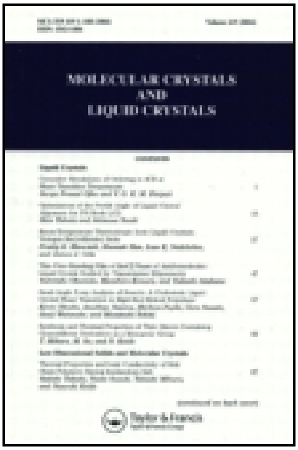

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Flexible Polymer Battery with Conducting Polymer as a Cathode

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Flexible Polymer Battery with Conducting Polymer As a Cathode

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Li polymer batteries were made of Li metal anode, UV cured polymer electrolyte and conducting polymer cathode, polypyrrole (PPy). PPy film doped with dodecylbenzenesulfonic acid (DBSA) showed high conductivity (~10 S/cm) and solubility (~90%) in organic solvents such as chloroform and *m*-cresol. Poly(ethyleneglycol) diacrylate (PEGDA) was prepared under UV irradiation in the presence of liquid plasticizer and showed ionic conductivity of ~10^{-3} S/cm. PEGDA was stable up to 5 V against Li/Li^+. Li/PEGDA/PPy cell showed fast redox reaction at room temperature and a coulombic efficiency of ~80% at galvanostatic charging-discharging test.

Keywords: Li polymer battery, polypyrrole, poly(ethyleneglycol) diacrylate

INTRODUCTION

Rechargeable lithium polymer batteries have received special attention as a main power source for the next century. Lithium metal oxides have been extensively used as a cathode material and at present $LiCoO_2$ is the only metal oxide used in the commercial cells in spite of its high cost. Recently, much attention has been paid to conducting polymers such as polypyrrole (PPy) and polyaniline (PANi) as a promising cathode material for rechargeable lithium batteries[1] since their processability and conductivity were enhanced by bulky surfactant dopants such as dodecylbenzenesulfonic acid (DBSA)[2]. The conducting polymers offer the additional flexibility and foldability to Li battery. Also, the conventional conductive agents and polymer binders for metallic oxides could be unnecessary due to high conductivity and solubility of conducting polymers which will save manufacturing cost and simplify cathode preparation process.

We, therefore, prepared soluble PPy or PPy/$LiMn_2O_4$ composite cathodes without auxiliary fillers, and fabricated a flexible lithium polymer battery along with lithium metal and plasticized polymer electrolyte, poly(ethyleneglycol) diacrylate (PEGDA) prepared under UV irradiation. In this study we reported the battery performance of Li/PEGDA/ PPy cell as a function of preparation conditions of PPy and PEGDA.

EXPERIMENTAL

PPy was chemically polymerized in aqueous solution using DBSA as a dopant and ammonium persulfate (APS) as an oxidant. The detailed procedure was described elsewhere[3]. PPy film electrodes were prepared by solvent casting of PPy/CH_3Cl solution (4 wt%) on to aluminum (Al) foil. PPy/$LiMn_2O_4$ composites were prepared by dip coating of PPy/$LiMn_2O_4$ in CH_3Cl solution on to nickel (Ni) mesh. PEGDA was complexed with lithium perchlorate ($LiClO_4$) in the presence of liquid plasticizers and cured under UV irradiation (Fusion F-450). The ionic conductivity of PEGDA film was measured with an impedance analyzer (Zahner IM6).

The flat Li/PEGDA/PPy cell was assembled by lamination of electrodes and electrolyte with appropriate pressure. The redox reaction was monitored by potentiostat (EG&G Model 362) interfaced with IBM PC. AC impedance analysis was used to investigate the interfacial phenomena between PPy and PEGDA. The cell performance was examined at a galvanostatic charging-discharging condition. (Toyo System Co., TOSCAT 300A).

RESULTS AND DISCUSSION

Fig. 1 showed electrical conductivity and polymerization yield of PPy. They decreased with higher monomer/oxidant ratio, [Mo]/[Ox], and the conductivity reached 20 S/cm at [Mo]/[Ox] of 2.5 because the high oxidant concentration makes longer conjugation length in PPy chain. However, below [Mo]/[Ox] of 7.5, PPy was insoluble in chloroform due to much higher molecular weight and we fixed this value to 7.5.

Fig. 2 showed cyclic voltammogram (CV) for Li/PEGDA/PPy cell at room temperature. The oxidation and reduction peaks occurred at 3.4 V and 2.9 V, respectively at a scan rate of 5 mV/s. Although the cathodic peak is not well defined the small peak separation indicated the fast redox reaction of the cell even at room temperature. The redox peaks are related to the insertion and release of Li^+ rather than ClO_4^- because the surfactant dopants was immobilized in polymer chain during redox process due to its bulkiness.

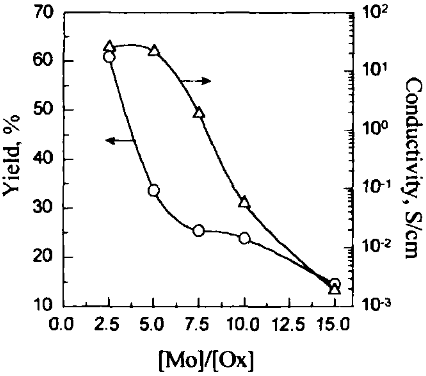


FIGURE 1 Conductivity and yield of PPy as a function of [Mo]/[Ox].

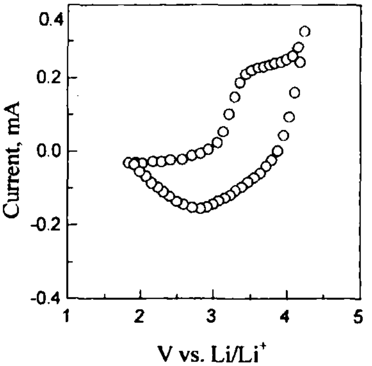
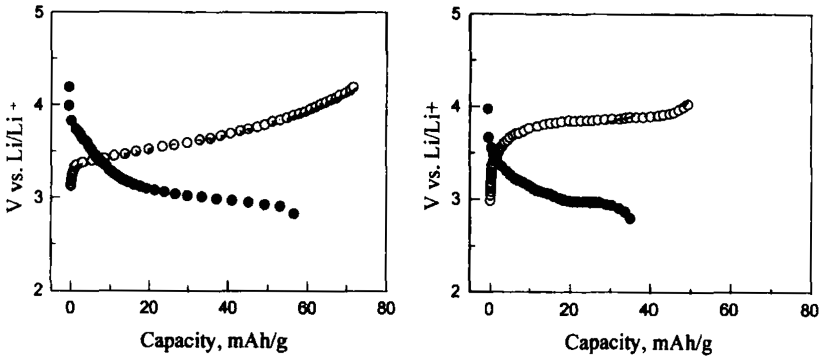


FIGURE 2 CV of Li/PEGDA/PPy cell at room temperature.

The battery performance of $Li/PEGDA/(PPy/LiMn_2O_4)$ and Li/PEGDA/PPy cell was shown in Fig. 3. The upper cut-off voltage and lower cut-off voltage are 4.2 V and 3.0 V for $Li/PEGDA/(PPy\text{-}LiMn_2O_4)$, respectively. The cut-off voltages were reduced to 4.0 and 2.8 V for PPy film cathode alone in order to avoid degradation of PPy. The current density was 0.2 mA/cm^2.

Initial discharge capacities for first cycle resulted in 59 and 38 mAh/cm^2, respectively. The coulombic efficiencies were c.a. 80 and 75%. The low capacity and coulombic efficiency rather than ideal value may be due to the poor contact between PPy and metallic current collectors as well as a little low conductivity of PPy. PANi doped with DBSA improved these properties and the results will be reported in future publication.



(a) (b)

FIGURE 3 The first charge-discharge profiles of Li polymer batteries: (a) Li/PEGDA/(PPy-$LiMn_2O_4$) and (b) Li/PEGDA/PPy.

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