Green Synthesis and Enhanced Photocatalytic Performance of rGO/ZnO/Fe_3O_4 Nanocomposites: A Sustainable Approach to Environmental Remediation

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Abstract

The fast industrialization and mounting pollution have necessitated the need for advanced materials in order to degrade pollutants efficiently. Metal oxide–based and graphene-derivative photocatalytic nanocomposites are excellent for harnessing light energy in environmental remediation. Among them, ZnO-based nanocomposites have drawn considerable attention because of their high photocatalytic activity and stability. However, improving the performance of these nanocomposites is still necessary for their wide applications. This study explores the green synthesis, detailed characterization, and enhanced photocatalytic efficiency of reduced graphene oxide rGO/ZnO/Fe_3O_4 nanocomposites. The nanocomposites were synthesized via a hydrothermal method, utilizing milk thistle extract as a natural reducing agent, representing a novel and sustainable approach to fabricating magnetic rGO/Fe_3O_4 nanocomposites. These composites were further integrated with zinc oxide to produce a multifunctional material, exhibiting high surface area, superior electrical and thermal conductivity, and robust mechanical strength. The photocatalytic performance was significantly enhanced due to the synergistic interaction between graphene and metal oxide nanoparticles, leading to efficient degradation of environmental pollutants. Electrochemical analysis via cyclic voltammetry revealed distinctive redox peaks, demonstrating efficient electron transfer processes essential for applications in energy conversion and storage. This green synthesis not only provides a sustainable pathway for the development of advanced nanocomposites but also underscores their potential in a wide range of applications, including environmental remediation, sensing, energy storage, and optoelectronics.