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# All Solution processed $BiVO_4/WO_3/SnO_2$ Heterojunction Photoanode for Enhanced Photoelectrochemical Water Splitting

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Global environmental deterioration has become more serious year by year and thus scientific interests in the renewable energy as environmental technology and replacement of fossil fuels have grown exponentially. Photoelectrochemical (PEC) cell consisting of semiconductor photoelectrodes that can harvest light and use this energy directly to split water, also known as photoelectrolysis or solar water splitting, is a promising renewable energy technology to produce hydrogen for uses in the future hydrogen economy. A major advantage of PEC systems is that they involve relatively simple processes steps as compared to many other H2 production systems. Until now, a number of materials including TiO2, WO3, Fe2O3, and BiVO4 were exploited as the photoelectrode. However, the PEC performance of these single absorber materials is limited due to their large charge recombinations in bulk, interface and surface, leading low charge separation/transport efficiencies. Recently, coupling of two materials, e.g., BiVO4/WO3, Fe2O3/WO3 and CuWO4/WO3, to form a type II heterojunction has been demonstrated to be a viable means to improve the PEC performance by enhancing the charge separation and transport efficiencies. In this study, we have prepared a triple-layer heterojunction BiVO4/WO3/SnO2 photoelectrode that shows a comparable PEC performance with previously reported best-performing nanostructured BiVO4/WO3 heterojunction photoelectrode via a facile solution method. Interestingly, we found that the incorporation of SnO2 nanoparticles layer in between WO3 and FTO largely promotes electron transport and thus minimizes interfacial recombination. The impact of the SnO2 interfacial layer was investigated in detail by TEM, hall measurement and electrochemical impedance spectroscopy (EIS) techniques. In addition, our planar-structured triple-layer photoelectrode shows a relatively high transmittance due to its low thickness (~300 nm), which benefits to couple with a solar cell to form a tandem PEC device. The overall PEC performance, especially the photocurrent onset potential (Vonset), were further improved by a reactive-ion etching (RIE) surface etching and electrocatalyst (CoOx) deposition.

**Keywords:** Photoelectrochemical, water splitting, heterojunction, electrocatalyst