Sonochemical degradation of estradiols: Incidence of ultrasonic frequency

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ABSTRACT

This paper presents an experimental study of the ultrasonic degradation of organic pollutants in terms of the effect of ultrasonic frequency (40–380–850–1000 kHz). The removal efficiency of two endocrine disrupting compounds [17\(\beta\)-estradiol (E2) and 17\(\alpha\)-ethinylestradiol (EE2)] is investigated using laboratory scale ultrasonic baths at low power intensities. Higher ultrasonic frequencies were found to be more effective for pollutant degradation with 850 kHz the best: \(9.0 \times 10^{-3}\) mg/kW h for E2 and \(6.8 \times 10^{-3}\) mg/kW h for EE2 at initial concentrations of 1 ppm. Additionally, the removal of p-nitrophenol was investigated under the same conditions, as a dosimetry reaction for estimating the hydroxyl radical production, key component in organic pollutant removal. In order to describe the overall phenomena occurring inside the reactor and to predict the apparent hydroxyl radical production, a simulation algorithm is proposed. It incorporates the solution of ODE systems that embodies bubble dynamics, heat and mass transfer through the bubble wall and chemical reactions in the gas–vapor phase for an initial bubble nuclei population. The experimental degradation measures of p-nitrophenol over the range of frequencies studied were found to be comparable with the model results of hydroxyl radicals produced during the sonication treatment.

ARTICLE INFO

Article history:
Received 17 April 2012
Received in revised form 10 August 2012
Accepted 23 August 2012
Available online 31 August 2012

Keywords:
Sonochemistry
Estradiol
Numerical simulation
Advanced oxidation process
Ultrasound frequency

1. Introduction

In recent years a number of new and complex chemical compounds have appeared in the effluent streams of wastewater processing plants as direct result of human activities; among the compounds causing most emerging concern are a group of organic pollutants such as estradiol, known as endocrine disruptor chemical (EDC). The discharge of EDCs (particularly estrogenic hormones) into the environment affects water quality and also impacts on the health of wildlife and humans [1–3]; moreover, several researchers attribute some changes observed in reproductive and developmental effects to the presence of EDCs in water [4–6]. Effluents from treatment plants are a major source of \(\beta\)-estradiol (E2) and 17\(\alpha\)-ethinylestradiol (EE2) across the globe because conventional wastewater treatment is not effective in...