Electrochemical and Optoelectrical Properties of Dye-Sensitized Solar Cells

邱鵬潔、姚品全

E-mail: 9707280@mail.dyu.edu.tw

ABSTRACT

In this study, commercial TiO2 nanocrystalline powders (Degussa P25) were used to fabricate the working electrode of porphyrin-sensitized solar cells(DSSC). The electrolytes included KI/I2 in propylene carbonate in which sputtered Pt were used as the counter electrode. The optoelectronic properties of the cells were characterized by current-voltage measurements and photon action spectra, respectively while the photoelectrochemical properties of the cells were investigated by typical electrochemical techniques, such as cyclic voltammograms (CV) as well as electrochemical impedance spectrum (EIS) to elucidate the behavior of redox couples and the key process parameters to influence of the diffusion-limited current density (Jlim) and electrochemical impedance under different I-/I3- concentration and composition. We thus focused on some of the key parameters in fabricating the working electrode, the electrolytes as well as the counter electrode. Firstly, the finely grinded TiO2 paste were spin-coated on ITO glass with different thickness. The as-deposited films were annealed at 450oC. Finally, mesoporous nanocrystalline TiO2 films were obtained. After soaked in 0.1mM terta (4-carboxyphenyl) porphyrin (TCPP) in ethanol with deoxycholic acid (DCA) as coadsorbent , the sensitized films were kept in dry air under ambient temperature at dark. The influences of the thickness of TiO2 on the cells performance were investigated. Platinized ITO glass were used for the counter electrodes by sputtering into which electrolytes with different compositions and molar ratio of I-/I3- mediators were injected with micro-syringe. In order to reduce the recombination (back electron transfer) of iodide with charge carriers on the working electrode, 4-Tert-Butylpyridine(TBP) was added to the electrolytes. The results shown that the thicknee of TiO2 was proportional to the no. of spin-coating. While the thickness of TiO2 increased to 6.3?慆, the cell had its best performance. In this case, the short-circuit current (Isc) increased to maximum value of 0.91 mA. The electrochemical analysis indicated that as the concentration of iodide increased, the diffusion-limited current density (Jlim) as well as Isc were increased. On the contrary, the equivalent resistances and open-circuit voltage (Voc) were diminished under identical conditions. The optimal composition of [KI] was 0.3M. Similarly, as the concentration of iodine increased, Jlim as well as Isc were increased, too. In addition, the tendency for equivalent resistances, filled factor (FF) and diffusion coefficient of triiodine still be valid. The cells had best efficiency when [I2]=0.05M. After the addition of TBP, the Isc was decrease to some extent while the VOC increased. The interface charge transfer resistance (RCT) derived from equivalent-circuit analysis diminished considerably. As the [TBP]=0.1M, the DSSC has best efficiency. In light of the thickness of platinum at counter electrode, the Jlim increased as the thickness of Pt increased while the equivalent resistance decreased. The electrode has optimal Pt thickness around 10nm. As a conclusion, the best parameters in fabricating DSSC in our system were the following: film thickness of TiO2 =6.3?慆,. [KI]=0.3M 、[I2]=0.05M、[TBP]=0.1M with 10nm of Pt. Under these conditions, The cell has Voc=0.45V、Isc=0.885mA、FF=0.53 and η =0.21%. The electrochemical analysis is a powerful technique in diagnosis the process parameters of DSSC owing to the close relationship between the cell performance and electrochemical characters.

Keywords : Dye-Sensitized Solar Cells ; TiO2 ; cyclic voltammograms ;electrochemical impedance spectrum ;diffusion-limited current density

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