A Novel Multi-Functional BiVO4/Pencil Graphite for Photo Electrochemical Wastewater Splitting for Green Hydrogen Production and Storage

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Photo-electrochemical (PEC) water splitting is a key technology for green hydrogen production. However, its widespread application is hindered by the scarcity of freshwater needed and the challenges related to the produced hydrogen storage and transportation. In this study, a novel approach is proposed by a 3-unit system that utilizes the abundant and cost-free wastewater as an alternative to freshwater. The wastewater is first purified using sunlight and voltage, then directly split to produce hydrogen, and finally, the produced hydrogen is stored on-site, eliminating the need for transportation. To further enhance the performance of the process, a multi-functional material is required to act as both a semiconductor for purification and splitting and as a powder for hydrogen storage. Therefore, bismuth vanadate (BiVO4) was selected due to its strong photoactivity and stability in visible light, while pencil graphite (PG) was chosen for its high electrical conductivity and large surface area. BiVO4/PG exhibited enhanced properties compared to pure BiVO4, including a unique dendritic-like structure, a lower band gap of 2.1 eV, an improved recombination rate, and a 6 times larger electrochemical active surface area. As a result, BiVO4/PG was able to effectively remove almost 100% of methylene blue organic dye in just 12 minutes under 1V and sunlight. It also achieved an impressive PEC water splitting performance, along with an 11.2% solar-to-hydrogen photoconversion efficiency. Lastly, BiVO4/PG powder successfully adsorbed hydrogen gas onto its surface, demonstrating its great potential as a new promising hydrogen storage material. Overall, this integrated system significantly contributes to addressing multiple hydrogen economy challenges, leading to a sustainable future.