

A quasi-solid state dye-sensitized solar cell based on a sol-gel nanocomposite electrolyte

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Dye-sensitized photoelectrochemical cells have established themselves as the most promising low-cost alternative for the photovoltaic conversion of Solar Energy. Briefly, this device is composed of three adjacent thin layers sandwiched between two transparent conductive electrodes: a high band-gap nanocrystalline semiconductor coated with a dye-sensitizer for absorption in the visible region, a platinized counter-electrode to collect the electrons and a redox electrolyte. The electrolyte provides the internal electric conductivity by diffusing among semiconductor nanoparticles, it sets the potential barrier necessary for photovoltaic conversion and transfers charge for regenerating the system by reducing the oxidized dye-sensitizer. Oxidation of the dye occurs upon photon absorption followed by very rapid injection of the excited electron into the Conduction Band (CB) of the semiconductor. Since the original model cell¹ reported in 1991, the study of this device has attracted an ever-growing interest from scientists of different disciplines around the world. These studies have established nanocrystalline TiO₂ in combination with ruthenium bipyridyl derivatives and the redox couple I₃⁻/I⁻ as the uncontested components of the cell. I₃⁻/I⁻ is obtained by simultaneously dissolving iodine and an iodide salt in a solvent solubilizing both, for example, several organic solvents such as propylene carbonate (PC) or acetonitrile (ACN)². The use of solvents in a solar cell has created a lot of skepticism regarding sealing problems, photochemical stability and solubilization capacity of the redox couple. For this reason, substituting liquid electrolyte by a solid gel electrolyte has been considered as offering several advantages compared with the original wet cells. In the present work we propose a Dye-sensitized Solid-State Solar Cell (DSSC) by using nanocomposite gel electrolytes made by the sol-gel method^{3,4}. These materials have many advantages. They are composed of two subphases, one organic and the other inorganic (silica) mixed in the nanoscale. The inorganic subphase provides the gelling agent and simultaneously works as a gluing material holding the working and the counter electrode together, without additional aids. The organic subphase is made of a mixture of chemical substances providing ionic conductivity. Such nanocomposite gels can accommodate appropriate solvents within the organic subphase (in other words, within the pores left by the inorganic network) so that ionic conductivity can be raised to a satisfactory degree. No matter whether one uses a liquid or a gel electrolyte, organic solvents are relatively bad solvents for alkaline iodide salts. Crystallization, for example, of KI has been a source of deterioration of the cell^{5,6}. For this reason, in the present work we make a comparative study of different nanocomposite gels made of silica and covalently linked poly(propyleneoxide), containing some different solvents in order to optimize cell performance and guarantee its durability.

The nanocomposite gels and the DSSC's

themselves have been studied by using some different techniques, namely, FTIR, conductivity, microscopy, time-resolved luminescence probing, cell efficiency measurements etc. Such studies have allowed us to make DSSC's with overall efficiency exceeding 5%, stable for several months under ambient conditions.

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