Synergistic coupling of Zn-Co bimetallic spinel oxide and graphitic carbon nitride for enhanced electrocatalytic and photocatalytic activity.

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The development of a unique semiconducting electrocatalyst with enhanced photo-electrochemical activity is crucial for sustainable energy conversion and environmental remediation. Likewise, spinel oxides (AB_2O_4 type) and graphitic carbon nitride (GCN) are promising candidates due to their low-cost synthesis, tunable properties, structural versatility, and stability [1][2]. In this work, we developed a Zn-substituted cobalt ferrite (ZCF) and g-C_3N_4 (GCN) heterostucture to boost electrocatalytic and photocatalytic performance. Interfacing Zn-Co Ferrite with g-C_3N_4 promotes accelerated charge separation and reduces charge recombination. The structural properties and cation distribution by Zn substitution in Cobalt ferrite (ZCF) were analysed by XRD reitvel refinement and Raman spectroscopy. The microstructure has been analysed by TEM, SEM and SAED techniques. The XPS technique was used to enforce the findings of XRD and Raman. The Zn substitution in CoFe2O4 was observed to tune the degree of inversion and enhance Fe ion occupancy, which helps tune the optical and electrochemical properties. The optical properties of ZCF and GCN@ZCF composite were analysed by UV-Vis and PL spectroscopy techniques. The oxygen reduction reaction (ORR) analysis was performed using a rotating disk electrode (RDE), and selectivity towards ORR is analyzed through a rotating ring disk electrode (RRDE). The synergy between the GCN and ZCF was found be effective for the reduction of oxygen in the alkaline medium. Further, ZCF samples and GCN@ZCF were studied through cyclic voltammetry (CV), Impedance spectra (EIS), and transient photocurrent techniques for improvement in PEC properties for hydrogen production. The results illustrated Zn substitution enhances electrochemical and photocatalytic properties of Cobalt ferrite, and the ZCF@GCN synergistic coupling was found to be effective in ORR and PEC hydrogen production.

References

[1] N. Zentefis, et al. Energy & Fuels 2025 39 (15), 7167-7181
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