The Influence of Deoxidize Potential of Electrolyte to the Open-circuit Voltage of Dye-sensitized Solar Cells

JIANG Qi-wei, WU Ji-huai
(Institute of Materials Physical Chemistry, Huaqiao University, Quanzhou 362021, China)

Abstract: The influence of different resolvents and different counter electrodes to the deoxidize potential of I_3^- and the open-circuit voltage (V_{OC}) of dye-sensitized solar cells (DSSC) were researched. On the condition of the same concentration of I_3^-/I^- and the same dye-sensitized TiO_2 film electrode, if the resolvents are different the one in which with higher I_3^- deoxidize potential on counter electrode has a higher open-circuit voltage. The use of graphite counter electrode results to higher V_{OC} compared with Pt counter electrode because of the little deoxidize overpotential of I_3^- on graphite electrode compared with which on the Pt electrode at little current density.

Key words: dye-sensitized solar cells; deoxidize potential of electrolyte; open-circuit voltage; cyclic voltampere
CLC number: O649 **Document code**: A **Article ID**: 0529-6579 (2007) S1-0246-02

Due to the high energy conversion efficiency and low production cost, DSSC based on porous TiO_2 thin films have caused widespread attention and have been investigated intensively as potential alternative to the traditional photovoltaic devices[1-4]. The V_{OC} was decided by the difference between the potential of dye sensitized TiO_2 film and the deoxidize potential of electrolyte on counter electrode[2]. The open-circuit voltage of DSSC has great influence to the overall photo-electricity converting efficiency[5].

1 Experiments

1.1 Cyclic voltampere test in I_3^-/I^- system

The cyclic voltampere curves were carried out in an N_2 purged water solution at the scan rate 100 mV/s by CHI660 B Electrochemical Detection[2]. A Pt electrode and a pure graphite electrode were tested respectively as the working electrode, with a Pt coil as the counter electrode and a AgCl/Ag electrode as the reference electrode. The electrolyte was the water solution containing 5 mmol/L I_2, 30 mmol/L KI and 0.1 mmol/L $LiClO_4$.

The cyclic voltampere curves of different electrolytes containing different kind of resolvents were also tested with the same device and with the same kind of Pt as working electrode and the same percentage of I_2, KI and $LiClO_4$.

1.2 The photovoltaic test of DSSC

The solar cells were the simulative cells which were formed with the dye-sensitized TiO_2 film immersed in one basic electrolyte and the counter electrode immersed in another electrolyte. Both of the electrolytes were connected with a salt bridge so that the different solvents will not be mixed and the ions around both of the electrodes will almost have no change in a short time. The basic electrolyte consisted of 0.1 mol/L LiI, 0.5 mol/L Tetra-n-butylammonium iodide, 0.1 mol/L I_2, and 0.5 mol/L tert-butylpyridine in acetonitrile. Here, we use the same kind of basic electrolyte connecting with dye-sensitized TiO_2 film to keep the same character of TiO_2 electrode during the research.

2 Results and discussion

From the cyclic voltampere curves we got Tab. 1 and Tab. 2. As shown in Tab. 1, The deoxidize current start point of Pt electrode is 687 mV, which is 746 mV of graphite electrode, positive shifting for about 60 mV compared to Pt. It is because that the overpotential on Pt electrode is higher than which on pure graphite electrode at little current density. The little overpotential on graphite electrode results to a higher cathode potential of dye-sensitized solar cells at little current density. A higher cathode potential led to a higher V_{OC}[2-4].

①收稿日期: 2007-01-10
基金项目: 国家自然科学基金资助项目 (50372022); 福建省新材料与器件重大专题资助项目 (2004HZ01-3)
作者简介: 姜奇伟 (1979年生), 男, 硕士研究生; 通讯联系人: 吴季怀, E-mail: jiw@hqu.edu.cn

Tab. 1　The character of Pt electrode and graphite electrode

Counter electrode	Deoxidize current start point/mV	V_{OC}/mV
Pt	687	790
Graphite	746	850

Tab. 2 shows the relationship between the V_{OC} and the deoxidize potential of I_3^- in different resolvents. Compared with using a (acetonitrile) as the resolvent, using b (acetone) or c (N, N-dimethyl formamide) will result to positive shift of deoxidize potential on counter electrode. And the positive shifts of deoxidize potential result to a higher V_{OC}.

Tab. 2　The V_{OC} and the deoxidize potential of I_3^- in different resolvents

Resolvent	Deoxidize current start point/mV	V_{OC}/mV
a	615	790
b	643	821
c	678	859

In summary, The deoxidize potential of I_3^- on counter electrode has very important influence to the V_{OC}. A higher deoxidize potential will result to higher V_{OC}. The use of graphite counter electrode for DSSC results to higher V_{OC} compared with Pt counter electrode because of the little deoxidize overpotential of I_3^- on graphite electrode compared with which on the Pt electrode at little current density. On the condition of the same concentration of I_3^-/I^- and the same dye-sensitized TiO_2 film electrode, if the resolvents are different the one in which with higher I_3^- deoxidize potential on counter electrode has a higher V_{OC}.

References:

[1] WANG G Q, LIN R F, LIN Y. A novel high-performance counter electrode for dye-sensitized solar cells[J]. Electrochimica Acta, 2005, 50: 5546-5552.

[2] KIYOAKI I, KOHSHIN T, TAKAHIRO Y. High-performance carbon counter electrode for dye-sensiti-zed solar cells[J]. Solar Energy Materials & Solar Cells, 2003, 79: 459-469.

[3] GRÄTZEL M. Dye-sensitized solar cells[J]. Photochemistry and Photobiology C: Photochemistry Reviews, 2003, 4: 145-153.

[4] GRÄTZEL M. Conversion of sunlight to electric power by nanocrystalline dye-sensitized solar cells[J]. Photochemistry and photobiology A: chemistry, 2004, 164: 3-14.

[5] ATSUSHI F, RYOICHI K. Effect of a redox electrolyte in mixed solvents on the photovoltaic performance of a dye-sensitized solar cells[J]. Solar Energy Materials & Solar Cells, 2006, 90: 649-658.

染料敏化太阳能电池电解质的还原电位对开路电压的影响

姜奇伟，吴季怀

(华侨大学材料物理化学研究所，福建 泉州 362021)

摘　要：研究了不同溶剂和不同对电极对 I_3^-的还原电位和染料敏化太阳能电池的开路电压的影响。在 I_3^-/I^-的离子浓度和染料敏化 TiO_2膜性能相同的情况下，能使 I_3^-在较高的电位下就能还原的对电极溶剂有较高的开路电压。相对于 Pt对电极，用石墨作对电极时有较高的开路电压，这是由于小电流时 I_3^-/I^-在石墨表面的还原反应过电位要比在 Pt表面小。

关键词：染料敏化太阳能电池；电解质的还原电位；开路电压；循环伏安

中图分类号：O649