

Development of ZnO/CdS Supported Alumina Beads: A Novel Approach for Tetracycline Degradation

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Structured Abstract

Background: Tetracycline (TC) contamination in water sources poses significant environmental and health risks due to its persistence and contribution to antibiotic resistance. Traditional treatment methods are often inadequate for its complete removal. Photocatalysis, especially under visible light, offers an efficient and eco-friendly alternative. This study focuses on developing ZnO/CdS heterojunction photocatalysts supported on alumina beads to enhance TC degradation. The effects of solvent type, hydrothermal temperature, and reaction duration on CdS deposition and photocatalytic performance were systematically studied. Characterization techniques including FESEM, XRD, UV-Vis-NIR spectroscopy, and BET surface area analysis were employed to assess the catalysts' morphology, crystallinity, optical, and surface properties.

Methods: ZnO seed layers were grown on alumina beads using 0.15 M $\text{Zn}(\text{NO}_3)_2$ via hydrothermal treatment at 120 °C for 6 h, followed by calcination. Then, CdS was deposited on ZnO coated alumina beads hydrothermally using 0.05M $\text{Cd}(\text{NO}_3)_2$ and 0.1M thiourea, varying solvent (distilled water/NaOH), temperature (120 °C, 150 °C, 180 °C), and time (6h, 8h, 10 h), then calcined at 350 °C after drying.

Results: The most effective catalyst was synthesized using distilled water at 120 °C for 6 h, achieving 57% TC degradation under 24 W visible light. Despite a lower surface area (244.17 m²/g), its larger pore size (6.54 nm) enhanced diffusion and light penetration. FESEM showed uniform spherical CdS on ZnO, while XRD indicated an amorphous structure. A 2.53 eV bandgap confirmed visible light activity. Scavenger tests revealed h^+ and $\bullet\text{O}_2^-$ as key reactive species. Comparative analysis showed that alkaline conditions or extended reaction times reduced performance due to CdS agglomeration, pore blockage, or overloading, highlighting the importance of optimized synthesis conditions.

Conclusion: This study successfully developed ZnO/CdS-coated alumina beads as visible-light-active photocatalysts for tetracycline degradation. The best performance was achieved at 120 °C for 6 hours in distilled water. Results highlight the importance of synthesis parameters in controlling morphology, surface properties, and charge carrier activity to maximize photocatalytic efficiency against persistent pollutants.

Keywords: ZnO/CdS, alumina beads, photocatalysis, tetracycline degradation, hydrothermal synthesis

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