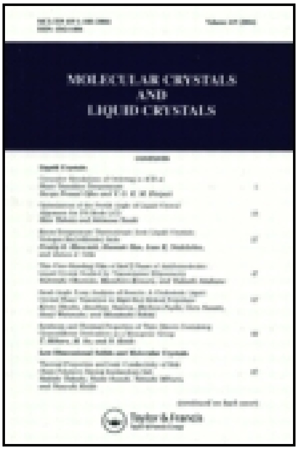

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Light-Emitting Electrochemical Cell (LEC) Using Polythiophene Derivative

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Light-Emitting Electrochemical Cell (LEC) Using Polythiophene Derivative

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Solid-state polymer light-emitting electrochemical cells have been fabricated using thin films of blends of polymer electrolytes and urethane-containing polythiophene (PURET) as active material. We have prepared various types of polymer electrolytes such as poly(acrylate)s and poly(ether ester)s. The devices emit orange-red light with the maximum intensity at 590 nm at room temperature. The typical voltage (V) – current density (I) – luminance characteristics of an ITO / PURET + polymer electrolyte complexed with $LiClO_4$ / Al cell under forward and reverse bias conditions were measured. The I-V curve is symmetric at zero bias. The apparent threshold voltages for current injection and visible light emission are around 2 ~ 3V.

Keywords: electroluminescence (EL); light-emitting electrochemical cell (LEC); polythiophene

INTRODUCTION

Electroluminescence (EL) in conjugated polymers [1] is believed to be the result of a radiative decay of singlet excitons confined in a polymer chain and the details of the mechanism have been proposed and discussed by many authors. However, these polymers are generally insoluble even heating at high temperature, thus restricted practical application. Discovery of fusibility, solubility and unique properties of poly(thiophene)s by attachment of pendant substitutents have stimulated synthesis of new types of conducting polymers [2,3]. Since poly(3-alkylthiophene)s were introduced as unique electroactive polymer, they have attracted considerable interest in material science for academic research as well as potential device applications.

Recently, Yang et al. proposed a novel type of light-emitting electrochemical cell (LEC) using conjugated polymer [4]. However, there has been only a few example of LEC utilizing PPV- and fluorene-derivatives. We report the electrical and luminescent properties of LEC using urethane containing poly(thiophene)s as active materials.

EXPERIMENTAL

[2-(3-thienyl)ethanol n-butozy carbonylmethyl urethane] (URET) and corresponding polymer, poly[2(3-thienyl)ethanol n-butoxycarbonyl methylurethane] (PURET) were synthesized according to the method reported in the literature [5]. Poly(ethylene oxide) (PEO, Mw = 1,000,000, 600,000, 8,000) was purchased from Polysicences. Copolymers of poly(acrylate)s and poly(ether ester)s were synthesized. Lithium perchlorate ($LiClO_4$) used as ionic dopant was purchased from Aldrich. Ethylene carbonate (EC) and propylene carbonate (PC) were used as plasticizer.

To fabricate LECs, we have spin-casted PURET films mixed with various polymer electrolytes on ITO-coated glass. Aluminum top electrodes were vacuum-evaporated at a pressure of about 1×10^{-6} Torr. UV-Vis absorption spectra were recorded with a JASCO Spectrometer. Photoluminescence (PL) and EL spectra of the devices were recorded with an ISS PC Spectrofluorometer under a constant current density. The current-voltage (I-V) characteristics and the intensities of EL emission were simultaneously measured with a Keithley 236 SMU and a TOPCON-BM7 luminance meter. All measurements were performed at room temperature.

RESULTS AND DISCUSSION

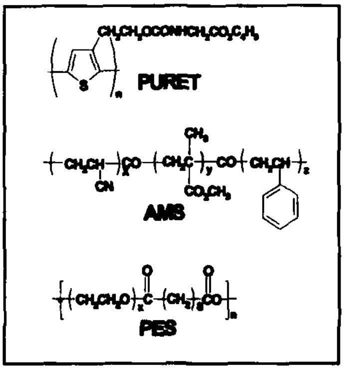


FIGURE 1. Chemical structure of polymers used in this study

We have synthesized various types of polymer electrolytes such as poly(acrylate)s (AMS) and poly(ether ester)s (PES). The chemical structures of the PURET and the polymer electrolytes are shown in Fig. 1. The ionic conductivities of the blended polymer electrolytes were in the range of $5.5 \times 10^{-8} \sim 3.1 \times 10^{-5}$ S/cm.

The absorption, PL and EL emission spectra of the LECs are shown in Fig. 2. An EL spectrum of the device was obtained under forward bias condition. The devices of blends of electroluminescent polymer, PURET, and electrolytes emit orange-red light with the maximum intensity at 590 nm at room temperature, which is red-shifted from the PL peak by about 55 nm.

Figure 3 shows the typical voltage (V) - current density (I) characteristic of an ITO / PURET + PEO ($LiClO_4$) / Al cell under forward and reverse bias conditions. The I-V curve is symmetric at zero injection. Visible light emission for the LEC is at 3 V for forward scan sweeping from 0 to 10 V, and around −2.5 V for reverse scan sweeping from 0 to −10 V.

The I-V curves of LECs using various polymer electrolytes are also

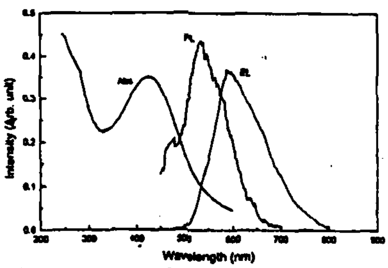


FIGURE 2 Absorption, PL and EL spectra of PURET-LEC

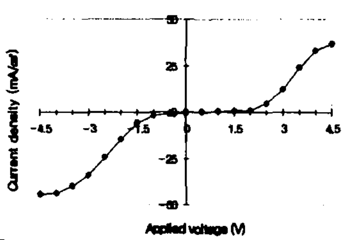
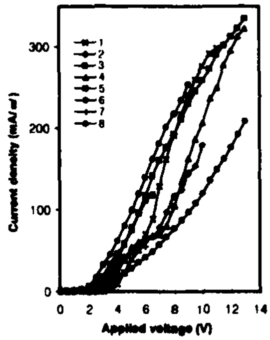


FIGURE 3 I-V characteristic of an ITO/PURET+PEO($LiClO_4$)/ Al cell

shown in Fig. 4. Their threshold voltages are around 2 ~ 3 V, which are close to the optical band gap of the PURET (2.0 eV).

However, control of the phase separation in polymer blended films was required to improve the emission efficiency of LECs.



1. AMS
2. AM
3. PEO (Mw:1,000,000)
4. PEO (600,000)
5. PEO (8,000)
6. PEO/PEG (600,000)/400)
7. PEO/PES (600,000)/60,000)
8. PES (60,000)

FIGURE 4 I - V characteristics of ITO / PURET + polymer electrolyte(1~8) ($LiClO_4$) / Al cells

CONCLUSIONS

We have fabricated solid-state polymer LECs using single-layered thin films of blends of polymer electrolytes and PURET. The emission spectra of LECs showed orange-red light with the maximum intensity at 590 nm at room temperature. The typical voltage – current density characteristics of LECs, ITO/ PURET + polymer electrolyte ($LiClO_4$) /Al, using various electrolytes under forward and reverse bias were symmetric at zero bias. The apparent threshold voltages for current injection and visible light emission are around 2 ~ 3V and close to the optical band gap of the PURET.

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