Optical and Electroluminescence properties of PPV derivatives including different crosslink unit

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Abstract

We synthesized new poly(p-phenylene vinylene) (PPV) derivatives including different portions of crosslink that could interconnect the backbone of PPV for application in optoelectronic devices such as light-emitting-diodes, photovoltaic cells, and lasers. The fluorescence and electroluminescence properties of PPV including crosslink were discussed with respect of their structure and length of crosslink unit.

1. Introduction

A lot of investigations have been carried out on the electroluminescence (EL) properties of poly(p-phenylene vinylene) (PPV) derivatives that could be utilized as a key material in optoelectronic device such as photovoltaic cells.[1, 2] Also, its derivatives have been widely studied as potential candidates for the fabrication of PLEDs and poly(2-methoxy-5-(2-ethyl-hexyloxy)-1,4-phenylene vinylene) (MEH-PPV) has been utilized for potential red-emitting devices. [3-7] Theses materials have shown many advantages in EL device applications due to their high quantum efficiency, wide range of spectral emission, and ease of device fabrication.[8]

The influence of side groups can modify the optical properties of PPV related materials. Several groups have found that incorporation of extremely bulky side groups onto the polymer backbones can effectively reduce the interchain coupling. For example, Miller and coworkers measured polarized absorption of oriented poly[2-methoxy-5-(2'-ethyl)hexyloxy]-p-phenylene vinylene (MEH-PPV) and assigned several optical structures based on band structure calculations.[9]

In this work, we synthesized new PPV derivatives that include crosslink unit which could interconnect the backbone of PPV. Optical and EL properties of PPV derivatives including different crosslink unit was observed to compare with that of

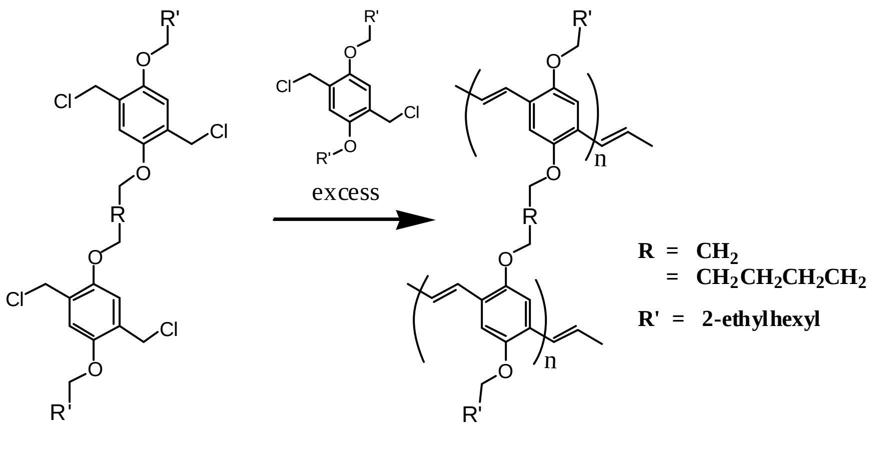

Fig. 1. Synthesis of PPV derivatives including crosslink unit.

pristine PPV. The intra-chain and inter-chain exiton formation was considered in the linear polymer and crosslinked polymer.

2. Results and Discussion

2.1 Synthesis of PPV derivatives

We synthesized MEH-PPV and its derivatives composed of the network structure in the polymer through a small degree of crosslink. This design is based on the premise that the aromatic polymer chains can be connected by conjugated covalent bonding without any change of chromophore. (**Figure 1.**)

This design is based on the premise that the aromatic polymer chains can be connected by conjugated covalent bonding without any change of chromophore. A technique of crosslink between the MEH-PPV chains is employed to control the degree of interchain interactive aggregates. The MEH-PPV with the network structure (97% MEH PPV) was prepared to contain 3 % of crosslinked repeating unit. Degree of crosslink higher than 10% makes the polymer insoluble in any organic solvents. After synthesizing the linear and the crosslinked polymer, the number average molecular weight (Mn) and molecular weight distribution were determined by employing the gel permeation chromatograph. The linear and crosslinked network MEH-PPV films are prepared to study the effect of the crosslink on their photoluminescence (PL) and electroluminescence (EL) properties.

2.2 Fabrication of Films

Polymer films were fabricated on borosilicate glass substrates as follows. The solution (3wt%) of each polymer sample in tetrachloroethane was filtered through acrodisc syringe filter (Millipore 0.2 µm) and then spin-cast on the borosilicate glass. The films were dried overnight at 100 oC for 48 hours under vacuum and their thickness was adjusted to about 260 nm that was determined by atomic force microscope. Single layered EL devices were fabricated as sandwich structures between two electrodes, where Al was used as cathode and ITO was used as anode. Current-voltage (I-V) curves of these devices were recorded with sweep interval of 10mV/sec and delay time of 2 sec under ambient conditions.

3. Spectral properties of PPV derivatives

We observed strong enhancement of PL and EL efficiency in PPV derivatives with a small degree of crosslink between the polymer chains. The EL spectra of polymer films are shown in Figure 2. The EL spectra of MEH-PPV film is characterized with two main peaks at 592 and 636 nm with a much weaker red shoulder at about 695 nm. It is well accepted that the emission peak at 592nm arises from single-chain excitons (e.g. intrachain excition), while the peaks at 636, 695 nm are associated with interchain interactions.

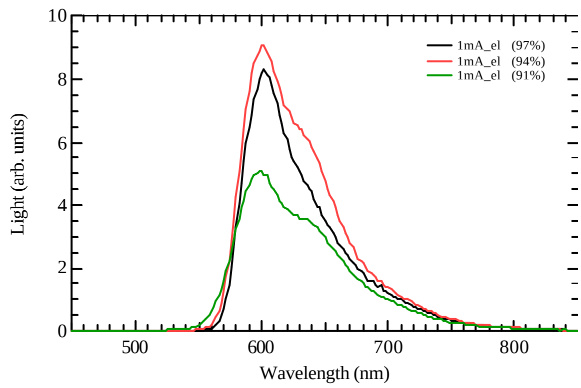

Fig. 2. The EL spectra of polymer films

Controlling the weakly emissive interchain species in the molecular aggregates by adding crosslink, the effect of interchain excimer or intrachain exciton formation can be considered on the fluorescence and EL behaviours. The crosslinking density was controlled by adding different feeding ratio of monomers in the reaction mixture.

The enhancement of EL intensity (Fig. 3.) is attributed to decrease of nonemissive interchain exciton formation from excimers and molecular aggregates in the crosslinked structure. These results suggest that the EL enhancement strongly depends on the molecular structure of the polymer. The effect of interchain excitation will contribute to the formation of higher degree of nonemissive exciton formation, thereby giving a significant diminishing effect on 0-0 vibronic transition. In the case of crosslinked PPV, since it is difficult to occur the energy transfer and charge transfer between the inter chain structure, the major factor to enhance the EL efficiency results from the enhancement of PL efficiency that is strongly affected by the suppressed interchain interaction.

This suggests that the EL efficiency strongly depends on the molecular structure of the films. Since neither energy transfer nor charge transfer is involved in crosslinked MEH-PPV, the major factor to enhance the EL efficiency results from the enhancement of PL efficiency that is strongly affected by the suppressed interchain interaction. The effect of interchain excitation will contribute to the formation of higher degree of nonemissive exciton formation, thereby giving a significant diminishing effect on 0-0 vibronic transition.

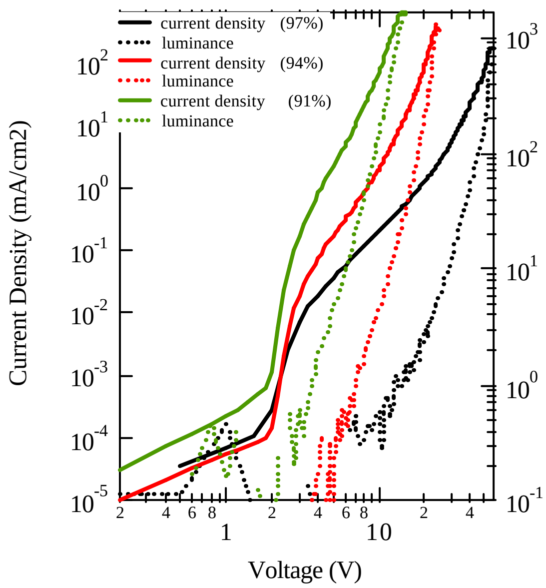

Fig. 3. The I-V curves of MEH-PPV derivatives.

4. Conclusions

We synthesized new PPV derivatives containing different chemical structure and portions of crosslink unit that connect the polymer backbone with chemical bonding. Optical and EL properties of PPV derivatives including different crosslink unit was observed to compare with that of pristine PPV. We found the electroluminescence property of new PPV derivatives in device was enhanced significantly which was correlated with the effect of crosslinking between PPV polymer backbone.

5. References

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