SENSITIZATION OF MESOSCOPIC AND STRUCTURED SEMICONDUCTOR THIN FILMS

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ABSTRACT

The basic purpose of the thesis is to present studies on dye-sensitized photovoltaic solar cells based on high band gap mesoporous semiconductor films. Upon excitation with visible light, dye molecules adsorbed at the surface of the semiconductor could inject electrons (or holes) into conduction band (or valence band) of the semiconductor. This effect could be utilized to construct photoelectrochemical cells that are stable and resistance for photo corrosion.

The first chapter of this thesis introduces the history and the theoretical background of dye-sensitized photovoltaic cells. Synthesis and preparation of the nanostructured materials is one of the most important prerequisite areas of study. Therefore a discussion on the production (synthesis or preparation) of solid materials from constituents in different physical states of matter, i.e., gas, liquid or solid is also contained in chapter 1.

The chapter 2 describes the mechanism of charge transport via interconnected particles and also explains the effect of the composite system in minimizing the recombination of photogenerated charge carriers and suppression the degradation of the dye or/and the liquid electrolyte. DS PECs constructed from a porous film consisting of a mixture tin(IV) oxide and zinc oxide sensitized with a ruthenium bipyridyl complexes generates an I_{sc} of ~20 mA cm^{-2} and V_{oc} of~700 mV at 1000 W m^{-2} in direct sunlight. Both oxides (ZnO and SnO_2) are essential for functioning of the cell.

Technological problems of DS PECs based on nanocrystalline electrodes of wide band-gap semiconductors that require further attention are improvement of the sealing to prevent the gradual loss of the electrolyte and controlling of the chemical irreversibility. The only conceivable way of achieving complete chemical stability is the replacement of the liquid electrolyte by a solid hole conductor to collect and transport the positive charge. Chapter 3 is on dye-sensitized solid-state cell (DS SSC) that use p-type semiconductor as the hole collector. In the n-type semiconductor/dye/p-type semiconductor (NDP) solid state DS cell, photoexcited dye molecules placed between n- and p-type semiconductor interfaces inject electrons and holes to the conduction band (CB) and valence band (VB) respectively. The maximum I_{sc}, V_{oc} and η(efficiency) obtained for the DS SSCs prepared using CuI as a p-type semiconductor is 10-11 mA cm^{-2}, 600 mV, and 3.0-3.5 % respectively. The stability of the cell is however low. The stability of solid-state DS cells made from CuI depends on the morphology of the TiO_2 film. Improved stability is noticed in largely non-porous films of high surface roughness. But the cells deliver somewhat smaller photocurrents and efficiencies.

The chapter 4 contained the conclusion of the studies on dye-sensitized photovoltaic cells based on mesoporous films and the future studies on further improvement of the cell.