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研究成果の概要

We designed and developed a novel light-driven system for overall water splitting by integrating photocatalytic and photoelectrochemical technologies and employing two semiconductors with different bandgaps in a Z-scheme configuration. This system addresses two key challenges commonly associated with conventional photocatalytic water splitting: (1) severe side reactions caused by redox mediators used to shuttle electrons, which significantly reduce the solar-to-hydrogen (STH) conversion efficiency, often to below 0.6%; and (2) the simultaneous generation of H_2 and O_2 in a single reaction chamber, which requires subsequent gas separation for practical applications.

The system incorporating a photocatalytic H_2 evolution reaction (HER) cell separated from an O_2 evolution reaction (OER) cell mediated by the I_3^-/I^- redox shuttle. Specifically, a mixed halide perovskite $FAPbBr_{3-x}I_x$ (FPBI, FA = $CH(NH_2)^{2+}$; absorption edge 620 nm) loaded with molybdenum selenide ($MoSe_2$) was developed as the photocatalyst for H_2 production while splitting HI and oxidizing I^- to I_3^-. A NiFe-layered double hydroxide modified $BiVO_4$ (NiFe-LDH/$BiVO_4$, absorption edge 520 nm) film grown on an FTO glass was employed for OER via water oxidation, with the linked carbon cloth electrode for I_3^- reduction. This design allows for the separate production of H_2 and O_2, completely avoiding back reaction (recombination of H_2 and O_2). Additionally, side reactions caused by the redox couple (the oxidation of I^- by the holes in $BiVO_4$) can be completely suppressed because the OER cell did not contain the redox mediates. Therefore, the system split water with an STH of 2.50%, which is the new record for Z-scheme photocatalytic overall water splitting.

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