The effect of $Cu_{2-x}O$ quantum particles on TiO_2 films of dye-sensitised solar cells

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Dye-sensitized photo electrochemical solar cells are gaining much attention as an alternative to the silicon based solar cells because of their low cost and high efficiency. The dye-sensitized solid-state solar cell of the structure [n-type semiconductor/Dye/ p-type semiconductor] has been introduced since the former cell suffers from some technological problems due to the presence of liquid electrolyte. Although solid state solar cells have been fabricated with many hole collectors, highest efficiency has been reported with the semiconductors, p-CuI and p-CuSCN, where Cu is one of the constitute in both the materials. CuI is widely used to fabricate dye-sensitized solid-state solar cells because it could be dip coated dissolving in many organic solvents. Since CuI is a volatile material, liberation of iodine at high temperature and expose to UV radiation is reported. Therefore this is a serious problem in dye-sensitized solid state solar cells based on CuI. Prolong illumination for several days completely deteriorate these cells due to the above reasons. But the effect of liberated copper in the photodecomposition of CuI is not intensively studied, which we addressed in the current report.
Since the liberated Cu in photodecomposition of CuI is very small, we purposely grew $Cu_{2-x}O$ quantum size particles on TiO_2 in our investigations to study its effects. Quantum particles of $Cu_{2-x}O$ were deposited on titanium dioxide particles by mixing TiO_2 (P-25) powder with $Cu(NO_3)_2$ solution with a known concentration and sintering at 500 °C. Sintering at 500 °C converts almost all of the $Cu(NO_3)_2$ adsorb on the surface of TiO_2 particles to copper oxide ($Cu_{2-x}O$). These samples ($TiO_2/Cu_{2-x}O$) were examined with diffusion reflectance spectroscopy and band edge positions of the samples were determined with Mott-Schottky measurements.

The colour of the samples varied with the Cu percentage added. The samples prepared with very low concentration of Cu appeared in pale yellow colour and it turned into black increasing the copper concentration. When those samples were examined with diffusion reflectance spectroscopy, apparent absorption in the visible region could be observed. However, it also clearly indicated that the absorption onset of TiO_2 red shifted incorporating copper to TiO_2. This band gap variation was further studied with the Mott-Schottky measurements. It gave clear evidence that band edge of $TiO_2/Cu_{2-x}O$ shifts towards more negative values in the energy scale incorporating more copper to the samples.

Therefore, we finally conclude that if Cu that produced in photodecomposition of CuI move on to the TiO_2 films of the dye-sensitized solid state cell, it would affect to lower the photovoltage of the solar cell because photovoltage of a dye-sensitized solar cell is determined by the band edge position of the semiconductor material. Since the $Cu_{2-x}O$ that deposit on TiO_2 electrode in decomposition of CuI is very much small, we could not quantitatively detect it with the available facilities.

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