The effect of mesoporous TiO2 pore size on the performance of solid-state dye sensitized solar cells based on photoelectrochemically polymerized Poly(3,4-ethylenedioxythiophene) hole conductor

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2016

Abstract

Photoelectrochemical polymerization of poly(3,4-ethylenedioxythiphene) (PEDOT) has recently been introduced and widely investigated for fabrication of the hole transporting material (HTM) in highly efficient solid state dye sensitized solar cells (sDSCs). In this work, the effects of the surface area and pore size of TiO2 film were for the first time investigated in the sDSCs employing the in-situ polymerizated PEDOT HTM. Three different varieties of mesoporous TiO2 particles with controllable surface area and pore size were synthesized through the basic route in order to study the corresponding sDSC photovoltaic performances. It was found that the pore size plays an important role in the kinetics of the photoelectrochemical polymerization (PEP) process and the formation of the PEDOT capping layer. Larger pore sizes provided a more favourable pathway for the precursor diffusion through the mesoporous pores during the PEP process, which contributed towards a more efficient PEP. However, the interfacial contact area between the formed polymer and the dyes on the surface of TiO2 particle would be lower in the case of larger pore sizes, which consequently caused a less efficient dye regeneration process. Electronic diffusion on the other hand was improved for larger particle sizes. Employing an organic dye LEG4 and the self-made TiO2 with an optimal pore size of 25 nm and particle size of 24 nm, the sDSCs showed a promising power conversion efficiency (PCE) of 5.2%, higher than 4.5% for the commercial TiO2 Dyesol DSL-30. By measuring the dye regeneration yield and the kinetics through photoinduced absorption, it was observed that the homemade TiO2 based device had more efficient dye regeneration compared to the Dyesol based device, which could result from the better interfacial contact between the PEDOT and the dye. This work provides important information on the effect of meso-pore size on sDSCs and points to the necessity of further photoanode optimization toward the enhancement of the PCE of polymeric hole conductor-based DSCs.