Synthesis and structural characterization of hybrid nanocomposites for sustainable photocatalytic applications

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Emerging contaminants in wastewater represent a critical environmental challenge, demanding cost-effective and sustainable treatment strategies. Hybrid nanocomposites have recently attracted interest due to their tunable structural and electronic properties for photocatalytic application [1]. In this study, two hybrid nanocomposite systems, *viz*. $ZnFe_2O_4/MnCO_3$ and Zn-doped $MnCO_3$ were synthesized using hydrothermal and calcination techniques. The materials were systematically characterized to their elemental composition, crystallinity, and morphology. Scanning electron microscopy (SEM) images revealed distinct particle morphologies and surface textures. $ZnFe_2O_4/MnCO_3$ exhibited sharp-edged angular particles, while Zn-doped $MnCO_3$ developed hierarchical nanosheets. Energy-dispersive spectroscopy (EDS) confirmed Zn surface enrichment in calcined Zn–$MnCO_3$ (71.9 wt%) and stable Fe incorporation in $ZnFe_2O_4$ composites (44 wt%). X-ray diffraction (XRD) identified crystalline phases of $MnCO_3$ (planes 012, 104, 110, 116), $Zn_5(CO_3)_2(OH)_6$ (221), and $ZnFe_2O_4$ (311) [2, 3]. The Zn-doped $MnCO_3$ system, calcined at 400 °C, showed improved crystallinity and phase stability. These findings demonstrate the ability to tailor hybrid nanocomposite structures through synthesis conditions, providing a foundation for future photocatalytic activity studies under simulated solar irradiation. This work contributes to the development of sustainable photocatalysts for environmental remediation and supports climate action goals through innovative material design.

References

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Figures

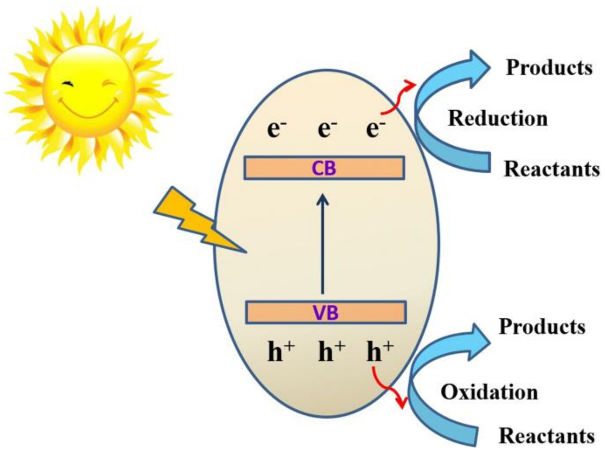

Figure 1: Schematic representation of photocatalysis: sunlight excites electrons (e^-) from the valence band (VB) to the conduction band (CB).