Chemical Engineering and Processing 49 (2010) 1176–1182

Contents lists available at ScienceDirect

Chemical Engineering and Processing: Process Intensification

journal homepage: www.elsevier.com/locate/cep

Electrocoagulation process applied to wastewater containing dyes from textile industry

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ARTICLE INFO

Article history:
Received 4 March 2010
Received in revised form 19 August 2010
Accepted 24 August 2010
Available online 24 September 2010

Keywords:
Electrocoagulation
Wastewater treatment
Dye
Textile industry

ABSTRACT

In the present work, electrocoagulation was applied for the colour removal of solutions containing Direct red 81. Experiments were performed for synthetic solutions in batch mode.

The study focuses on the effect of following operational parameters: electrolysis time, current density, initial pH, inter-electrode distance, initial dye concentration and type of supporting electrolyte.

The obtained results showed that decolouration optimal conditions are the following: initial pH of about 6, current density of 1.875 mA/cm^2, inter-electrode distance of 1.5 cm and finally the use of NaCl as supporting electrolyte. In best conditions, high decolouration efficiency was obtained, reaching more than 98% of colour removal.

Fourier transform infrared spectroscopy (FTIR) analysis was used to characterize the residual EC by-product with and without the presence of dye.

1. Introduction

Wastewater samples collected from the neighbourhood of textile industry plant located in Boufarik (Algeria) revealed a high contamination by synthetic dyes, most of them being toxic. In Algeria, the agricultural reutilization of treated wastewater, even industrial is becoming a strong requirement. Furthermore, local environmental legislation is becoming more and more stringent [1].

Azo dyes, which contain one or more azo bonds (–N=N–), are among the most widely used synthetic dyes. The discharge of such dyes in the ecosystem is considered as a major environmental concern [2]. Dye effluents, are not only aesthetic pollutants by nature of their colour, but may interfere light penetration in water, and thereby disturbing biological activities of aquatic life [3].

It has been also demonstrated that some azo dyes are toxic and even mutagenic towards living organisms in aquatic environment. In addition, the stability of their molecular structures renders them resistant to biological or even chemical degradation [2].

Therefore, it is necessary to treat dye effluents prior to their discharge to the receiving water stream in order to meet the environmental regulations.

The actually operated conventional processes in Boufarik plant, cannot meet the quality requirements: the dye bioelimination is negligible and the coagulation/flocculation with iron salts as currently used in the plant is not effective enough.

One of methods developed to overcome the drawbacks of conventional water and wastewater treatment technologies was electrocoagulation (EC).

Electrocoagulation (EC) is a potentially effective method for treating different kinds of wastewater with high removal efficiency [4].

EC process provides a simple, reliable and cost-effective method for the treatment of wastewater without any need for additional chemicals, and thus a secondary pollution. It also reduces the amount of sludge which needs to be disposed.

EC technique uses a direct current source between metal electrodes immersed in polluted water [5]. The electrical current causes the dissolution of metal plates into wastewater.

The metal ions, at an appropriate pH, can form wide ranges of coagulated species and metal hydroxides that precipitate and adsorb dissolved contaminants or destabilize and aggregate the suspended particles [4].

The most widely used electrode materials in EC process are aluminum and iron. In the case of aluminum, main reactions are as follows:

$$\text{Anode}: Al_{(s)} \rightarrow Al^{3+} + 3e^- \quad (1)$$

$$\text{Cathode}: 3H_2O + 3e^- \rightarrow (3/2)H_{2(g)} + 3OH^- \quad (2)$$

$$Al^3 + 3H_2O \rightarrow Al(OH)_3 + 3H^+ \quad (3)$$

Freshly formed amorphous $Al(OH)_{3(s)}$ flocs have large surface areas, which are beneficial for a rapid adsorption of soluble organic

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doi:10.1016/j.cep.2010.08.019