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Materials preparation for the future hydrogen economy: PEC water splitting

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Semiconductors have been used in solar water splitting since the initial report on hydrogen production using TiO2. Thus far, materials explored to achieve theoretical solar to hydrogen efficiency (STH), included cadmium selenide (CdSe), zinc oxide (ZnO), copper(I)oxide (Cu2O), tungsten trioxide (WO3) and hematite (α-Fe2O3). All these failed due to their band edge alignments that do not straddle water oxidation and reduction potentials. Of these materials, hematite has received much attention for photoelectrochemical water splitting attributed to its stability in aqueous solution, a small band gap of 1.90 eV-2.20 eV, non-toxicity and abundance. However, it has associated limitations such as high electron-hole recombination rate, short hole diffusion length (2-4 nm) accompanied by short excited lifetime of 10 ps, and poor minority charge carrier mobility of 0.1 cm2 V-1s-1, leading to low photocurrent during water splitting. Furthermore, hematite promises a maximum theoretical STH efficiency of ˜16.8 %, with photocurrent densities above 12 mAcm-2, but the reported findings are far below 10 mAcm-2. The future is in the hydrogen economy which requires clean energy production to reduce the carbon foot print and consequently combat climate change.

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