Fabrication of 3D interconnected porous TiO_2 nanotube arrays templated by graft copolymer for dye-sensitized solar cells

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3D interconnected porous TiO_2 nanotube arrays were prepared using a sol-gel process assisted by poly(vinyl chloride-*graft*-4-vinyl pyridine), PVC-*g*-P4VP graft copolymer and a ZnO nanorod template. A 7 μm long ZnO nanorod array was grown from the FTO glass via a liquid phase deposition method. The TiO_2 sol-gel solution templated by the PVC-*g*-P4VP graft copolymer produced a random 3D interconnection between the adjacent ZnO nanorods during spin coating. Upon etching of ZnO, TiO_2 nanotubes consisting of 10-15 nm nanoparticles were generated, as confirmed by wide-angle x-ray scattering (WAXS), energy-filtering transmission electron microscopy (EF-TEM) and field-emission scanning electron microscopy (FE-SEM). The ordered and interconnected nanotube architecture showed an enhanced light scattering effect and increased penetration of polymer electrolytes in dye-sensitized solar cells (DSSC). The energy conversion efficiency reached 1.82% for liquid electrolyte, and 1.46% for low molecular weight (Mw) and 0.74% for high Mw polymer electrolytes.