Environmental Engineering and Management Journal xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
http://www.eemj.icpm.tuiasi.ro/; http://www.eemj.eu

"Gheorghe Asachi" Technical University of Iasi, Romania

ELECTROCHEMICAL DEGRADATION OF CRYSTAL VIOLET FROM AQUEOUS SOLUTION USING GRAPHITE ELECTRODE

Kanayo Oguzie[1,2]*, Paul Njoku[2], John Anyanwu[1], Emeka Oguzie[1]

[1]Africa Centre of Excellence in Future Energies and Electrochemical Systems (ACE-FUELS), Federal University of Technology Owerri, PMB 1526, Owerri, Imo State, Nigeria
[2]Department of Environmental Management, Federal University of Technology Owerri, PMB 1526, Owerri, Imo State, Nigeria

Abstract

Industrial wastewater containing synthetic dyes poses significant environmental and health risks due to their persistence and toxicity, necessitating the development of efficient and sustainable treatment methods. This study investigates the electrochemical degradation of crystal violet dye in aqueous solution using graphite electrodes as both the anode and cathode. The effects of key process parameters, including electrolysis time, initial dye concentration, pH, temperature, current density, and supporting electrolyte concentration, were systematically evaluated. The experimental results indicated that the degradation of crystal violet follows first-order kinetics. The pH of the solution was adjusted using NaOH and H_2SO_4 to create alkaline and acidic conditions, respectively. The degradation efficiency was highest in acidic conditions, with efficiencies of 95% at pH 2 after 20 minutes, and 99% after 60 minutes, compared to lower efficiencies at neutral and alkaline pH values. A significant increase in degradation efficiency was observed with increasing dye concentration and current density. Density functional theory (DFT) calculations using Fukui functions for electrophilic, nucleophilic, and radical attacks revealed that the central carbon atom (C4) in the crystal violet molecule is the most vulnerable site for oxidative degradation. Overall, the study demonstrates that electrochemical oxidation using graphite electrodes is an effective method for the degradation of crystal violet dye in aqueous solution.

Key words: crystal violet, electrochemical oxidation, Fukui functions, operating parameters, wastewater

Received: February, 2024; Revised final: February, 2025; Accepted: February, 2025

* Author to whom all correspondence should be addressed: e-mail: kanayo.oguzie@futo.edu.ng; Phone: +234 8037069183