Influence of agitation rate on a semi-industrial photoreactor for olive mill wastewater treatment by photo-Fenton reaction

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Olive mill wastewaters (OMWs) generated in the Mediterranean countries present an environmental problem due to its high organic load and the presence of toxic and inhibition growth compounds such as residual oil matter and phenolic compounds. The various attempts to treat OMWs by conventional methods have not yielded satisfactory results due to the recalcitrant nature of the organic material contained in OMWs (Thanekar, Panda and Gogate, 2018).

Advanced oxidation processes (AOPs) have the capacity to degrade biodegradable and non-biodegradable compounds, in addition to a wide number of persistent organic compounds (Oller, Malato and Sánchez-Pérez, 2011). Photo-degradation with artificial UV-irradiation lamps can accelerate the degradation of pollutants more than dark degradation (Fenton Reaction), (García and Hodaifa, 2017).

METHODOLOGY

Crude OMWs were collected from an olive oil mill in the province of Seville (Spain) during the month of October 2019. These OMWs corresponding to wastewaters from olives and olive oil washing machines.

The experiments were performed in a batch stirred photo-reactor with total capacity of 10 L. In these experiments, OMWs without any pre-treatment are mixed to obtain a constant initial organic load.

Photo-Fenton reaction was carried out in presence of H_2O_2 and $FeCl_3$ as catalyst. The $[FeCl_3]/[H_2O_2]$ ratio was equal to 0.03. The initial pH was adjusted to 3 with hydrochloric acid solution (37%, w/w). 7.5% (w/v) of H_2O_2 solution was added at a constant flow rate equal to 3.2 L/h during the first 15 minutes of the reaction. A temperature control system was used to maintain the reactor temperature at 20 ºC. UV irradiation light was supplied through medium pressure UV immersion lamps. During the experiments, samples at different times were collected.

RESULTS AND DISCUSSION

As it can be observed in Fig. 1 the photo-degradation is performed in two steps. The first step, an instantaneous reaction (t < 3 min) with conversion values higher than 0.45 in all experiments. In this sense, the conversion values recorded, at this step, have raised with the augment of the agitation rates, and the highest TOC conversion recorded equal to 0.66 was obtained when operating at 500 rpm. In the second step, a slower reaction rate where take place, registering different reaction velocities for each agitation rate studied. At the end of this step, the highest TOC conversion value (85% approximately after 90 min) was determined for 300 rpm.

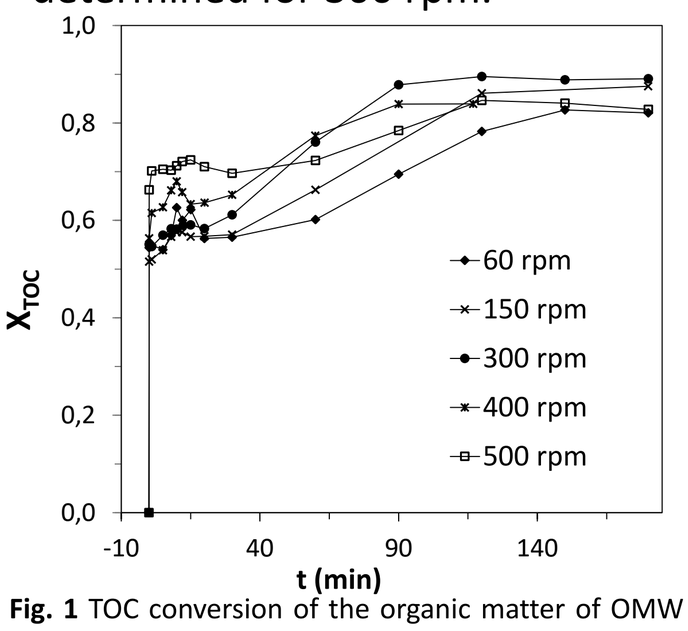

Fig. 1 TOC conversion of the organic matter of OMW during the experiments. Common operating conditions: Initial average TOC of OMW = 854.2±261 mg/L, initial pH = 3, $[H_2O_2]/[FeCl3]$ = 0.03 and temperature = 20 ºC.

Fig. 2 shows the TOC removal percentages registered at different times throughout the photo-reaction experiments. In all cases, the TOC removal percentages were increased throughout the reaction. The global removal percentages was decreased when the agitation rate exceeded the 300 rpm.

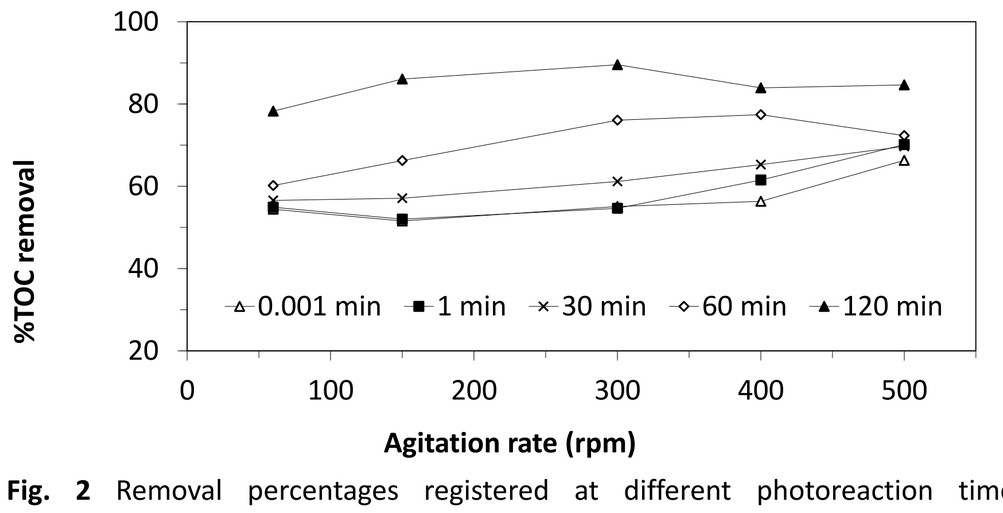

Fig. 2 Removal percentages registered at different photoreaction times throughout each experiment performed for the different agitation rates. Common operating conditions: Initial average TOC of OMW = 854.2±261 mg/L, initial pH = 3, [H2O2]/[FeCl3] = 0.03 and temperature = 20 ºC.

CONCLUSIONS

At this scale, the best agitation rate used is 300 rpm and the photo-degradation time needed is higher than 60 min. In these conditions, the TOC removal percentages expected are in the range from 76% to 90%.

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