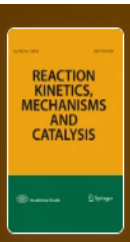
Synthesis and characterization of $NiFe_2O_4$ piezoelectric nanoparticles: a comprehensive study on the influence of natural surfactants, kinetics, and thermodynamics

Published: 15 March 2024

Volume 137, pages 1651–1666, (2024) Cite this article



Reaction Kinetics, Mechanisms and Catalysis

Aims and scope →

Submit manuscript →

Karukh Ali Babakr ✉, Ibrahim Nazem Qader, Omid Amiri, Murat Özabaci, Peyman Aspoukeh & Samir Mustafa Hamad

Abstract

Using piezoelectric nanoparticles created with natural surfactants to remove dyes from water is a promising, environmentally friendly approach with potential benefits in sustainability, efficiency, cost-effectiveness, and innovation in water treatment technologies. This study investigates the influence of natural surfactants on the synthesis of hydrothermal-based Ni ferrite nanoparticles designed for dye removal. Three fruit juices —grape, orange, and peach—were employed in the preparation process, and their properties were scrutinized through X-ray diffraction (XRD), scanning electron microscope (SEM), and Energy-dispersive X-ray spectroscopy (EDAX). The research also explores the effects of varying time and temperature parameters on dye removal. Results indicate that Ni-ferrite nanoparticles synthesized with grape juice exhibit enhanced efficacy in degrading crystal violet dye. Moreover, the morphology of these nanoparticles diverges from those produced through alternative methods documented in the literature. The study's findings suggest that the degradation of Crystal Violet (CV) by a $NiFe_2O_4$ catalyst through piezoelectric means adheres to pseudo-second-order kinetics. Thermodynamic analyses reveal that CV piezo degradation is an endothermic process. The presence of nearly spherical nanoparticles in all samples is accompanied by the remarkable identification of bar-shaped crystalline particles with piezoelectric properties with a length of around 3 µm and a diameter of 300 nm in samples synthesized with grape juice. This unique morphological characteristic, which has not been previously reported for nickel ferrite, represents a novel finding. In conclusion, we posit that natural surfactants, exemplified by grape juice, exert a substantial influence on the microstructure of nanoparticles, thereby influencing their potential applications.