

# Synthesis of a Novel Nanostructures From Zn-ZnO/MoS<sub>2</sub> for Effective Removal of High-Concentration Dyes and Bacteria From Water Within a Record Time Alongside Green Hydrogen Production

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The contemporary era's heavy reliance on fossil fuels has exacerbated environmental degradation, particularly air and water pollution, necessitating a transition to sustainable options. Nanomaterials present a promising avenue for both energy production and water purification. Traditional photocatalysts, such as TiO<sub>2</sub>, faced limitations due to their inefficient UV light absorption caused by a wide bandgap. To address this challenge, a novel nanocomposite, Zn-ZnO/MoS<sub>2</sub>, has been engineered to efficiently utilize visible light for wastewater treatment and green hydrogen production, employing advanced techniques like pulsed laser ablation. Rigorous characterization via UV-Vis, XRD, TEM, DLS, AFM, and BET analyses has verified its effectiveness. Varied MoS<sub>2</sub> concentrations in Zn-ZnO/MoS<sub>2</sub> composites have notably narrowed the ZnO bandgap to 2.6 eV, enhancing visible light activation. Material coupling has led to a reduction in electron-hole pair recombination rates, resulting in a 65% improvement in specific surface area, Which led to a change in the mechanism of action of our compound in removing organic pollutants from photocatalysis to adsorption. The composite has demonstrated superior electrocatalytic potential in water splitting compared to IrO<sub>2</sub>, achieving a remarkable 61% enhancement in performance at 1.5 V and significantly 80000 times lower production costs. Moreover, it exhibits exceptional efficiency in organic pollutant removal, achieving a staggering 99% adsorption rate on Iodine blue dye within just 5 minutes, coupled with potent antibacterial properties. This versatile material holds promise for green energy production, antibacterial applications, and wastewater treatment.