

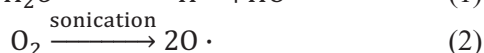
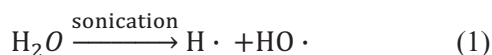
## The effects of initial concentration and frequency on sonochemical degradation of phenol

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### 1. Introduction

Phenol is one the most common contaminants in wastewater of chemical industries. Improper treatment can introduce phenol to water body, which is the big concern to people because of its damage on human health even at trace concentration. Because of its aromatic structure, phenol is stable and resistant to biological oxidation that cannot be treated by conventional method to meet the new stringent environmental regulation. AOPs (advanced oxidation processes) have shown the good alternative because OH radical produced in AOPs can effectively oxidize phenol [1-3]. Among of AOPs, ultrasound has been received the great attention due to its cavitation effects.

Cavitation is the process of formation and collapse of small bubbles introduced to liquid by ultrasonic irradiation. This process causes a local extremely high pressure and temperature that result in the formation of radicals [4]. The sonication of water produces radicals inside bubbles that as shown in Eq [1-4]:



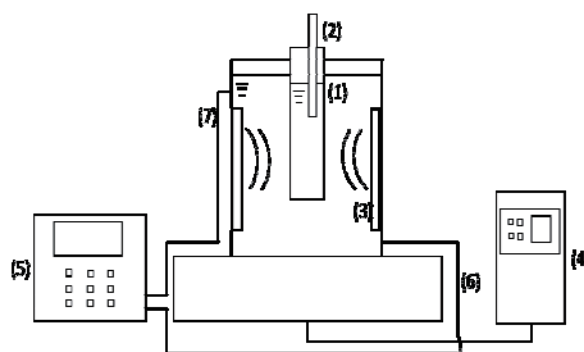
Radical oxidation is the main mechanism of phenol degradation [5] and it closely depends on ultrasonic frequency [6]. Some optimal frequencies have been reported to exist. Petrier et al found that phenol degradation was favored at higher frequency and 200 kHz is the optimum among 20, 200, 500 and 800 kHz [6]. Kidak et al showed that phenol degradation at 300 kHz is that best compared with 20 and 520 kHz [7]. And it is noticeable that at high concentration, the phenol oxidation reaction is zero order [8] but at small concentration the reaction is pseudo-first reaction [7].

In this research we aim to investigate the impact of initial concentration together with frequency on sonochemical degradation of phenol.

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### 2. Experimental

For all experiments, high purity deionised water was used. Phenol (99%), potassium ferro cyanide (98%), 4-aminoantipyrine (98%), aminium hydroxide (28-30%),  $\text{KH}_2\text{PO}_4$  (99%) were purchased from Samchun and  $\text{K}_2\text{HPO}_4$  (99%) was purchased from Kanto. Phenol was analysed by direct photometric method.



**Fig.1** Experiment scheme for ultrasound batch. (1) reactor, (2) thermograph, (3) transducer, (4) ultrasound controller, (5) cooling system, (6) cooling water inlet, (7) cooling water outlet.

Ultrasound batch from Mirae ultrasound Corp was used and could produce of 35, 72, 100 and 172 kHz frequency. In the experiment 35 and 172 kHz frequencies were used and their calibrated power intensities were 2.9 and 1.85 W/ml kHz, respectively.

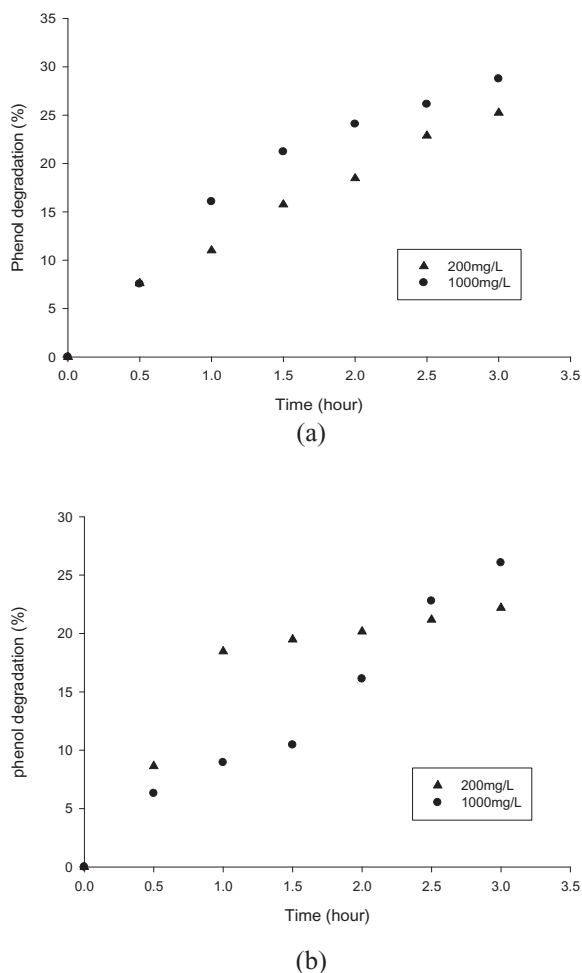
The solutions were prepared at concentrations of 200 and 1000 mg/L. 500 ml of solution was contained in glass wall reactor and sonicated for 3 hours. At every 30 minutes, 5 ml of sample was taken for phenol analysis.

During experimental processes the temperature was controlled at  $24 \pm 0.5^\circ\text{C}$

### 3. Result and discussion

The effect of initial concentration and frequency in phenol solution is shown Fig. 2. The rate of decomposition increased with increasing input concentration of phenol. Those results were same with two frequencies. In case of non-volatile compounds, main degradation process provoke in

interface of cavitation bubble. At high concentration of solutes may accumulate during the formation and growth of bubbles. Therefore, high concentration of non-volatile compounds can make the high degradation rate. Those results same with previous research [9].



**Fig.2** Phenol degradation at different initial concentration and frequency

In case of frequency effect, 35 kHz condition can make higher degradation rate of phenol than 170 kHz. The cavitation event occurring at a low frequency is more violent and efficient on the inside of the cavitation bubble. However, at a low frequency the acoustic period is shorter than a high frequency. Previous results present that optimum frequency presence with compounds.

The degradation rate of non-volatile compounds at higher frequencies (200, 500, 800 kHz) is faster than at lower frequencies (20 kHz) [6]. More researches with frequency under the same experimental conditions (same calorimetric power and reaction volume) and several of frequencies

were needed.

### Acknowledgments

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### References

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