

Application of Poly(ethylenedioxythiophene) thin film to Counter Electrode in Dye-Sensitized Solar Cells

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Dye-sensitized solar cells fabricated using chemically polymerized poly(3,4-ethylenedioxythiophene) on a conductive glass as a counter electrode showed comparable conversion efficiency with a cell using platinum sputtered counter electrode.

Dye sensitized solar cells (DSCs) have been attracting considerable attention because of high efficiency, simple fabrication process and low fabrication costs.¹ Counter electrodes of the cells are usually made of Pt which is vacuum deposited on conducting glasses to catalyze reduction of I_3^- to I^- in redox electrolyte. Since Pt is one of the expensive materials in DSCs, development of the electrodes with the other materials expected to reduce production cost of the cells.

Recently, Johas et al. developed an electronically conducting polymer, poly(3,4-ethylenedioxythiophene) (PEDOT), and showed that PEDOT have high room temperature conductivity and remarkable stabilities.² In addition, Yohannes et al. reported that electrochemically polymerized doped PEDOT can catalyze the reaction of I_3^-/I^- redox couple in an organic solar cell.³

In this poster, we report the application of chemically polymerized PEDOT to a counter electrode on dye-sensitized solar cells. Production cost of 3,4-ethylenedioxythiophene monomers could be reduced by mass production, so chemically polymerized PEDOT seems to be more suitable for the counter electrode material than Pt. Influence of dopant anion on the catalytic activity was also examined.

Procedures of chemical polymerization of TsO⁻ doped PEDOT (PEDOT-TsO) were followed by the method of Leeuw et al.⁴ Polystylenesulfonate doped PEDOT (PEDOT-PSS) electrode was prepared as follows. PEDOT-PSS dispersed in water (Aldrich) was filtrated and spincoated on an ITO glass and heated. Thickness of the PEDOT-TsO and PEDOT-PSS are each 30-50nm. Conductivities of these PEDOT-TsO and PEDOT-PSS films were ~550 S/cm and ~10 S/cm, respectively.

Dye adsorbed TiO₂ films on conducting glasses (F doped SnO₂, 10 ohm/square, NSG) were fabricated using commercial TiO₂ powder (P25, Nippon Aerosil) and Ru dye ((Bu₄N)₂[Ru(dcbpyH)₂(NCS)₂], Solaronix) as reported procedure.¹ The resulting film was clipped with the counter electrode and then an electrolyte solution was introduced into the mesoporous TiO₂ film through capillary action. The electrolyte solution was composed of 0.1 M of LiI, 0.3 M of 1,2-dimethyl-3-propylimidazolium iodide (DMPImI), 0.05 M of I₂ and 0.5 M of *t*-butylpyridine (*t*BP) in methoxyacetonitrile.

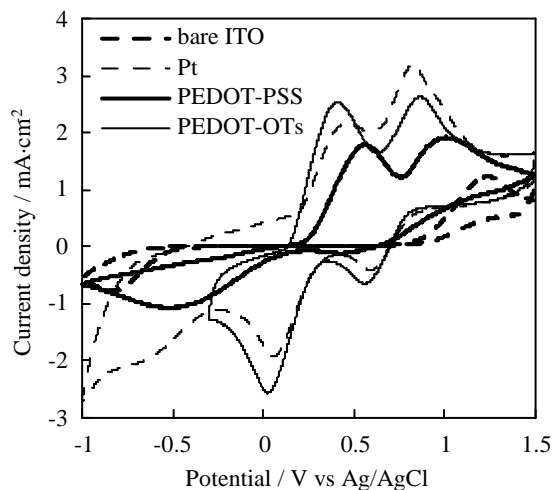
Figure 1 shows the cyclic voltammograms of I^-/I_3^- redox electrolyte on PEDOT films. The oxidation/reduction peaks of I^-/I_3^- observed on the PEDOT-TsO electrode were similar to the behavior on the Pt electrode. In the case of the PEDOT-PSS electrode, the oxidation current was significantly decreased and the reduction peaks were separated. The significant decrease of the

oxidation current could be explained by the reduction of the redox active site of the PEDOT-PSS film due to the exposure of PSS⁻, which prevent the approach of I^- or I_3^- to the active site of the PEDOT chain resulting increase the overpotential.

Figure 2 shows photocurrent-voltage curves of the cells with PEDOT-TsO, PEDOT-PSS, and Pt counter electrode under AM 1.5 irradiation. The cell with PEDOT-TsO showed the almost same properties as the cell with Pt. However, lowering of *FF* were observed in the cell with the PEDOT-PSS. This result agreed with the lower catalytic activity of I_3^- reduction of PEDOT-PSS on CV. As compared to PEDOT-TsO, the conductivity of PEDOT-PSS is relatively low, which could lead to the lowering of *FF*.

A quasi-solid-state dye sensitized solar cell with PEDOT-TsO CE shows excellent durability as well as the cell using a Pt CE without any sealings (at least 80 days).⁶ This durability was caused by the excellent stability of the PEDOT film.²

- 1 a) B. O'Regan et al, *Nature*, **353**, 737 (1991). b) Md. K. Nazeeruddin, et al, *J. Am. Chem. Soc.*, **115**, 6382 (1993)
- 2 F. Jonas et al, *Synth. Met.*, **41-43**, 831 (1991).
- 3 T. Yohannes et al, *Sol. Energy Mater. Sol. Cells*, **51**, 193 (1998).
- 4 D. M. de Leeuw, et al, *Synth. Met.*, **66**, 263 (1994).
- 5 S. Bialozor et al, *Electrochem. Commun.*, **2** 480 (2000)



6. Fig. 1. Cyclic voltammograms of iodide species on ITO, PEDOT-TsO, PEDOT-PSS, and Pt in AN solution of 10mM LiI, 1mM I₂ and 0.1M LiClO₄. W. Kubo, et al, *Chem. Lett.*, 948 (2002)

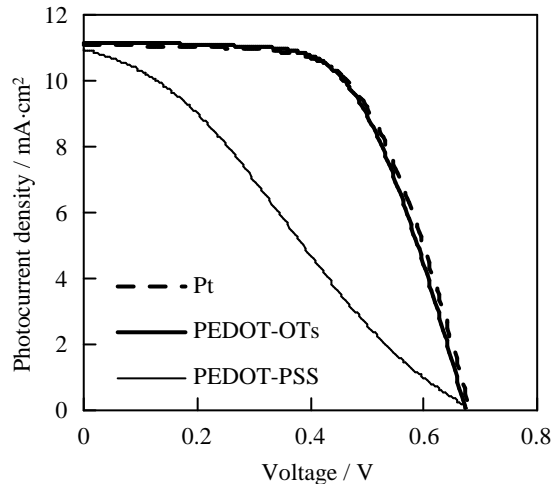


Fig. 2. Photocurrent-voltage curves of the cells with PEDOT-TsO, PEDOT-PSS and Pt as counter electrodes under AM1.5 (100mW cm⁻²)