

Study of bacteria sterilization at low discharge voltage by using microplasma

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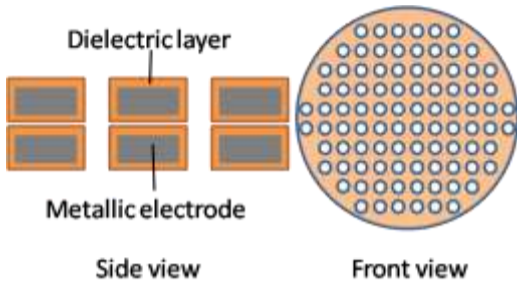


INTRODUCTION

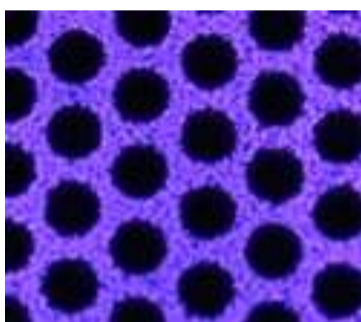
In recent years, infective diseases such as new influenza caused by pathogenic organisms, were spread world wide. It is expected that alternatives to chemical sterilization methods such as new safety sterilizing process using nonthermal plasma to be developed. Therefore we investigated sterilization of bacteria at low voltage by using microplasma.

METHODS

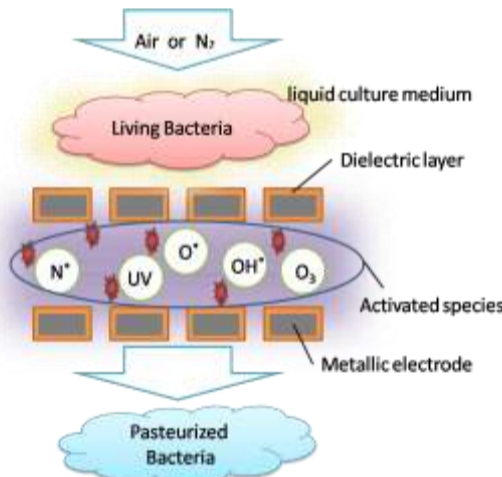
(1) Microplasma Electrodes



Pair of metal plates covered with dielectric materials is used as a dielectric barrier electrode.

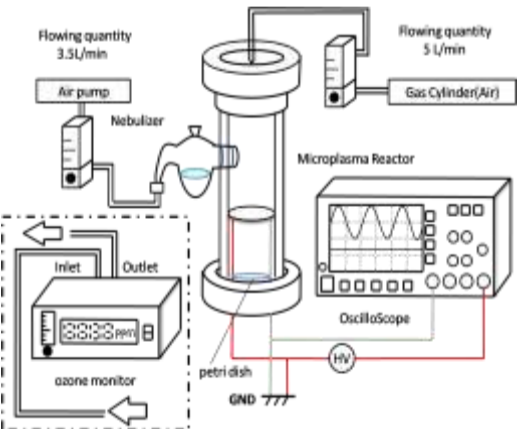


The image of microplasma electrodes during discharge at discharge voltage of 1 kV.



Each bacteria could be attacked and decomposed by atomic oxygen and nitrogen species, UV, OH radicals and O₃ generated between the electrodes.

(2) Experimental Setup

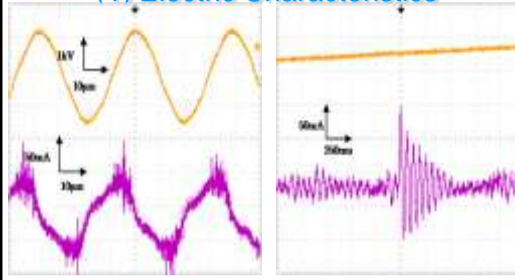


Discharge Voltage	1.0~1.4 [kV]
Flowing Quantity	8.5 [L/min]
Carrier Gas	Air, N ₂
Processing Object	<i>E.coli</i> , <i>B.subtilis</i>

The liquid culture medium was introduced in the microplasma reactor and sprayed at a gas flow rate of 3.5 L/min, through the electrode against a petri dish with culture medium. Gas flow rate was 5 L/min. Sprayed bacteria with liquid culture medium was sterilized in plasma reactor. Discharge voltage and discharge current were measured by a digital oscilloscope.

RESULTS

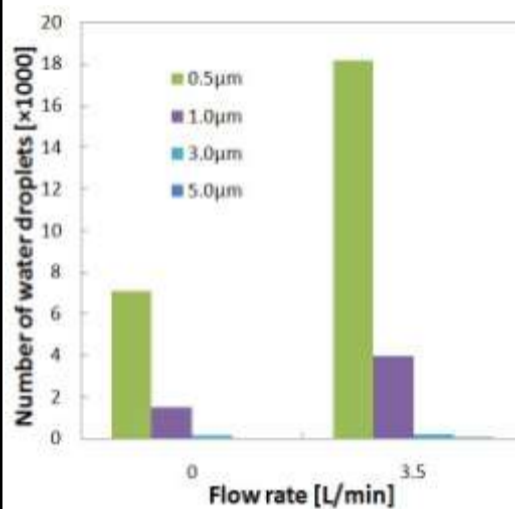
(1) Electric Characteristics



Spike-like currents occur at the steepest slopes of the discharge voltage. This is a typical waveform of dielectric barrier discharge.

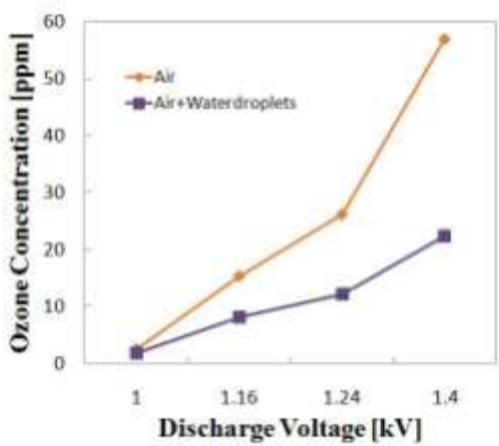
The microplasma reactor can generate atmospheric plasma at about 1 kV, since its discharge gap is narrow (about 50 µm).

(2) Characteristics of Particles by Nebulizer



The diameter of water particles, which are made by a nebulizer, are 1µm to 5µm. The size of colon bacilli is about 0.5 µm to 2.5 µm, thus *E. coli* HB101 and *B. subtilis* JCB20036 could be in the water drops made by the nebulizer.

(4) Ozone Generation



Concentration of ozone with sprayed distilled water was lower than that with only air. In the case with sprayed distilled water, flowed gas was cooled down and dried with iced water before measuring the concentration.

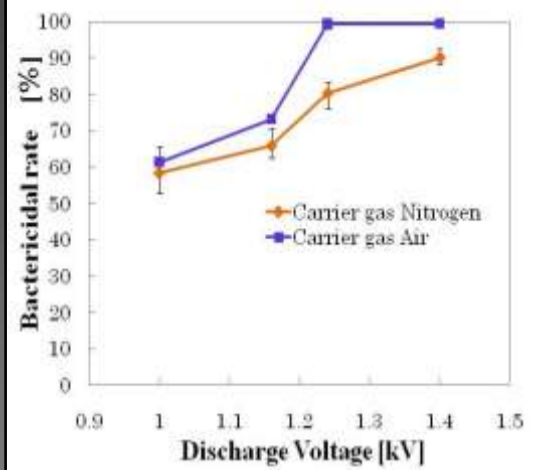
(5) Rate of sterilization



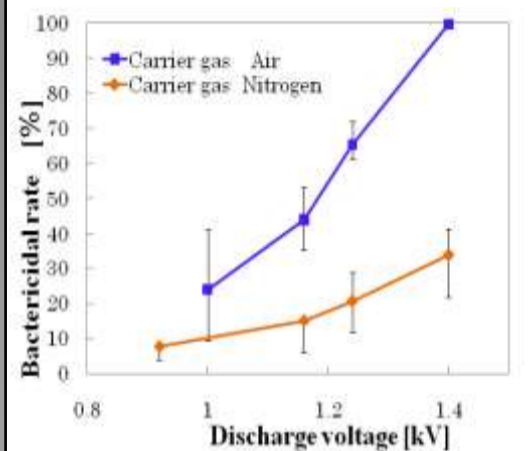
Without discharge. Vd=1.4 kV. Images of the *B. subtilis* treated samples by air-plasma.



Without discharge. Vd=1.4 kV. Images of the *B. subtilis* treated samples by nitrogen-plasma.



The sterilization rate of *E. coli* versus discharge voltages for both carrier gases of air and nitrogen increased as the discharge voltage increased. Sterilization rate with air was higher than that with nitrogen.



Similar sterilization rates were obtained for *B. subtilis* for both carrier gases, air and nitrogen.

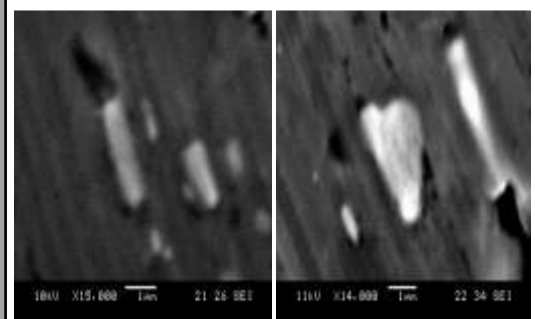


Image of *B. subtilis* treated sample by SEM.

CONCLUSION

In this study, the following conclusions were obtained.

- 1) Sterilization by microplasma was confirmed at a relatively low discharge voltage of 1.0 kV for both carrier gases: air and nitrogen.
- 2) The sterilization rate by air plasma was higher than the results by nitrogen plasma due to the combination effect of ozone, high electric field, UV radiation and other radicals.
- 3) The sterilization rate of *E. coli* was higher than the results for *B. subtilis* due to the characteristics of the cell walls, which are different in thickness and chemical composition.

References

[1] M. Nagatsu, F. Terashita and Y. Koide, Jpn. J. Appl. Phys, **42**, No. 7B, 856-859 (2003).
 [2] F. J. Trompeter, W. J. Neff, O. Franken, M. Heise, M. Neiger, S. Liu, G. J. Pietsch, and A. B. Saveljew, IEEE Trans. on plasma science, **30**, No. 4, 1416-1423, (2002).
 [3] R. Stainer, J. Ingraham, M. Wheelis, and P. Painter, *The microbial world. 5th edition*, (Prentice Hall, New York, 1986).