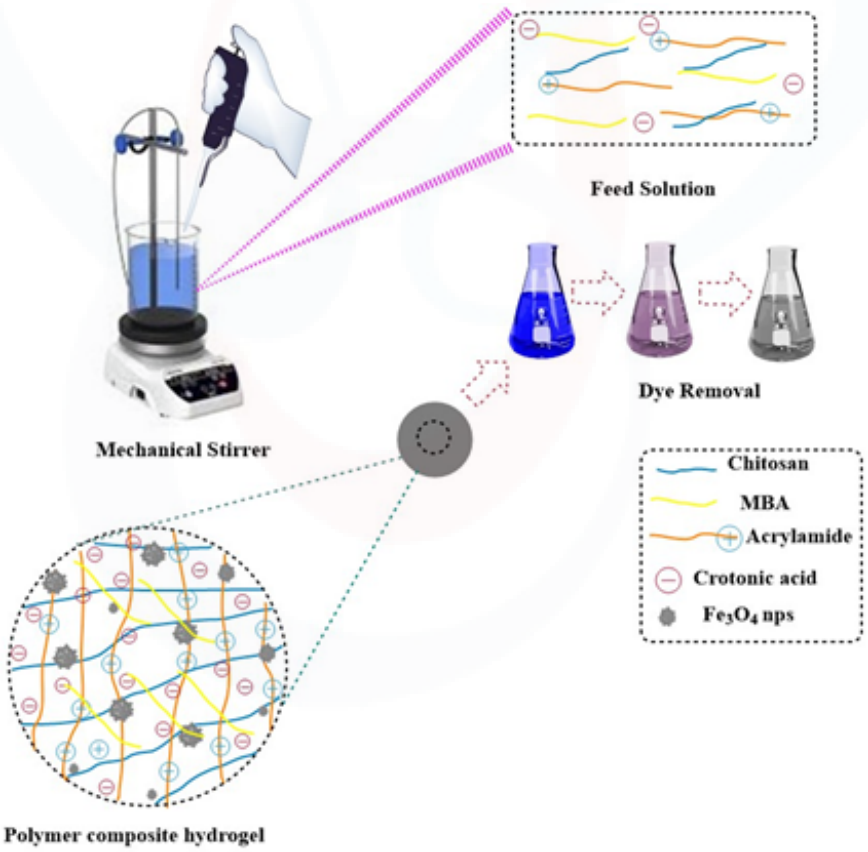
ISBN:
978-1-917892-15-5

Isha R. Patel[1], Shital R. Patel[2], Bhavinkumar V. Patel[2], Niraj H. Patel[1*]

[1]*Department of Organic Chemistry, Institute of Science & Technology for Advanced Studies & Research, The Charutar Vidya Mandal (CVM) University, Vallabh Vidyanagar, Anand, Gujarat 388120, India.*

[2] *Natubhai V. Patel College of Pure and Applied Sciences, The Charutar Vidya Mandal (CVM)University, Vallabh Vidyanagar, Anand, Gujarat 388120, India*

A Chitosan-Derived Magneto-Responsive Hydrogel Matrix for Efficient Capture of Charged Organic Pollutants: Pseudo-Second-Order Kinetics and Langmuir Isotherm Compatibility



ISBN:
978-1-917892-15-5

Abstract: Industrial and natural wastewater streams often contain a complex mixture of persistent organic pollutants, particularly synthetic dyes, which pose serious environmental and health concerns. The development of efficient, multifunctional adsorbents is thus imperative for effective wastewater treatment. In this study, magnetite-incorporated chitosan/poly(acrylamide-co-crotonic acid) (CS/AM-CA) composite hydrogels were synthesized via a one-pot free radical polymerization technique. The adsorptive performance of the synthesized composites was evaluated using Methyl Orange (MO) and Malachite Green (MG) as model anionic and cationic dyes, respectively. Spectroscopic analyses, coupled with batch adsorption experiments, revealed that electrostatic interactions, hydrogen bonding, and π–π stacking are the principal mechanisms governing dye adsorption. The influence of critical operational parameters—such as pH, initial dye concentration, adsorbent dosage, and contact time —was systematically studied to optimize adsorption efficiency. Kinetic modeling indicated that the adsorption followed a pseudo-second-order model, suggesting chemisorption as the rate-limiting step. Equilibrium data showed strong agreement with the Langmuir isotherm model, confirming monolayer adsorption behavior. Under optimized conditions, the composite hydrogel achieved dye removal efficiencies exceeding 95% for both MG and MO. Furthermore, the adsorbent demonstrated excellent reusability, retaining high performance over five successive adsorption–desorption cycles without significant loss of efficiency or structural integrity. These findings establish the magnetite CS/AM-CA composite hydrogel as a robust, reusable, and highly effective adsorbent for the simultaneous removal of oppositely charged dyes from aqueous systems. The composite's high removal capacity, regeneration potential, and broad applicability suggest its strong potential for use in large-scale, sustainable wastewater remediation technologies.

Keywords: Chitosan hydrogel, Fe_3O_4 nanoparticles, Adsorption kinetics, Isotherm models, Dye removal.

Biography: Isha Patel is a doctoral researcher specializing in polymer-based nanocomposite hydrogels for environmental remediation. Her research focuses on the synthesis of chitosan-derived composite materials for the adsorptive removal of organic contaminants from wastewater. She specializes in kinetic and isothermal modeling, as well as mechanistic elucidation of dye–adsorbent interactions. Her work integrates polymer chemistry, nanotechnology, and environmental engineering, aiming to develop sustainable, multifunctional materials for wastewater remediation. She has presented her findings at national and international scientific forums.