

Enhanced Characteristics of Dye-Sensitized Solar Cells by Modification of TiO₂ Films

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Interests in the novel dye-sensitized solar cells stem from their high solar conversion efficiency and potentially low energy-processing techniques. One of the key issues to improve further the efficiency is to block the interface states lying below the conduction band edge. The interface states mediate recombination of the injected conduction band electrons with oxidized dyes and/or triiodide ions. Besides, incorporating larger TiO₂ particles can increase both V_{oc} and J_{sc} due to better light-scattering properties.

For the purpose of improving the solar cell conversion efficiency by reducing the back electron transfer, in this study we utilized a thin TiO₂-WO₃ composite layer under the TiO₂ layer, modified the film with polypyrrole (PPy), and incorporated carbon nanotubes (CNT) or TiO₂ particles of different morphology into the TiO₂ film.

TiO₂-WO₃ composites were prepared by dissolving WCl₆ in ethanol and then by adding TiCl₄. The composite was spin-coated on a conducting glass, followed by coating a layer of P-25. PPy was grown by a cyclic method on the TiO₂ surface under illumination. TiO₂ having different morphology was synthesized by a sol-gel method using TiCl₃ in water. Commercially available single-wall CNT was used. XRD, SEM, TEM, CV, and UV made the characterization of the materials.

An under-layer of TiO₂-WO₃ composite enhanced both J_{sc} and V_{oc} . The V_{oc} increase can be explained by assuming that the back electron transfer to I₃⁻ was blocked by the presence of the composite layer. The flat band potential of the composite layer was measured to lie below that of the outer TiO₂ layer. This favorable conduction band position apparently facilitated the electron transfer, resulting an increase in the J_{sc} . The modification of the TiO₂ film with PPy improved the J_{sc} . The result is also explained by

the reduction of the back electron transfer to I₃⁻. The PPy grew on the sites where I₃⁻ ions can adsorb and thus to prevent the I₃⁻ adsorption. The growth of PPy on the conducting glass was avoided by maintaining the applied potential below 0.7 V. The ambient hydrolysis of TiCl₃ yielded tubular anatase TiO₂ particles^[1] of 150 nm in length and 20-50 nm in diameter. The incorporation of the tubular TiO₂ enhanced the J_{sc} by 30 % compared with P-25. A similar increase in the J_{sc} was obtained by incorporating single-wall CNT. The film with the tubes appeared to be more porous and thus allow more dye molecules to adsorb. The detailed mechanism of the enhancement will be discussed.

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REFERENCES

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