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Sonochemical degradation in presence of particle

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1. Introduction

Sonolysis has been carried out as one of the oxidation processes recently. Sonochemical degradation is applied to the removal of organic pollutants in aqueous solutions due to cavitation effects [1,2]. The cavitation effects can be divided as pyrolysis and generation of OH radicals. Pyrolysis is a chemical degradation effect which occurs in the cavitation bubble under extreme conditions, high temperatures of about 4000-5000 K and high pressures. The generation of OH radicals are dissociated in water. The OH radicals which are formed by ultrasound irradiation attack the organics in the bulk solution.

Especially, adding particles such as Al_2O_3 and quartz used as sonocatalyst seems to make more cavitation phenomenon for increasing bubbles by providing nuclei site. According to the researchers, the particle can decreases the cavitation threshold and enhances the cavitation power [3,4]. Also the growth of bubble which stick to surface of concave makes caviation when the particle is irradiated by ultrasound [5]. However, this mechanisms are not clear yet, and it is unknown that the insert of particle affect pyrolysis or OH radical production.

A. Keck at al. [6] explained that the nature and concentrations of particle did not influence, but T. Tuziuti et al. [3] found that the result was different depending on the amount of particle.

The object of this study is the enhancement of cavitation phenomenon with particle according to the ultrasonic frequency and the amount of particle at specific particle size.

2. Material and Method

The particle was quartz in which the median size measured using Mastersizer 2000 (Malvern Instruments Ltd.) was 35 μm and the amount of particles was changed from 0.1 to 10 g/L. The reactor type was cup-horn type (Mirae Ultrasonic Tech.), it was placed on the transducer conneted along with sonicator. The volume of solution was 500 mL as shown in Fig. 1. The input power was measured by power meter (METEX M-4660M), it was around 90 W, and the range of frequency was 35-930 kHz. The temperature was fixed at 25±1 ℃ by using water jacket.

For measuring the amount of OH radicals, KI oxidation dosimetry was used [7]. The initial concentration of KI was 10 g/L, and the absorbance for calculating the concentration of I_3^- was at 355 nm using UV spectrophotometer (Analytik jena). The total irradiation time was 1 hr, and the samples were taken at 10 minute intervals.

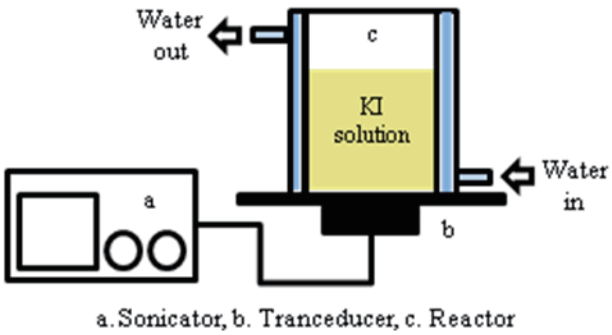

Fig. 1 The schematic experimental set up.

3. Result and Discussion

The particles which are used as sonocatalyst increase the generation of OH radical. However it depends on ultrasonic frequency, size and amount of particles.

In Fig. 2, the experimental result in this study is that the increasing amount of OH radical presented were not 35 kHz but at 283, 930 kHz. At 35 kHz, the particle inhibited slightly for generating radical regardless the amount of particle and this is similar the past research [6]. The average of relative $k_{Abs.}$ means that the kinetic constant with particles ($k_{Abs.}$) divided by without particle is as shown in Fig. 2. And the kinetic constant is the amount of I_3^- which represent the increasing amount of OH radical per unit time.

The constants of attenuation in the ultrasound intensity equation is related with the particle size. That means the amount of particle and frequency are also connected with the sound attenuation when the particle size is fixed [6]. The sonocatalyst mechanism is known that the additional particle react like nuclei for providing cavitation bubbles [3,4]. This phenomenon takes place on the surface of particle, therefore increasing amount and size of particle are same.

However, the particle do not play a role when the size is so small because the particle and the fluid move together [3], on the other hand the particle which is close to the ultrasonic transducer

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can block the energy input in solution when the size is too big [4]. For these reasons, T. Tuziuti et al. [3] studied the effect of particle at 42 kHz and there were optimal dose when the size was 10 μm. Therefore, the particle size and amount should be considered at the same time, and further study is needed more because it is uncertain whether the similar results using bigger size of particle could appear if the amount of particle increases more at 35 kHz or not.

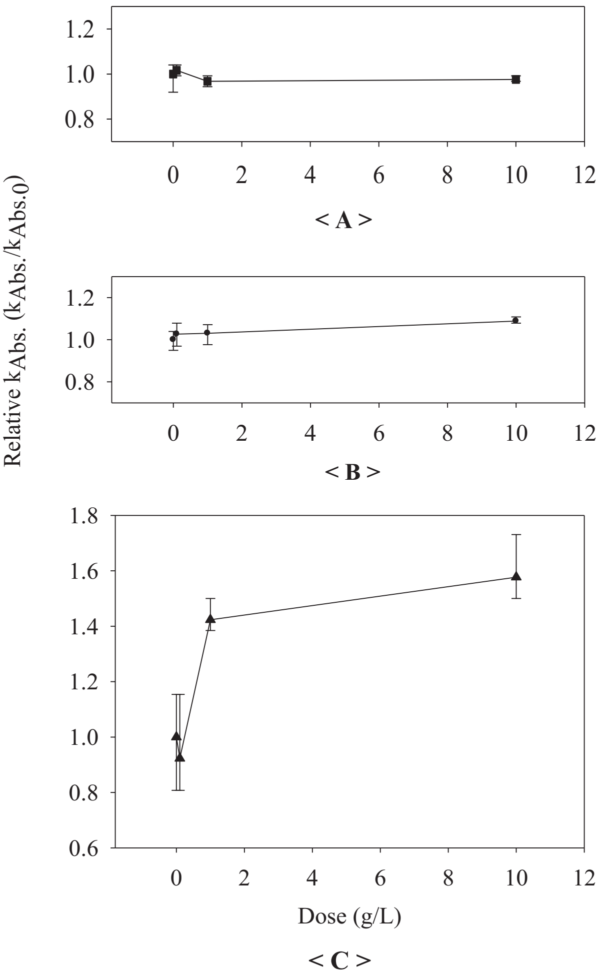

Fig. 2 Relative kinetic constants depending on doses of particles at <A> 35 kHz, <B> 283 kHz, <C> 930 kHz. (Power 90W, Particle size 35 μm, Doses 0.1, 1, 10 g/L

At 283 and 930 kHz, the particle improved the OH radical as the amount of particle increases. As the results divide by the absolute and relative values, the increasing absolute amount of OH radical at 283 kHz was more than that at 930 kHz. This result is same as homogeneous system [8]. However, Fig. 2 shows that the relative values compared with and without particle were higher at 930 kHz than 283 kHz. At high frequency, the cavitation bubbles occur more than low frequency and are stable [9], and the particle could make the OH radical in the bubble dissolve in the bulk phase [6]. Therefore, the quantity of OH radical at high frequency formed with particle in ultrasonic system could be more than that at low frequency with particle.

In other case, A. Keck et al. [6] studied the frequency and amount of particle with different particle size (3 μm), and as the amount of particle increases the generation of OH radical was impeded by particle at high frequency. But the particle size used in experiment was different, so it shows that the two parameters the particle size and amount could affect the production of OH radical. And based on these results, it is possible to improve the degradation of organic pollutants with particle in sonolysis.

4. Conclusion

The objects of this study are the enhancement of cavitation phenomenon with particle according to the ultrasonic frequency and the amount of particle at specific particle size.

The particle size and amount should be considered at the same time, and further study is needed more because there are a lot of uncertainties. And the quantity of OH radical at high frequency formed with particle in ultrasonic system could be more than that at low frequency with particle. Additionally, based on these results, it is possible to improve the degradation of organic pollutants with particle in sonolysis.

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References

1. Y. Son, E. Cho, M. Lim and J. Khim: Jpn. J. Appl. Phys. **49** (2010) 07HE05.
2. M. Lim, Y. Son, B. Park and J. Khim: Jpn. J. Appl. Phys. **49** (2010) 07HE06.
3. T. Tuziuti, K. Yasui, M. Sivakumar, Y. Iida and N. Miyoshi: J. Phys. Chem. A **109** (2005) 4869.
4. N. Shimizu, C. Ogino, M.F. Dadjour and T. Murata: Ultra. Sonochem. **14** (2007) 184.
5. E.N. Harvey, D.K. Barnes, W.D. McElroy, A.H. Whiteley, D.C. Pease and K.W. Cooper: J. Cell. Comp. Physiol. **24** (1944) 1.
6. A. Keck, E. Gilbert and R. Koster: Ultrasonics **40** (2002) 661.
7. S. Koda, T. Kimura, T. Kondo and H. Mitome: Ultra. Sonochem. **10** (2003) 149.
8. M. Lim, Y. Son and J. Khim: Ultra. Sonochem. xx (2010) xxx.
9. N. de Jong, F.J. Ten Cate, C.T. Lancke, J. R.T.C. Roelandt and N. Born: Ultrasonics **29** (1991) 324.