Tribocatalytic Degradation of Chloramphenicol Using Eu-Doped ZnO Catalysts: A Sustainable Approach to Pharmaceutical Pollutant Removal

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Significance and Relevance

The study demonstrated that Eu doping enhanced the tribocatalytic activity of ZnO for degrading chloramphenicol under mechanical agitation. Characterization by XPS confirmed successful incorporation of Eu, while SEM and EDS revealed uniform distribution and modified surface morphology. UV-Vis spectroscopy showed significant degradation efficiencies for all Eu-doped ZnO catalysts, with improvements over undoped ZnO. This work is novel as it highlights the role of rare-earth doping in tribocatalysis, offering an innovative, energy-efficient method for degrading pharmaceutical pollutants, a growing environmental concern.

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Introduction and Motivations

Pharmaceutical pollutants, such as paracetamol and chloramphenicol, are emerging contaminants in water systems, posing significant risks to ecosystems and human health. Conventional water treatment methods often fail to degrade these persistent compounds effectively. Tribocatalysis, a novel approach leveraging mechanical energy to activate catalysts, offers an energy-efficient and sustainable solution. Zinc oxide (ZnO) is a promising catalyst due to its semiconductor properties, and rare-earth doping, such as europium (Eu), can enhance its activity. This study explores Eu-doped ZnO for tribocatalytic degradation, motivated by the need for innovative technologies to tackle pharmaceutical pollution.

Results and Discussion

Tribocatalysis has emerged as an innovative and sustainable approach for degrading organic pollutants in wastewater. This study investigates the tribocatalytic degradation of pharmaceutical contaminant chloramphenicol, using zinc oxide (ZnO) catalysts doped with europium (Eu) at concentrations of 1, 2, and 3 mol%. The catalysts were synthesized via the sol-gel method, ensuring uniform doping and optimal surface properties for catalytic performance.

The catalysts were characterized using X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS) and Fourier-transform infrared spectroscopy (FTIR) to analyze their chemical composition, surface morphology, and elemental distribution.

The tribocatalytic degradation of the target pollutants was evaluated under mechanical agitation, and degradation efficiencies were determined using UV-Vis spectroscopy. The study revealed that Eu doping significantly influenced the tribocatalytic activity of ZnO by modifying its electronic structure and enhancing pollutant degradation.

This work demonstrates the potential of Eu-doped ZnO catalysts in addressing pharmaceutical contamination in water, emphasizing the role of tribocatalysis as an eco-friendly and effective water treatment technology.