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Use of Electrochemical Processes for Treating Pharmaceutical Contaminated Water

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ABSTRACT

The objective of this study is to evaluate the effectiveness of two electrochemical processes (Electro-Fenton and Electrocoagulation) in degrading two different pharmaceutical contaminants, Atenolol and Nystatin. To achieve this objective, a series of experiments was conducted in a batch-mode electrochemical reactor using iron and aluminum electrodes. The results obtained demonstrated that for Atenolol, the EC process did not work well and led to unsatisfactory efficiency. To improve the situation, it was decided to adopt the Electro-Fenton process. The obtained results have demonstrated that the maximum degradation rate (90%) was achieved at an initial pH of 3, an H_2O_2 concentration of 8 mM, a current intensity of 0.25A, and an initial solution concentration of 1.87 * 10-5 mol/L (5mg/L). For Nystatin, remarkable degradation rates of around 99% were obtained using only the Electrocoagulation (EC) process with a neutral pH and an initial concentration of $2.69*10^{-5}$mol/L.

Keywords: Electro-Fenton - Electrocoagulation – Atenolol – Nystatin – degradation – Pharmaceutical.

1 Introduction

The treatment of water contaminated by pharmaceuticals has become a major concern due to its potential impact on the environment and public health. Pharmaceutical residues frequently present in wastewater from hospitals and pharmaceutical industries can persist in conventionally treated water, leading to contamination of drinking water sources [1]. In this context, electrochemical processes have emerged as promising solutions for treating these contaminated waters [2]. These processes exploit chemical reactions using electricity to eliminate contaminants present in water. The main objective of this work was to study the performance of two electrochemical treatment processes, namely electrocoagulation and electro-Fenton, on the treatment of synthetic aqueous solutions containing recalcitrant organic substances, notably Atenolol and Nystatin.

2 Experimental

Experiments were carried out in a batch electrochemical reactor of 1000 ml capacity, with aluminum/aluminum or iron/iron electrodes, of 17.5 cm^2 of submerged area. The electrode distance between anode and cathode was maintained constant at a value of 2 cm during electrolysis. A direct current was supplied by a DC regulated power source. Proper agitation was provided to maintain a uniform concentration inside the cell with a processing time of (0-40 min). A stock solution was prepared by dissolving an appropriate quantity of Atenolol or Nystatin in distilled water. The concentration of the supporting electrolyte was adjusted by adding NaCl. The pH of the solution was adjusted by adding a diluted sulfuric acid or NaOH. The sample was collected then analyzed by UV-vis spectroscopy (λ_{max}= 224nm for Atenolol and λ_{max} =306nm for Nystatin

3 Results and Discussion

The results showed that the EC process did not work well for Atenolol, leading to unsatisfactory yields. To remedy this situation, the Electro-Fenton process was adopted. Results showed that the best degradation

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rate (97.14%) was recorded for an acid pH of 3, wish is a critical factor in the Electro-Fenton process, as seen in figure 1. An acidic pH, generally between 2 and 4, favors the speciation of iron and the production of reactive hydroxyl radicals, allowing more efficient oxidation of organic pollutants. The tested currents varied between 0.1 A and 0.45 A, resulting in energy consumption ranging from 4.77 Wh/kg to 21.89 Wh/kg, respectively. The corresponding rate obtained between 93%and 96%. Selecting an intensity of 0.25A, yielded both high removal efficiency and reduced energy consumption, achieving a degradation rate of 96.08%.

The highest rate of ATL degradation is recorded with a concentration of H_2O_2 of 8 mM, due to a higher production of oxidizing radicals. Above this concentration, the efficiency drops due to the trapping of OH· radicals by excess of H_2O_2. The effect of initial pollutant concentration was examined. The highest removal efficiency was recorded for a concentration of $1.87*10^{-5}$ mol/L and a treatment time of 40 minutes.

Similarly, for Nystatin, two types of electrodes were tested (iron and aluminum). A remarkable degradation rates were achieved using only the electrocoagulation process with aluminum electrodes, under the following conditions: current intensity of 0.25A, a treatment time of 40 min. Following this, the impact of initial NYS concentration was investigated. As depicted in Figure 2, the highest removal efficiency was observed at lower concentrations, with complete removal achieved after only 6 and 10 minutes.

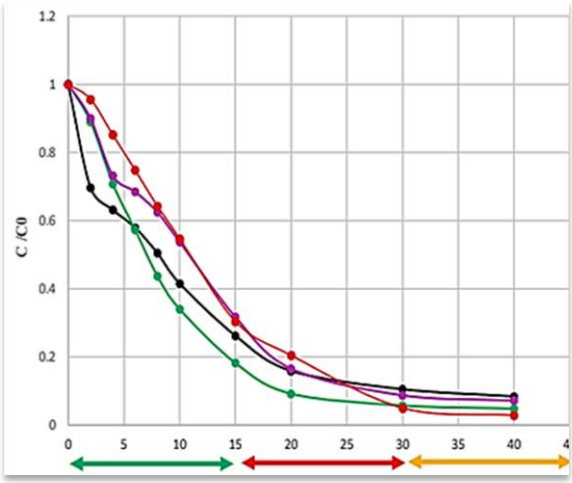

Figure1: pH effect.

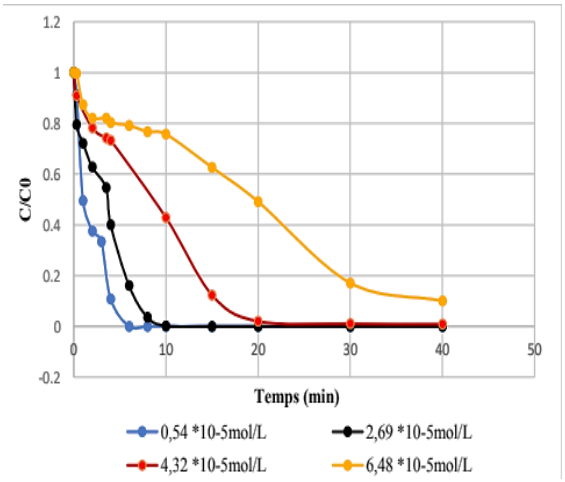

Figure2: Effect of initial NYS concentration

4 Conclusions

The study demonstrated the interest of the EC (Electrocoagulation) and EF (Electro-Fenton) processes respectively, for the treatment of pharmaceutical contaminated effluent. Applying only the electrocoagulation process to Nystatin with aluminum electrodes, produced significant degradation rates of around 99%, offering promising solutions for the treatment of these types of contaminants. Similarly, Atenolol was significantly degraded, with a degradation rate of 90%, following the use of the EF process with iron electrodes.

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