A Multi-Functional and Highly Efficient Photo-Electrocatalytic 3D ZnO Nanoflowers for Simultaneous Water Splitting and Wastewater Treatment

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Developing sustainable technologies to harness solar energy for wastewater treatment and hydrogen fuel production is crucial for addressing global energy and environmental challenges. In this study, a highly efficient zinc oxide (ZnO) photoelectrocatalyst was developed to simultaneously treat wastewater and produce green hydrogen. The catalyst was fabricated through a facile and environmentally friendly electrochemical anodization method, which can be completed within 15 minutes at a temperature range of 1-5°C, offering a rapid and low-energy synthesis approach.The ZnO photoelectrocatalyst was synthesized by electropolishing three samples for 10 minutes and subjecting them to different anodization fabrication times. Characterization techniques, including XPS, XRD, SEM-EDX, UV-VIS, and Mott-Schottky plot were utilized to determine the optimal fabrication time, which was found to be 5 minutes. The SEM images revealed unique nanowire structures that resemble nanoflowers, which greatly enhance photocatalytic efficiency. The synthesized catalyst exhibited superior organic wastewater treatment capabilities compared to existing solutions, degrading 99% of methylene blue, a common organic dye pollutant, in just 5 minutes. Furthermore, the photoelectrode demonstrated remarkable water-splitting performance, achieving an anodic potential shift at a current of 10 mA/cm2 toward (0.5V vs. RHE) under illumination conditions, indicating a highly efficient water-splitting process. In addition, Solar to hydrogen efficiency reaches 22.7% at 0.7 V. The development of this highly efficient and environmentally friendly catalyst offers a promising approach to managing and taking advantage of polluted wastewater, contributing to addressing both the global water and the global energy crisis.

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