

Degradation of RO16 Dye using Electrocoagulation Process with Aluminium Electrodes: Effects of Initial pH and Current Density

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Structured Abstract

Background: The widespread use of synthetic dyes, especially in the textile industry, has significantly contributed to environmental pollution due to their chemical stability and resistance to treatment. Reactive Orange 16 (RO16), a commonly used azo dye, poses serious ecological risks due to its high solubility, vibrant colour, and toxicity. Conventional techniques often involve chemical additives, generating sludge and causing secondary pollution. Electrocoagulation (EC) emerges as a promising solution due to its simplicity, cost-effectiveness, and minimal chemical usage. Although synthetic dyes revolutionized industrial production, recent studies highlight their drawbacks, prompting interest in safer alternatives. This study utilizes aluminium electrodes in an EC system to degrade RO16 dye from aqueous solutions under varying operational conditions such as initial pH, current density, and electrolysis time. The goal is to evaluate the dye removal efficiency of RO16 using EC and determine optimum conditions for decolourization.

Methods: RO16 solutions were subjected to electrocoagulation in an electrolytic cell set up equipped with aluminium electrodes. The effects of three critical operational variables included initial pH, applied current density, and reaction time were evaluated. This was conducted to determine optimal conditions for maximum decolourization. Analytical quantification of dye removal was performed using UV-Visible spectrophotometry. The kinetic behaviour of the dye degradation was elucidated via pseudo-first-order and pseudo-second-order models, while adsorption equilibrium data were fitted to Langmuir and Freundlich isotherm models to interpret the sorption mechanisms.

Results: The study achieved a maximum RO16 removal efficiency of 96.24% at neutral pH 7 within 160 minutes, and 97.88% at a current of 0.2 A within 110 minutes. Dye removal was strongly enhanced at increased current densities and neutral pH, attributed to improved generation of aluminium hydroxide flocs and effective destabilization of dye molecules. Kinetic analysis revealed that the decolourization process followed a pseudo-first-order model, indicating physisorption predominance, while equilibrium adsorption was best described by the Langmuir isotherm, suggesting monolayer coverage of dye onto the floc surface.

Conclusion: In conclusion, the findings of this study indicated that electrocoagulation using aluminium electrodes is an efficient technique for RO16 wastewater treatment. Optimizing pH and current density improves decolourization, supporting EC as a viable, sustainable solution for industrial wastewater management.

Keywords: Electrocoagulation, RO 16, Initial pH, Current density, Kinetic and Isotherm modelling.

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