INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The escalating demand for energy from renewable sources, driven by the depletion of fossil resources and environmental concerns, underscores the importance of green energy solutions. Solar energy, an abundant and renewable resource, presents a viable option, since only 0.015% reaching Earth is capable of meeting total global energy demand. While photovoltaic cells convert solar energy to electricity, challenges in storage and distribution necessitate alternative approaches, such as converting solar energy to chemical energy, specifically hydrogen fuel. This study explores solar light utilization for chemical energy generation as a promising avenue to meet contemporary energy needs sustainably. In this study, Titanium dioxide (TiO_2) thin films are fabricated using a sol-gel spin coating method, incorporating modifiers and surfactants to control film structure and porosity. Photocatalytic overall water splitting (POWS) is explored as a sustainable solution for renewable hydrogen production. An optofluidic planar microreactor is constructed for photocatalytic water splitting with Pt/TiO_2 photocatalyst thin films as photocatalyst. The Pt/TiO_2 film with thickness 1650±119 nm showed a highest rate of 16.35 mmol h^{-1} g^{-1} (4.7 µmol h^{-1} cm^{-2}) hydrogen production at an optimum reactant flowrate of 0.3 mL min^{-1} under visible light irradiation. The stability study carried out for 4 cycles of 5 h each proved that the photocatalyst was stable and the film was well adhered to the glass substrate. Another optofluidic planar microreactor, utilizing IrO_2/TiO_2 films, is developed for oxygen production through water splitting under visible light. An oxygen evolution rate of 3.99 mmol h^{-1} g^{-1} (1.84 µmol h^{-1} cm^{-2}) was observed from the IrO_2/TiO_2 film of 3078 ± 362 nm thickness at an optimal flow rate of 0.3 mL min^{-1} in the presence of visible light. The stability study showed that the IrO_2/TiO_2 film was stable for at least 4 cycles, indicating the superior activity of the film firmly adhered to the glass substrate. The study culminates in the development of a single semiconductor-based photocatalyst, TiO_2, with Pt and IrO_2 as co-catalysts for overall water splitting. The $2.5IrO_2/0.5Pt/TiO_2$ photocatalyst exhibits ideal POWS, producing hydrogen and oxygen from pure water under visible and simulated solar light (SSL). The rate of hydrogen and oxygen production were 9.73 and 5.32 µmol g^{-1} h^{-1}, respectively, with a H_2/O_2 ratio of 1.82 under SSL with intensity 101.4 mW cm^{-2}. The research provides insights into catalyst properties, scalability, and integrated systems for large-scale hydrogen production, contributing to the advancement of renewable energy and photocatalysis.