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Enhancing Photocatalytic Hydrogen Production: Modification of TiO_2 by Coupling with Semiconductor Nanoparticles

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Abstract : Photocatalytic water splitting to produce hydrogen (H_2) has obtained significant attention as an environmentally friendly technology. This process, which produces hydrogen from water and sunlight, represents a renewable energy source. Titanium dioxide (TiO_2) plays a critical role in photocatalytic hydrogen production due to its chemical stability, availability, and low cost. Nevertheless, TiO_2's wide band gap (3.2 eV) limits its visible light absorption and might affect the effectiveness of the photocatalytic. Coupling TiO_2 with other semiconductors is a strategy that can enhance TiO_2 by narrowing its band gap and improving visible light absorption. This paper studies the modification of TiO_2 by coupling it with another semiconductor such as CdS nanoparticles using a reflux reactor and autoclave reactor that helps form a core-shell structure. Characterization techniques, including TEM and UV-Vis spectroscopy, confirmed successful coating of TiO_2 on CdS core, reduction of the band gap from 3.28 eV to 3.1 eV, and enhanced light absorption in the visible region. These modifications are attributed to the heterojunction structure between TiO_2 and CdS.The essential goal of this study is to improve TiO_2 for use in photocatalytic water splitting to enhance hydrogen production. The core-shell TiO_2@CdS nanoparticles exhibited promising results, due to band gap narrowing and improved light absorption. Future work will involve adding Pt as a co-catalyst, which is known to increase surface reaction activity by enhancing proton adsorption. Evaluation of the TiO_2@CdS@Pt catalyst will include performance assessments and hydrogen productivity tests, considering factors such as effective shapes and material ratios. Moreover, the study could be enhanced by studying further modifications to the catalyst and displaying additional performance evaluations. For instance, doping TiO_2 with metals such as nickel (Ni), iron (Fe), and cobalt (Co) and non-metals such as nitrogen (N), carbon (C), and sulfur (S) could positively influence the catalyst by reducing the band gap, enhancing the separation of photogenerated electron-hole pairs, and increasing the surface area, respectively. Additionally, to further improve catalytic performance, examining different catalyst morphologies, such as nanorods, nanowires, and nanosheets, in hydrogen production could be highly beneficial. Optimizing photoreactor design for efficient photon delivery and illumination will further enhance the photocatalytic process. These strategies collectively aim to overcome current challenges and improve the efficiency of hydrogen production via photocatalysis.
Keywords : hydrogen production, photocatalytic, water spliiting, semiconductor, nanoparticles
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