

# Improvement of Conducting Polymer Charge Storage Electrode of Energy Storable Dye Sensitized Solar Cell

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Recently, novel three-electrode-type solar-rechargeable battery, "energy storable dye-sensitized solar cell" (ES-DSSC, Fig.1), was developed by our group<sup>1)</sup>. The ES-DSSC was constructed by hybridization of a typical Grätzel cell and a conducting polymer charge-storage electrode. In this study, improvement of the conducting polymer charge-storage electrode has been investigated to increase charge capacity (CC).

The ES-DSSC has two compartments separated by a cation exchange membrane (Fig.1). In compartment A, a photo-anode of sintered TiO<sub>2</sub> nanoparticle layer with N3Dye and a Pt mesh counter electrode (1cm×1cm, 0.1mm×100mesh) were soaked in 0.5M LiI and 0.05M I<sub>2</sub> propylene carbonate (PC) solution. In compartment B, a PPy charge-storage electrode (1cm×1cm) was soaked in 0.5M LiClO<sub>4</sub> PC solution. The charge-storage electrode was prepared by electropolymerization of pyrrole in 0.1M LiClO<sub>4</sub> PC solution under constant current (50μAcm<sup>-2</sup>) condition, where polymerization electricity of the pyrrole was regulated to 50, 100 and 200mCcm<sup>-2</sup>. Electrochemical measurement of the charge-storage electrode was carried out in 0.5M LiClO<sub>4</sub> PC solution. Surface structure of PPy was measured by SEM and TM-AFM. Photo-charge and discharge of the ES-DSSCs was investigated for open circuit voltage change and discharge current for each photo-charging time.

In order to increase the CC, polymerization amount of PPy should be increased. However, storage efficiencies decreased with the increase in the polymerization amount of the PPy<sup>1)</sup>. Furthermore, output voltage also decreased with the increase of the thickness of the PPy. To solve the problems, the relationship between surface structure and redox properties of the PPy was studied. The anodic shift of the redox potential of the thick PPy was confirmed by CV (Fig.2). From the AFM measurement (Fig.3), it was confirmed that the surface roughness of the thick PPy was very large. Therefore it is concluded that the control of the surface structure of PPy is important to prevent the anodic shift of the redox potential. Polymerization current density was one of the factors, where 100μAcm<sup>-2</sup> was better than 50μAcm<sup>-2</sup> to keep the PPy surface smooth. For the further improvement of the PPy electrode, stainless mesh (1cm×1cm, 0.1mm×100mesh) with large surface area was used as a polymerization substrate. Table 1 summarized the properties of the ES-DSSC with various charge-storage electrodes. In the case of the stainless mesh, excellent values were obtained both in the CC and IDC.

## Acknowledgments

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## Reference

1) H. Nagai, and H. Segawa, *Chem. Commun.* 974-975, 2004.

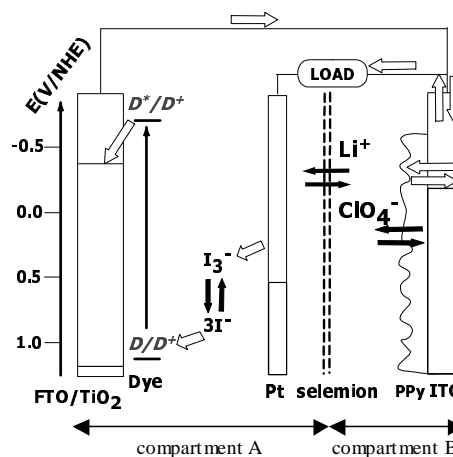


Fig.1. The profile of the mechanism of the ES-DSSC. White arrows represent the electron transfer. Black arrows represent the diffusion of Li<sup>+</sup> and ClO<sub>4</sub><sup>-</sup>.

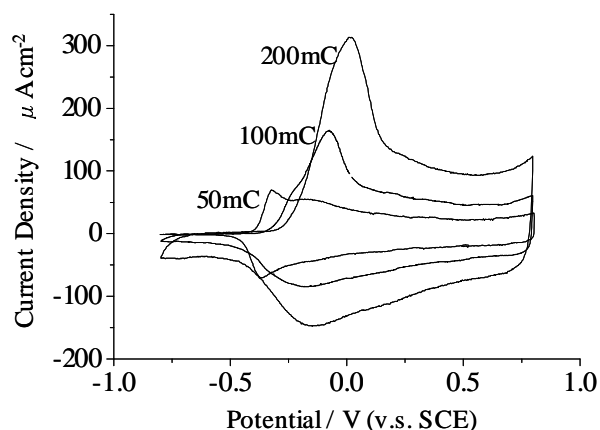


Fig.2. CV of PPy on ITO electrodes in 0.5M LiClO<sub>4</sub> PC deoxidized by N<sub>2</sub>. The scan rate is 5 mV/s.

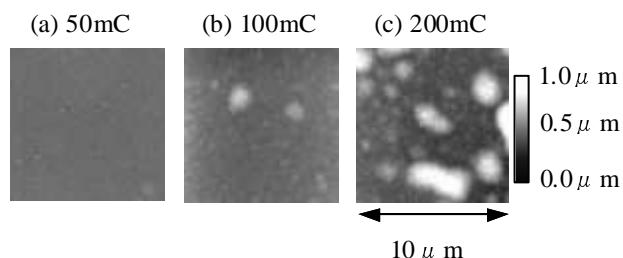


Fig.3. PPy surface on the ITO measured by TM-AFM.

Table 1. Voc, CC, and IDC of the ES-DSSCs with various PPy charge-storage electrodes.

	Voc (mV)	CC (mC/cm <sup>2</sup> )	IDC (μA/cm <sup>2</sup> )
50mC PPy/ITO	452	2.67	21.2
200mC PPy/ITO	355	7.75	12.8
200mC PPy /stainless mesh	432	6.99	19.9

Voc: voltage at 5 minute after photo-charge saturation.  
CC: charge capacity at the saturated state of photo-charging (30minute for 50mC and 200mC PPy on ITO, 60minute for 200mC PPy on stainless mesh).  
IDC (Initial Discharge Current): current density just after the photo-charge.