ABSTRACT

Thesis Title: Exploring Charge Transport Properties in Group II-VI Semiconductors and their Graphene Composites for Advanced Dye Wastewater Treatment

Dye wastewater discharged into water bodies, predominantly by textile industries, is an escalating environmental concern leading to ecological issues. Previous approaches to combat this problem via physicochemical and biological methods have proven economically inefficient and resulted in secondary pollutants. Photocatalysis using semiconducting materials has emerged as a promising method for wastewater decontamination. However, challenges such as wide bandgaps and short exciton lifespan hinder the practical application of compound semiconductors. For instance, TiO_2, a potential material for pollutant decomposition, is limited to UV light due to its wide bandgap. In contrast, Zinc telluride (ZnTe) with a direct bandgap of ~2.26 eV shows promise, especially when combined with graphene oxide (GO) or reduced graphene oxide (RGO), offering features like cost-effectiveness, large surface area, stability, reusability, and visible-light absorption. Despite these advantages, ZnTe nanomaterials suffer from fast electron-hole recombination affecting their photocatalytic performance. Concurrently, metal oxides and sulphides like ZnO, ZnS, CdS, ZnSe, WO_3, and CeO_2 have been used for industrial effluent treatment through photocatalytic decomposition, yet they face limitations similar to those of single metal oxides.

This study aims to address these challenges through the synthesis of a reduced graphene oxide-zinc telluride (RGO-ZnTe) nanocomposite and the heterojunction photocatalyst (ZnSe/ZnTe). The RGO-ZnTe nanocomposite exhibits enhanced photocatalytic activity, attributed to improved charge transfer facilitated by higher carrier mobility, strong interfacial contact, visible light absorption, and low electron-hole pair recombination. Additionally, micro-sized and hollow heterostructures of two compound semiconductors, such as ZnSe/ZnTe, are proposed to overcome the limitations associated with single metal oxides. We intend to synthesize ZnSe/ZnTe common cation heterostructures through an in-situ hydrothermal route, exploring their potential in azo dye degradation, with a focus on morphology and surface area. My primary objective is to synthesize and evaluate the performance of a graphene-semiconductor-based RGO-ZnTe composite and the heterojunction photocatalyst (ZnSe/ZnTe) for wastewater treatment applications. This study further aims to investigate the charge transfer mechanism and highlight the potential of these composite materials in environmental remediation. Additionally, my research seeks to extract the mobility of each catalyst using the spatial-charge-limited conduction (SCLC) theory of thermionic emission and comprehensively discuss how the mobility of charge carriers influences the degradation efficiency of the photocatalysts.

In summary, this research aims to contribute to the development of efficient and sustainable photocatalysts for advanced dye wastewater treatment, addressing both macroscopic and microscopic parameters to enhance their practical applications in environmental remediation.

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FORWARDED

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