Solar Cells Using Dye-Sensitized Nanoparticle TiO_2 and in situ Photoelectropolymerized Conductive Polyaniline

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A dye-sensitized solar cell (DSSC) typically shows excellent efficiencies for light harvesting and electron collection, properties that result from a nanoparticulate structure and tight integration of the dye with an n-type semiconductor, usually TiO_2. The weakness of a DSSC is characteristically its hole transport properties, most commonly carried out by a liquid-phase redox system, usually iodide/tri-iodide. Substantial worldwide effort is underway to develop a hole transport medium that complements the effectiveness and efficiency of the other components of a DSSC. Here we report the in situ generation of a hole-transport medium within the pores of a DSSC by a novel photoelectropolymerization of aniline.

Electrodes were prepared by first sintering commercial 25 nm TiO_2 particles to a transparent electrode. The nanoparticles were sensitized by adsorption of a monolayer of the dye 5-(4-aminophenyl)-10,15,20-tris(4-carboxyphenyl)porphyrin (TC_3APP), where the carboxy groups were selected for good adsorption to the TiO_2, and the aminophenyl group was selected to serve as a nucleus for a growing polyaniline chain. The counter electrode was prepared by electropolymerizing a thin layer of polyaniline onto a transparent electrode. Between these two electrodes was placed one drop of a solution including acid and electrolyte in aniline as solvent. No iodide or other redox-active materials were added. Irradiation of the cell generates a significant photocurrent that gradually builds up over several minutes and then very slowly levels off. During the relatively constant phase of the photocurrent, current-voltage curves can be measured to determine the efficiency of the cell. Under simulated solar irradiation of intensity 13 mW/cm^2, the cell produces an open-circuit potential of 0.6 V and a short-circuit current of 0.2 mA/cm^2 with a fill factor of 0.7, corresponding to an overall energy conversion efficiency of 0.8%.