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Localization of Ultra High Pressure and Temperature using Methylene Blue Oscillation under Pressure Radiation

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1. Introduction

It has been known that the periodic light pulse from the bubble in the pressure radiation field is the evidence of high pressure and high temperature condition. Some researchers have studied for the nuclear fusion reaction using single bubble sonoluminescence phenomenon. However, in the present paper, we study the multibubble sonoluminescence phenomena as the starting point of this research to achieve very unusual high pressure and high temperature reaction condition. We designed a special device equipped with sonicator to identify the luminescence and to find the optimum power. As an indication of the reaction, methylene blue, a dye, is used to find the decomposition characteristics due to the [OH] radical produced by the MBSL phenomena.

2. Methods and Results

2.1 Apparatus and procedures

An experimental apparatus for multibubble-sonoluminescence consists of sonicator(Mionix, S-4000-010) with titanium horn tip and glass cell inserted into horn tip. The sonicator vibrates horn tip with 20kHz and generates maximum power of 600W. The cylindrical cell whose diameter and height are 20mm and 110mm is located between a horn tip and an adapter and is fixed with three rubber O-rings in the adapter. It secures the position of the cell and a seal between the cell and overall environment. The T-type cell has two hollow arms. One is for the inlet of the argon gas(purity, 99%) and the other is for the outlet. The argon gas is used to keep constant pressure level in the cell. The cell is submerged in water bath in order to prevent the solution inside the cell from going up to high temperature by MBSL. The water bath was designed with acryl(180 x 150 x 160) with thickness of 10mm. The cooled water maintains the temperature of water bath at 15 ℃ by circulating through a thermostat.

To identify the MBSL and visualize it, the still camera(NIKON, D80) with micro lens(NIKON, AF MICRO KIKKOR 105mm 1:2.8D) is used for close-up photography on the bulb mode. Degradation of methylene blue concentration by MBSL was measured with UV Spectrometer(UNICO, UV-2100). The spectrometer has range of 200nm to 1000nm wavelength with stability of ±0.002A/hr.

2.2 Methylene blue degradation

We prepare aqueous MB solution by mixing 500ml of distilled water with 0.1mM of methylene blue(Sigma Aldrich, 99%) and stirring it over 20hrs providing sufficient time on stirrer(CONRNING, PC-420D) set the plate on 20℃. The experimental initial concentration of MB is 0.01mM diluted with 450ml of distilled water with 0.1mM of MB. By following the same method, we also prepared 0.005mM and 0.001mM of MB. Concentration standard curve is obtained with 0.01mM, 0.005mM, and 0.001mM of MB by measuring the absorbency of 664nm wavelength generated by UV spectrometer. The glass cell was filled with the amount of 0.01mM aqueous MB solution 14ml. The horn tip is inserted into the cell and located at the height about 3.6Cm from the bottom of the cell. The MBSL condition was found through many trials and errors. The MBSL was observed in the luminal solution of 0.1mM (Fig. 1) with input power of 1%(6W).

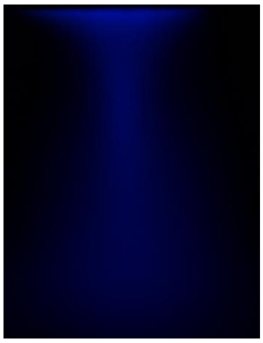

Fig. 1. MBSL at 20kHz on the 1% input power

We increase the input power by 1% from 1%(6W) to 10%(60W) and by 10% from 10%(60W) to 70%(420W). When the horn tip is driven at low acoustic intensity (0.5W/ml ~ 5W/ml), the bright, cone-shaped area directly below the horn existed and ring-shaped light appeared between the horn tip and the bottom of the cell, as we increase the input power at higher acoustic intensity (10W/ml ~35W/ml), the blue light of ring-shaped area become weakend and the only triangular-shaped area maintained its blue light (Fig. 2). The degradation of the concentration of MB under different input power in Fig. 4 indicates similar result of Fig. 3. With lower power consumption, the degradation was much enhanced. The amount of power consumption is almost proportional to the amount of input power.

It is considered that declining the light intensity of the ring-type bright area is caused by quenching effect.

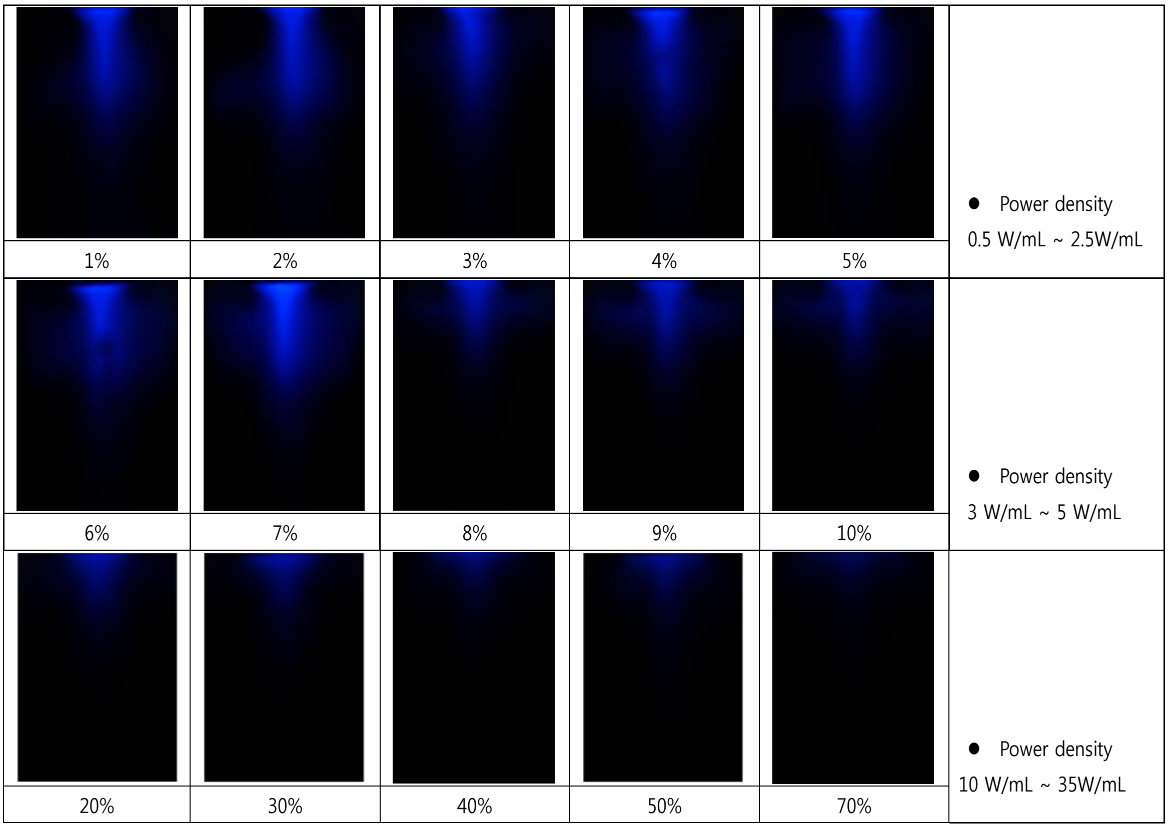

Fig. 2. An aspect of MBSL under different power density

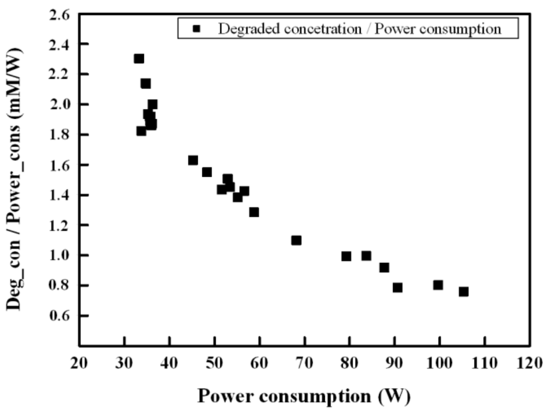

Fig. 3. At low power consumption the concentration of methylene blue was much more degraded

3. Conclusions

In the present study, we successfully design the MBSL reactor which is expected to be used for many applications in the nuclear industry. Quarter of the wave length is the key design parameter to determine the length of the reactor. The visualization study clearly provides that at the low power, below 30W, wider region of MBSL is observed in the rector. Also, the decomposition rate of methylene blue clearly supports that the reactor shows effective MBSL in the low power region.

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