Electrochemical Degradation of Reverse Osmosis Concentrates from Sanitary Landfill Leachate

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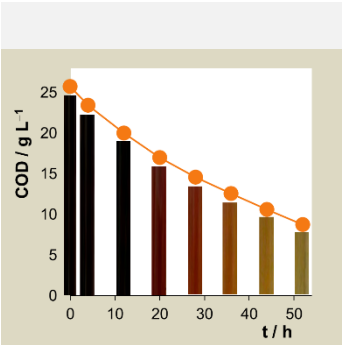
A. Fernandes[1], *A. Martinez-Cruz*[2], *L. Ciríaco*[1], *M.J. Pacheco*[1], *F. Carvalho*[3], *A. Lopes*[1]. *(1) Fiber Materials and Environmental Technologies (FibEnTech-UBI) and Department of Chemistry, Universidade da Beira Interior, R. Marquês de D'Ávila e Bolama, Covilhã, Portugal, annabelf@ubi.pt. (2) Institute of Engineering, National Autonomous University of Mexico, Circuito Escolar s/n, Ciudad Universitaria, Delegación Coyoacán, Mexico City, Mexico. (3) Department of Technology and Applied Sciences, School of Agriculture, Polytechnic Institute of Beja, Beja, Portugal.*



The electrochemical oxidation of reverse osmosis concentrate from sanitary landfill leachate, with an initial chemical oxygen demand (COD) of 26 g L^{-1} and total nitrogen concentration of 8 g L^{-1}, was carried out in batch mode with recirculation, using 3 L of sample and an electrochemical cell equipped with a boron-doped diamond (BDD) anode, at an applied current density of 200 A m^{-2}. The results obtained showed that electrochemical oxidation with BDD anode, when performed at the experimental conditions applied, is an effective technology to remove the organic load and nitrogen-containing species from reverse osmosis concentrate of sanitary landfill leachate. After 52-h treatment, a clarified solution was obtained, with COD and total nitrogen removals of 17 and 6 g L^{-1}, respectively, being ammonia the main nitrogen source in solution, enabling its discharge into urban wastewater treatment plants with biological and/or membrane technologies.

Introduction

Conventional sanitary landfill leachate (SLL) treatment has been complemented and, in some cases, completely replaced by reverse osmosis technology. Despite the good quality of the treated water, the efficiency of the process is low, and a large volume of reverse osmosis concentrate (ROC) is generated, containing all the pollutant load of the leachate, but much more concentrated, that has to be discharged or further treated [1].

Electrochemical oxidation has been widely studied for effluents treatment and has shown high efficiency in the removal of recalcitrant organic matter, especially when boron-doped diamond (BDD) anodes are used [2,3].

The aim of this work was to evaluate the feasibility of the electrochemical oxidation process, using an electrochemical cell equipped with a BDD anode, to degrade concentrates obtained from the reverse osmosis of sanitary landfill leachate (SLL-ROC).

Material and Methods

The reverse osmosis concentrate sample used in this study was collected at a Portuguese intermunicipal sanitary landfill site. The treatment applied at this landfill site comprises two reverse osmosis systems followed by a stripping column. The ROC sample was collected in the reverse osmosis reservoir, and its physicochemical characteristics are presented in Table 1.

The electrochemical oxidation experiments were conducted in batch mode with recirculation, in triplicate, being the experimental conditions presented in Table 2.

Table 1. SLL-ROC physicochemical characteristics.

Parameter	Mean value ± SD [a]
COD / g L^{-1}	25.8 ± 0.4
TDC / g L^{-1}	16.0 ± 0.2
DOC / g L^{-1}	9.8 ± 0.2
DIC / g L^{-1}	6.2 ± 0.1
TDN / g L^{-1}	8.0 ± 0.1
$N\text{-}NH_3$ / g L^{-1}	7.7 ± 0.3
pH	7.80 ± 0.04
Conductivity / mS cm^{-1}	81.6 ± 0.4

[a] SD – Standard deviation.

Table 2. Electrochemical oxidation experimental conditions.

Operational variable	
Sample volume / L	3
Recirculation flow rate / L min^{-1}	4; 5; 6
Anode area / cm^2	400 (BDD)
Cathode area / cm^2	400 (SS [a])
Applied current intensity / A	8
Treatment duration / h	52

[a] SS – Stainless steel.

The SLL-ROC samples, before and after the electrochemical experiments, were analyzed, according to the standard procedures [4], for the following parameters: chemical oxygen demand (COD), total dissolved carbon (TDC), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), total dissolved nitrogen (TDN), and ammonia nitrogen ($N\text{-}NH_3$). COD determinations followed the closed reflux titrimetric method. TDC, DOC, DIC, and TDN were measured in a Shimadzu TOC-VCPH analyzer combined with a TNM-1 unit. Before TDC, DOC, DIC, and TDN determinations, samples were filtered through 0.45 mm membrane filters. Ammonia nitrogen was determined using a Kjeldatherm block-

digestion-system and a Vapodest 20 s distillation system, both from Gerhardt. The pH was measured using a HANNA pH meter (HI 931400). The electrical conductivity was determined using a Mettler Toledo conductivity meter (SevenEasy S30K).

Results and Discussion

From the different recirculation flow rates studied, the best results were attained at 6 L min^{-1}. At this flow rate, the SLL-ROC electrochemical oxidation treatment achieved, after 52-h experiment, a COD removal of 17 g L^{-1} (66%) and a significant removal in color (Graphical abstract). Figure 1 shows the variation with time of the different carbon forms evaluated.

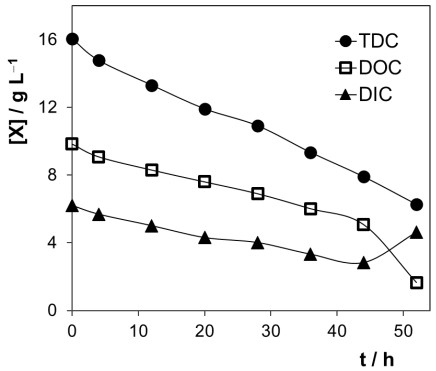


Figure 1. TDC, DOC, and DIC variation with time along the electrochemical oxidation treatment of SLL-ROC, at a recirculation flow rate of 6 L min^{-1}.

A DOC removal of 8 g L^{-1} (83%) was attained, indicating a high degree of mineralisation of the organic compounds, especially in the last hours of treatment. According to the results presented, it can be inferred that, most likely, the organic compounds oxidation led to the formation of carboxylic acids, which, in the last hours assay, were oxidised to CO_2 that reacted and led to the formation of carbonates and bicarbonates.

Figure 2 presents the TDN and N-NH_3 decays with time along the electrochemical oxidation treatment.

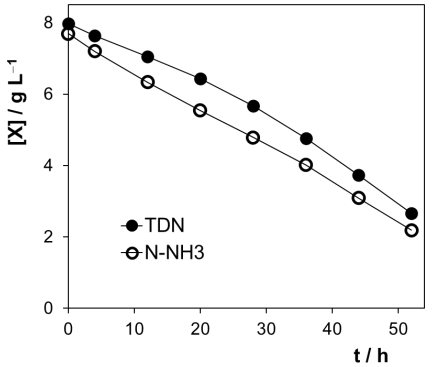


Figure 2. TDN and N-NH_3 variation with time along the electrochemical oxidation treatment of SLL-ROC, at a recirculation flow rate of 6 L min^{-1}.

A nitrogen removal of approximately 6 g L^{-1} (70%) was observed, being ammonia the main nitrogen source in solution. The results obtained suggest that, along the electrochemical oxidation treatment, nitrogen is mainly oxidised to N_2 and/or other nitrogen volatile forms.

Conclusions

Electrochemical oxidation, performed in batch mode with recirculation, using a BDD anode, is an effective technology for treating reverse osmosis concentrates from sanitary landfill leachate. At the experimental conditions studied, COD and nitrogen removals increased with recirculation flow rate. At 6 L min^{-1}, after 52-h treatment, a clarified solution was generated, with approximately 9 g L^{-1} of COD and 3 g L^{-1} of total nitrogen, mainly in the form of ammonia nitrogen, potentiating the application of a biological or membrane post-treatment.

Acknowledgments

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