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Basic Study on Aggregation and Dispersion of Nanodiamond Particles by Ultrasound Exposure
超音波照射によるナノダイヤモンド微粒子の分散と凝集に関する基礎研究

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1. Introduction

Ultrasound material treatment like sonochemistry, emulsification, particle dispersion by using acoustic cavitation have been studied as the investigation using the sonochemical reactor. The investigation on the control of dispersion and aggregation of nano-sized diamond particles by ultrasound exposure using sonochemical reactor are investigating in our laboratory. Recently, Studies of Drug Delivery System (DDS) with nanoparticles is performed. The term of DDS means the system (ingenuity and technology) to act the required drugs on the required time at the required parts of the body. We investigate the DDS by using ultrasound and nano sized diamond particles which are good biocompatible drug career.[1)] Acoustic cavitation bubble occurs when it was irradiated with ultrasound in the solution. Acoustic cavitation bubble generated shock wave and active oxygen. The dispersion and flocculation control using by this shock wave and active oxygen. So far in our laboratory, we've done the only study on the dispersion of nano-sized diamond particles.The purpose of this study is development of aggregation technique of dispersed nano-sized diamond particles and control the size of diamond particles.

This time, the relationship between the the ultrasound irradiation time and particle size of the nano-sized diamond particles and the relationship between the ultrasound irradiation time and the pH in the nano-sized diamond particle suspension were considered in this paper.

2. Experimental method

The powder of 30 mg composed of diamond particles having a nominal primary size of 5nm was used in this study. Our experimental system of surface modification by ultrasound exposure is shown in **Fig.1.** Nanometer sized diamond particles was prepared by suspending 30 mg of aggregated nanometer sized diamond particles in 500 ml of distilled water and stirring fully.[2)]

A stainless vibrating disc with a bolt clamped Langevin type transducer of 40kHz resonance frequency (HEC-45402 Honda Electronics Co,LTD.) was attached on the bottom of a 100mm long, 100 mm wide, and 150 mm high water tank. The output signal from a function generator (AFG-3252 Tektronix) is amplified by using a power amplifier (E&I 2100L) with a gain of 50 dB. The amplified signals are applied to the langevin type transducer. Ultrasound exposure was performed to generate acoustic cavitation in distilled water with suspended diamond particles. After sonication, changes of the size distributions were measured with a size distribution measuring system (Beckman Coulter LS230), and each pH values in the suspension of nanometer sized diamond particles were measured with a pH meter(SK-620PH 、 skSATO) before and after sonication.

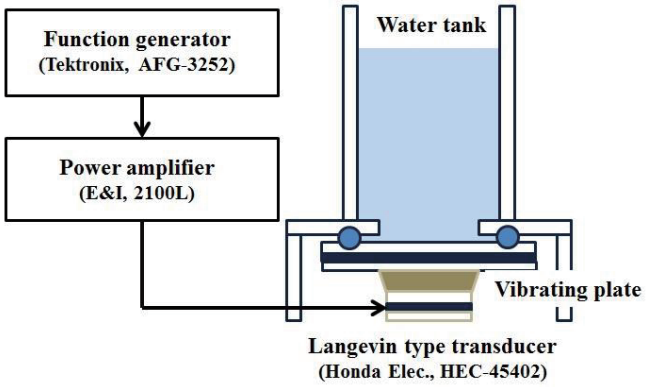

Fig. 1 Experimental system of surface modification by ultrasound exposure.

3. Experimental results

The measurement results are shown in the follows. The measurement results are the relationship between ultrasound exposure time and the sizes of nanometer sized diamond suspension and relationship between ultrasound exposure time and pH in the suspension.

3.1 Change in the particle size after sonication

Changes of size distribution at nanometer sized diamond suspension by ultrasound exposure were evaluated. The nanometer sized diamond size distribution was measured with the particle distribution measurement system. **Figure.2** shows the relationship between the ultrasonic exposure time and the size distributions of the nanometer sized diamond particles in the suspension.

It was found in Fig.2 that the size distribution of diamond particles after 135 minutes sonication was wider than that after 90 minutes sonication.

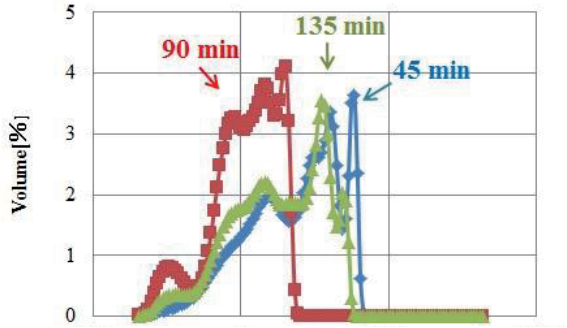

Fig. 2 Relationship between ultrasound exposure time and size distribution of diamond particles.

3.2 Changes of pH after sonication

The change in pH in the sonicated the nanometer sized diamond suspension by sonication time was measured by using pH meter after sonication.Figer.3 shows the relationship between the ultrasonic exposure time and changes of the pH in the particle suspension. It was found by Fig.3 that the pH values changed between 6 and 7 alternatively. Furthermore, it was found by comparing Figs. 2 and 3 that the particle size tends to decrease with increase of pH in the suspension of diamond particle and the particle size tends to increase with decrease of pH.

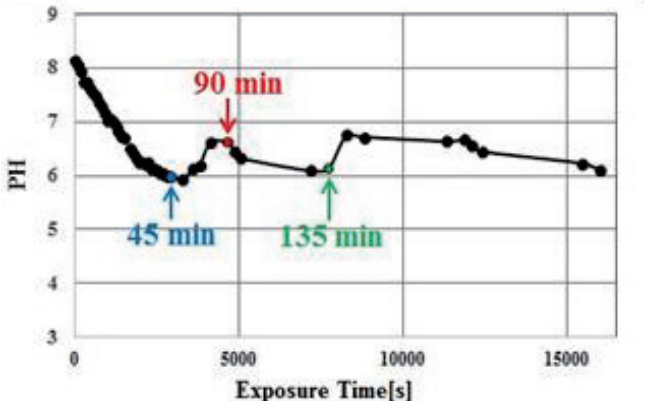

Fig. 3 Relationship between ultrasound exposure time and pH in sonicated nanometer sized diamond particles suspension

It is known that water molecules are dissociated to generate OH radicals which is one type of active oxygen by acoustic cavitation and these OH radicals contribute to surface modification of the nanometer sized diamond particles. Therefore, it can be considered that pH increased during dispersion of diamond particles.

4. Conclusion and future works

The changes of the particles dispersion and pH in nanometer sized diamond particles suspension by sonochemical reaction were measured in this time. Dispersion of the nanometer sized diamond particles is chemical reaction by OH radicals which are dissociated by acoustic cavitation. It was observed that size of nanometer sized diamond particle increased with decrease of pH. The pH value in the diamond particle suspension after 45 minutes sonication was smaller than that after 90 minutes sonication. The size distribution of diamond particles after 135 minutes sonication was wider than that after 90 minutes sonication. I thought with OH radicals were dissociated from the nanometer sized diamond by a number of factors. As a result, I think the pH rises.

We will investigate the following items as future works, i) measurement of the components in the diamond particle suspension after re-aggregation, ii) consideration of conditions for re-aggregation of diamond particles in the suspension, iii) consideration of the effect of pH value in diamond suspension on the size distribution of diamond particles, iv) consideration of the effect of ultrasound intensity and frequency on the size distribution of diamond particles.

Furthermore, we would like to measure the size distribution and pH in the diamond particle suspension in real time.

References

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