Dye-sensitized Photovoltaic Cells with an Extremely Thin Liquid Film as the Redox Mediator

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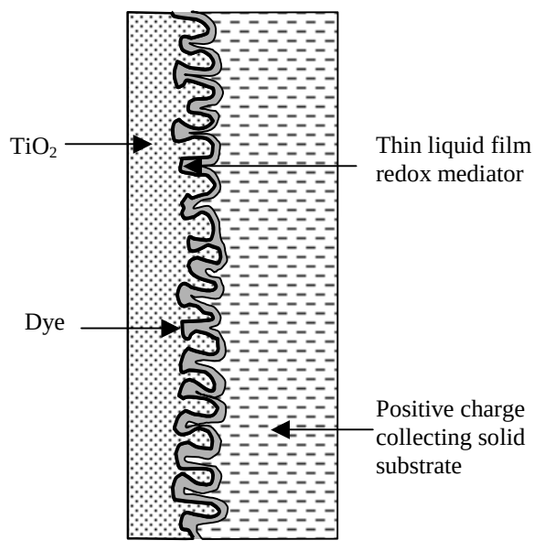
Dye-sensitized photovoltaic devices of wet and solid-state types have been extensively investigated as promising systems for conversion of solar energy. Both types have their merits as well as drawbacks. Wet type cells have reasonably high efficiencies but suffer from the complication of confining a sizable quantity of liquid electrolyte. Solid-state cells reported to date have relatively low efficiencies and the difficulty of making a solid-to-solid contact over a large effective surface area spanning a small geometrical projection contributes to instability. A third possible version of a dye-sensitized photovoltaic device is a system where a dye coated n-type nanocrystalline surface and a positive charge collecting solid interposes in between an extremely thin film of a redox electrolyte (see the figure). This kind of system has three important fundamental advantages: (1) The liquid film assures good surface contact. (2) The problem of slow diffusion limited transport is greatly circumvented when the distances the ionic carriers move in the electrolyte is made small. (3) Redox mediation of electron transport across the electrolyte via first order kinetics is highly desirable. However most redox couples do not function that way, recombination or the initial electron acceptance leads to formation of transient species of short lifetime τ. When the thickness L of the liquid film is extremely small (i.e., few nm), the condition $(D\tau)^{1/2}$ (diffusion length) > L can be readily realized even if τ becomes small. Again this type of system has the practical benefit of avoiding the problems encountered in sealing. Highly viscous electrolytes can be used, as the liquid film is very thin.



The properties the positive charge collecting solid substrate should have are optical transparency, good electrical conductivity and a catalytically active surface. Thus materials with metallic or semiconducting properties can be used. To illustrate the concept we constructed cells of the above type using graphite as the positive charge collecting surface and different redox electrolytes were tested. There was clear evidence for improvement of stability (even if very simple procedures are used for sealing), although the lack transparency lowers the efficiency. A number of semiconductor positive charge collecting substrates were also examined. Fabrication procedures and results of measurements will be reported.