Quasi-solid-state Dye-sensitized Solar Cells based on Organic/Inorganic gel electrolytes

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Quasi-solid-state (QSS) Dye-sensitized Solar Cells (DSSC) constitute a promising alternative to liquid electrolyte DSSCs, since they do not face the sealing problems that increase the cost of fabrication of liquid-electrolyte cells. QSS-DSSCs employ a gel electrolyte, which comprises the redox couple, necessary to make the cell function, and the material making the gel. Various materials have been used for this purpose in the past. Our approach is to synthesize sol-gel organic/inorganic nanocomposite gels based on a silica backbone and an organic subphase, which hosts the iodide/iodine redox couple. The sol-gel synthesis has the advantage that the electrolyte is applied as a sol, i.e. a liquid, which can penetrate into the nanoporous structure of the semiconductor electrode and thus offer optimized electrical conduct. Subsequently, the sol gels and provides the sealing material that protects electrolyte. Furthermore, the presence of silica provides the binding substance that holds anode and cathode together. The fabrication then of such a cell is very easy. It suffices to prepare the two electrodes, i.e. the nanocrystalline Titania electrode with attached dye-sensitizer and the platinized counter electrode, drop one drop of the sol on one electrode, squeeze the second electrode against the first with the electrolyte sol between them, let it dry and it is ready for use.

A typical sol-gel electrolyte is made by using a silicate alkoxide with a polymer chain covalently attached. Usually, the polymer is a polyethylene or a polypropylene oxide oligomer. It is also possible to mix the alkoxide with a polyethylene or polypropylene oxide oligomer without covalent attachment. However, best results have been obtained with covalently attached oligomers. The inorganic and the organic materials obtain a certain degree of organization in the gel so that they make an organic and an inorganic subphase in the form of percolating clusters with nanoscale sizes. The redox couple is hosted by the organic subphase. The percolating organic cluster allows for substantial ionic conductivity. Ionic conductivity is lower than it can be obtained in liquid electrolytes, however, optimization procedures have led to the synthesis of gels with substantial ionic conductivity and satisfactory cell performance. Thus efficiency as high as 7% has been recently reported by using a QSS-DSSC[*].

Future projects related with the above systems are to introduce conjugated polymers into the gel structure hoping to obtain combined electronic and ionic conductivity and higher electrolyte performance. This matter is being currently studied in our and in cooperating laboratories.

[*]*Increase of the efficiency of Quasi-Solid State Dye-sensitized Solar Cells by a synergy between titania nanocrystallites of two distinct nanoparticle sizes: Elias Stathatos and Panagiotis Lianos, Advanced Materials, 19(2007)3338-3341.*