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Counter Electrodes Prepared by Few Layer and Multilayer Graphene Mixed with Molybdenum Disulfide for Platinum-Free Dye-Sensitized Solar Cells

Huafan Univ., ○Yu-Chen Chou, Huai-Yi Chen

E-mail: hychen@cc.hfu.edu.tw

In the development of clean energy, solar energy is a kind of abundant and environmentally safe energy source. The dye-sensitized solar cell (DSSC), which consists of a transparent conductive oxide, a dye-sensitized titanium dioxide (TiO_2) photoanode, an electrolyte and a counter electrode (CE), is a photochemical cell that has potential development and application. So far, the platinum (Pt) is the most widely used CE in DSSCs, but the use of noble Pt has greatly restricted the commercial production of DSSCs. Graphene (GP) oxide and flake have been synthesized or combined with molybdenum disulfide (MoS_2) to work as CEs for DSSCs [1,2]. In this study, a composite electrode material of MoS_2 and GP was used as well. However, few layer (particle size ~2 nm) and multilayer (particle size ~50 nm) GP nanopowders were added at different weight percent to MoS_2 powder and mixed to produce CEs for DSSCs. The substitution possibilities of traditional Pt CEs by MoS_2/GP ones in DSSCs were studied.

We used screen printing to fabricate the CEs of DSSCs in this work. The experiment was divided into three parts. First, the multilayer GP was mixed with MoS_2 at weight percentage of 1, 3, 5, 7, and 10 wt.% to prepare different CEs. Secondly, the multilayer GP was replaced by few layer one to make different CEs. Finally, at the weight percentage of the best resulting effect in the preceding experiment, different amounts of few layer and multilayer GP nanopowders were mixed with MoS_2 powder to produce a variety of CEs for DSSCs. The characteristics of the DSSCs were then studied using I-V curve, electrochemical impedance spectroscopy (EIS), Tafel curve and so on.

Experimental results show that the conversion efficiency of DSSC increases with the doping concentration of GP and then decreases. The efficiency reaches the maximum at doping concentration of 5wt.%. Meanwhile, the CEs prepared using few layer GP for DSSCs have better conversion efficiency than using multilayer one. In addition, we also found that under the optimal conditions of GP doping concentration (5wt %), the 80%: 20% ratio of few layer and multilayer GP can obtain the highest conversion efficiency of DSSC (3.47%). On the other hand, the conversion efficiency of the DSSC prepared by the use of both fewer layer and multilayer GP nanopowders mixed with MoS_2 powders is higher than just only use of few layer or multilayer GP nanopowder mixed with MoS_2 powder.

[1]C. J. Liu, *et al.*, *J. Mater. Chem.*, 2012, **22**, 21057-21064.

[2] G. Yue, *et al.*, *Electrochim. Acta*, 2012, **85**, 162-168.