Platinum-Free Counter Electrodes Prepared Using Cobalt and Nickel Nanopowders for Dye-Sensitized Solar Cells

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In recent years, dye-sensitized solar cells (DSSCs) have drawn much attention due to their low cost, environmental friendness and good stability. A typical DSSC is a sandwich structure composed of a transparent conductive oxide, adsorbed photosensitized dye (usually N719 dye) and a counter electrode (CE). Many studies related to DSSCs have focused on the development of a quasi-solid electrolyte, the effective redox pair and new synthetic dye molecules. Very few studies have focused on the development of CE. A major problem with the conventional DSSC is the use of platinum (Pt) as the CE because the cost of Pt material is very high. If Pt CE could be replaced with a cheaper Pt-free CE that has good electrical properties, it is expected to increase conversion efficiency and reduce production cost of DSSCs.

Cobalt (Co) is magnetic and does not react with water and air at room temperature. Its nature is similar with that of iron and nickel. Nickel (Ni) is also magnetic and its oxidation is slow at room temperature and it is considered to have corrosion resistance. Because the cost of Co and Ni is lower than Pt, they are therefore expected to be able to reduce the production cost of DSSCs if they are used as CEs in DSSCs. They can cost several hundred times lower especially at large-scale production. The cobalt sulfide (CoS) [1], nickel sulfide (NiS)[2], and Ni-doped cobalt sulfide (CoS_2) [3] have been studied and used as CEs for DSSCs. Their solar cell conversion efficiency can be comparable to or even higher than that of Pt CE. In this work, we prepare the CEs of DSSCs using nanopowder mixtures of Co and Ni, and study their cell-related features. During the experiment, Co 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. Meanwhile, the CEs were screen printed on top of FTO glass to make DSSCs. The current-voltage characteristic curves, electrochemical impedance spectroscopy (EIS) and Tafel curves of the DSSCs are tested and discussed. The surface morphology and crystallization behavior of the CE material have also been explored to fully understand the physical and chemical properties of the DSSCs presented here.

[1] C.W. Kung, et al., ACS Nano **6** (2012) 7016–7025.

[2] S.S. Rao, et al., Electrochim. Acta **133** (2014) 174–179.

[3] Hee-Je Kim, et al., Appl. Surf. Sci. **328** (2015) 78–85.