Korean J. Chem. Eng., 36(9), 1441-1449 (2019)
DOI: 10.1007/s11814-019-0334-7

pISSN: 0256-1115
eISSN: 1975-7220

Treatment of reactive dyebath wastewater by electrocoagulation process: Optimization and cost-estimation

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(*Received 24 February 2019 • accepted 3 July 2019*)

Abstract−Reactive dyestuff is commonly used in the textile industry. Reactive dyebath wastewater (RDW) was treated with a batch, monopolar, parallel lab scale electrocoagulation process (EC) having 0.042 m^2 effective electrode area. The effects of process parameters, such as initial pH, current density and electrolysis period on COD and color removal efficiency, were investigated by using response surface methodology (RSM). At the optimal conditions, 85.8% color and 76.9% COD removal were obtained with 1.84 €/m^3 operating cost for Al electrode, while 92.0% decolorization and 80.9% COD removal were obtained with 1.56 €/m^3 operating cost for an iron electrode. The iron electrode was found superior to aluminum as a sacrificial anode material in terms of COD and color removal with low cost. The cost of electrical energy, electrode, and chemical consumptions for electrocoagulation were considered to find an optimum and feasible solution. As a result, the operating cost consists of approximately 2% for energy, 28% for electrode and 70% for chemical consumption for both electrodes. Based upon the data, it is clearly seen that operating cost covers mostly for HCl to adjust pH due to the high pH and alkalinity of RDW, which was neglected in many studies. The first-order reaction kinetics with a higher slope for the color were well fitted, resulting in faster color removal than that of COD for both electrodes.

Keywords: Electrocoagulation, Kinetic, Optimization, Operating Cost, Reactive Dye

INTRODUCTION

The textile industry is characterized by intensive water consumption and wastewater generation [1]. Textile wastewater composition and discharge into the receiving water body has become a global problem both environmentally and aesthetically [2]. Colored effluents have shown toxic effects for aquatic organisms and decrease the light permeability of the aquatic environment and negatively affect natural photosynthetic activity [3-5]. Reactive dyes are widely used for cotton fabric in the textile industry. Reactive dyeing process has some negative aspects, such as low fixation efficiency (20-40%) and intensive water usage in the washing process [6,7]. Performing the dyeing process expediently with the desired removal efficiency is possible by adding some dye auxiliary chemicals, which makes difficult the treatment [8].

There are many studies on decolorization and COD from textile wastewater using treatment methods such as biological processes [9-11], chemical coagulation [12,13], electrocoagulation [14-16], membrane filtration [17,18], adsorption [19,20] and advanced oxidation processes [21-23]. Conventional methods cannot be used with confidence because they are limited due to complex wastewater character and strict discharge limit by the reason of regulation in legislation. Technically applicable, economical sustainable methods and their optimizing the operating conditions have gained huge importance for solving environmental problems arising from textile wastewater in recent years. As a result, the electrocoagulation process, which is as an alternative treatment method, has become widespread. Many researchers reported that the electrocoagulation process was applied successfully for industrial wastewater such as textile [24], paper [25], olive oil [26], dairy [27], tannery [28], slaughterhouse [29], and metal plating [30,31].

Metal ions formed by dissolution of the anode electrode (aluminum or iron) react with OH^- ions formed at the cathode electrode thus metal hydroxides which are insoluble and have a very high adsorption capacity. In this process, pollutants can be removed by a combination of coagulation, adsorption, flotation, and precipitation [32]. Iron and aluminum electrodes are constituted prevalently due to being cheap, easily accessible and having proven applicability [33]. Electrocoagulation process can be designed either horizontally or vertically according to the way where the electrode plates are placed, as single-pole parallel, single-pole series and bipolar as to the connection type [34-38]. pH, current density and efficiency, electrode connection type, electrode material, inner-electrode distance, temperature, and electrolysis time become important factors on process efficiency to reveal the pollutant removal mechanism at electrocoagulation process [29,39-41].

Metal hydroxide types, which occur in the electrocoagulation process and play an important role in pollutant removal, and floc load case (positive in acidic conditions, negative in alkali conditions) change according to medium pH [42]. In the electrocoagu-

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