1. Introduction

Cavitation events are widely used to treat a large variety of water pollution [1]. High power ultrasonic waves propagation in an aqueous medium generates cavitation bubbles with high temperature and pressure. Moreover highly reactive oxidising species are formed from water sonolytic rupture. These radicals can oxidise organic pollutants such as organic compounds in dilute aqueous solution.

Chlorinated organic compounds such as dichloromethane, trichloroethylene (TCE) and perchloroethylene (PCE) are excellent solvents and are used in different industries such as dry-cleaning, metal cleaning and vapor degreasing. These organic compounds are toxic and harmful, and are highly persistent in the environment. Removal of these compounds from water is not easy. In literature it can be found some methods, (known as advanced oxidation processes (AOPs)), used in the treatment of these compounds, such as photolysis [2], Fenton’s reaction [3], ozonolysis [4], but all have their own drawbacks. Several works point out that ultrasound ultrasonic waves can be considered as advanced degradation process, due to hydroxyl radicals generation during the water sonolysis and/or high temperature and pressure. At present, the ultrasound treatment is showed to be an alternative method in the degradation of different organic compounds such as PCBs, phenols, benzene derivatives and dyes.

The aim of this work is to evaluate the degradation of perchloroethylene aqueous solution by ultrasonic and electrochemical methods.

2. Experimental set-up

Figure 1 shows the equipment used in sonochemical experiments. In all experiments 200 cm³ of solution was irradiated with 20 kHz ultrasonic waves at 20°C during 5 hours. The electrochemical treatment was carried out with a lead electrode (0.2x3.5x2.5 cm³) as cathode, a lead dioxide electrode (0.5x4.5x2.7 cm³) was used as anode and 0.05M Na₂SO₄ as background electrolyte. In figure 2 it can be seen a sketch of the electrochemical cell used. In these experiments a current density of 4mA cm⁻² was applied.

PCE degradation and formation of subproducts were monitored using Ion exchange chromatography (IC), high performance liquid chromatograph (HPLC) and Purge and Trap Gas Chromatography Mass Spectrometry (PT-GC-MS). Aqueous and gaseous phases were analyzed.

3. Results and discussion

3.1.- Sonochemical degradation of PCE

3.1.1.- Initial concentration of PCE

First parameter to analyze was PCE initial concentration. These experiments were carried out with three PCE initial concentrations: 14, 65 and 100ppm.

3.1.2.- Ultrasonic intensity

Sonochemical treatment was carried at different ultrasonic intensity. In figure 4 it can be observed the effect of ultrasonic intensity on PCE degradation. Figure 5 shows the concentration variation of main products of degradation with the reaction time. TCE, DCE and chloride anion were the major products obtained at the end of the degradation and PT-GC-MS analysis showed traces of CHCl₃, CCl₄, hexachloroethane, hexachlorobutadiene and hexachloropropene after 5 hours of ultrasonic irradiation. Table 1 shows the yield of chloride ion obtained at different ultrasonic intensities.

3.2.- Electrochemical degradation of PCE

In this work the electrochemical degradation of PCE were carried out in a divided cell, and the PCE solution was used as catholyte. Figure 6 shows the PCE normalized concentration decay with the time. Experimental results show PCE was cathodically degraded, decreasing the solution concentration to values lower than 6% of the initial value with a yield of chloride formation of 35%. Figure 7 shows the concentration variation of the products of degradation with the reaction time. TCE, DCE and chloride anion were the only products obtained at the end of the reaction.

4. Conclusions

In this work it was analyzed the degradation of perchloroethylene in aqueous solution by ultrasonic and electrochemical methods. PCE solution was degraded by two method, but higher yield of chloride formation were achieved with electrochemical degradation. Moreover it is important to emphasize that the reaction products detected by the GCMS analysis obtained after the sonochemical degradation are different to those ones obtained by electrochemical degradation. This fact could indicate different mechanism of degradation.

5. References


6. Acknowledgements

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