

Highly Efficient Solar Cells using TiO₂ Nanotube Arrays Sensitized with a Donor-Antenna Dye

Karthik Shankar,[†] Jayasundera Bandara,[‡] Maggie Paulose,[†] Helga Wietasch,[‡] Oomman K. Varghese, Gopal K. Mor,[†] Thomas J. LaTempa,[†] Mukundan Thelakkat,^{*} and Craig A. Grimes^{*,†}

Department of Electrical Engineering, Materials Research Institute, The Pennsylvania State University, University Park, Pennsylvania 16802, and Applied Functional Polymers, Universitystr-30, University of Bayreuth, 95440 Bayreuth, Germany

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ABSTRACT

Donor antenna dyes provide an exciting route to improving the efficiency of dye sensitized solar cells owing to their high molar extinction coefficients and the effective spatial separation of charges in the charge-separated state, which decelerates the recombination of photogenerated charges. Vertically oriented TiO₂ nanotube arrays provide an optimal material architecture for photoelectrochemical devices because of their large internal surface area, lower recombination losses, and vectorial charge transport along the nanotube axis. In this study, the results obtained by sensitizing TiO₂ nanotube arrays with the donor antenna dye Ru-TPA-NCS are presented. Solar cells fabricated using an antenna dye-sensitized array of 14.4 μm long TiO₂ nanotubes on Ti foil subjected to AM 1.5 one sun illumination in the backside geometry exhibited an overall conversion efficiency of 6.1%. An efficiency of 4.1% was obtained in the frontside illumination geometry using a 1 μm long array of transparent TiO₂ nanotubes subjected to a TiCl₄ treatment and then sensitized with the Ru-TPA-NCS dye. Open circuit voltage decay measurements give insight into the recombination behavior in antenna-dye sensitized nanotube photoelectrodes, demonstrating outstanding properties likely due to a reduction in the influence of the surface traps and reduced electron transfer from TiO₂ to ions in solution.