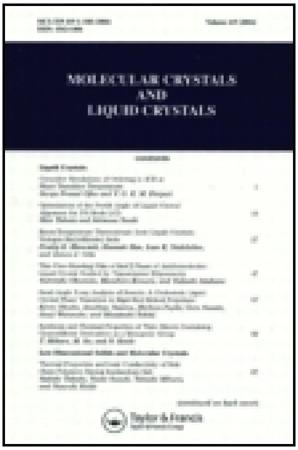

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Use of a Single Anionic Conductor as a Hole-Injecting Material for Polymer Light-Emitting Diodes

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Use of a Single Anionic Conductor as a Hole-Injecting Material for Polymer Light-Emitting Diodes

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A single anionic conductor (SAC) was employed to improve the hole injection properties in an Al anode/SAC/poly[2-methoxy-5-(2'-(ethylhexyloxy)-1,4-phenylenevinylene) emissive layer/indium tin oxide cathode device. The SAC possesses an excellent hole-injection property, because of ionic space charge accumulation near the anode by the good chain segmental motion of the soft block in the polymer chains of the SAC. Thus, a balanced injection of an electron-hole pair can be achieved to greatly improve the quantum efficiency.

Keywords electroluminescence; single anionic conductor

INTRODUCTION

The potential applicability of polymer light-emitting diodes to flat panel displays, which can be operated at a relatively low driving voltage, triggered much attention for the last decade and have produced many research products on this field [1]. However, the charge injection property in the electroluminescent (EL) device is not so good due to the energy barrier between emitting layer and electrodes, and furthermore balanced injection is difficult to achieve [2]. A single ion conductor

(SIC) was firstly used as an electron injecting material in polymer light-emitting devices [3]. In this report, we tried to improve the hole injecting property by using a novel hole injecting material, a single anionic conductor (SAC).

EXPERIMENTAL

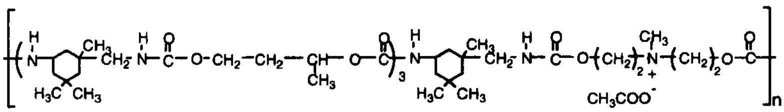

FIGURE 1 Chemical structure of a single anionic conductor with polyurethane backbone.

We synthesized a SAC with polyurethane backbone as shown in Figure 1. Figure 2 shows the schematic physical morphology of single ion conductors. An emissive material, poly[2-methoxy-5-(2'-(ethyl-hexyloxy)-1,4-phenylenevinylene)(MEH-PPV) dissolved in 1,2-dichloroethane was spin-coated with a 60 nm thickness on indium-tin oxide (ITO) coated glass substrates. After baking the polymer, SAC dissolved in DMF were spin-coated with a 15 nm thickness on top of the emissive layer. The Al cathode was evaporated *in vacuo* under a pressure of about 10^{-6} torr.

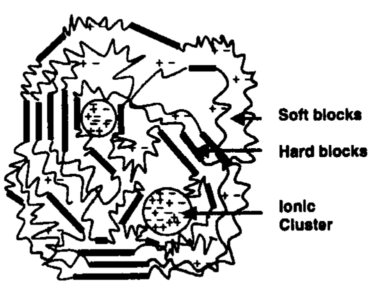

FIGURE 2 Schematic physical structure of single ion conductors (SICs). The SICs possess soft and hard blocks. The ionic cluster can be easily dissociated due to the solvation effect of the polyether soft chains.

RESULTS AND DISCUSSION

The inset of Figure 3 shows the schematic energy band diagram of the Al/SAC/MEH-PPV/ITO device. The highest occupied molecular orbital (HOMO) of MEH-PPV is ~4.9 eV below the vacuum level, while ITO has a work function of ~4.7 eV. When we use ITO as an anode, the energy barrier for hole injection results in a barrier of 0.2 eV. Hole injection from ITO is more dominant than electron injection from the Al electrode in positively biased field. Therefore, the hole-injecting layer (HIL) between ITO and MEH-PPV in positive bias field did not contribute the enhancement of both brightness and efficiency in an ITO/SAC/MEH-PPV/Al device, because of insufficient injection of the minority carriers (electrons). This fact made us impose a negative bias field on the ITO/MEH-PPV/SAC/Al device to check the hole injecting property.

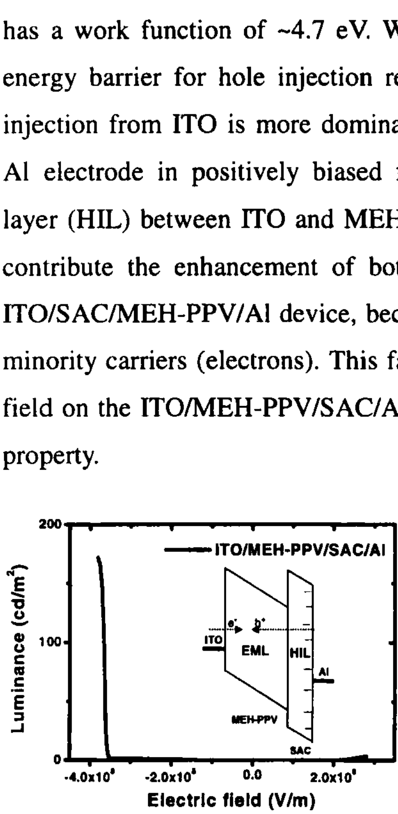

FIGURE 3 Luminance vs. electric field of ITO/MEH-PPV/SAC/Al device. The inset shows the schematic energy band diagram of the device.

Figure 3 shows the luminance vs. electric field characteristics of a negatively biased ITO/MEH-PPV/SAC/Al device. The negatively biased device without the SAC layer emitted very weak light below 1 cd/m^2. However, it was observed that the luminance of the device with the SAC layer is greatly improved (172 cd/m^2 at 4 mA), which attributes to the hole injecting property of the SAC material. The improvement of luminance attributes to the dominant hole injecting property, leading to a balanced injection. This hole injecting property also originates from the space charge accumulation near the electrode as reported elsewhere [4-5]. The soft block in the ionic polyurethane can provide a favorable pathway for ion conduction and accumulation due to the good segmental motion of the soft-block polymer chains. In addition, the SAC layer plays a role in improving the adhesion between the emitting layer and the Al electrode [6]. The interfacial adhesive strength between the polymer and metal was significantly enhanced through the C-O-Al complex formation. Therefore, the ionic polymers in the hetero-structured device play a role as a compatibilizer to improve the adhesion between the emitting layer (EML) and the metal electrode. On account of above-mentioned reasons, the incorporation of SAC with soft and hard blocks in the EL device induces higher EL intensity and efficiency, compared with the single layer device, due to the excellent hole-injection properties, which results from the accumulated ionic space charges near the anode. The external quantum efficiency of our device reached 0.74 % photons/electrons at 3.5 mA.

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