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ELECTROCHEMICAL TREATMENT OF CHEMICAL INDUSTRY WASTEWATER USING STEEL AND TIRUO$_2$ ELECTRODES

TRATAMENTO ELETROQUÍMICO DE EFLUENTE DE INDÚSTRIA QUÍMICA UTILIZANDO ELETRODOS DE AÇO E TIRUO$_2$

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RESUMO

O tratamento eletroquímico de efluente de uma indústria química produtora de aditivos para borracha utilizando eletrodos de aço e TiRuO$_2$ foi estudado. Análises espectrofotométricas na região UV-visível foram realizadas em amostras eletrolisadas do efluente nos tempos de 0, 10, 20, 30 e 40 min para determinar se transformações moleculares ocorreram. As eletrólises causaram transformações moleculares no efluente com o eletrodo de TiRuO$_2$ mais acentuadas do que com o de aço. Também, a toxicidade biológica diminuiu após as eletrólises com eletrodo de aço, o que permite inferir que o tratamento eletrolítico modifica as moléculas persistentes tornando-as mais biodegradáveis.

ABSTRACT

The treatment of chemical industry wastewater by an electrochemical method was investigated using steel and TiRuO$_2$ electrodes. Visible-UV spectrophotometric analyses have been performed in samples electrolyzed at 0, 10, 20, 30 and 40 min to determine the molecular changes in the wastewater. Although the steel electrode caused changes in molecules present in the raw effluent, the TiRuO$_2$ electrode showed to promote more significant changes. It has been observed an increase in the cellular viability after electrolysis; this could be a decrease in the biological toxicity after the treatment. The electrolytic process is an efficient method to modify

persistent molecules, normally, found in wastewater of rubber chemical industry and, turn then biocompatible to the environment.

Key words: wastes pollutant, electrodes biodegradation, electrolytic process, persistent molecules.

1. INTRODUCTION

The concern regarding conservation of the environment has lead to great interest for environmental technology in using the water and energy resource. This interest seeks the materials recycling, reduction of water consumption and the reduction of conventional treatment costs (ARCHIBALD et al., 1998).

The electrolytic system has shown to be efficient as an alternative form to the treatment of different types of industrial effluents (TOLENTINO e BIDOIA, 2000). This treatment has much versatility (DE LEVIE, 1999; SCHILLER e BIDOIA, 2000). Therefore it reduces toxicity by breaking recalcitrant substances, such as: aromatic rings, in biodegradable products. Thus, the electrolytic treatment, as pre-treatment, increases the efficiency of the conventional biological processes (INAZAKI et al., 2002).

The cost to set up a wastewater treatment system is directly proportional to the variety of toxic substances that should be removed. In general, many of the wastewaters contain recalcitrant organic compounds (WEBER, 1999).

The electrolytic process produces electrooxidation of the organic substances. Thus, it is not necessary the use of oxidant chemical products in the process (BRATFICH et al., 1999). Also, it promotes the coagulation and flocculation processes, as well as it allows the treated wastewater to be recycled. This process is compatible with environmental standards (RÉGIS e BIDOIA, 2001). Therefore, the reactions during the effluent treatment will indicate the appropriate material to be used as electrodes (SMITH, 1972). This work aims to monitor molecular transformation during the electrolytic process applied to the effluent of a chemical industry. The effluent consists of antioxidants and antiozonants (RÉGIS e BIDOIA, 2002).

2. MATERIAL AND METHODS

The electrolytic treatment has been applied in the effluent of a rubber chemical industry aiming to transform the recalcitrant molecules in the effluent in more biodegradable ones. The effluent contains a high content of organic material, such as aromatic amine: n-phenyl-n-isopropyl-p-phenylenediamine (brand name is Flexzone

3P); n-phenyl-n'-1,3-butyldimethyl-p-phenylenediamine (brand name Flexzone 7P), ketones, oils and greases that are toxic material and extremely waste pollutants.

The electrodes (MORAES et al., 2000) were two titanium metal plates (0.1 cm thickness, total geometric area of 8.0 cm^2 each plate) spaced 0.5 cm apart, covered by a mixture of TiO_2 and RuO_2. The formula to prepare the $TiRuO_2$ electrodes is described in an expired patent, currently available as public domain (DE NORA, 1970).

The steel electrodes (SAE 1020 from Usiminas Co. – Brazil) used contains six plates with geometric area of 475 cm^2 and spaced among them by 0.1 mm. They have thickness of 3 mm.

Each test consisted of 50 mL volume of raw industrial effluent electrolyzed with a 0.5A direct current and the potential varies in the range of 7.0 to 8.0 V. The current was applied by a power supply (Dawer DC, model FCC-3005D) and the effluent was under agitation at room temperature conditions. After different electrolysis durations (0, 10, 20, 30 and 40 min), the chemical industry effluent has been analyzed by a visible-UV method to determine the molecular changes in the wastewater by peak shifting showed in a spectrum obtained from a visible-UV spectrophotometer Shimadzu, model 2401 PC.

The cellular viability was made using a tube test containing *Saccharomyces cerevisae* suspension. The *S. cerevisae* suspension was put in contact with the effluent after being electrolyzed and the viable and the died cells were counted using a Neubauer glass slide (RÉGIS e BIDOIA, 2001).

3. RESULTS AND DISCUSSION

3.1. Steel Electrodes

Figure 1 shows visible-UV Spectrum after electrolysis of raw effluent, using steel electrodes, under 0, 10, 20, 30 and 40 min duration. It appears a peak about 290 nm after electrolysis signalizing that molecules were transformed. The absorbance increases after electrolysis due to the coagulation by iron hydroxide. After the coagulation the raw effluent turns more transparent and the absorbance increases.

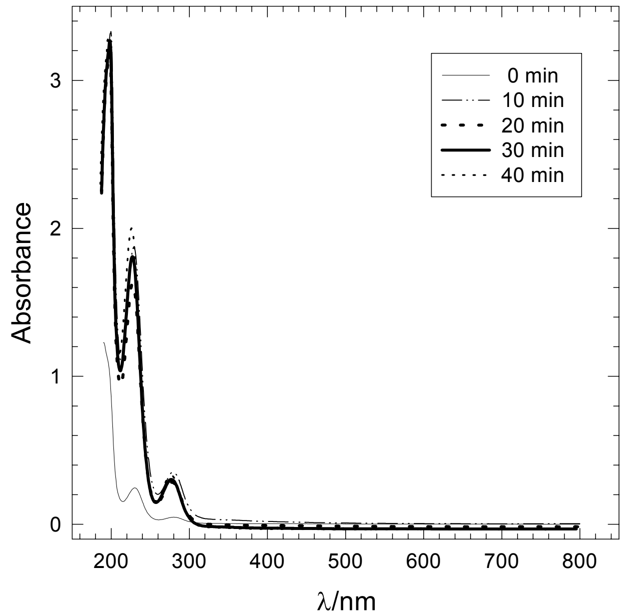

Figure 1 - Visible-UV spectrum in the electrolyzed raw effluent as a function of electrolysis duration. Steel electrodes, I = 0.5 A and T=26°C.

Figure 2 shows the microorganism cellular viability (%) for *Saccharomyces cerevisiae,* on function of electrolysis duration, using steel electrodes. Thus, the increase of electrolysis duration, will lead to a less toxic and biodegradable effluent.

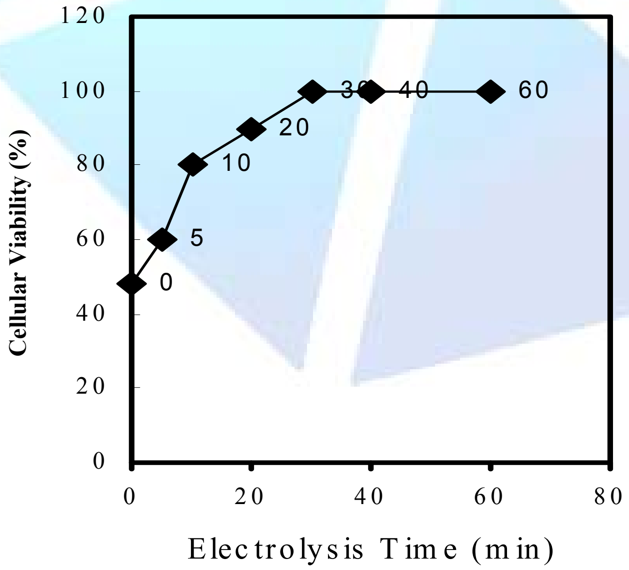

Figure 2 - Representation of the cellular viability (%) for Saccharomyces cerevisiae on function of electrolysis duration. Steel electrodes, I = 0.5 A and T=26°C.

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3.2. $TiRuO_2$ Electrodes

Visible-UV Spectrum made with effluent after electrolysis using $TiRuO_2$ electrodes shows more intensive peak changes. After 20 min of electrolysis, it has been observed (see Figure 3), that the substances found in the effluent were deeply modified, once the shift in the peaks in the spectrum has occurred as well as the peak intensity. In this case, the electrodes of $TiRuO_2$ did not promote a coagulation of substances, but it increases eletrooxidation.

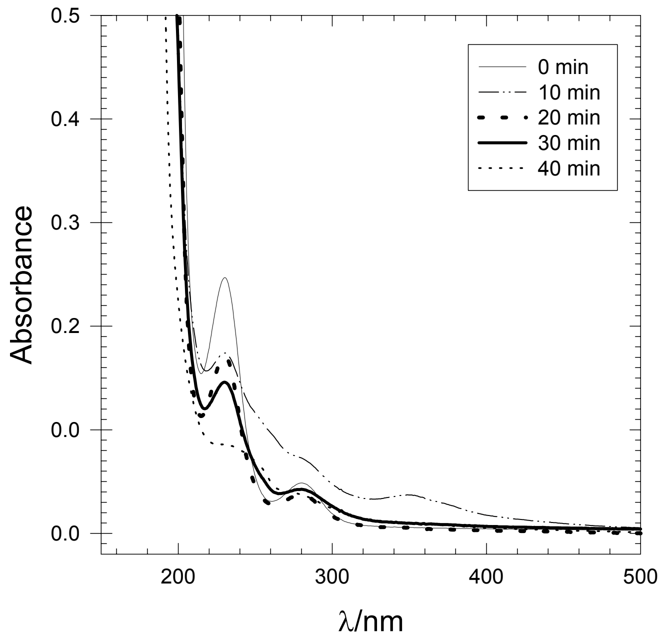

Figure 3 - Visible-UV spectrum in the electrolyzed effluent as a function of electrolysis duration. $TiRuO_2$ electrodes, I = 0.5 A and T=26°C.

The peaks of electrolyzed effluent compared with non-electrolyzed are quite different. In this case, there is no coagulation because the system is free of iron hydroxide, but the electro oxidation by $TiRuO_2$ causes decrease of chemical concentration without to change the transparency.

4. CONCLUSIONS

- Visible-UV Spectrum of electrolyzed raw industrial effluent, with $TiRuO_2$ electrodes, has shown more intensive changes in peaks than electrolyzed effluents with steel electrodes;
- The electrolytic process is an efficient method to modify persistent molecules found in rubber chemical industry effluent;

- Increase in the cellular viability of *S. cerevisiae* after electrolysis with steel electrodes, which infers to a decrease in toxicity levels after the related treatment;
- As for as chemical substances have not been added to the final effluent during treatment and it has been shown that biodegradation can be reached, the related treatment is biocompatible to environmental requirements.

5. ACKNOWLEDGEMENTS

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