

Basic research on development of cells for measurement of sonochemical reaction in focused ultrasound field

集束超音波音場における音響化学反応計測用セルの開発
に関する基礎検討

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1. Introduction

The acoustic cavitation generated by ultrasound is caused to mechanical damage to human body and tissues. ¹⁾ To assess safety of ultrasound to human body, it is important to estimate the amount of acoustic cavitation generated by ultrasound in MHz range that is used widely in diagnosis and therapy. In our laboratory, the cavitation sensor is developed. Hydrothermally synthesized lead zirconate titanate (PZT) polycrystalline film is deposited on Ti hollow cylindrical pipe in our cavitation sensor. We measured the spatial distribution of the acoustic cavitation in a sonoreactor by using our cavitation sensor. ²⁻⁴⁾ Then we think that it is important to measure the amount of active oxygen species and acoustic cavitation for estimation of damage to human body.

We fabricated original "cell" for measurement of sonochemical reaction. In our previous study, cell was placed at acoustic field, the disturbance to the acoustic field by cell was small. Therefore we used original cell to measure the amount of active oxygen generated by focused ultrasound near focal point. ⁵⁾ The relationship between applied voltage to focused ultrasound transducer as acoustic source and the amount of active oxygen was measured by using original cell. The amount of active oxygen was increased in proportion to applied voltage. However the measurement error was also increased with increase of applied voltage.

The objective of this study is development of the new type cell for measurement of sonochemical reaction and estimation of its availability.

2. Materials and method

2.1. Our conventional cell structure

It was found from our previous study that the cell should have front and rear acoustic windows with thin membrane for transparency of ultrasound without reflection and attenuation. Therefore we used polyvinylidene chloride film (PVDC by Asahi Kasei) with thickness 11 μm . Our conventional cell structure is shown in **Fig. 1 (a)**. The thickness of PVDC is about tenth of ultrasound wavelength. These acoustic windows did not block the ultrasound propagation. As disturbance of acoustic field was decreased by using our conventional cell, the reproducibility of measurement was improved. ⁶⁾

The relationship between applied voltage to focused ultrasound transducer as acoustic source and the amount of active oxygen was measured by using original cell. The amount of active oxygen was increased in proportion to applied voltage. However the measurement error was also increased since the ultrasound propagation was blocked by the bubble cluster at the cell bottom (**Fig. 1 (b)**, and **(c)**). Since the bottom surface of the cell was perpendicular to the ultrasound beam which was shot up vertically, the bubble cluster was easy to trap on the bottom surface. Therefore, we developed the new type cell with original structure. It is difficult to trap the bubble cluster on the bottom surface.

2.2. Our new cell structure

Our new cell structure is shown in **Fig. 2 (a)**. The new cell has the semicircle shaped bottom with radius 15 mm. This bottom did not trap the bubble cluster rushed to the bottom by acoustic streaming. The bottom has the thin PVDC membrane acoustic window with thickness of 11 μm . Therefore, the bottom acoustic window did not block the ultrasound propagation. Furthermore, the surface of PVDC membrane acoustic window was coated with hydrophilic glass coating agent. Thus, it becomes difficult to trap the bubble cluster.

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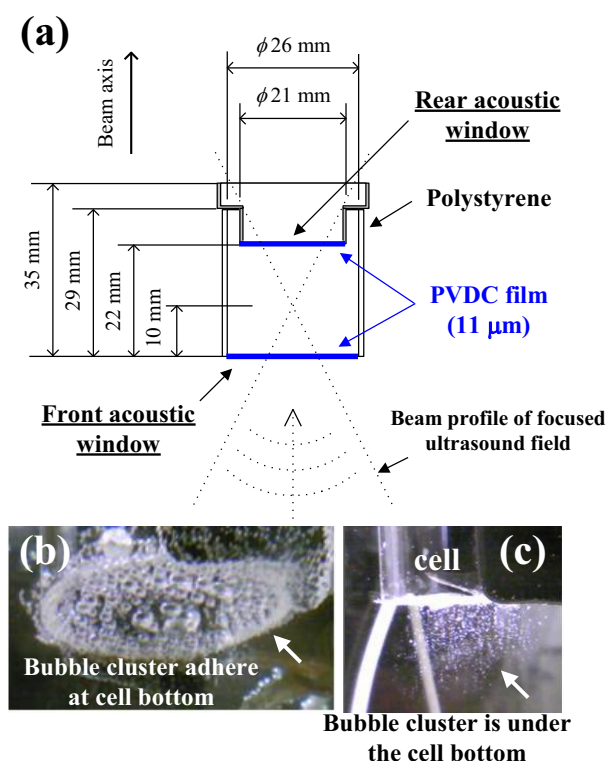


Fig. 1 Schematic diagram and photograph of our conventional type cell for measurement of sonochemical reaction (a) structure, (b) bottom view, (c) side view

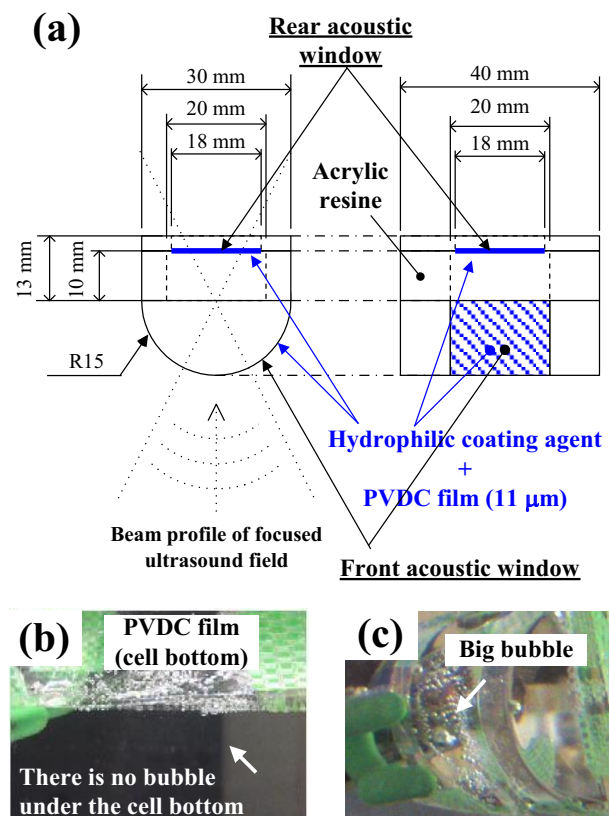


Fig. 2 Schematic diagram and photograph of our new type cell for measurement of sonochemical reaction (a) structure, (b) side view, (c) bottom view

3. Result and discussion

The new type cell was exposed to ultrasound with similar acoustic power to the conventional type cell. We compared at bottom of cell conventional type with that of new type cell.

Continuous waves at 1.78 MHz from a function generator (AFG3252, Tektronix) was amplified by using a RF power amplifier (A300, ENI) with gain of 55 dB. Output amplified signals (CW) were applied to a concave shaped ultrasound transducer (nominal frequency: 1.6 MHz, Material No. C-6, Fuji Ceramics) as the acoustic source. The applied voltage was 257.5 V_{p-p}. The new type cell (in Fig. 2 (a)) was placed at focal point in focused ultrasound field and was exposed to ultrasound.

The results are shown in Fig. 2 (b) and (c). The bubble cluster was trapped at the new type cell bottom with lapse of time. However, the amount of trapped bubble at the bottom of new type cell is extremely smaller than that of the bottom of conventional type cell. We thought the amount of bubble cluster was decreased by using semicircle shaped cell bottom and hydrophilic coating PVDC film on the surface of the cell bottom.

4. Conclusion and future works

We developed the new type cell that inhibit from trapping bubbles on the bottom surface. The amount of trapped bubbles at the bottom surface of the new type cell by ultrasound exposure is extremely decreased. In our future works, we will research about relationship between applied voltage to ultrasound transducer as acoustic source and the amount of active oxygen by using new type cell.

References

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