

Effect of TiO₂ concentration for sonophotocatalytic degradation of Bisphenol A

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1. Introduction

When ultrasound was applied in aqueous solution, cavitation bubbles produces with extremely high temperature and pressure. The collapse of a bubble transfers the high energy to the interfacial region, where the dissolved organic pollutants in the aqueous phase can undergo a transformational reaction via pyrolysis and a radical reaction. The hydrophobic compounds directly diffuse into the cavitation bubbles, which were decomposed by high temperature and pressure. Conversely, the hydrophilic compounds were mainly degraded at the interfacial region by radicals generated from the inside of cavitation.

Bisphenol A (BPA) is one of the endocrine disruption compounds (EDCs) that has been widely used in the plastic industry [1-3]. This compound presents in low levels of aquatic environments. BPA can be degraded by traditional physical, chemical and biological treatments, but the degradation rates were low and high EDC or toxicity compounds were produced [2]. Recently, advanced oxidation processes (AOPs) have been adopted for enhancing the degradation rate and mineralization of organic compounds. And ultrasound can be applied to a combination of AOPs. These combination processes produce higher OH radicals than individual systems (Bisphenol A [1,2,4], dyes [5,6]). However, the results of the optimum processes and dose of catalysts for degradation of organic compounds differed from previous research [7,8].

The aim of this study is to compare the BPA removal rates and mineralization under sono, photo, and sonophotocatalytic processes. The effects of ultrasonic frequency and catalysts concentration were examined in sonophotocatalytic processes.

2. Experimental Procedures

BPA (99+% purity) was obtained from Sigma-Aldrich. High purity powders of TiO₂ (Degussa) was used. The initial concentration of BPA was 10 mg/L (0.044 mM) and the total volume of the solution was 1 L.

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The concentration of catalyst in an aqueous solution was 3.2 mM. Experiments were performed in a cylindrical water jacketed pyrex reactor. Fig. 1 shows the schematic of the reactor.

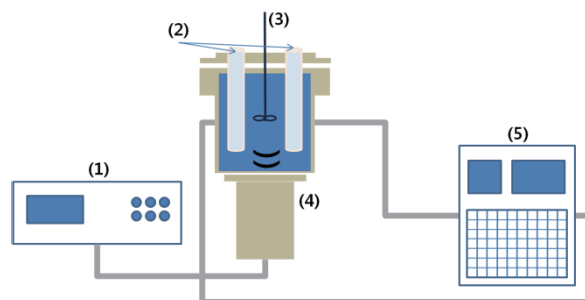


Fig. 1 Schematic diagram of the sonophotocatalytic reactor: (1) ultrasonic controller, (2) UV lamp, (3) mixing system, (4) cup-horn type transducer, (5) cooling water system.

The 300, 500 kHz and 1 MHz were individually irradiated by the MX-300, MX-500 and Megasonic (Mirae Ultrasonics Tech., Korea) with single PZT (Tamura corp.). The diameter of the transducer was 10 cm at three frequencies (300, 500, 1,000 kHz). The delivered ultrasonic energy was measured by a power meter (METEX; M-4660M). The range of delivered power was between 67 and 75 W. Four UV-C lamps (Sankyo Denki) were used for photolysis and sonophotocatalytic reactions. Each UV lamp delivered 6 W. A mixing system was used for the catalyst in solution and the mixing rate was 300 rpm. Samples were taken every 20 min for analysis of total organic carbon (TOC) and BPA concentrations during a period of 120 min. The suspension was then filtered with a syringe filter (0.45 μm, Whatman). BPA and the total organic carbon (TOC) concentration were analyzed by high performance liquid chromatography (HPLC; Dionex, Ultimate 3000) and TOC analyzer (GE, SEIVERS 5310 C laboratory analyzer).

3. Result and discussion

The Fig. 2 (a) shows the sono, photo and sonophoto degradation of the BPA in aqueous

solution. The degradation rate of BPA was higher at 500 kHz than 300 kHz and 1 MHz. The cavitation event was more violent at low frequency than high frequency. However, at high frequency the acoustic period is shorter and the size of cavitation bubble is decrease.

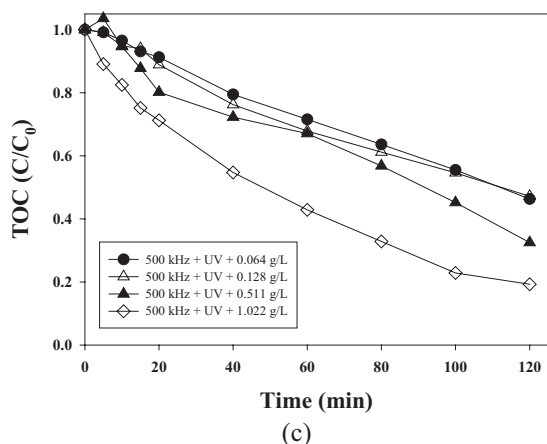
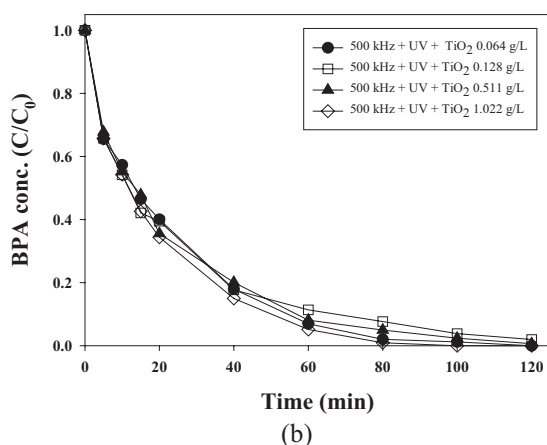
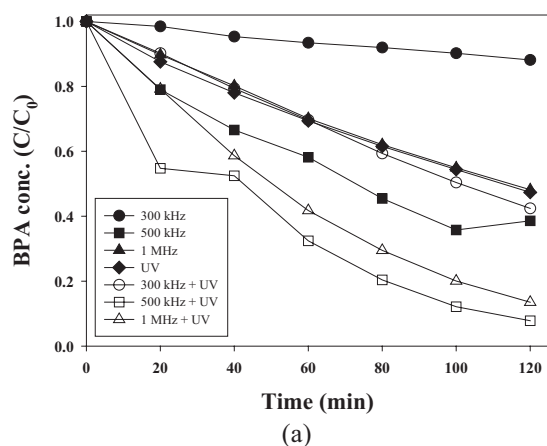


Fig. 2 Sono, photo, sonophoto and sonophotocatalytic degradation of BPA (a) sono, photo, sonophoto degradation of BPA, (b) sonophotocatalytic degradation of BPA (c) mixing system.

As consequence the most of formed radicals have enough time to recombine. As a result, at high frequency makes high H_2O_2 concentration in aqueous solutions, which can the higher degradation rates of non-volatile compounds than low frequency. Therefore, we can choose a 500 kHz for sonophotocatalytic process. When individual UV and ultrasound was applied to the BPA solution, 50 % of BPA was degraded. The sonophoto process can degrade over 90% BPA solution within 2 hours. But the amount of TOC was almost the same as the initial concentration of TOC. To enhance the degradation of BPA and TOC, a sonophotocatalytic process was adopted in this study and effect of concentration TiO_2 was determined.

Sonophotocatalytic process can make the 100% of BPA and TOC degradation within 120 min (**Fig. 2(b), (c)**). The degradation of BPA is faster than TOC, because some organic compounds cannot degrade. Therefore, some previous researches put some catalysis or H_2O_2 , combination of photocatalytic process for enhancing TOC degradation. And higher concentration of TiO_2 (1.022 g/L) can make higher degradation of TOC (80% decrease within 2hrs).

Further research was needed the effect of several of catalysts on the degradation of target materials and mineralization. And various kinds of catalysts shapes/types were needed to solve the recovery of catalysts.

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