2P4-5

Effect of Frequency on Ultrasonic Degassing

超音波脱気に対する周波数の影響

Yoshiyuki Asakura[1†] and Keiji Yasuda[2]
([1]Honda Electronics; [2]Grad. School Eng., Nagoya Univ.)
朝倉　義幸 [1†], 安田　啓司 [2] ([1]本多電子, [2]名古屋大学・工)

1. Introduction

Degassing of liquid is necessary to high-performance liquid chromatography, ultrasonic cleaner, dialysis and so on. When ultrasound is irradiated to water, degassing, that is, decrease of dissolved gas concentration occurs[1)]. However, the effect of ultrasonic frequency on degassing behavior has not been widely reported. In this study, the change in dissolved oxygen with ultrasonic irradiation time was investigated by using a wide range of ultrasonic frequencies.

2. Experiment

The experimental setup is shown in **Fig. 1**. To circulate cooling water, a vessel with a double layer structure was used. The inside diameter of the vessel was 56 mm. The vessel and vibration plates with a transducer were made from SUS304 stainless steel. Transducers attached to the vessel were a Langevin multi-frequency transducer with 45 mm diameter at the frequency of 22, 43, and 129 kHz, and disk transducers with 50 mm diameter at 209, 308, 400, 514, 1018, and 1960 kHz (Honda Electronics). Transducers were driven by a power amplifier which amplified a continuous sinusoidal wave produced by a signal generator. An effective electric power applied to transducers was calculated from a voltage at both ends of the transducers and a current measured by an oscilloscope and a current probe, respectively, and was constantly controlled by a control system. The ultrasonic power, that is, the energy applied to the sample per unit time was obtained by calorimetry.

Ultrapure water was used as sample. Sample volume and temperature were 100 mL and 298 ± 0.1 K. Dissolved oxygen (DO) in the ultrapure water was measured by the fluorescence dissolved oxygen meter (HQ40d, HACH) to investigate the degassing behavior.

3. Results and discussion

Ultrasound at 15 W of ultrasonic power was irradiated to ultrapure water saturated with air, and ultrasonic frequency was changed from 22 kHz to

Yoshi@honda-el.co.jp

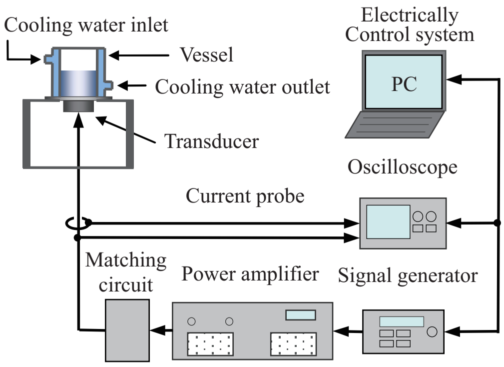

Fig. 1　Experimental setup.

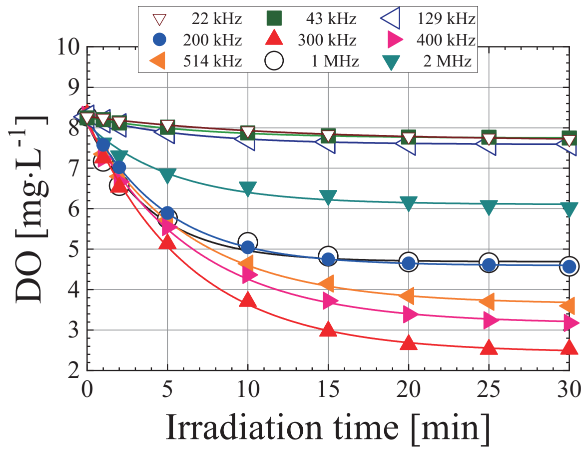

Fig. 2　Effect of ultrasonic frequency on time change of DO in ultrapure water at 15 W

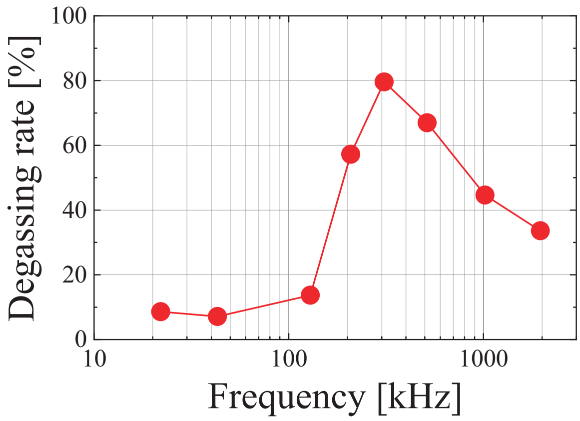

Fig. 3　Dependence of degassing rate on the ultrasonic frequency at 15 W

1960 kHz. The effect of ultrasonic frequency on time change of the DO in the ultrapure water by ultrasonic irradiation is shown in the **Fig. 2**. The DO decreases exponentially with time. **Fig. 3** shows the dependence of degassing rate on the ultrasonic frequency at 15 W of ultrasonic power for 30 minutes. Degassing rate means the ratio of DO to initial DO. At 308 kHz, the degassing rate is maximum and rises to about 80 %.

The effect of ultrasonic power on the degassing rate for various ultrasonic frequencies is shown in the **Fig. 4**. On cross key data, nitrogen is used as gaseous phase in the vessel. In the case of air, as the ultrasonic power becomes higher, the degassing rates firstly increase and after that decrease except for 22 kHz. On the other hand, in the case of nitrogen, the decrease of the degassing rate was not apparent. At high ultrasonic power, it was observed that the water surface moved greatly. Therefore, it is considered that the decrease of the degassing rate with the increment in ultrasonic power is caused by gas flow into the liquid phase from the gaseous phase. **Fig. 5** shows the degassing rate at 209 kHz and 30 W when a plate of polystyrene foam is placed on the water surface. Since inflow of gas from the gaseous phase is inhibited, the degassing rate with the plate of styrene foam increases greatly.

Dependence of sonochemical reaction by the KI method on the ultrasonic frequency at 15 W is shown in **Fig. 6**. In this method, triiodide ion is generated from iodine ion by ultrasonic cavitation. Sonochemical efficiency has also maximum value at 300 kHz. Tendency of frequency dependence of sonochemial efficiency resembles that of degassing rate. Finebubbles in the water repeat expansion and contraction by ultrasonic irradiation, and grow by rectify diffusion[2]. Therefore, the dissolved gas concentration in the liquid decreases due to bubble growth. On the other hand, bubbles grown by ultrasound cause cavitations. Consequently, the frequency dependence of sonochemical efficiency and the degassing rate correlate to each other by cavitation phenomena.

4. Conclusion

It was proved that the frequency dependency of degassing is large, and the frequency dependence of sonochemical efficiency and degassing rate correlate to each other.

5. References

1. N. Gondrexon, V. Renaudin, P. Boldo, Y. Gonthier, and C. Pettier, Chem. Eng. J., **66** (1997) 21.
2. L. A. Crum, J. Acoust. Soc. Am., **68**, (1980) 203.

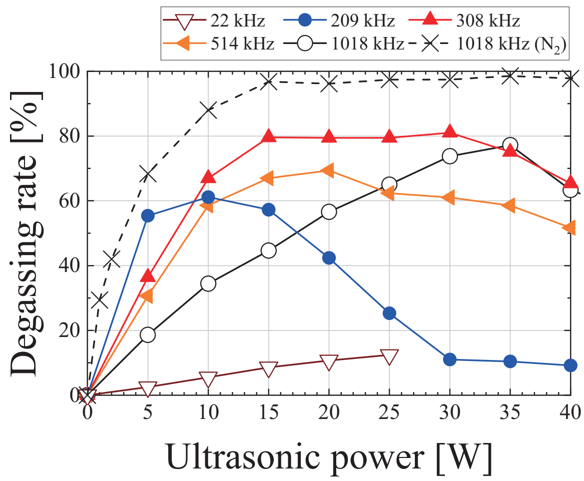

Fig. 4 Effect of ultrasonic power on degassing rate

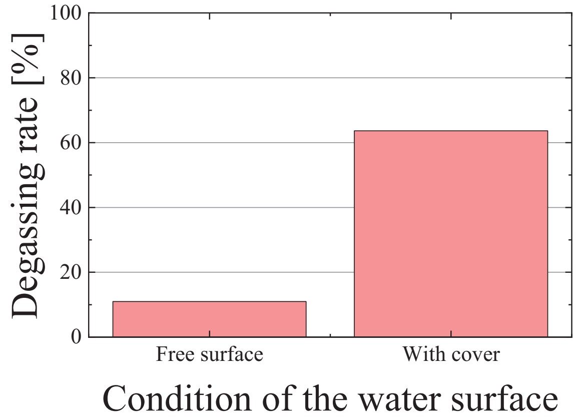

Fig. 5 The degassing rate with and without the plate of polystyrene foam at 209 kHz and 30 W

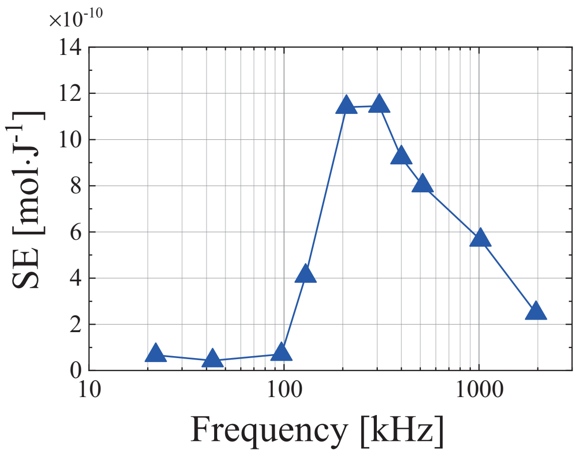

Fig. 6 Dependence of sonochemical efficiency (SE) by the KI method on the ultrasonic frequency at 15 W