

가지형 공중합체를 이용한 나노구조 TiO₂ 제조 및 염료감응 태양전지 응용

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Synthesis of Organized TiO₂ Electrodes Using Graft Copolymer and Their Applications to Dye-Sensitized Solar Cells

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The morphology of mesoporous TiO₂ films plays an important role in the operation of a DSSC. For example, the energy conversion efficiency of DSSCs with well-organized mesoporous TiO₂ films is much higher than those with traditional films possessing a random morphology. In previous research, well-organized mesoporous TiO₂ films have mainly been synthesized using an amphiphilic block copolymer, e.g., a poly(ethylene oxide) (PEO)-based template. A graft copolymer is more attractive than a block copolymer due to its low cost and the ease with which it can be synthesized. In this work, we provide the first report on the successful synthesis of well-organized mesoporous TiO₂ films templated by an organized graft copolymer as a structure directing agent. Well-organized mesoporous TiO₂ films with excellent channel connectivities were developed via the sol gel processing using an organized PVC-g-POEM graft copolymer synthesized by one-pot ATRP. The careful adjustment of copolymer composition and solvent affinity using a THF/H₂O/HCl mixture was used to systematically vary the material structure. The influence of the material structure on solar cell performance was then investigated. A solid-state DSSC employing both the graft copolymer templated organized 700 nm-thick TiO₂ films and graft copolymer electrolytes exhibited a solar conversion efficiency of 2.2% at 100 mW/cm². This value was approximately two-fold higher than that attained from a DSSC employing a random mesoporous TiO₂ film. The solar cell performance was maximized at 4.6% when the film thickness was increased to 2.5 μm. We believe that this graft copolymer-directed approach introduces a new and simple route toward the synthesis of well-organized metal oxide films as an alternative to a conventional block copolymer-based template.

Key words : dye-sensitized solar cell(염료감응 태양전지), graft copolymer(가지형 공중합체), polymer electrolyte(고분자 전해질), mesoporous TiO₂(메조기공 TiO₂), sol-gel(졸겔)

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Synthesis of Mesoporous Titanium Dioxide Nanoparticles and Their Application into Dye Sensitized Solar Cells

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In order to improve the overall power conversion efficiency in dye-sensitized solar cells (DSSCs), it is very important to secure the sufficient surface area of photocatalytic nanoparticles layer for absorbing dye molecules. It is because increasing the amount of dye absorbed generally results in increasing the amount of light harvesting. In this work, we proposed a new method for increasing the specific surface area of photocatalytic titanium oxide (TiO₂) nanoparticles by using an inorganic templating method. Salt-TiO₂ composite nanoparticles were synthesized in this approach by spray pyrolyzing both the titanium butoxide and sodium chloride solution. After aqueous removal of salt from salt-TiO₂ composite nanoparticles, mesoporous TiO₂ nanoparticles with pore size of 2~50 nm were formed and then the specific surface area of resulting porous TiO₂ nanoparticle was measured by Brunauer-Emmett-Teller (BET) method. Generally, commercially available P-25 with the average primary size of ~25 nm TiO₂ nanoparticles was used as an active layer for dye-sensitized solar cells, and the specific surface area of P-25 was found to be ~50 m²/g. On the other hand, the specific surface area of mesoporous TiO₂ nanoparticles prepared in this approach was found to be ~286 m²/g, which is 5 times higher than that of P-25. The increased specific surface area of TiO₂ nanoparticles will absorb relatively more dye molecules, which can increase the short circuit current (J_{sc}) in DSSCs. The influence of nanoporous structures of TiO₂ on the performance of DSSCs will be discussed in terms of the amount of dye molecules absorbed, the fill factor, the short circuit current, and the power conversion efficiency.

Key words : Dye-sensitized solar cell(염료감응형 태양전지), Porous particle(다공성입자), specific surface area(비표면적)

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