Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

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Version of record first published: 04 Oct 2006

To cite this article: Eunjung Kang, Jihwan Keum, Youngk Yoo Kim, Won Jei Cho & Chang Sik Ha (1998): Polymeric Light-Emitting Diode Using Fluorine-containing Polymer and Polyimide Heterojunction, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 316:1, 261-264

To link to this article: http://dx.doi.org/10.1080/10587259808044504

Mol. Cryst. Liq. Cryst., 1998, Vol. 316, pp. 261–264
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Polymeric Light-emitting Diode Using Fluorine-containing Polymer and Polyimide Heterojunction

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Polymeric light-emitting diode (PLED) using fluorine-containing polymer and polyimide heterojunction was fabricated to enhance the device characteristics because of the high thermal stability by the carbon-fluoride bond in fluorine-containing polymers as a heat resistant material. Poly(vinylidene fluoride-*co*-hexafluoropropylene) (PVdF-HFP) was used due to its good solubility in common solvents as well as high thermal stability. Poly(etherimide) (PEI) was also introduced as a thermally stable polymer. The PLED in the structure of anode/TPD-dispersed PVdF-HFP/Alq3-dispersed PEI/cathode exhibited turn-on voltage of *ca.* 14 Vdc. The bright greenish yellow light was emitted at 17 Vdc.

Keywords: polymeric light emitting diode (PLED), carbon-fluoride bond, PVdF-HFP, PEI, TPD, Alq3.

INTRODUCTION

Polymers are homogeneous and usually amorphous materials with adequate mechanical properties in comparison with inorganic low molar mass compounds.

Especially, flexible polymers have the advantage of excellent film-forming properties so

that they seem to be one of the best materials for the fabrication of organic light-emitting diode (OLED)[1-5]. However, most of them have low glass transition temperature, leading to the thermal instability. Among them, fluorine-containing polymers have been used for the heat resistance application due to their characteristic properties by carbon-fluoride bond. In addition, they have higher dielectric constant in general than other polymers.

In the present study, PVdF-HFP was used for the first time to fabricate OLED. PEI was also used as a thermally stable host material as reported in our previous results [6-9].

EXPERIMENTAL

Molecular structures of PEI, tris(8-hydroxyquinolinato) aluminum (Alq3), *N,N'*-diphenyl-*N,N'*-di(m-tolyl) benzidine (TPD), and PVdF-HFP used in this study are shown in Figure 1. A double polymeric layer structure was constructed in the present PLED. TPD-dispersed PVdF-HFP was used as a hole transport layer (HTL), while Alq3-dispersed PEI was used as an emission layer (EML). The solution blend of TPD/PVdF-HFP (30/70 *w/w*) were prepared in dimethylacetamide (DMAc) at a concentration of 0.3 wt.%. The solution was spin-coated onto ITO-glass followed by soft-baked for 1 hr at 65 °C. On the TPD/PVdF-HFP thin film, the mixture solution of Alq3/PEI (70/30 *w/w*) in chloroform (0.5 wt.%) were spin-coated and soft-baked at for 1 hr at 50 °C. Aluminum was thermally evaporated onto the polymeric layer under *ca.* 3×10^{-5} Torr. Photoluminescent (PL) and electroluminescent (EL) spectra were measured using a fluoremeter (SFM 25, KONTRON Co. Ltd.). The current-brightness-voltage characteristics of the PLEDs were obtained using a photomultiplier tube (PMT) and an electrometer (Keithley 6517).

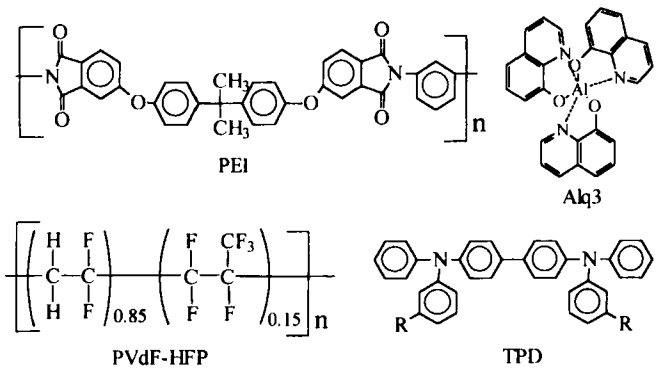


FIGURE 1 Molecular structures of PEI, Alq3, TPD, and PVdF-HFP.

RESULTS AND DISSCUSSION

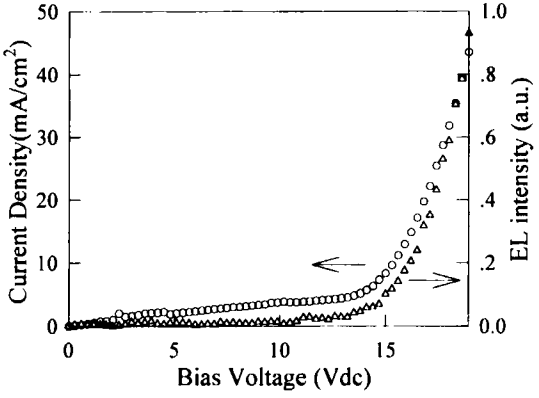
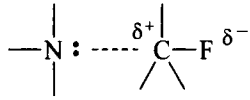


FIGURE 2 Dependence of current density and EL intensity on bias voltage in ITO/PVdF-HFP:TPD /PEI:Alq3/Al device.

Figure 2 shows the PLED characteristics between current density or EL intensity and bias voltage. It can be observed that the current density increases linearly with bias voltage without any emission of light from the device below 14 Vdc. It means, below that voltage, that the weak ohmic current passes through the device due to the

unbalanced injection of holes or electrons from anode or cathode. However, above 14 Vdc, the behavior of current density curve resembles a schottky type diode showing an exponential increase of current with bias voltage. At this voltage, the photons emitted from the PLED was detected with PMT. A greenish-yellow light was easily observed with human eyes at 17 Vdc. Although the turn-on voltage was slightly high, the light was stable. In the present doped polymer system, it is suggested that the positively charged carbon in a carbon-fluoride dipole of PVdF-HFP may encourage the electron-donating property of tertiary amine in TPD in spite of relatively low composition of TPD (30 wt.%) for emitting light. The schematic is presented as follows;



In conclusion, PLED utilizing TPD-dispersed PVdF-HFP and Alq3-dispersed PEI heterojunction was fabricated and worked well. In spite of relatively low amount of TPD in PVdF-HFP as well as polymeric double layer structure, the turn-on voltage was low as *ca.* 14 Vdc.

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