

# Color tunable electroluminescence with polymer blends composed of PVK and copolymer containing SiPh-PPV and MEH-PPV unit

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## Abstract

We report on white light emission from a light emitting diode(LED) prepared by blending a red emitting copolymer, *m*-SiPh PPV-co-MEH PPV, and a blue emitting polyvinylcarbazole (PVK). White light emission was realized when the weight ratio of the *m*-SiPh PPV-co-MEH PPV : PVK equals to 1 : 30, in which the commission Internationale de L'Eclairage coordinates were  $x=0.3266$  and  $y=0.3438$ .

## 1. Introduction

Since an organic light emitting diode(OLED) was reported by Tang and Vanslyke [1], it has become an active field of research because of its potential application in flat panel display. Since the monochrome OLED display was put into market in 1998, the full color OLEDs were extensively investigated.

In order to achieve the full color display, two approaches were used. The first, patterning red, green and blue emitter was using a selective deposition. Another approach is based on a white-emitting diode, from which the three primary colors could be obtained by micro-patterned color filters. Several studies have been reported on white OLEDs [2-7].

In this paper, we report on the emission characteristics of OLEDs fabricated by blending a copolymer containing MEH-PPV and SiPh-PPV unit (*m*-SiPh PPV-co-MEH PPV) and a polyvinylcarbazole (PVK).

## 2. Experimental

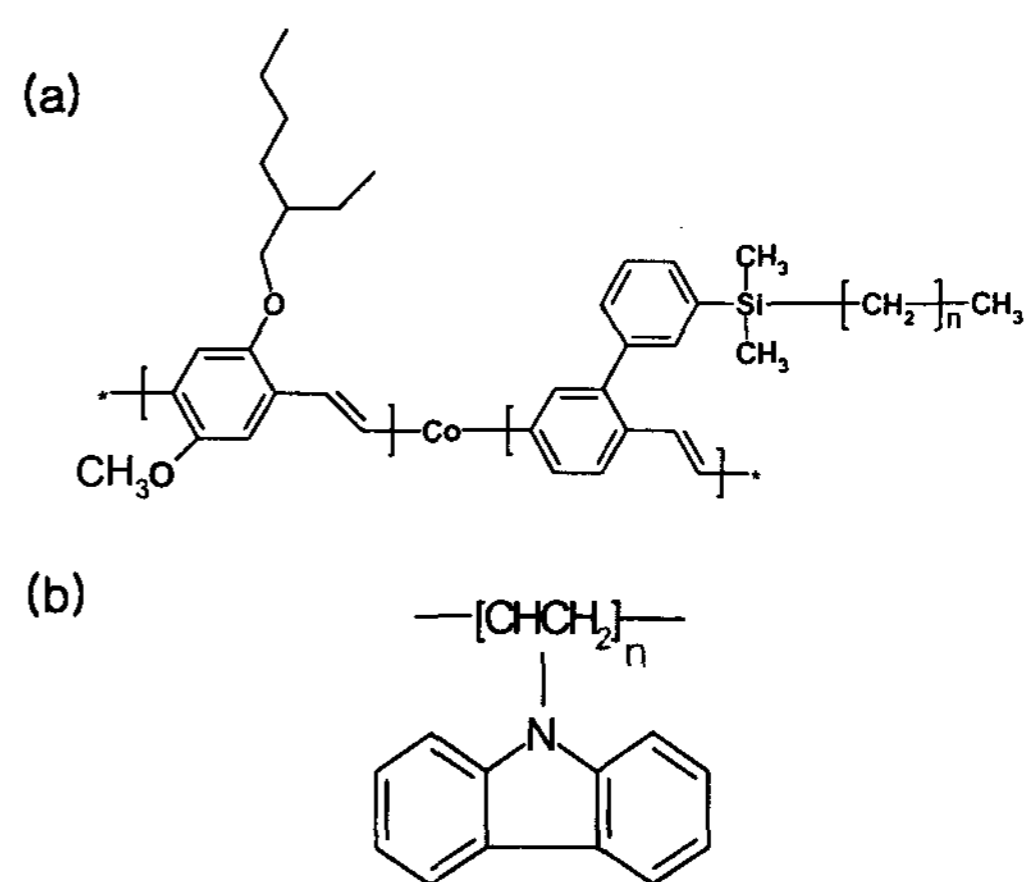
Scheme 1 shows the chemical structures of *m*-SiPh PPV-co-MEH PPV and PVK used in this study. The copolymer, *m*-SiPh PPV-co-MEH PPV was synthesized. The PVK and tris(8-hydroxyquinoline

aluminum)(Alq) was purchased from Aldrich chemical. Co. Inc. and TCI Co. LTD, respectively.

The configuration of the device is indium-thin oxide (ITO)-coated glass as an anode/PEDOT:PSS as a buffer layer / blend of *m*-SiPh PPV-co-MEH PPV and PVK as an active layer / Alq as an electron transporting layer / LiF / Al as a cathode.

The patterned ITO-coated glass ( $30 \Omega / \text{sq.}$ ) was sonicated in a detergent solution followed by a de-ionized water rinse, dipped into acetone, trichloroethylene and isopropyl alcohol. After drying, the PEDOT was formed on the ITO-coated glass substrate by spin-cast technique.

The polymer blends were obtained by mixing *m*-SiPh PPV-co-MEH PPV and PVK with the weight ratio of 1:1, 1:5, 1:10, 1:30, 1:50 in chloroform. The Pure *m*-SiPh PPV-co-MEH PPV, PVK and their blends were spin-coated onto ITO



Scheme 1. Molecular structures of (a) *m*-SiPh PPV-co-MEH PPV and (b) PVK

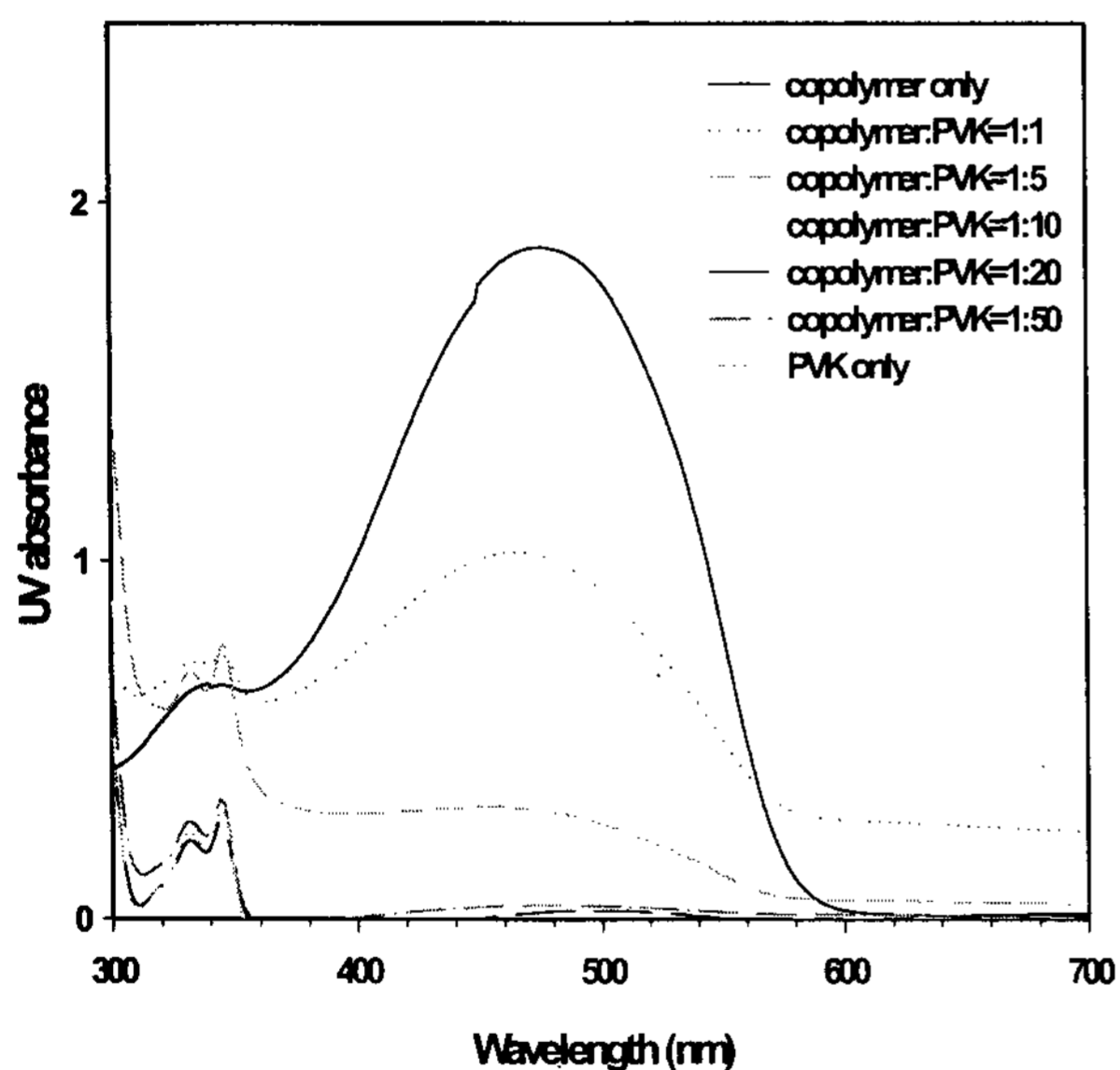
substrates. Then Alq(2nm), LiF(0.5nm), Al(150nm) were deposited by vacuum thermal evaporation under a vacuum of about  $1 \times 10^{-6}$  torr. The active area of the device was  $0.09 \text{cm}^2$ .

The electroluminescence (EL) and photoluminescence (PL) spectra were taken with a monochromator (PI instrument Spectra-pro 300i). The Commission International De L'Eclairage (CIE) coordinates were measured with Spectroradiometer (Minolta CS-1000). The current-voltage-luminance (I-V-L) characteristics were measured by Keithley 2400 Source Meter and Newport-1830C Optical power meter. The energy levels of the materials were measured from cyclic voltammetry method and UV absorption spectrum.

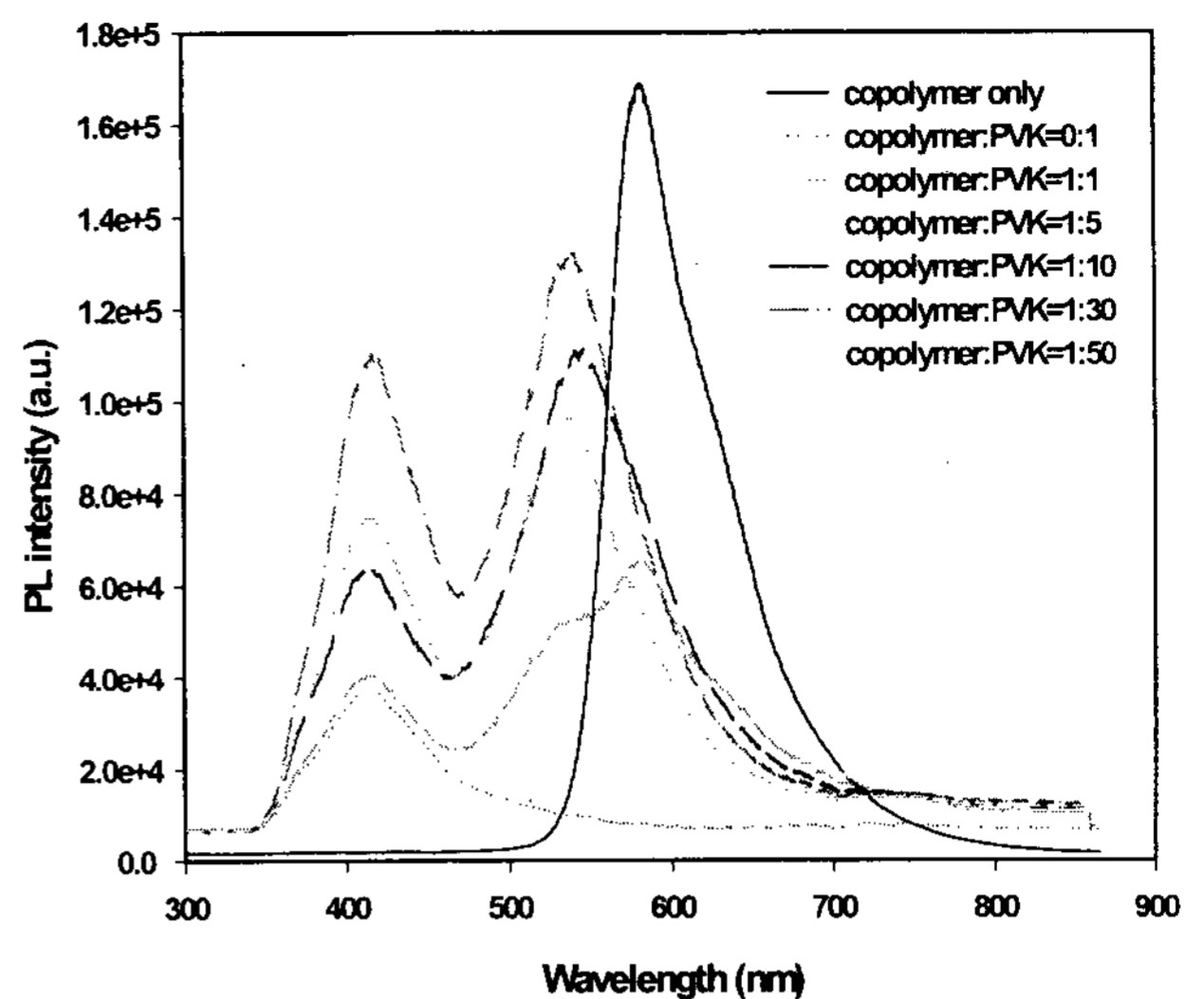
### 3. Results and discussion

The UV absorption spectra of SiPh PPV-co-MEH PPV, PVK and their blend films are shown in Fig. 1. The maximum absorption peaks of m-SiPh PPV-co-MEH PPV and PVK are at 470nm and at 340nm, respectively.

The energy levels (HOMO: highest occupied molecular orbital or ionization potential and LUMO: lowest unoccupied molecular orbital) of the materials were measured by cyclic voltammetry method and



**Figure 1 UV-vis absorption spectra of m-SiPh PPV-co-MEH PPV, PVK, and their blend films**



**Figure 2 PL spectra of m-SiPh PPV-co-MEH PPV, PVK, and their blend films with different weight ratios. (Ex: 325nm)**

UV absorption spectra. Band gap of m-SiPh PPV-co-MEH PPV corresponds absorption edge located at 585nm (2.12eV). HOMO level of m-SiPh PPV-co-MEH PPV was measured to be 5.27eV and LUMO level was 3.15eV.

PL spectra of pure m-SiPh PPV-co-MEH PPV, pure PVK, and their blends are presented in Fig. 2. The maximum peaks of m-SiPh PPV-co-MEH PPV and PVK films in PL spectra are at 586nm and 420nm, respectively. As the composition of the blend changes from a m-SiPh PPV-co-MEH PPV-poor to a PVK rich ratio, the PL emission shifts to short wavelength. All films in the PL spectra were excited at 325nm.

Figures 3 and 4 show the characteristics of applied voltage vs. current density and luminance vs. current density of the OLEDs with m-SiPh PPV-co-MEH PPV and PVK and their blends, respectively.

The EL output of the m-SiPh PPV-co-MEH PPV could be clearly seen in a dark room at around 10V, and maximum brightness of  $16000 \text{ nW/cm}^2$  could be obtained at 17V. Further increase in voltage causes rapid degradation of the device. In the case of the OLEDs with an m-SiPh PPV-co-MEH PPV copolymer-rich blends, the brightness of the emitted light increased about 5 times[8], but it had less effect on a PVK-rich blend, as can be seen in Fig. 4.

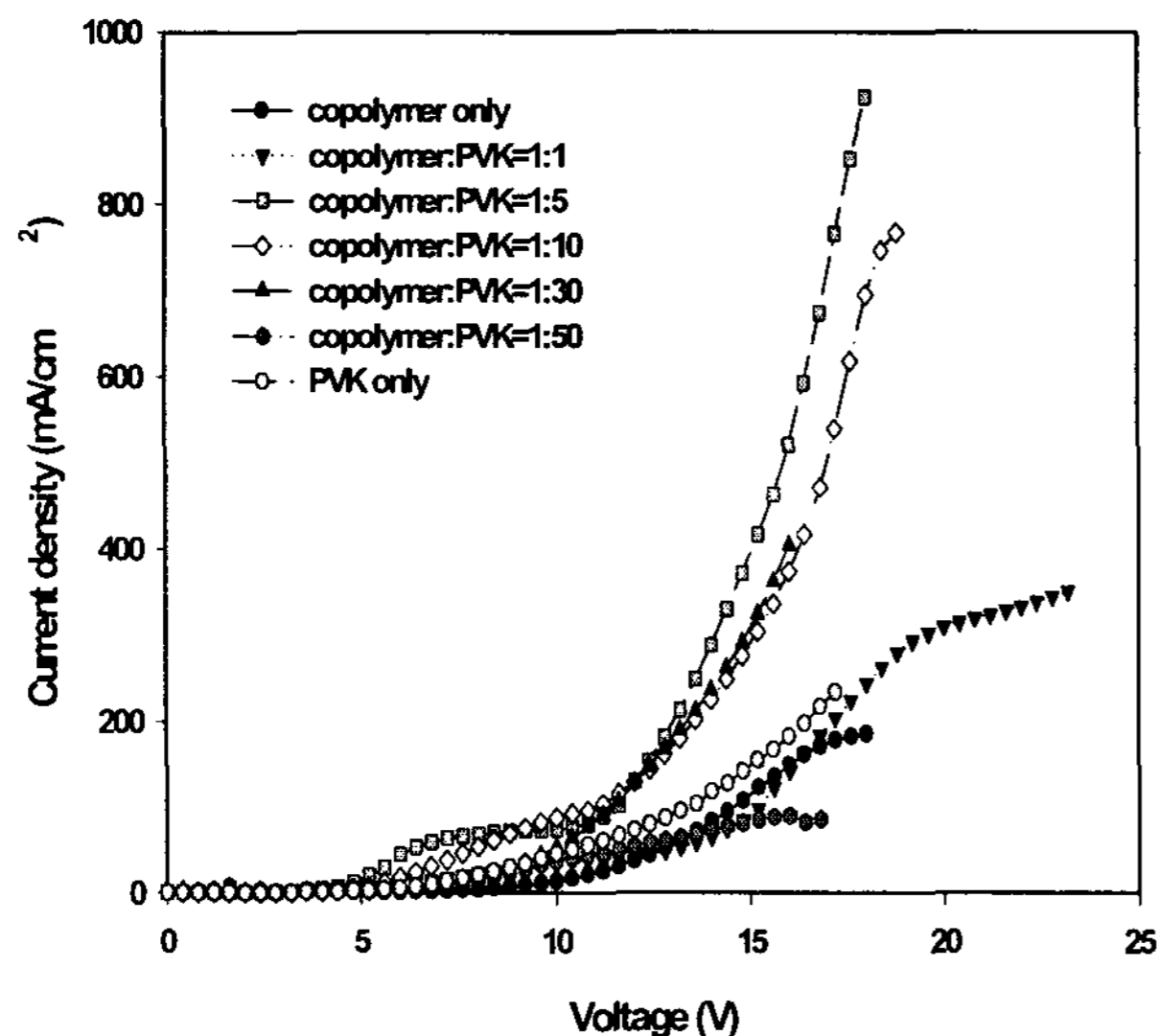


Figure 3 Voltage-Current characteristics of EL devices.

Figure 5 shows the EL spectra of pure m-SiPh PPV-co-MEH PPV and its blends with PVK. Figure 6 shows the x, y chromaticity diagram coordinates of the EL color of the polymeric emitters. The emitted light from OLEDs with the pure m-SiPh PPV-co-MEH PPV is orange-red with a maximum intensity at 586nm. However, the EL peaks of OLEDs with m-SiPh PPV-co-MEH PPV copolymer blends show blue-shift with increasing PVK concentration. It can be seen not only that emitted light from PVK in the violet region, and that from m-SiPh PPV-co-MEH PPV in the orange-red region, but also that the emitted light of the blends moves systematically from the red to the blue region as the percentage of PVK increases. Further, blends containing 30 wt.% PVK and 1 wt.% m-SiPh PPV-co-MEH PPV yielded an EL spectrum with a white emission, as can be seen in Fig. 6. In that condition, CIE coordinates are  $x=0.3266$  and  $y=0.3438$

#### 4. Conclusion

White OLEDs is realized by blending with a blue light emitting material, PVK and red light emitting material, m-SiPh PPV-co-MEH PPV. The emission spectra can be tuned by varying the weight ratio of PVK and m-SiPh PPV-co-MEH PPV. CIE coordinates changed from blue to red according to the weight ratio

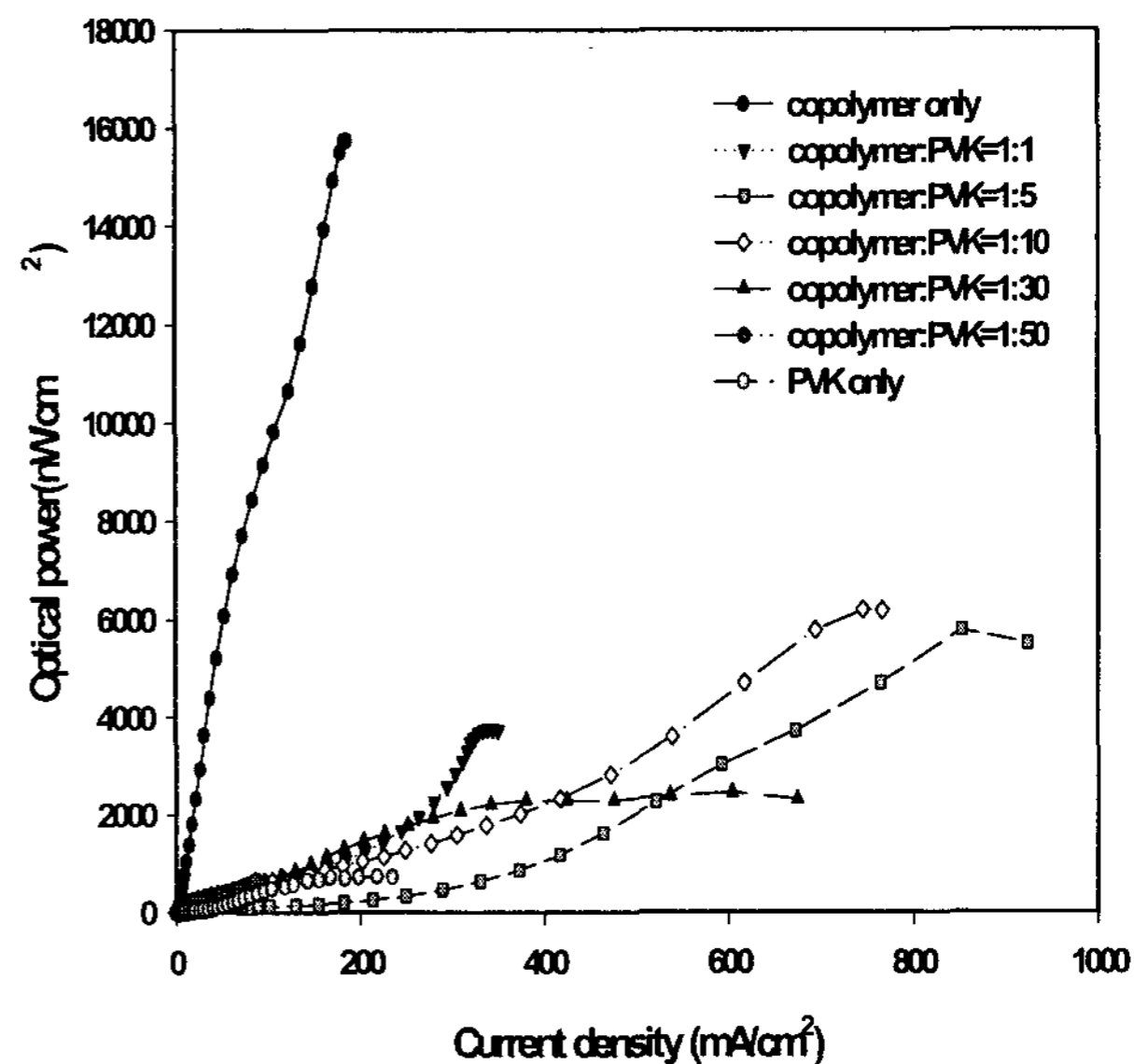


Figure 4 Current - Luminance characteristics of EL devices.

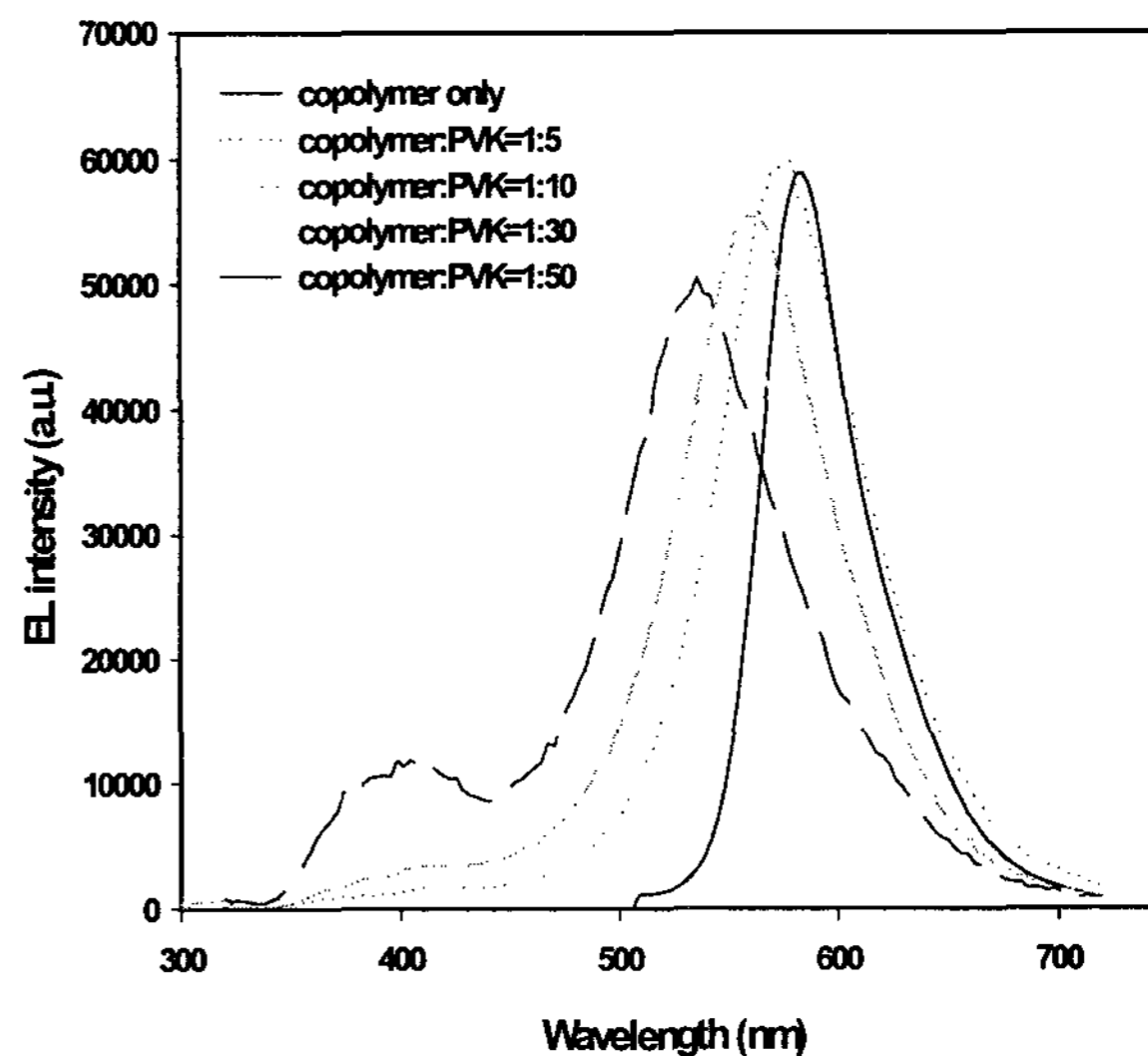
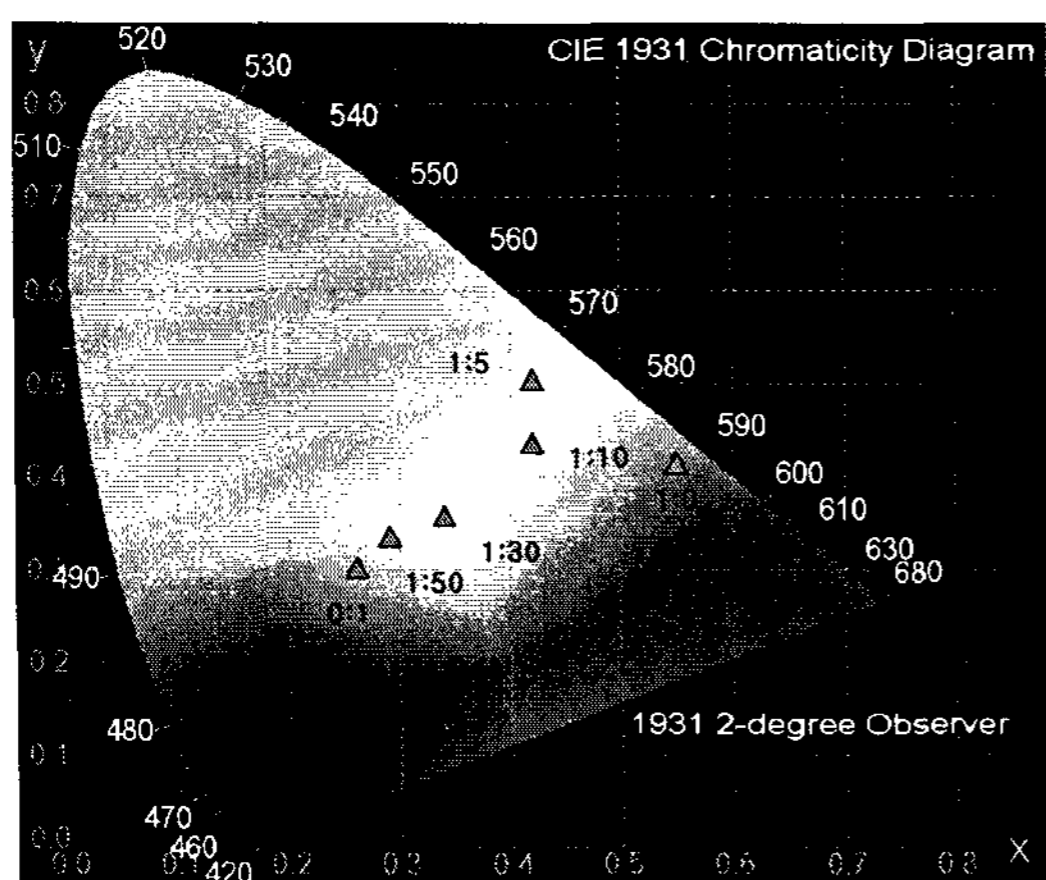


Figure 5 Electroluminescence spectra of m-SiPh PPV-co-MEH PPV : PVK at different weight ratios.

of m-SiPh PPV- co-MEH PPV and PVK. White light emission is realized when the m-SiPh PPV-co-MEH PPV : PVK weight ratio equals 1 : 30. In that condition, CIE coordinates are  $x=0.3266$  and  $y=0.3438$

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**Figure 6 CIE (1931) chromaticity diagram showing the coordinates of the EL color of m-SiPh-co-MEH PPV(1:0), PVK(0:1), m-SiPh PPV-co-MEH PPV : PVK (1:5, 1:10, 1:30, 1:50 wt.%)**

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## 5. References

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