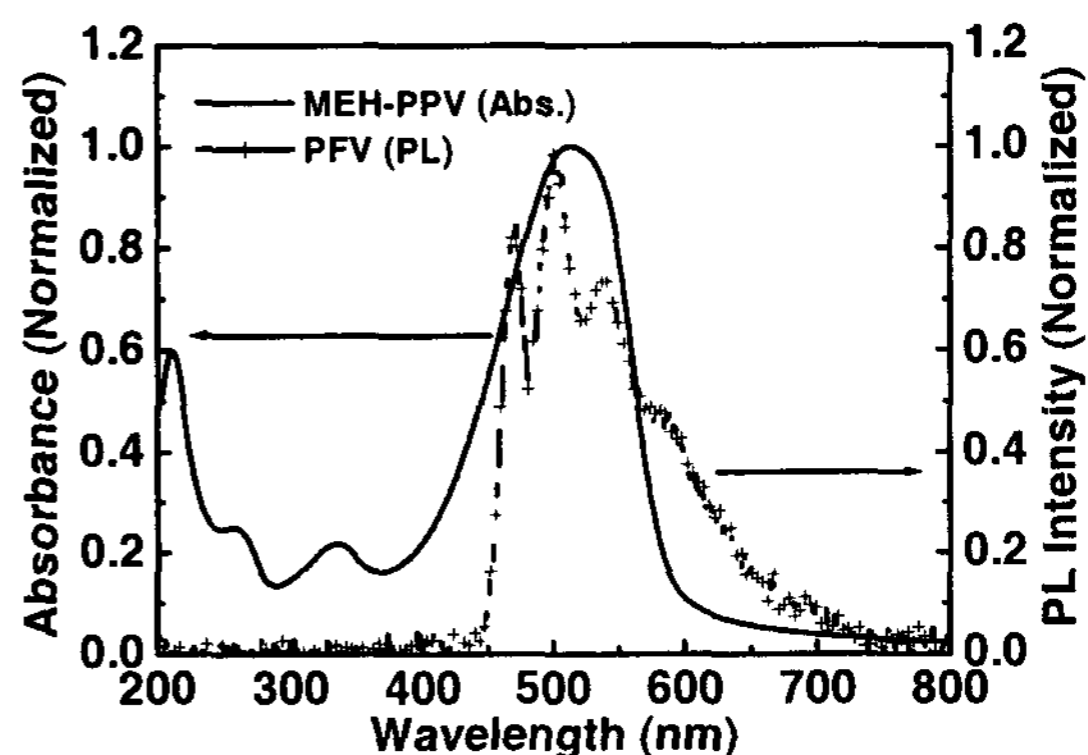
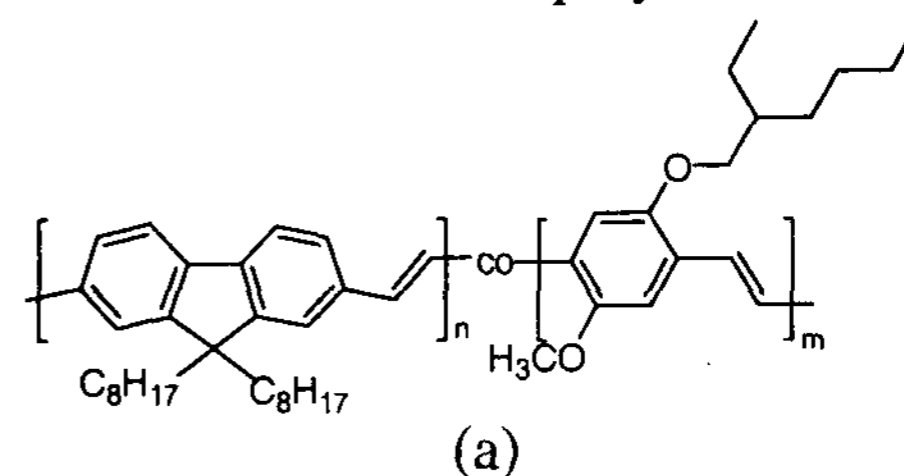


Figure 1: Chemical structure of PFV-co-MEH-PPV (a) and the spectral overlap (b) between normalized absorption spectrum of MEH-PPV and PL spectrum of PFV.

Motivated by those observations, we adapt a different approach for achieving high efficiency in two-component systems. Instead of blending two polymers from solutions, we directly synthesized copolymers of MEH-PPV and poly[9,9-di-*n*-octyl)fluorene-2,7-vinylene] (PFV), hereafter PFV-co-MEH-PPV [Figure 1 (a)], with various ratios by the Gilch

polymerization as described in detail elsewhere.⁵ Since the film morphology of the copolymers is improved considerably by inhibiting phase separation typical of the blending systems, we expect that the resulting PLED devices would exhibit better device performance.

2. Results

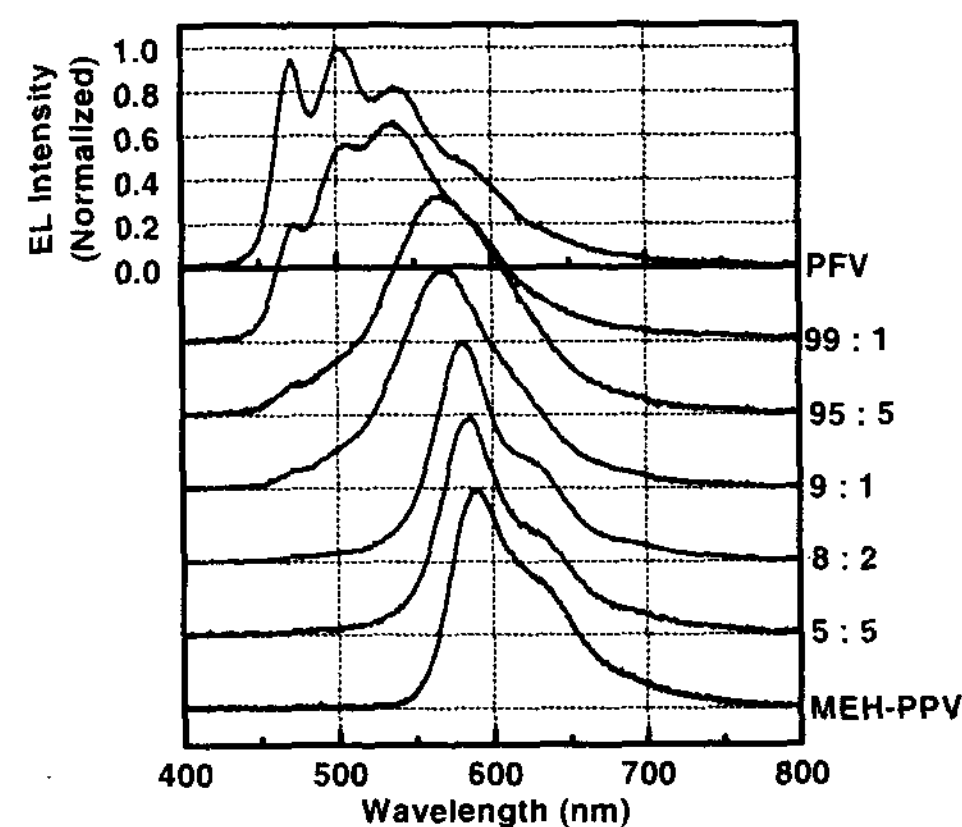
Figure 1 (b) shows the absorption spectrum of MEH-PPV together with the photoluminescence (PL) spectrum of PFV both obtained in thin film condition. Because of the strong overlap between the two spectra, an efficient energy transfer from PFV (as the host) to MEH-PPV (as the guest) segments is expected even in the copolymer systems using these two polymers. This is obviously demonstrated in Figure 2 (a) exhibiting the electroluminescence (EL) spectra of the ITO/PEDOT:PSS/copolymer/Al devices. When the copolymers even with small amount of MEH-PPV ($\geq 5\%$) are employed as an active emitting layer of PLED, the EL spectra are dominated by the spectral features of MEH-PPV. These results indicate that the injected charges transfer from PFV to MEH-PPV segments and recombine mostly in MEH-PPV segments of copolymers. Since the devices using the copolymers (specially 10% of MEH-PPV copolymer) show almost two orders of magnitude larger in efficiency as shown in Figure 2 (b), the energy transfer seems to provide somehow efficient recombination processes in these copolymer systems.

3. Impact

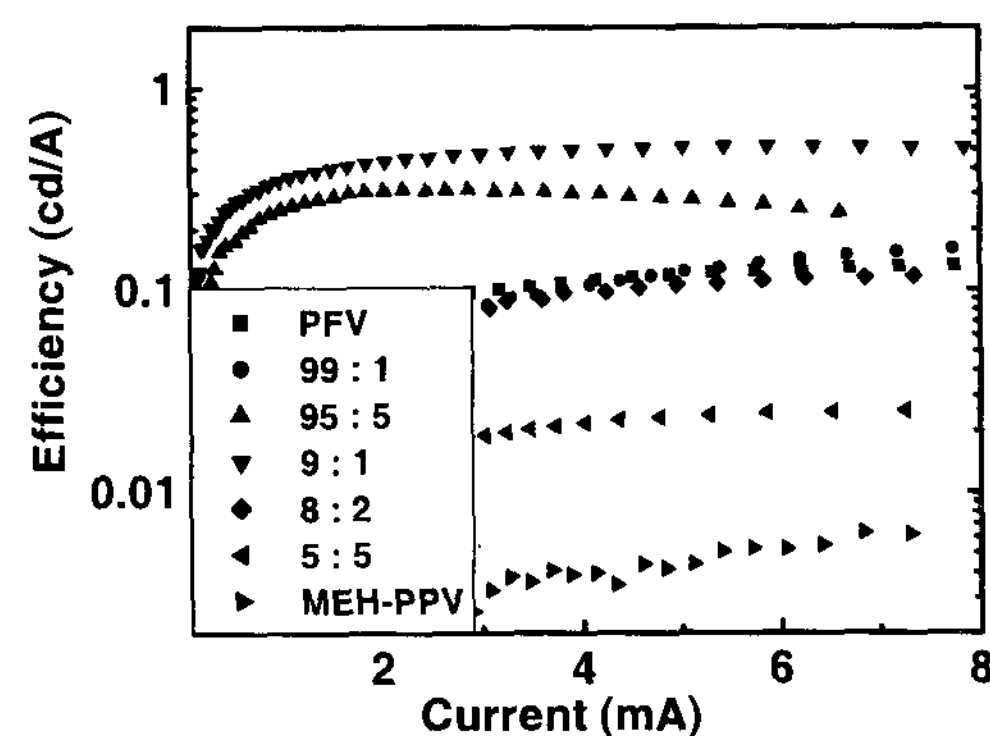
We tentatively attribute this to the intrachain energy transfer process, which exists only in the copolymers (but not in the blending systems), and act as an efficient EL route as well as interchain energy transfer.

4. Acknowledgements

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(a)



(b)

Figure 2: Normalized EL spectra (a) and efficiency (b) of PLED with copolymers.

5. References

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