Efficient Solar Hydrogen Production Using Hematite Photoanode Modified with CoFe Prussian Blue Catalyst via a Novel Surface Modification Approach

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Producing sustainable fuel such as hydrogen gas is essential to mitigate the harmful effects of CO2-emissions, such as global warming and climate change on natural life cycles. Hematite (α-Fe2O3) is used as a light-harvesting electrode in photoelectrochemical cells, which exhibits several desirable properties. However, its solar-to-hydrogen conversion efficiency is low due to the sluggish kinetics of water oxidation on its surface. In this research, a novel surface modification approach is investigated to accelerate the kinetics by enhancing the hematite photoanode with an oxygen evolution catalyst (OEC). First, hematite electrodes were prepared by chemical bath deposition. Second, the hematite surfaces were modified with phosphate layer. Third, the phosphate layer was precipitated with CoFe Prussian blue-type OECs. Moreover, the procedure was conducted three times for confirmation. Techniques indicated that the modification of the hematite surface reduces the resistance and recombination rate of the charge transfer by 73% and 60%, respectively, which accelerates water oxidation kinetics, validating the approaches. Consequently, the photocurrent density generated on the bare photoanode at 1.23 V versus the reversible hydrogen electrode under standard solar irradiation (1.0 sun, AM 1.5G) was increased by more than 3-fold. The applied bias photon-to-current conversion efficiency was calculated to be 0.8%. This value is especially promising as it paves the path towards the utilization of solar hydrogen as a renewable and carbon-free energy source in the future.