Electroluminescent Properties of a Triphenylamine-Containing Poly(phenylenevinylene)

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1. Introduction

π-Conjugated polymers, represented by poly(phenylenevinylene) (PPV) derivatives, have attracted a great deal of attention due to their potential applications as electroluminescence (EL) materials for light-emitting-diodes (LEDs). Poly(phenylenevinylene) (PPV) derivatives, have attracted a great deal of attention due to their potential applications as electroluminescence (EL) materials for light-emitting-diodes (LEDs).[1-2] Polymer-based LEDs are more easily fabricated by a spin-coating process in comparison with the devices made from low-molecular-weight materials by a vapor-deposition process, and make excellent large area displays. However, the polymer-based single-layer-type LED devices encountered the problem of a high driving voltage due to a high energy barrier for charge injection, or a low external quantum efficiency due to the unbalanced charge injection of electrons and holes.[3] To overcome these problems, π-conjugated polymers with a charge-transporting ability have been designed and synthesized.[4] Triphenylamine (TPA) derivatives are most widely used as hole transporting materials for LEDs because of their high hole drift mobility. By covalently introducing such a TPA structure into a PPV backbone, a good luminescent property, hole transporting ability, and high morphological stability are expected to be successfully combined in the conjugated PPV polymer and provide excellent applicability for an LED application. In this paper, we describe the EL studies of the triphenylamine-containing PPV, poly(4-methyltri-phenylene-alt-1, 4-phenylenevinylene) (MPA-pPV), and discuss the effects of the polymer structure on the luminescence properties and the LED performance.

2. Experimental

MPA-pPV was newly synthesized by the modified Wittig-Horner condensation described in our previous paper.[5] We used rubrene for the fluorescent molecular dopant, bathocuproine for the electron-blocking material, tris(8-quinolino-lato)aluminum (Alq3) for the electron-transporting material, and poly(ethylenedioxythiophene): poly(styrene sulfonic acid) (PEDOT: PSS) for the buffer material between the ITO and polymer (Figure 1). These materials are commercially available. Various types of LEDs were then fabricated. The LED configurations are shown in Table 1.

3. Results and Discussion

The luminance–current density (L–I) characteristics of the LEDs are shown in Fig.2. The turn on
voltages of single-layer LED A was 3 V, and its highest maximum luminance was 640 cd/m² at 10 V. The rubrene-doped single-layer LED B showed a higher efficiency than that of A. However, LED C, introduced PEDOT : PSS as a hole-injection material between the ITO and the polymer, did not exhibit an improvement in the efficiency. These results suggest that MPA-pPV has a good hole injection ability and a high hole mobility as not only an emissive polymer but also as a host polymer to a fluorescent dopant.

Double-layer devices composed of an emission layer and a hole-blocking layer (or an electron-transporting layer) were fabricated to realize a more balanced charge injection. The double-layer LED D, using bathocuproine as a hole-blocking material showed a higher efficiency than that of A. On the other hand, Alq₃ is well known as an efficient electron-transporting material. The double-layer LED E, using Alq₃ as the electron-transporting material, showed a higher efficiency than that of D, and its external quantum efficiency was increased by a factor of 100 (0.33%) in comparison with that of the single-layer LED A. The emission wavelength of 550 nm was attributed to the Alq₃ emission, which indicated that MPA-pPV acts as a hole-transporting layer rather than an emissive layer.

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References