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Investigation of chemical effect and energy distribution in sonophotoreactor

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1. Introduction

In recent years, the studies using ultrasonic (US), ultraviolet light (UV), and a combination of US/UV process for degradation of organic pollutants were investigated many researchers. When US is applied to the aqueous phase, numerous cavitation bubbles including the formation, oscillation and implosive collapse occur continuously and locally in micro-scale. Cavitation event is caused by chemical (OH radical formation) and physical effects (microjet, micro-streaming, shock wave) [1,2].

Direct photolysis has been always considered as one possible alternative because it is possible for molecules of most organic compounds to transform, to cleave bonds, and even to undergo complete destruction in the presence of UV irradiation causing dissociation of the oxidants and formation of highly reactive pollutants which produce hydroxyl radicals that attack the organic pollutants [3,4].

In the combination process using both the US and UV has been studied for enhancing the degradation of target compounds. However, the design of reactor using combination of US and UV processes is insufficient [5-7].

The purpose of this study was designed to optimize the sonophotoreactor. The specific objectives of this investigation is to analyze UV and US intensity distribution and chemical effects of each energy. And the relationship of both measured energy and chemical effects has to be determined.

2. Experimental Methods

The sonophotoreactor was used in this study consisted of a stainless steel with the bath type reactor (L : 0.6m, H : 0.25m, W : 0.11m). (**Fig. 1**) The water level fixed with 16cm and the volume of 10L. Solution used the distilled water.

The UV lamp (SANKYO DENKI, wavelength : 254nm, Diameter : 2.2cm, Length : 18.5cm) is placed at the center of the wall as shown in **Fig. 1**(a). The maximum electric power consumption of the UV lamp was 10.5W.

The electric power consumption of UV lamp was measured as power meter (M-4660m, METEX). Radio Meter (VILBER LOURMAT, RMZ – 3W, France) was used to measured the UV intensity. The area of Radio Meter sensors is 1.767cm^2. And UV intensity was measured by width direction and the reflected UV intensity from stainless steel was disregarded.

Fig. 1(b) shows the measurement of US intensity. The transducer contained PZT transducer (Tamura Corp.) and could produce an ultrasound of 283kHz frequency. The maximum power of the transducer was 80W. Reflected energy in the wall was ignored. The US intensity measured from the center of wall to the opposite wall using a cavitation meter(ppb, pb-308). The area of cavitation meter sensor is 15.08cm^2. The data of measured intensity was derived an 1 cm interval horizontally.

Chemical effect of UV and US intensity was measured by KI method. Potassium iodide (Junsei, 99.5%) was used. The concentration of I_3^- was measured by UV-vis spectrophotometer (Analyticjena, SPECORD 40, Germany) [8,9].

Progressed after investigation for 1hour by potassium iodide(KI) solution 35mL in quartz tube (Diameter: 2cm, Length: 30cm, thickness: 2cm) at each location. The concentration of the KI solution is 10g/L. The horizontal between 100~10% were measured by KI oxidation.

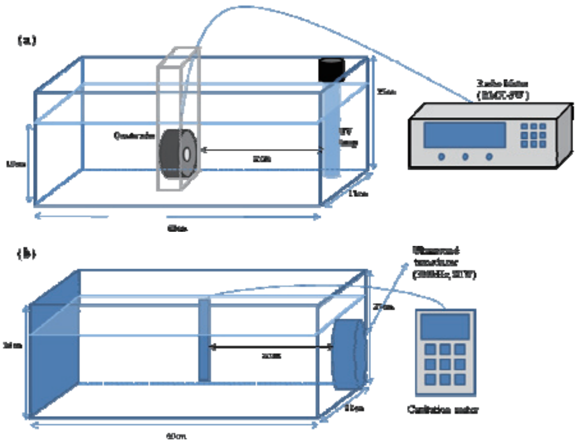

Fig. 1 UV and US intensity measurement experiment

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US and UV experiment were identical using the same conditions like temperature, quartz tube, investigation time, KI solution concentration, etc were keeps similar.

3. Results and Discussion

Fig. 2 was shown the UV intensity and chemical effect horizontally. The UV intensity was decreased by increasing the horizontal direction. The measured value of UV intensity at 10cm was 0.526 mW/cm^2. Compared to the initial intensity (1.327 mW/cm^2) there was 60% decrease in the value. It was indicated that UV intensity was scattered and adsorbed in water. The chemical effect was decreased by distance. Absorbance and intensity were decreased from 3cm (I_3^-conc. : 0.5717, intensity : 1.327 mW/cm^2) to 13cm (I_3^-conc. : 0.2265, intensity : 0.392) .

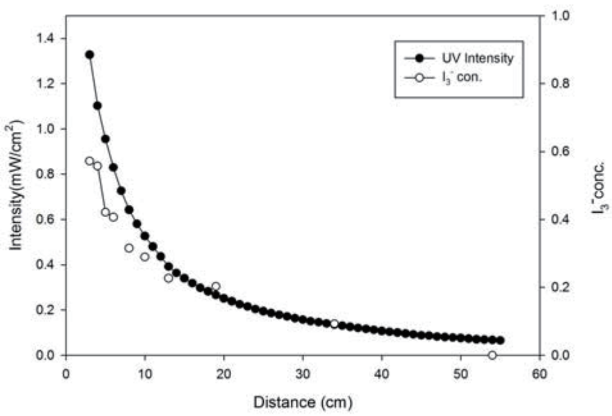

Fig. 2 UV(254nm, 10.5W) intensity and chemical effect horizontally

The according to the data, the reactor was design. This optimized design of the reactor is expected to have a significant impact the UV intensity and chemical effects.

Fig. 3 shows the intensity of ultrasound, similar to the intensity of UV to decrease the distance. In addition to obstacle (UV lamp) in front of ultrasound transducer to install the UV lamp is the result of the intensity. In the presence of UV lamp, the intensity of ultrasound was measured at 7 cm distance from ultrasound transducer edge. It is because of the US intensity which significantly reduced about 90% due to UV Lamp which worked as barrier.

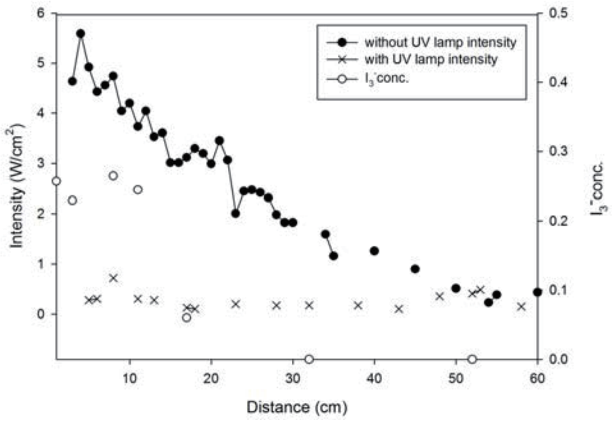

Fig 3. US (283kHz, 80W) intensity (with obstacle, with obstacle) and chemical effect horizontally.

4. Conclusion

As a result of chemical effects on the UV lamp that causes a reasonable distance within 10cm, and the intensity of UV of the above conditions must be 0.328 W/cm^2 was concluded. And chemical effects of US causes the distance is less than 13cm. Compared with experimental results in UV which did not show significant difference. The intensity of US condition should be more 6.234 W/cm^2 was concluded.

As a result, chemical effects of UV (254nm, 10.5W) and US (283kHz, 80W) for generating a valid distance is within the expected 10 ~ 13 cm.

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