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マイクロ流路における高導電率溶液中の液中プラズマの放電特性
Discharge characteristics of in-liquid plasma in high conductivity solution on microchannel

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1. Introduction

Applications in the medical and biotechnology fields using atmospheric pressure or in-liquid plasmas have been attracted attention. It is important to elucidate the reaction mechanism between reactive oxygen/nitrogen species (RONS) and microorganisms. Microchannel devices can analyze the function and the response to RONS of individual cells. Therefore, the response of individual cells to RONS produced from the plasma can be analyzed by the combination of the plasma generator and microchannel device. In order to treat cells using an in-liquid plasma on the microchannel, the discharge characteristics of the small-size in-liquid plasma are required to be clarified. In this study, the effect of electrical conductivity of the solution on the current-voltage characteristic of the in-liquid plasma and the plasma treatment to yeast cells was investigated.

2. Experimental

A schematic view of the microchannel is shown in Fig. 1. The microchannel device consisted of three layers (top PDMS/middle PDMS/slide glass substrate). The width and the depth of the flow path were 500 μm. Two tungsten rods with a diameter of 500 μm were used as electrodes and installed at a distance of 500 μm. The through-holes with a diameter of 2 mm were formed at top PDMS layers for inlet and outlet of the liquid sample via silicon tube.

A pulsed power supply based on a magnetic pulse compression circuit was used to generate in-liquid plasma. The input peak voltage was 3 kV, a pulse width was about 1 μs, and a frequency was 250 Hz.

The yeast cells were suspended in a KCl solution on which the conductivity was adjusted to 1.2 to 18.7 mS / cm. The solution containing yeast cells was flowed at a flow rate of 0.35 ml / min by using a syringe pump. The plasma treatment time was 4 minutes. The treated solution was recovered from the outlet. The diluted suspension containing yeast cells was applied to a YPD agar medium and incubated at 30 degree C for 48 hours. The number of survived cells was determined by a colony count method.

3. Results

Fig. 2 shows the number of survived cells as a function of electric conductivity. The number of survived cells was about 9.0×10^2 CFU / ml at the conductivity of 5.0 mS / cm and the inactivation effect was one order of magnitude in comparison with the other conductivity. The production of RONS would be large at the conductivity of 5.0 mS / cm from the results of the current-voltage characteristic and resulting that the effective inactivation was observed.

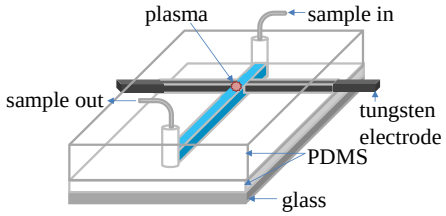

Fig.1 Schematic diagram of microchannel.

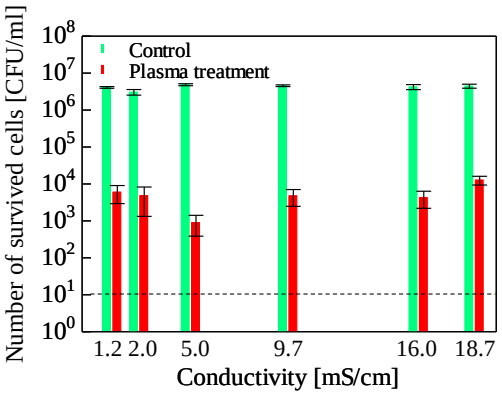

Fig.2 The number of survived cells as a function of electric conductivity.