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Photocatalytic Water Splitting for Green Hydrogen Production

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Abstract: *The increasing global energy demand and environmental concerns associated with fossil fuels have intensified the search for sustainable and clean energy alternatives. Green hydrogen, produced via photocatalytic water splitting, has emerged as a promising solution due to its high energy density and zero carbon emissions. This review comprehensively discusses the fundamental principles, mechanisms, and recent advancements in photocatalytic water splitting for hydrogen production.*

Photocatalytic water splitting utilizes semiconductor-based photocatalysts to absorb solar energy and drive the redox reactions of water into hydrogen (H_2) and oxygen (O_2). Key challenges include enhancing light absorption, charge carrier separation, and surface reaction kinetics. Various strategies such as doping, heterojunction construction, cocatalyst loading, and nanostructuring have been explored to improve photocatalytic efficiency.

This paper highlights the role of different photocatalysts, including TiO_2, g-C_3N_4, metal-organic frameworks (MOFs), and perovskite oxides, in optimizing hydrogen evolution rates. Additionally, the integration of advanced characterization techniques (e.g., in-situ X-ray photoelectron spectroscopy (XPS) and transient absorption spectroscopy) provides deeper insights into reaction mechanisms.

Despite significant progress, scalability and economic feasibility remain critical hurdles. Future research should focus on developing low-cost, stable, and highly efficient photocatalysts, along with reactor design innovations for large-scale applications. This review aims to provide a comprehensive understanding of photocatalytic water splitting, offering valuable insights for researchers working toward sustainable hydrogen production. .

Keywords: photocatalytic water splitting