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Editorial

Photocatalytic Hydrogen Evolution

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Solar energy conversion is one of the sustainable technologies that tackles the global warming and energy crisis. Photocatalytic hydrogen (H_2) production is a clean technology to produce eco-friendly fuel with the help of semiconductor nanoparticles and abundant sunlight irradiation. Titanium oxide (TiO_2), graphitic-carbon nitride (g-C_3N_4) and cadmium sulfide (CdS) are the most widely explored photocatalysts in recent decades for water splitting.

As the guest editors, we have comprehensively investigated the role of sacrificial agents on the H_2 production efficiency of TiO_2, g-C_3N_4 and CdS photocatalysts [1]. The activity of the catalysts was evaluated without any noble metal co-catalysts. The effects of the most widely reported sacrificial agents were evaluated in this work. The activity of the catalysts was influenced by the number of hydroxyl groups, alpha hydrogen and carbon chain length of the sacrificial agent. We found that glucose and glycerol are the most suitable sacrificial agents to produce H_2 with minimum toxicity to the solution. The findings of this study would be highly favorable for the selection of a suitable sacrificial agent for photocatalytic H_2 production.

Hong et al. demonstrated the photoelectrochemical (PEC) efficiency of $MoSe_2$/Si nanostructures for H_2 production and carbon dioxide (CO_2) reduction [2]. PEC deposition coupled with the rapid thermal annealing method was applied to fabricate the electrodes on the Si substrate. PEC H_2 evolution and CO_2 conversion efficiencies of the $MoSe_2$/Si electrode were higher in visible light irradiation as compared to dark conditions.

Kim et al. synthesised monodispersed spherical TiO_2 particles with a disordered rutile surface for photocatalytic H_2 production [3]. The photocatalyst was synthesised through sol-gel and a chemical reduction technique using Li/ethylenediamine (Li/EDA) solution. The samples were calcined at various temperatures to tune the anatase to the rutile phase ratio. The disordered rutile surface and mixed crystalline phase of TiO_2 significantly increased the H_2 production under solar light irradiation.

Idrees et al. reported the photocatalytic activity of Nb_2O_5/g-C_3N_4 heterostructures for molecular H_2 production under simulated solar light irradiation [4]. A hydrothermal technique was utilised to develop the three dimensional Nb_2O_5/g-C_3N_4 heterostructure with a high surface area. H_2 production efficiency of Nb_2O_5/g-C_3N_4 (10 wt. %) was higher than that of pure Nb_2O_5 and g-C_3N_4. The photogenerated electron hole pairs were successfully separated through a direct Z-scheme mechanism at the heterojunction.

Kim and Woodward described the band gap modulation of tantalum (V) perovskite by anion control [5]. Perovskites such as $BaTaO_2N$, $SrTaO_2N$, $CaTaO_2N$, $KTaO_3$, $NaTaO_3$ and TaO_2F were studied in this work. Pt-loaded $CaTaO_2N$ was utilised as a visible-light-driven photocatalyst for H_2 production using CH_3OH as the sacrificial agent.

Son et al. reported the impact of sulfur defects on the H_2 production efficiency of a CuS@$CuGaS_2$ heterojunction under visible light irradiation [6]. The activity of the CuS@$CuGaS_2$ heterojunction was higher as compared to pure CuS. This was ascribed to the introduction of structural defects to promote the photo-generated electron hole separation.

The recent accomplishments in the synthesis and application of various photocatalysts for H_2 production are briefly reviewed by Zhang et al. [7]

Tremendous efforts should be taken in the future to commercialise this photocatalytic technology at the industry level. The studies should also be performed with cheap materials, industrial wastewater and seawater for H_2 production.

Finally, we would like to convey our sincere thanks to all the authors for their significant contributions in this special issue.

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References

1. Kumaravel, V.; Imam, M.D.; Badreldin, A.; Chava, R.K.; Do, J.Y.; Kang, M.; Abdel-Wahab, A. Photocatalytic hydrogen production: Role of sacrificial reagents on the activity of oxide, carbon, and sulfide catalysts. *Catalysts* **2019**, *9*, 276. [CrossRef]
2. Hong, S.; Rhee, C.K.; Sohn, Y. Photoelectrochemical Hydrogen Evolution and CO2 Reduction over MoS2/Si and MoSe2/Si Nanostructures by Combined Photoelectrochemical Deposition and Rapid-Thermal Annealing Process. *Catalysts* **2019**, *9*, 494. [CrossRef]
3. Kim, N.Y.; Lee, H.K.; Moon, J.T.; Joo, J.B. Synthesis of Spherical TiO2 Particles with Disordered Rutile Surface for Photocatalytic Hydrogen Production. *Catalysts* **2019**, *9*, 491. [CrossRef]
4. Idrees, F.; Dillert, R.; Bahnemann, D.; Butt, F.K.; Tahir, M. In-Situ Synthesis of Nb2O5/g-C3N4 Heterostructures as Highly Efficient Photocatalysts for Molecular H2 Evolution under Solar Illumination. *Catalysts* **2019**, *9*, 169. [CrossRef]
5. Kim, Y.-I.; Woodward, P.M. Band gap modulation of Tantalum (V) perovskite semiconductors by anion control. *Catalysts* **2019**, *9*, 161. [CrossRef]
6. Son, N.; Heo, J.N.; Youn, Y.-S.; Kim, Y.; Do, J.Y.; Kang, M. Enhancement of Hydrogen Productions by Accelerating Electron-Transfers of Sulfur Defects in the CuS@ CuGaS2 Heterojunction Photocatalysts. *Catalysts* **2019**, *9*, 41. [CrossRef]
7. Zhang, Y.; Heo, Y.-J.; Lee, J.-W.; Lee, J.-H.; Bajgai, J.; Lee, K.-J.; Park, S.-J. Photocatalytic hydrogen evolution via water splitting: A short review. *Catalysts* **2018**, *8*, 655. [CrossRef]