

Solid-state dye sensitized solar cells fabricated on a compact TiO₂ barrier layer

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A dye sensitized solid-state solar cell (DSSC) was fabricated consisting of a dense TiO₂ (D) and a porous TiO₂ (P) layers. The dense TiO₂ layer of the type TiO₂(D);TiO₂(P)/Dye/Cul DSSC prevents the short circuit problem, which is normally encountered in DSSC and while the poor dye adsorption of the dense TiO₂ film is overcome using a porous TiO₂ layer. The dense TiO₂ film provides the opportunity of optimizing the porous TiO₂ layer and the overall cell performance.

Nanocrystalline dense films of TiO₂ were prepared by the procedure described below. Titanium tetra-isopropoxide (5 mL, Aldrich) was mixed with propan-2-ol (25 mL) and acetic acid (5.5 mL) followed by addition of water dropwisly (5 mL). Few drops of the suspension were spread on a 150 °C heated conducting tin oxide glass plate, puffed off the loosely bound crust and again, the suspension was spread. After three such cycles, the film was sintered at 450 °C for 15 minutes and loose crust on the surface was wiped off. This process was repeated until a film ~ 10 μm is formed. A porous Degussa TiO₂ layer was applied on the compact TiO₂ layer by doctor blade method. The films were dyed keeping them immersed in a 5.0 X 10⁻⁴ M solution of cisbis(thiocyanate)bis(2,2'-bipyridyl 4,4'-dicarboxylate) ruthenium(II) in ethanol for 6 hours. Cul solution was prepared dissolving 1 g of Cul in 30 mL of acetonitrile then 15 mg of triethylamine hydrothiocyanate (THT) was added to the Cul solution. The dye-coated plate was placed on a hot plate (~110 °C) and the Cul solution was lightly spread over the dyed surface. A Pt sputtered conducting tin oxide glass plate was pressed on the Cul surface (served as the back contact) to measure the energy conversion efficiency (AM 1.5, 1000 Wm⁻² illumination) and the incident photons to photocurrent conversion efficiency (IPCE), using a solar cell evaluation system.

The TiO₂(D)/Dye/Cul solar cell delivers I_{sc} = 1.31 mA, Voc = 345 mV while TiO₂(D);TiO₂(P)/Dye/Cul delivers I_{sc} = 5 mA and Voc = 465 mV. The maximum energy conversion efficiency and the fill factor delivered from the IV curve are 0.13% and 28% respectively for the TiO₂(D)/Dye/Cul solar cell and corresponding values for the TiO₂(D)/TiO₂(P)/Dye/Cul cell are 1.2% and 55% respectively.