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A Preponderant Enhancement of Conversion Efficiency by Surface Coating of SnO_2 Nanoparticles in Organic MK-2 Dye Sensitized Solar Cell

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Nanocrystalline SnO_2 colloids are synthesized by hydrolysis of $SnCl_4 \cdot 5H_2O$ in aqueous ammonia solution. The synthesized SnO_2 nanoparticles with ca. 15 nm in diameter are coated on a fluorine-doped thin oxide (FTO) conductive substrate and heated at 550°C. The annealed SnO_2 film is treated with aqueous $TiCl_4$ solution, which is sensitzied with MK-2 dye (2-cyano-3-[5'''-(9-ethyl- 9H-carbazol-3-yl)-3',3'',3''',4-tetra-n-hexyl-[2,2',5',2'',5'',2''']-quater thiophen-5-yl]). Compared to bare SnO_2 film, the conversion efficiency is significantly improved from 0.22% to 3.13% after surface treatment of SnO_2 with $TiCl_4$, which is mainly due to the large increases in both photocurrent density from 1.33 to 9.46 mA/cm^2 and voltage from 315 to 634 mV. It is noted that little change in the amount of the adsorbed dye is detected from 1.21 for the bare SnO_2 to 1.28 μmol/cm^2 for the $TiCl_4$- treated SnO_2. This indicates that the photocurrent density increased by more than 6 times is not closely related to the dye loading concentration. From the photocurrent and voltage transient spectroscopic studies, electron life time increases by about 13 order of magnitude, whereas electron diffusion coefficient decreases by about 3.6 times after $TiCl_4$ treatment. Slow electron diffusion rate offers sufficient time for regeneration kinetics. As a result, charge collection efficiency of about 40% before $TiCl_4$ treatment is improved to 95% after $TiCl_4$ treatment. The large increase in voltage is due to the significant increase in electron life time, associated with upward shift of fermi energy.

Keywords: dye-sensitized solar cell, SnO_2, MK-2 dye