INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

This thesis investigates the advanced treatment and mineralization of industrial wastewater using innovative hybrid advanced oxidation processes (AOPs). Industrial wastewater, characterized by high chemical oxygen demand (COD) and total organic carbon (TOC), was treated through various ternary hybrid AOPs, combining adsorption, Fenton reactions, and sonication or hydrodynamic cavitation (HC). The development and efficacy of advanced oxidation processes (AOPs) employing Fe_3O_4-based nanocomposites for industrial wastewater (WW) treatment. A ternary hybrid AOP combining sonication, Fenton reactions, and adsorption was employed using Fe_3O_4@AC nanocomposites, achieving 94.75% COD and 89% TOC removal within 60 min. LC-MS analysis identified the effective degradation of over 25 organic pollutants, including herbicides and pesticides, with a 60% reduction in wastewater toxicity. Synergistic interactions between activated charcoal adsorption, Fenton reactions, and sonication-induced microconvection were responsible for the enhanced mineralization. Next, work extended to sonoenzymatic treatments using laccase immobilized on Fe_3O_4 nanoparticles (Fe_3O_4@Laccase), demonstrating 90.3% COD removal with sonication-assisted enzymatic activity. Structural analysis via FTIR revealed enzyme conformational changes contributing to improved kinetics and substrate affinity. Toxicity analysis indicated a 70% reduction, the biocatalyst retained activity over six cycles. Additionally, Fe_3O_4@AC nanocomposites were incorporated into chitosan-based hydrogel beads (Fe_3O_4@AC@CH) to develop a floatable hybrid AOP system. Under optimized conditions, COD and TOC removal reached 96.12% and 78.14%, respectively, with significant degradation of major pollutants. Sonication enhanced mass

transfer, while the hydrogel's porous structure facilitated adsorption and surface Fenton reactions, resulting in synergistic pollutant degradation. The beads maintained catalytic performance for six reuse cycles. Lastly, a novel combination of hydrodynamic cavitation (HC), Fe_3O_4@AC nanocomposites, and Fenton reactions was investigated. Optimized conditions yielded 99.37% COD and 88.80% TOC removal. The HC-based process exhibited superior cavitational yields and significantly enhanced reaction kinetics. The Fe_3O_4@AC nanocomposites demonstrated high stability and reusability. The findings illustrate the potential of these hybrid AOPs for scalable and efficient industrial wastewater treatment, contributing to sustainable environmental management.