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Sonoelectrochemical treatment of pesticide

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1. Introduction

Recently, various kinds of pesticides have been monitored in an aqueous environment over a wide region around the world [1-3]. Considering their potential threat to human health [4] and bio-refractory property [5], it is crucial for us to develop an efficient treatment technology to remove them.

To deal with this issue, many researchers have studied advanced oxidation processes (AOPs) such as photocatalytic oxidation, sonochemical oxidation, electrochemical oxidation, etc. Out of these AOPs, electrochemical oxidation features its eco-friendly advantages including requiring no-additional chemicals, consuming electrical power solely. However, there is a challenge that needs to be overcome, which is its low energy efficiency [6].

Ultrasound can be adopted to enhance the energy efficiency of electrochemical treatment promoting mass transfer and activating electrode surface.

The objective of this work is to study the effect of operating conditions on degradation kinetics of 2,4-dichlorophenol in sonoelectrochemical treatment.

2. Materials and Methods

2.1 Chemicals

2,4-dichlorophenol was purchased from Sigma-Aldrich and used as received. Sodium sulfate as supporting electrolyte was supported by Samchun Chemical. Deionized water for all the solutions used in this work is from Millipore Milli-Q.

2.2 Sonoelectrochemical system

Sonoelectrochemical system consists of three components, which are electrochemical (EC), sonochemical (US) and thermostat equipment. Schematic design of the whole systems is shown in **Fig. 1**.

For electrochemical equipment, platinum (coated on Ti, mesh type, width: 6 cm, height: 7 cm) and stainless steel (mesh type, width: 8 cm, height: 7 cm) were used as anode and cathode respectively and electrical power was provided by regulated DC power supply (PNCYS EDP-3010).

Ultrasound generator and transducer for sonochemical equipment were purchased from Mirae Ultrasound, Korea. Transducer was installed at the bottom of the reactor.

Cylindrical reactor with cover (diameter: 10 cm, height: 15 cm, solution volume: 1 L) was made of stainless steel and equipped with water jacket.

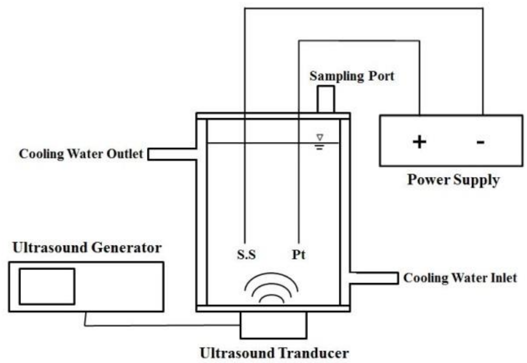

Fig. 1 Schematic design of sonoelectrochemical system

2.3 Analytical Method

2,4-dichlorophenol concentration was analyzed with HPLC equipped with ZORBAX SB-C18 column (4.6 mm ID × 150 mm, 5 μm) and G4212B 1260DAD Detector (λ=222 μm). Temperature of the column was kept at 35 ℃ constantly. The mobile phase was phosphoric acid, deionized water and acetonitrile in the volumetric ratio of 1:39:60 with a flow rate of 1.5 mL min^{-1}.

Kinetic constants were calculated with assumption of pseudo first reaction.

3. Results and Discussion

Kinetic studies were conducted varying frequency and power density. Kinetic constants obtained from each experiment are summarized in **Table. 1.**

3.1 Effect of frequency

72, 300, 700 kHz of ultrasound were applied to sonoelectrochemical system at 50W/L power density. As shown in **Fig. 2**, 72 kHz of sonication showed the best removal efficiency and the fastest kinetic constant.

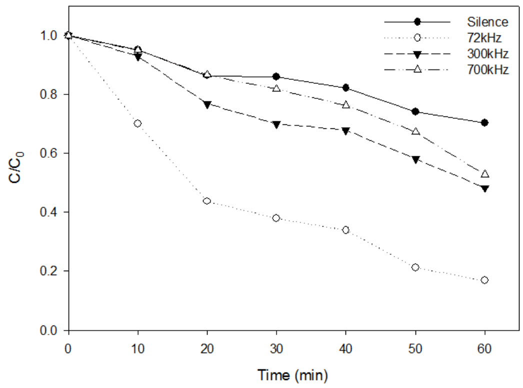

Fig. 2 Degradation of 2,4-dichlorophenol at different frequency

Differences in removal efficiencies and kinetic constants are due to the mechanistic effect of low frequency ultrasound that is not valid for high frequency ones.

Table. 1 Summary of kinetic constants

	k (min^{-1})	R^2
Effect of frequency		
Silence	0.0057	0.9694
72kHz	0.0305	0.9681
300kHz	0.0113	0.9728
700kHz	0.0086	0.9076
Effect of power density		
70W/L	0.0491	0.9871
50W/L	0.0305	0.9681
35W/L	0.0400	0.9826
20W/L	0.0312	0.9677

3.2 Effect of power density

2,4-dichlorophenol was also treated with different power densities and results are shown in **Fig. 3**. At the highest power density of 70W/L, it showed the highest kinetic constant value. This is due to the number of cavitation bubbles induced by ultrasound. More bubbles can be generated with higher power density and bigger synergistic effect can be obtained.

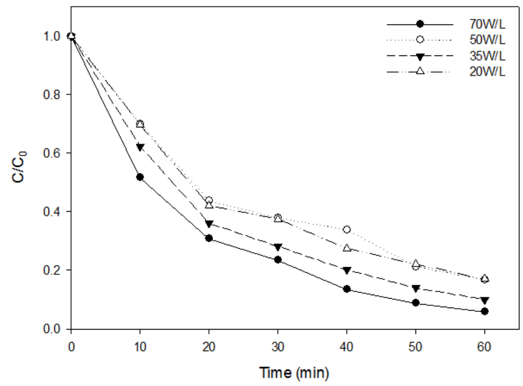

Fig. 3 Degradation of 2,4-dichlorophenol at various power density

4. Conclusion

2,4-dichlorophenol was treated in sonoelectrochemical system at various frequencies and power densities. Low frequency was more efficient posing more synergistic effect and high power density exhibited better performance.

Acknowledgment

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