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Rational construction of carbon quantum dots-zinc cobalt oxide heterostructure as bifunctional catalyst for oxygen evolution reaction and wastewater treatment

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ABSTRACT

Semiconductor photocatalysts are promising for Oxygen evolution reaction (OER) and also for reducing organic pollutants in wastewater. However, their limited activity under UV light and the fast recombination of electron-hole pairs, hinder their utilization in wastewater treatment. To address these challenges a novel photocatalyst based on carbon quantum dots (CQDs) supported Zinc–Cobalt Oxide ($ZnCo_2O_4$) was developed, which demonstrated enhanced photocatalytic efficiency. Experimental findings indicated that 0.7 CQDs/$ZnCo_2O_4$ exhibited superior photocatalytic performance compared to $ZnCO_2O_4$ and CQDs/$ZnCO_2O_4$ composites materials, achieving over 100 and 96 % decomposition of methylene blue (MB) and methylene orange (MO) dyes after 50 and 140 min under UV light. The enhanced performance of 0.7 CQDs/$ZnCo_2O_4$ can be attributed to the charge transfer rate and synergistic effect between the coupled CQDs and $ZnCo_2O_4$. Moreover, studies with radical scavengers reveal that $\bullet O_2$, •OH, and h^+ play crucial roles in the breakdown of MB and MO dyes. Furthermore, 0.7 CQDs/$ZnCo_2O_4$ displayed very low overpotential of 220 mV at 100 mA cm^{-2} for OER activity with a robust durability for 250 h at 500 mA cm^{-2}.

1. Introduction

Rapid industrial development has resulted in a significant number of effluent pollutants. Effluents comprise complex constituents such as excessive concentration of refractory organic contaminants and high degree of chrominance with low biodegradability. These dangerous pollutants have a detrimental effect on environment, ecological well-being, and human health [1,2]. Therefore, wastewater treatment and efficiently complying it with the ecological discharge standards is challenging in industrialization and urbanization [3,4]. Current wastewater treatment techniques include adsorption, electrochemical processing, sludge activation, ozonation, ion exchange, membrane treatment, and photocatalytic degradation. Though all these techniques are considered sustainable and eco-friendly [5,6], photocatalytic degradation is suggested more effective than the others due to its facility, tunability, efficiency, and more importantly, accessibility of the

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