POLYIODIDE FORMATION AND ION TRANSFER FACILITATION IN GEL ELECTROLYTE FOR DYE SOLAR CELLS

[1]CHAO-MING SHIH, [2]YUN-LING WU, [3]S. RAJESH KUMAR, [4]SHINGJIANG JESSIE LUE

Department of Chemical and Materials Engineering, Chang Gung University, Taiwan
E-mail: jessie@mail.cgu.edu.tw

Abstract - The objective of this work is to provide evidence of polyiodide formation from iodine/tri-iodide redox couple in dye sensitized solar cells. The polyiodides are detected using Raman spectroscopy and X-ray photoelectron spectroscopy(XPS). These intermediates facilitate ion transport in the electrolyte through Grothuss mechanism. The net effect on solar cell performance is increased photocurrent density, improved photovoltaic efficiency, and longer lifetime.

Index Terms - Dye solar cells, gel electrolyte, photovoltaic efficiency, polyiodides.

I. INTRODUCTION

Solar cells is considered a potential renewable energy source [1,2]. The electrical resistance of a solar cell has to be minimized for a high voltaic efficiency [3]. In our previous work, we reported that incorporation of titanium dioxide (TiO_2) nanoparticles and agarose into electrolyte solvent could enhance photovoltaic efficiency of dye sensitized solar cells [4]. In this work, we further investigate the mechanism behind this gel electrolyte containing colloidal TiO_2 with focus on possible intermediate polyiodide ion formation and the interplay of the additives.

II. MATERIALS AND METHODS

A. Electrolyte Preparation

Iodine, lithium iodide, ionic liquid (1-methyl-3-propyl imidazolium iodide, PMI), and N-methylbenzimidazole (NMBI) were mixed in 1-methyl-2-pyrrolidinone/3-methoxy propionitrile (NMP/MPN, 6:4) mixture to prepare control electrolyte. Additives of 1% agarose and/or 0.5% TiO_2nanoparticles were incorporated to investigate the property and photovoltaic efficiency of dye solar cells.

B. Solar Cell Assembly and Test

The solar cell had an area of 2 cm^2 and consisted of fluorine-doped tin oxide (FTO) conductive glasses. Porous TiO_2 layer was coated on the FTO and soaked in 520-DN dye to form working electrode. The counter electrode was made with platinum. The assembled solar cells were tested under 100 mW/cm^2 xenon illumination.

III. RESULTS AND DISCUSSION

Incorporation of agarose into the electrolyte reduced the ion diffusivities and conductivity. However, the agarose resulted in a stabilized system for theTiO_2 nanoparticles to form mono-dispersed colloids and prevented solvent from vaporization. The charged TiO_2 nanoparticles enhanced polyiodide ion formation and significant I_3^- and I_5^- signals were found on Raman spectra and X-rayphotoelectron spectroscopy(XPS) analysis. These intermediate were produced at higher rates when both agarose and TiO_2 nanoparticles were present. Therefore it is hypothesized that these polyiodides may transfer along the TiO_2 nanoparticlesurface and increase transport rate and ionic conductivity, via Grothuss-type transfer mechanism. The solar cell containing agarose and TiO_2 nanoparticles exhibited increases in photocurrent density and photon-to-electron conversion efficiency, as well as longer life time.

CONCLUSION

Agarose addition into electrolyte resulted in a stable gel electrolyte and TiO_2 nanoparticles formed ion conduction channels for polyiodides. This gel electrolyte has potential application in dye sensitized solar cells.

REFERENCES

[1] S.J. Lue, P.W. Lo, L.-Y. Hung, Y.L. Tung, Application of micro-porous polycarbonate membranes in dye-sensitized solar cells: Cell performance and long-term stability, Journal of Power Sources 195 (2010) 7677-7683.

[2] H.S. Chen, S.J. Lue, Y.L. Tung, K.W. Cheng, F.Y. Huang, K.C. Ho, Elucidation of electrochemical properties of electrolyte-impregnated micro-porous ceramic films as framework supports in dye-sensitized solar cells, Journal of Power Sources 196 (2011) 4162-4172.

[3] P.W. Lo, F.Y. Huang, Y.L. Tung, K.W. Cheng, S.J. Lue, Correlation between dye-sensitized solar cell performance and internal resistance using electrochemical impedance spectroscopy, J. Phys. Chem. Biophys. 5 (2015) 181.

[4] S.J. Lue, Y.-L. Wu, Y.-L. Tung, C.-M. Shih, Y.-C. Wang, J.-R. Li, Functional titanium oxide nano-particles as electron lifetime, electrical conductance enhancer, and long-term performance booster in quasi-solid-state electrolyte for dye-sensitized solar cells, Journal of Power Sources 274 (2015) 1283-1291.

★★★