



NOTE

Ultrasonic Decomposition of Organic Compounds in Wastewater

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The simplicity in design and use by small-scale in ultrasonic presented a chemical device for treatment of contaminated water. The environmental problem in the petrochemical fields are wastewater and organic pollutants. The effectiveness of ultrasound reactor in decomposition of organic pollutants in aqueous media was studied. Decomposition rate of organic compounds affected by factors such as the ultrasonic power, time, concentration, pH and temperature. Decomposition degree of benzoic acid increased with increasing ultrasonic power. It was observed that H_2O_2 has negative contribution on the decomposition of benzoic acid.

Key Words: Ultrasound, Benzoic acid, Wastewater, Treatment.

The objective of wastewater treatment is to decrease undesirable pollutants. Ultrasonic irradiation has received considerable interest as an advanced oxidation process because it leads to rapid degradation of chemical contaminants in water^{1,2}. Sonication of aqueous solutions induces the formation and collapse of cavitation bubbles. During the collapse high temperatures and pressures are obtained, leading to the formation of chemical species such as hydroxyl radicals. Those high-energy appearance causes degradation of organic compounds in aqueous solutions³⁻⁶.

The application of ultrasound alone are not sufficient for the treatment of pollutants in an aqueous media, because the time scale and the dissipated power necessary to mineralize different chemical pollutants are not economically feasible. Ultrasonic processes can be used as a preoxidation step before biological treatment⁷. Thus, complex compounds in the wastewater are converted into lower molecular weight compounds before discharging it into a classical wastewater treatment plant. In addition, sonochemical treatment can be combined with other techniques to increase the efficiency of destruction⁸⁻¹¹.

During the preoxidation steps, destruction of longer chain aliphatic acids or aromatic compounds had formed lower acids such as formic acid, benzoic acid and acetic acid, which are also pollutants and also sometimes these low molecular weight compounds are difficult to oxidize by the established methodology¹². It is necessary to characterize the ultrasonic destruction of such lower acids to avoid undesired reactions

prior to complete biological degradation to produce a clean effluent^{13,14}.

Benzoic acid is used in metal treatment, textiles, plastics, chemicals, powders, catalysts, photography and wood bleaching. However, benzoic acid and its solutions are corrosive, toxic and poisonous, neither its crystals nor its solutions should be discarded to the environment without proper treatment. In addition, it is one of the human health hazards^{15,16}.

In this project, benzoic acid was sonicated in an ultrasonic reactor. The effects of parameters such as ultrasonic power, hydrogen peroxide, temperature were investigated on the degradation degree of benzoic acid.

Sonication of benzoic acid was done with an ultrasonic reactor. A 200 mL pyrex glass-spherical vessel (20 mm in diameter with a wall thickness of 0.9 mm) was used as reactor. The solution of benzoic acid was sonicated directly and the jacket condenser cooled the solution during the reaction.

The amount of benzoic acid remaining unconverted in the reaction mixture was determined by titration with 10^3 M NaOH solution with phenolphthalein as indicator (2 % in weight). Dilute (10^3 M) NaOH solution was used so that the readings of titration were in the range of 10-11 mL, with the least count of the burette used as 0.01 mL.

For a typical run, 200 mL of aqueous solution of benzoic acid was charged to the reactor. A run took 3 h and each run was repeated at least two times. Representative samples withdrawn periodically were analyzed by volumetric titration. The effects of parameters such as ultrasonic power, H_2O_2 ,

temperature were studied on the ultrasonic degradation degree of benzoic acid.

Effect of time: 200 mL solution of benzoic acid with a concentration of 200 ppm was sonicated directly at 40 °C at different period. Fig. 1 shows the results for the effect of exposure time on the degradation of benzoic acid. When reaction time is increased at the same reactor area, ultrasound intensity increases (Fig. 2). An increase in ultrasound intensity means an increase in the degradation.

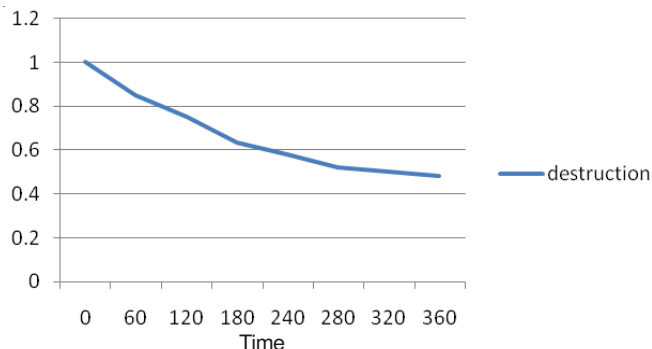


Fig. 1. Effect of exposure time on the degradation of benzoic acid

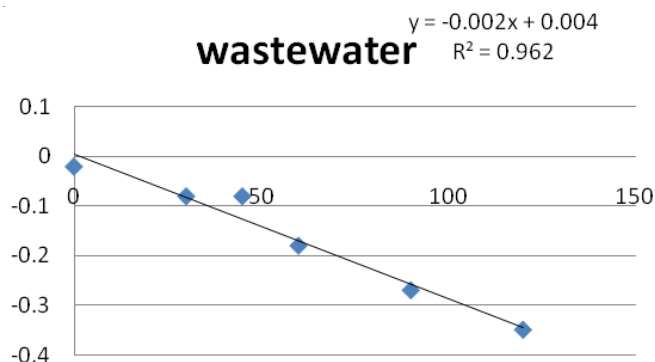


Fig. 2. Reaction rate of destruction of benzoic acid

On the other hand, when reaction time is increased transmittance of ultrasonic energy into the reactor increases. Due to this energy, the number of cavitation bubbles increase and realizing a higher concentration of OH radicals into the aqueous solution of organic pollutant. These OH radicals react with the pollutant in the solution. Due to this radical reaction the degradation of benzoic acid increases.

Effect of H₂O₂ addition: According to the theory of hot spot, the temperature and pressure of localized hot spots formed can excessively reach 5000 K and 1000 atm respectively in the ultrasonic cavitation. Under these conditions, hydrogen peroxide readily decomposes into hydroxyl radicals causing high degradation rate.

Sonication experiments were repeated with benzoic acid solutions including H₂O₂. Hydrogen peroxide was added to 200 mL benzoic acid solution with initial concentration of 200 ppm in such amount that its concentration was 0.04 or 0.08 M in solution.

Fig. 3 displays the effect of H₂O₂ amount added to benzoic acid solution. As seen from Fig. 3, in the concentration range studied the amount of H₂O₂ added has negative contribution on the degradation of benzoic acid when compared with the

absence of H₂O₂. Increasing the amount of H₂O₂ decreases the degradation of benzoic acid. The degradation degree of benzoic acid remains always below the degradation obtained in the absence of H₂O₂. The lower degradation degree in the presence of H₂O₂ may be attributed to the increased level of OH scavenging by the pollutant and by H₂O₂ itself. As known well, during the sonolysis of aqueous solutions, OH and H are generated by the thermolysis of water in the solution medium and H₂O₂ can scavenge hydroxyl radicals produced.

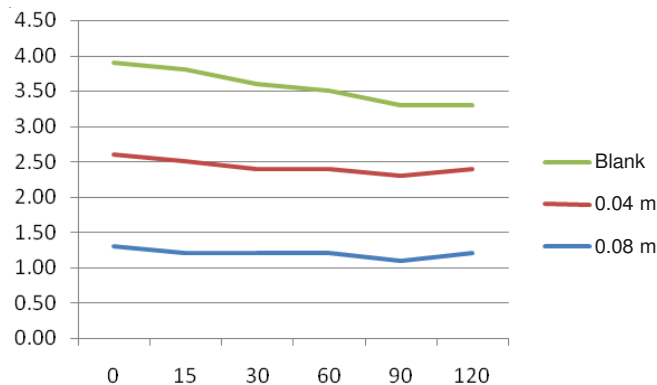


Fig. 3. Effect of H₂O₂ on the destruction of benzoic acid solution

Conclusion

In this study, ultrasonic degradation of benzoic acid was studied indirectly using the ultrasonic reactor. The effects of parameters such as reaction time and H₂O₂ were investigated on the degradation degree of benzoic acid. Degradation degree of benzoic acid increased with increasing time. It was seen that, in the concentration range studied, the amount of H₂O₂ added had negative contribution on the degradation of benzoic acid. Increasing the amount of H₂O₂ decreased the degradation.

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