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Enhanced dye bioremediation using cobalt oxide-incorporated pydroxyapatite for Peroxidase immobilization

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This study focuses on developing a highly efficient catalyst for methylene blue (MB) degradation by synthesizing cobalt oxide-incorporated hydroxyapatite (HAp-CoO) as a support for immobilizing horseradish peroxidase (HRP). The resulting composite was characterized through FTIR, XRD, SEM, and BET analyses, which confirmed its mesoporous structure and large surface area, ideal for enzyme immobilization. The immobilization process yielded 86% of HRP on HAp-CoO at an optimal pH of 7.0, enhancing enzyme stability and uniformity. The immobilized HRP demonstrated significant thermal stability, maintaining robust activity over a wider temperature range (40-50°C). Kinetic analysis revealed an increase in the Michaelis-Menten constant (Km) from 3.74 mM (free HRP) to 6.12 mM (HAp-CoO@HRP), indicating a slight reduction in substrate affinity. The immobilized enzyme showed superior stability in various organic solvents, retaining higher activity levels than its free form. Catalytic efficiency was tested for MB degradation at 50 mg/L, 100 mg/L, and 200 mg/L, with HAp-CoO@HRP achieving up to 92% degradation at 50 mg/L. Increasing the catalyst concentration from 100 to 400 mg further boosted the degradation rate, reaching 97% within 8 hours. HAp-CoO@HRP maintained 79% efficiency after five reuse cycles and retained 85% of its activity after 28 days of storage at 4°C. These results position HAp-CoO@HRP as a highly robust and effective catalyst for dye bioremediation, offering great potential for application in wastewater treatment.

Biography

Dr. Yaaser Q. Almulaiky is an Associate Professor of Biochemistry at the University of Jeddah, Saudi Arabia. He obtained his Ph.D. in Biochemistry from King Abdulaziz University, with a dissertation focused on environmental biomarkers in marine species. His research interests include enzyme immobilization, nanoparticles, and their applications in medicine, environmental science, and food industries. Dr. Almulaiky has published extensively on topics such as enzyme catalysis, nanomaterials, and biocatalysis, contributing to numerous international journals. He also serves on several editorial boards and is actively involved in academic consulting and research funding projects related to enzymology and toxicology. His teaching experience spans various subjects, including organic chemistry, molecular biology, and analytical toxicology at both undergraduate and postgraduate levels.