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The use of artificial intelligence models in the prediction of optimum operational conditions for the treatment of dye wastewaters with similar structural characteristics

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ABSTRACT

This work assesses the effectiveness of an artificial intelligence (AI) model based on an artificial neural networks (ANN) – genetic algorithm (GA) in the prediction of the behavior and optimization of the treatment of sulfate wastewaters with Bromophenol blue dye using an electro-oxidation (EO) process. Trials were made with a filter press-type reactor with a boron-doped diamond (BDD) anode. The ANN model was trained with 51 electrolytic experiments by using the electrolysis time, flow, current density, pH and dye concentration as input variables and the discoloration efficiency as the output one. The performance of ANN was measured with RMSE and MAPE values of 10.73 % and 8.81 %, respectively, calculated from real and predicted values. Optimum conditions determined by GA were reached for the inputs of 10 min, 11.9 L min^{-1}, 31.25 mA cm^{-2}, 2.8 and 41.25 mg L^{-1}, giving a discoloration efficiency of 88.8 ± 0.3 %, close to 95.5 % predicted by the model. To validate the AI model, the same experimental conditions were applied to treat wastewaters with Bromothymol blue and Thymol blue, with analogous structures to Bromophenol blue, and a mixture of the three dyes by EO. In all cases, the loss of color decayed following a pseudo-first-order kinetics, with similar apparent rate constants. For the dye mixture, 69 % COD was reduced at 60 min, with 13 % average current efficiency and 0.26 kW h (g COD)$^{-1}$ energy consumption. The AI model is a strong tool to design, control and operate the EO process with a BDD anode to treat wastewaters with similar dyes.

1. Introduction

Advanced oxidation processes (AOPs) are widely used for the depollution of wastewater with recalcitrant pollutants such as synthetic dyes, pharmaceuticals, herbicides and pesticides. These technologies have several advantages against conventional wastewater treatments methods. While biological treatment technologies have good removal efficiencies against wastewaters with high biodegradable organic load, they are very inefficient for treating wastewaters with high content of refractory pollutants (Wu et al., 2018).

Among the pollutants of interest, synthetic dyes have been received recently great attention because they are hardly treatable by conventional methods. When these pollutants enter the water bodies can cause several environmental implications like aesthetic problems and reduce the penetration of sunlight to the water. Moreover, some of these compounds are considered as endocrine disruptors and it is well-know that can originate some types of cancers (El-Ghenymy et al., 2014; Mendoza-Mendoza et al., 2018)

To avoid all the environmental implications caused by the discharge of synthetic dyes, powerful advance oxidation methods are required for the effective degradation of these pollutants prior to their disposal into the natural water streams (Nidheesh and Gandhimathi, 2012; Solano et al., 2016; Mendoza-Mendoza et al., 2018). Among the electrochemical advanced oxidation processes, electro-oxidation (EO) is the most used process because of its high efficiency to destroy synthetic dyes with the expenditure of

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