Elucidating Photoelectrocatalytic Mechanism Related To The Reconstructed Interfaces of Ternary Nanostructured α-Fe_2O_3/Au/TiO_2 Photonanode by X-ray Spectroscopies

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Abstract

Hematite (α-Fe_2O_3) has increasingly paid wide attention as one of the most promising photoanode materials in semiconductor-based sunlight-driven photoelectrocatalytic water splitting devices. However, the full exploitation of solar-to-hydrogen conversion efficiency of α-Fe_2O_3 water splitting cell is still finite by poor majority carrier conductivity, short hole-diffusion lengths, and sluggish kinetics for the oxygen evolution reaction (OER) at the photoelectrode/electrolyte interface. In this study, we reported that adjusting the composition of the electrolyte with the integrating a crystalline α-Fe_2O_3 core, metallic Au nanoparticles, and an amorphous TiO_2 overlayer could be as a strategy to enhance photocatalytic performance. Under simulated solar illumination, the photoelectrocatalytic performance of α-Fe_2O_3/Au/TiO_2 was significantly improved with the photocurrent density was found to be 4-fold greater than that of pure α-Fe_2O_3 at 1.23 V versus RHE. X-ray absorption spectroscopy (XAS) was performed to investigate the electronic properties of the α-Fe_2O_3 and how it was modified with Au and TiO_2 decoration. The significant improvement could be attributed to the relayed pumping of photogenerated charge carriers through the photoelectrode/electrolyte interface reconstructed by Au nanoparticles and TiO_2 overlayer. Using the power of scanning transmission X-ray microscopy (STXM) as a spectromicroscopic technique, the photohole transport mechanism was revealed and accordingly provide insight into the impact of material heterogeneities on its performance.