

Electro-coagulation as an Efficient Method for Wastewater Treatment

¹Aditya V Gaud, ²Naeem R Shaikh, ³Ashrat S Gaikwad, ⁴Sonali S Hendre, ⁵Prajakta S Kamble, ⁶Pravina B Piste and
⁷Umesh S Shelke

^{1, 2, 3, 4, 5, 6, 7}Analytical Chemistry Research Laboratory, Rajarshi Chhatrapati Shahu College, Kolhapur, Maharashtra, India.

Abstract

Electro-coagulation (EC) is an advanced electrochemical treatment technique increasingly applied for the removal of pollutants from industrial and municipal wastewater. In this process, coagulant metal ions are generated in situ through the anodic dissolution of sacrificial electrodes, commonly iron or aluminum, under the application of direct current. These metal ions undergo hydrolysis to form metal hydroxides, which effectively destabilize and aggregate a wide range of contaminants, including suspended solids, heavy metals, emulsified oils, dyes, phosphates, pathogens, and organic compounds.

Electro coagulation integrates the mechanisms of coagulation, flocculation, flotation, and electrochemical oxidation within a single treatment unit, thereby eliminating the need for external chemical coagulants. Compared to conventional chemical coagulation, EC offers several advantages such as higher pollutant removal efficiency, effective treatment of highly colored and turbid wastewater, improved removal of colloidal particles, and reduced sludge production.

The performance of the EC process is strongly influenced by operational parameters including electrode material, current density, pH, solution conductivity, and treatment duration. Electrocoagulation has been successfully employed in the treatment of textile effluents, metal plating wastewater, oil- and grease-laden wastewater, pharmaceutical effluents, municipal sewage, and landfill leachate. Recent studies have also demonstrated enhanced treatment efficiency through the integration of EC with membrane filtration and other advanced processes.

Keywords: Electrocoagulation, wastewater treatment, pollutant removal, electrochemical process.

Introduction

Electrocoagulation (EC) is a rapidly growing electrochemical process for wastewater treatment that has gained considerable attention in both research and industrial settings. In this method, sacrificial metal electrodes (typically iron or aluminum) are dissolved under direct current to release metal ions, which hydrolyze to form metal hydroxides that act as in situ coagulants. These hydroxides destabilize and aggregate pollutants such as suspended solids, heavy metals, dyes, oils, and organic compounds, thereby facilitating their removal [1-8].

Compared to conventional chemical coagulation, EC eliminates the need for external chemical coagulants, reducing chemical consumption and secondary pollution [7]. The process also integrates coagulation, flocculation, flotation, and electro-oxidation within a single reactor, enhancing overall efficiency [9]. Another important advantage is the ability to remove very fine colloidal particles: the electric field mobilizes charged colloids, increasing their collision and aggregation probability, which is often difficult in traditional coagulation processes [7].

Operational parameters such as current density, pH, conductivity, electrode material and configuration, and

treatment time strongly influence EC performance. For example, optimization studies using Al-based EC for greywater treatment found that current density and pH significantly affect removal efficiency, with optimized conditions achieving COD removal of over 86% [10]. Also, continuous-flow EC systems have been developed to treat industrial organic pollutants, showcasing high removal efficiencies and improved scalability [11].

EC has been successfully applied to a wide variety of wastewater types, including on-site wastewater (for phosphorus removal), textile effluents, mineral processing wastewater, and municipal sewage [6-9]. Its adaptability and relatively simple configuration make it suitable for decentralized and modular systems, as well as for integration with other processes (e.g., adsorption or advanced oxidation) to meet stringent discharge standards.

Despite its strengths, EC still faces challenges, including electrode passivation, higher energy consumption for low-conductivity waters, and management of the generated sludge [8,11-15]. Ongoing research is focused on improving reactor design, developing hybrid systems, and optimizing process parameters to enhance efficiency, reduce costs, and extend the technology's application.

*Corresponding Author: Umesh S Shelke