Nickel-Graphene Composite Counter Electrode for High-Efficiency Dye-Sensitized Solar Cell

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Dye-sensitized solar cells (DSSCs) have drawn much attention in recent years due to their low cost, environmental friendliness and good stability. A DSSC is typically comprised of a semiconductor nanocrystal (TiO_2), dye, electrolyte containing triiodide and a counter electrode (CE). The CE usually consists of a conductive glass substrate coated with a catalytic material for accelerating the reduction reaction of triiodide ions ($I_3^- + 2e^- \rightarrow 3I^-$). Platinum (Pt) is still the most effective CE catalyst for DSSCs because of its superior electrocatalytic activity for I_3^-/I^- redox couple. However, Pt is a noble material and is susceptible to be corroded by I_3^-/I^- electrolytes. Therefore, it is necessary to develop low-cost Pt-free CE materials. Transition metal nickel (Ni) and its alloys are often used as catalysts for hydrogenation [1]. Ni composites with high specific surface area, good electrical conductivity and excellent catalytic activity can be easily fabricated [2-4] as well. Meanwhile, the price of Ni is several hundred times lower than that of Pt, which is expected to lower the production cost of the solar cell, especially when it is mass produced. Ni composite is thus considered to be a promising alternative to Pt in DSSCs. Carbon (C)-Ni nanocomposite thin films grown by hot filament chemical vapor deposition (HFCVD) and direct current (DC) sputtering in a two-step process have been prepared as DSSC CE [5]. C-Ni thin films exhibit enhanced conductivity compared to fluorine-doped tin oxide (FTO) and a good electrocatalytic activity for iodide ions in the redox electrolyte. In this work, we prepare the CEs of DSSCs using nanopowder mixtures of graphene (GP) and Ni, and study their cell-related properties. In the experiment, GP and Ni powder mixtures of different weight percentages are added with acetylene black, polyvinylidene difluoride (PVDF), ethyl cellulose (EC), terpineol (TP) and other substances to facilitate the reaction for preparation of CEs. At the same time, the CEs were screen printed on top of FTO glass to fabricate DSSCs. The current-voltage characteristics, electrochemical impedance spectroscopy (EIS) and Tafel curves of the DSSCs are measured and discussed. The surface morphology and crystallization behavior of the CE material have also been studied to fully understand the physical and chemical properties of the DSSCs presented here.

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