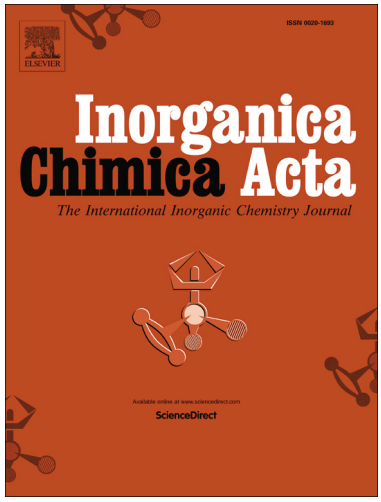

Research paper

Studies on the efficiency enhancement of co-sensitized, transparent DSSCs by employment of core-shell-shell gold nanorods

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Studies on the efficiency enhancement of co-sensitized, transparent DSSCs by employment of core-shell-shell gold nanorods

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This paper is dedicated to Dr. Carlo Mealli on occasion of his 70th birthday

Abstract: In this article, we present studies concerning the efficiency enhancement of dye-sensitized solar cells (DSSC) containing cocktails of organic donor-π-acceptor (D-π-A) dyes (**L0** and **L1**) and a squaraine sensitizer (**SQ2**) by means of the localized surface plasmon resonance (LSPR) effect induced by gold nanorods (GNRs) embedded within the semiconductor layer. In view of the potential application of DSSC devices for building integration, dye cocktails were selected to maximize transparency in the 500-600 nm region, where human eye sensitivity has its peak. Thus, the chosen organic dyes and the squaraine sensitizer had absorption maxima in the 380-410 nm region and above 660 nm, respectively. Thanks to their specific asymmetry, GNRs with a 3:1 aspect ratio could enhance organic dye absorption thanks to their transverse resonance component as well as squaraine absorption in the far-red/near-infrared (NIR) spectral range due to their longitudinal resonance component; furthermore, they were sequentially coated with thin layers of SiO_2 and TiO_2 in order to make them robust enough to withstand thermal film sintering and minimize charge recombination during the photovoltaic operation. Whereas incorporation of GNRs in the photoanode did not improve the efficiency of cells prepared with the **L0**/**SQ2** dye combination, a significant increase of 23% (from 3.50% to 4.32%), comparable to that observed for Ru-sensitizer **N719**, was observed in the case of the **L1**/**SQ2** dye cocktail.

Keywords: Gold nanorods; titanium dioxide; dye-sensitized solar cells; UV-Vis spectroscopy

1. Introduction

Since their discovery in 1991,[1] dye-sensitized solar cells (DSSCs) have been viewed as a promising alternative to silicon photovoltaics due to their low processing costs and inexpensive constituent materials.[2] The working principle of DSSCs is based on sensitization of a large-bandgap semiconductor layer (most often nanocrystalline TiO_2) by means of a suitable dye capable of absorbing visible light. Organic dyes, thanks to their larger molar absorption coefficients compared to traditional Ru-sensitizers,[3] could be particularly useful for the fabrication of DSSCs with thin TiO_2 layers,[4] potentially applicable to the construction of colored, transparent "solar windows" for building-integrated photovoltaics (BIPV).[5] For such an application, the transparency requirement obviously limits the maximum efficiency of the devices, since the use of very thin photoanodes constituted by nanoparticles with selected grain dimension and extremely reduced scattering properties is required.

The human eye typically responds to visible light from 400 to 700 nm, with its sensitivity peaking in the 500-600 nm region.[6] For this reason, glass transparency is maximized when light transmittance is enhanced in such wavelength interval. As a matter of fact, the latter wavelength range is also where the absorption maxima of the most common Ru-based DSSC sensitizers, such as **N719** and **N749** (Figure 1), are found.[7]