REMOVAL OF CONGO RED DYE FROM WASTEWATER USING ELECTROCOAGULATION PROCESS

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Figure 1. Schematic Diagram of EC cell: (1) DC supply, (2) Congo Red Dye effluent, (3) Magnetic stirrer.

The use of synthetic dyes in the textile industry represents an environmental challenge in the treatment of effluents. Therefore, this study aims to evaluate the electrocoagulation technique applied to a synthetic effluent containing Congo Red dye using aluminum electrodes. The electrocoagulation process was applied to different concentrations of Congo Red dye (50 to 250 mg L-1) and different currents (0.30 A to 0.90 A) for a period of 20 minutes. The highest currents (0.75 A and 0.90 A) and the highest concentrations (200 mg L^{-1} and 150 mg L^{-1}) of dye gave the best results of 91.98% and 89.09%, respectively. In addition, toxicological tests were performed on *Artemia salina*, with 60% of the samples surviving 100% and 40% surviving 82%.

Introduction

The use of dyes, especially synthetic ones, which have a high potential for contaminating waterways, can directly interfere with aquatic life, causing oxygen depletion by making the process of photosynthesis impossible, in addition to the natural toxicity of the dye [3]. Congo Red dye has a molecular structure that makes it difficult to eliminate in the environment.

To remove Congo Red dye from synthetic wastewater, the electrocoagulation process has gained prominence because it is a highly portable treatment, low cost and maintenance, easy to operate, and does not require the constant addition of chemical products [2].

The objective of this work was to evaluate the electrocoagulation process using scrap electrodes (aluminum) applied to the removal of Congo Red dye from synthetic wastewater.

Material and Methods

The synthetic effluent containing the Congo Red dye was prepared at concentrations from 50 - 250 mg L^{-1} with distilled water and the dye, using the analytical reagent (Dinâmica).

The electrodes used were scraps from an aluminum-based (5cmx3cmx3cm). The electrodes were attached to the reactor (3,5cm distance between each electrode), connected to 6 mm gauge wires, and their ends connected to the power source. The electrocoagulation process was performed in a 0.5 L reactor with the addition of 0.4 L of the Congo Red dye effluent at a stirring speed of 120 rpm, Figure 1. NaCl at a concentration of 4 g L^{-1} was used as electrolyte.

For each test, the initial and final samples were analyzed after the electrocoagulation treatment, and the analyses performed were pH, dye concentration by spectroscopy at a wavelength of 498 mm [1], conductivity, chemical oxygen demand (COD) [4] and toxicity (*Artemia salina*), using the microcrustacean as a bioindicator to evaluate the degree of toxicity tolerance in relation to the treated effluent, In addition, electrode wear and sludge production after effluent treatment were evaluated using the gravimetric method [4]. The experimental design was 2^2 factorial with 11 trials and 3 center points.

Results and Discussion

After the tests, the final concentration of Congo Red dye in the synthetic wastewater varied between 16.58 ± 0.5 and 60.82 mg L^{-1} ± 0.5. In terms of percentage removal, Figure 2 shows the results obtained, where a decrease in concentration of between 56.13% and 91.98% was observed in the different tests.

The most significant decreases in effluent concentration (91.98%) and COD (91.98%) were observed in Test 3 (current 0.75 A and dye concentration 200 mg L-1), and a significant reduction in anode was observed.

The toxicological test generally obtained results with an average survival rate of 95.18%. About 60% of the tests achieved 100% final survival, while the other 40% were above 82%, Figure 3.

The final pH of the effluent ranged from 9.85 to 10.73. Increasing the current results in more effective color removal because the higher the current, the greater the dissolution of the anode, which increases the number of metal hydroxide flakes and wich can be verified with the ANOVA statistical analysis - Table 1. The higher the current, the more dye is removed, as shown in Figure 4.

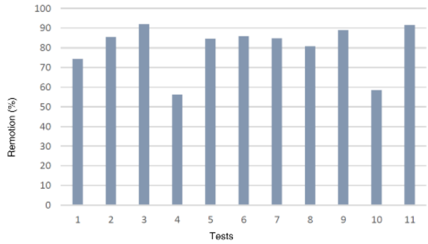

Figure 2. Percentage removal of Congo Red dye concentration (V=0.4 L; 120 rpm, C=4 gL^{-1} NaCl).

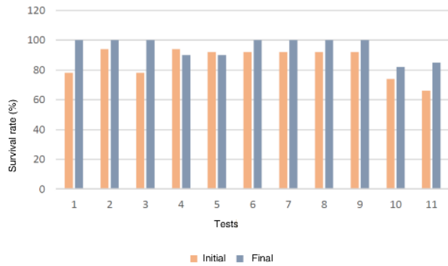

Figure 3. Initial and final toxicological test after electrocoagulation treatment of synthetic wastewater using the microcrustacean *Artemia salina*.

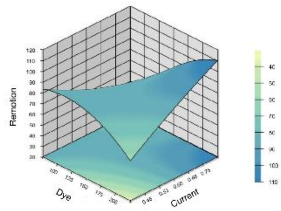

Figure 4. Response surface for the interaction between current (A) and Congo red dye concentration (mg L^{-1}) in electrocoagulation treatment using aluminum electrodes.

Table 1. ANOVA for removal of Congo Red dye by electrocoagulation using aluminum electrodes.

Factors	SS	Df	MS	F	p-value
Current	906,4	4	226,6	29,3	0,00177
Dye	68,5	3	22,8	2,97	0,01734
Current*Dye	554,1	1	554,1	74,53	0,000724
Residues	0,8	2	0,4		

SS = sum of squares; Df = degrees of freedom; MS = mean squares;
F = Fcalculated=1379.47/Ftabulated=18.51; *linear interaction between factors.

For good efficiency in the process of removing the dye concentration, sludge is consequently generated. The results varied between 0.20 g ± 0.5 and 0.55 g ± 0.5. The generation of sludge is directly related to the wear of the electrodes, in addition to the applied current and dye concentration. In order to dispose of the sludge properly, it must be treated.

Conclusions

The electrocoagulation method was found to be effective for the treatment of dye-containing wastewater, with concentration removals of up to 91.98%. The survival rate against *Artemia salina* reached 100% in 60% of the tests. Statistical analysis also showed that the higher the current, the higher the concentration of dye removed under the conditions evaluated in this study. Suggestions for future work: Use reagents that can lower the pH of the solution prior to treatment; vary the time of analysis of the reduction of the electrodes; check the characteristics and toxicity of the sludge produced.

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