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Dispersion effect of nano particle according to ultrasound exposure by using focused ultrasonic field

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1. Introduction

Recently, since the technique of nano particle synthesis has improved, its commercialization has also advanced in fields such as cosmetics, medicine, catalyst, pigments, toner, and ink in which they are used in the state of the colloidal dispersion system and the powder of the low concentration. When synthesized nanosize particles are used as raw material, however, the control of agglomeration and dispersion behavior becomes extremely difficult for particle diameters of 100 nm or less. In the past several years there has been increasing interest in dispersion methods using ultrasonic power for nano particle[1-2]. Because the material dispersed by the method is much purer than that produced by bead milling. We also have already reported a high purity dispersion method using focused ultrasonic field[3]. The present study focuses on the effects of ultrasonic irritation on aqueous suspension of TiO_2 nanoparticles under various exposure conditions.

2. Experimental procedure

To obtain a focused ultrasonic field, an ultrasonic dispersion system was fabricated using a cylindrical piezoelectric vibrator as shown in Fig. 1. A glass tube, whose thickness, diameter, and length measured 0.3, 5.5, and 35 mm, respectively was placed in the center an aluminum water tank.

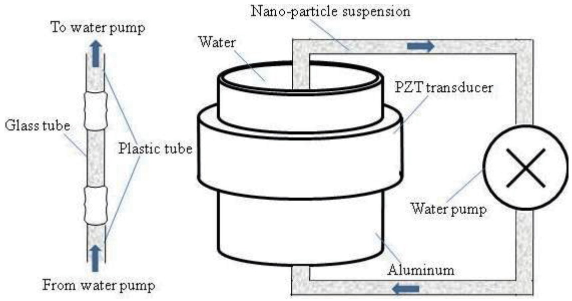

Fig. 1 Construction of ultrasonic dispersion system

Aqueous suspension of TiO_2 (P25) was circulated through a plastic tube connecting the glass tube to a water pump. The aluminum water tank was then inserted into the cylindrical vibrator of 480 kHz resonance frequency.

The water tank of 36 mm inner diameter was filled with water for transmission of ultrasonic energy to the glass tube. The TiO_2 suspension of 0.025 % was circulated with a flow rate of 3 mL/s to prevent change of pH in the suspension[4]. An electric signal from a power amplifier (NF-HSA4014) drove the cylindrical piezoelectric vibrator. The ultrasonic wave from the vibrator was focused on the center of the glass tube. The ultrasonic cavitations due to the high pressure amplitude disperse the nanoparticles in the suspension. The particle size distribution was measured using a particle counter (GRIMM Aerosol Technik).

3. Results and discussion

To obtain the electro-acoustic efficiency of the ultrasonic transducer, the admittance loci were measured as shown in Fig. 2. The diameter of admittance locus is reduced when an acoustic load is loaded on the surface of the vibrator. The electro-acoustic efficiency of the ultrasonic transducer can be obtained by using the difference of the diameter in admittance locus as[5]

$$\eta_{ea} = \frac{|Y_{mo}|}{G_{f_0}}\left(1-\frac{|Y_{mo}|}{|Y_{moo}|}\right). \qquad (1)$$

Here Y_{mo} and Y_{moo} are motional admittance with the acoustic load and the non-acoustic load, respectively. G_{f0} is conductance at resonant frequency with the acoustic load. From the results of Fig. 2 and eq(1), the electro-acoustic efficiency of the ultrasonic transducer was obtained as 48 %.

To investigate the effect of radiation power of ultrasound, the particle size distributions were measured for different input electric powers and exposure time of the ultrasound as shown in Fig. 3. These results show the tendency that the dispersion effect become well as the power and the exposure time of ultrasound increased. In the result of the suspension without ultrasonic irritation, the second peak in the range of 150~300 nm was broken after the strong ultrasound was irritated. It causes the increment in the range of 50~150 nm of the results in the materials dispersed by the ultrasound. It confirmed that the dispersion effect is best when the exposure time is 10 min and the acoustic power is

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about 5.5 W.

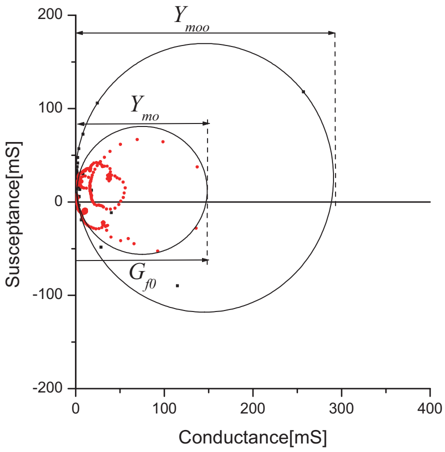
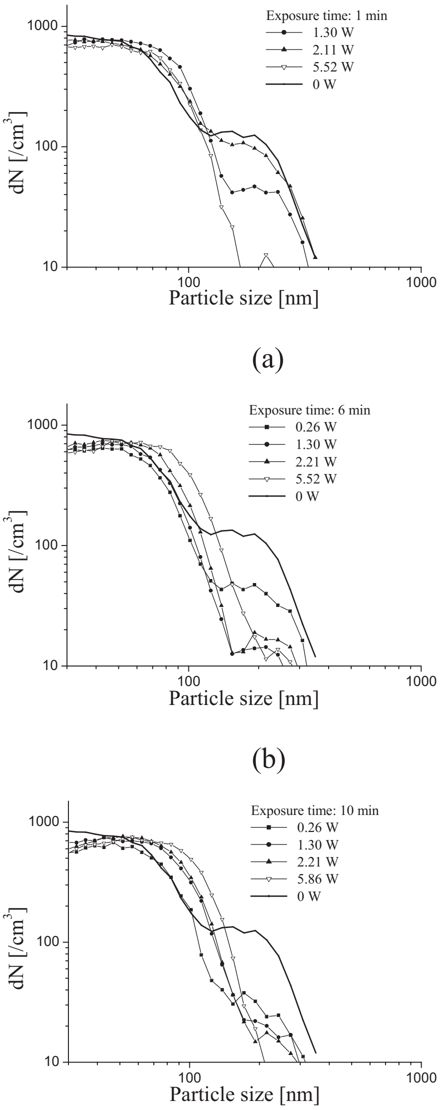


Fig. 2 Admittance loci of the cylindrical transducer.

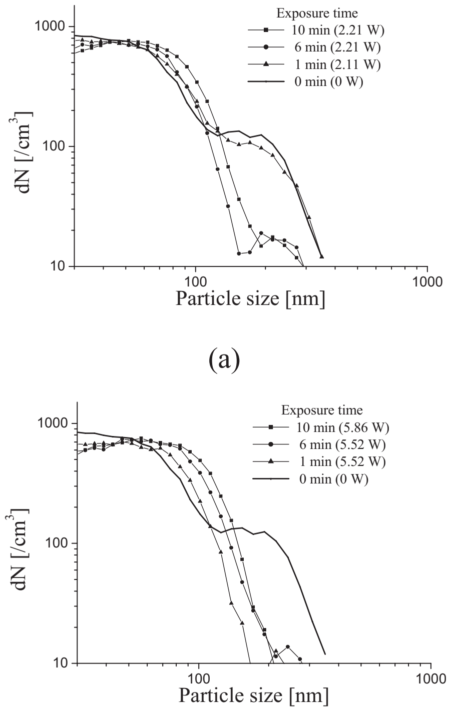


(a)

(b)

(c)

Fig. 3 Dispersion effect according to the ultrasonic power exposed on the suspension of the nanoparticle.



(a)

(b)

Fig. 4 Dispersion effect according to the ultrasonic exposure time.

4. Conclusion

The effects of a focused ultrasonic field on dispersion in aqueous TiO_2 suspension was investigated. The particle size distribution of the suspension was measured for various exposure conditions of ultrasonic irritation. The dispersion effect of the nanoparticles increased as the exposure time and the power of the ultrasound increased. It was concluded that focused ultrasonic irratation is a useful way of pure dispersion of nanoparticles in aggregated aqueous suspensions.

Acknowledgment

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