

Sonoelectrochemistry applied to degradation of methyl paraben

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Introduction

Several pollutants of water, like the methyl paraben (MePa), an organic compound used in cosmetic industry as a preservative, are suspected to interfere in hormone action, presenting endocrine disrupting effects¹. Recent progresses in Advanced Oxidation Processes (AOPs) include environmental sonochemistry, which involves the application of ultrasound to induce *in situ* cavitation to destroy or to accelerate the removal of liquid-phase contaminants².

Experimental

Degradation of MePa solution (100 mg L⁻¹ in 0.05 mol L⁻¹ K₂SO₄ aqueous solution) under sonochemical and sonoelectrochemical conditions was investigated, using a frequency of 20 KHz and 523 W of electrical power. The energy dissipated in the reactor was measured by a calorimetric method³. The sonoelectrochemical and electrochemical systems consist in a one-compartment pyrex cell (400 mL) with temperature control at 35 ± 1 °C. A BDD electrode with geometric area 9.68 cm² was used as anode and a platinum wire with the same area as cathode. The reference electrode was an Ag/AgCl coupled to the transducer. The 120 minutes electrolyses were performed using 10.8 mA cm⁻².

Results and Discussion

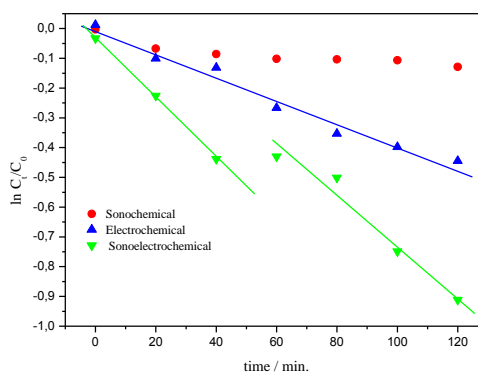


Figure 1: MePa concentrations decay with electrolysis time for the treatment of 100 g L⁻¹ in K₂SO₄ 0.05 mol L⁻¹ aqueous solutions, considering the different process indicated in the figure.

Table 1: Kinetic and energetic parameters for galvanostatic oxidation of methyl paraben where CE is the current efficiency and EC energetic consumption

j_{app} (10.8 mA cm ⁻²)				
Process	k_{ap} 10 ⁻³ min ⁻¹	CE (%)	EC (kW h m ⁻³)	TOC _{removal} (%)
Sonochemical	-----	-----	-----	9.09
Electrochemical	2.35	27.73	2.03	26.51
Sonoelectrochemical	-----	56.35	2.02	51.79

Figure 1 shows the concentration decay as a function of the electrolysis time and the kinetic analysis of the concentration decay indicate pseudo first-order reaction with $k_{ap} = 10^{-3} \text{ min}^{-1}$ for the electrochemical process. The degradation mechanism is based on generation of hydroxyl radicals that react with the MePa molecules. In the sonoelectrochemical process the degradation tendency changes between 40 and 60 minutes of electrolysis, i.e. the degradation rate has two distinct regions. One possible explanation is that at this point phenol is formed and because its volatility the predominant step of the mechanism is the fragmentation process occurring inside the micro bubbles. In this case, the predominant process is pyrolytic until the formation of aliphatic compounds. There is a competition between the thermolytic and radicalar mechanisms justifying the concentration decay profile, considering the formation of the aliphatic compounds.

The degradation process is controlled by mass transport where $CE < 100\%$, indicating a consequence of the value of current applied, 10.8 mA cm^{-2} , above the limiting current value. This decrease in current efficiencies may associate to secondary reactions as O_2 evolution and H_2O_2 generation. The best results were obtained for the sonoelectrochemical process that showed a synergic effect.

Conclusions

Only sonolysis is not effective for MePa removal but its effect can be intensified coupling another efficient removal process like the electrochemical process, to obtain better degradation conditions.

Acknowledgements

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References

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