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The effects of pH on the sonolysis of PCE

Qiongyuan Gao‡ (Korea Univ.), Myunghee Lim (Korea Univ.), Sunmee Kim (Korea Univ.),
Jongtae Kim (Korea Univ.), Younguk Kim (Myongji Univ.), Jeehyeong Khim (Korea Univ.)

1. Introduction

Perchloroethylene (PCE) is widely used as a organic solvent and suspected to bring about cancer [1]. Though the solubility of PCE to the water is very limited, it is one of the most frequently detected pollutants in the groundwater [2, 3].

Many processes such as UV/H_2O_2 system [1], biodegradation [2, 4, 5] were used for the degradation of PCE. However, every method has its own limitations such as low rates of degradation, production of more toxic by-products, and so on. Sonication, the application of ultrasound, for the degradation of PCE could be an attractive means in terms of its higher effectiveness [6-8].

In the sonochemical degradation of contaminants, the effect of pH, which plays an important role in the most of treatment process in the environmental field, was also investigated in some previous studies [9-12].

The effect of pH and the extent of pH drop during the sonochemical degradation of aqueous phase PCE were evaluated in this study.

2. Experimental section

The sonochemical degradation of aqueous phase PCE was carried out using batch reactor. At first, the drop of pH was measured with adjusted initial pH and then the pH was controlled constant with buffer solution.

The experiments were carried out in a vessel containing 480ml of solution with a capacity of 500mL. The temperature was kept constant at 20±1℃.

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hyeong@korea.ac.kr

For sonication, a laboratory sonicator having a maximum power capacity of 750 W (Sonics & Materials, VCX750) was used. Frequency and power intensity applied to the batch reactor were 20 kHz and 0.58W/mL, respectively. The horn tip diameter is 13mm.

PCE (98.0%), buffer solution of pH 3 and 10 were purchased from Samchun Chemical (Seoul, Korea). Tap water after purifying with a Milli-Q system (resistivity=18.2 MΩ cm) was used. Initial aqueous phase concentration of PCE was adjusted to 30 mg/L. The solutions with initial pH 3, 5, 7, 10 were prepared by using NaOH (0.1N, Samchun) and H_2SO_4 (0.1N, Samchun).

Sample aliquots (1mL) were extracted every 30min from the aqueous solution. PCE concentrations were analyzed by GC-FID (Agilent Technologies 6890N). The pH of solution was determined by pH meter (Thermo Orion model 420A).
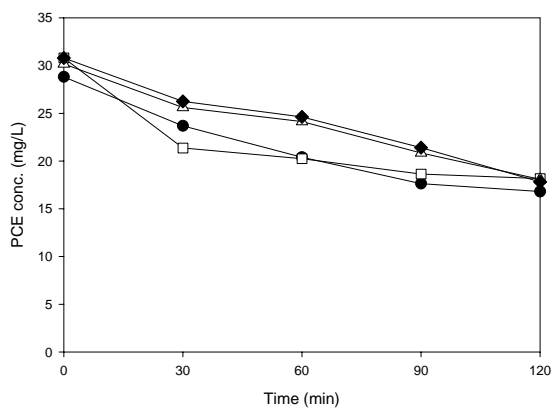
3. Results and discussion

The degradation of PCE and drop of pH from the initial pH adjustment only were shown in **Fig. 1**.

Though the reaction rate seemed slightly faster in low initial pH but the effects were not significant. as shown in Fig. 1(a) and it agreed with the previous study [12].
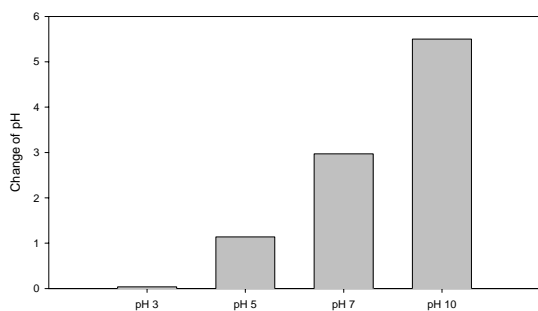
As the degradation occurred by the sonication, the pH dropped significantly down to 3-4. The big drop of solution pH was observed at the high initial pH. Regardless of difference of initial pH, during sonication, the pH of the solution was decreased to below 4.5. The dechlorination process could cause the increase of pH. However, as the degradation of PCE by ultrasound was an oxidation process by pyrolysis and radicals, the pH of the solution drops. Also, the formations of HCl and other acid species were pointed out as the cause of pH drop [12-14].

(a)

(b)

Fig. 1 The degradation of PCE at various initial pH ((a): (initial pH: ●: 3, □: 5, △: 7, ◆: 10), (b) extent of pH drop after sonication for 120min)

But in case of using buffer solution, there is no pH change (less than 0.1 pH unit) during sonication [13].

The results obtained at the constant pH of 3 and 10 with buffer solutions were given in **Fig. 2**. As observed in the Fig. 1(a), the pH of the solution was not a critical variable in the reaction rate of sonochemical degradation of PCE.

The results from this study showed that the pH condition of the aqueous solution did not make much difference in the sonochemical degradation of PCE. However, the pH drop was very significant and the final pH of the aqueous solution is around 4 with given condition.
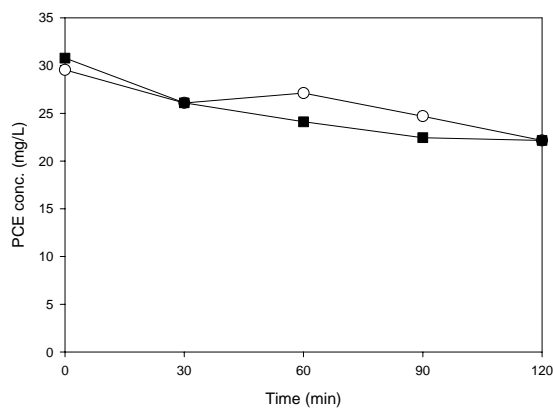

Fig. 2 Degradation of PCE using buffer solution (○: buffer pH 3, ■: buffer pH 10)

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