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High-speed Sterilization for Medical Equipment Using Microwave Air Torch Plasma

マイクロ波空気トーチプラズマを用いた医療機材のハイスピード滅菌特性

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Characteristics of the sterilization of medical equipments were studied using the air torch plasma produced by microwave discharge. Silicone points which is used in dental treatment was used as medical equipment. A factor of sterilization is NOx related particles produced in the plasma. Bacilli spores that adhere to silicone points were sterilized, and the inactivation period of bacilli on silicone points with population of 10^4 require 60 minutes.

1. Introduction

High-speed sterilization of medical equipments has been performed by the high-pressure steam (autoclave) and the ethylene oxide gas. However, above methods have some problems concerning damage to the equipment and residual toxic gas. Recently, plasma sterilization using an RF discharge has been studied as a safe and pollution-free method. Typical treatment period required for the sterilization is more than 3 hours. Reduction of sterilization time is necessary for the high-speed and safety sterilization for medical equipment. In this experiment, characteristics of the microwave plasma sterilization using air has been studied in order to realize a rapid sterilization method for medical devices.

2. Experimental Procedure

The glass pipe with inner diameter 11 mm wrapped by a stainless wire spirally is inserted into the stainless chamber with the dimension of 72 cm in length and 18cm in inner diameter. The chamber and the inside of the glass pipe are evacuated, and then the air flows into the inside of the glass pipe. When the microwave of 2.45GHz is absorbed to the stainless wire, air plasma is produced in the glass pipe. The radicals with high sterilization ability is emitted from the glass pipe opening edge which is several cm apart from the plasma generation area in the glass pipe.

The sample microorganism used in this experiment is the spore of *Geobacillus stearothermophilus*, and is put on silicone point that is the small dental equipments with various populations. After the treatment, spores are

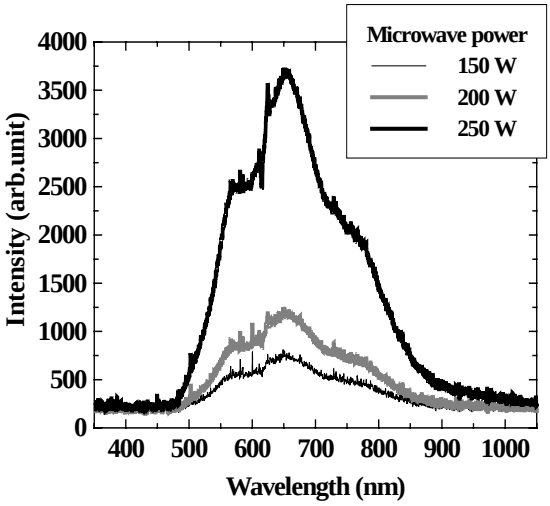

Fig. 1. Typical emission spectra of down -stream region at the plasma torch.

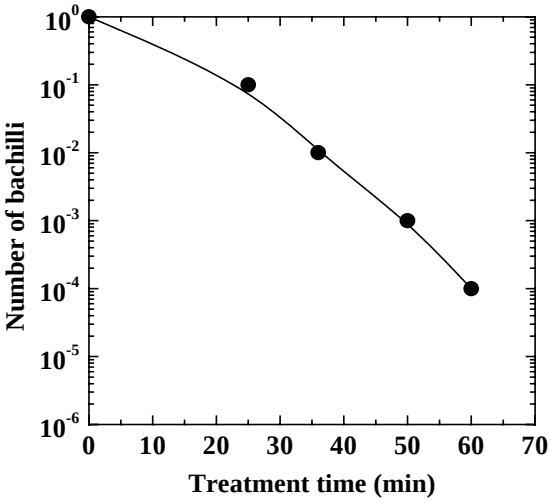

Fig. 2. Population curve of bacillus adhered on silicone point.

Table I. Period required for sterilization with different sample material of treatment time.

	Population	Sterilization period [min
BI	10^5	25
Silicone point	10^4	50

Fig. 3. SEM image of surface of silicon point.

cultivated in culture medium for 24 hours, and then successful of the sterilization is confirmed by pigment in the medium.

3. Results and Discussion

Typical emission spectra of the plasma torch downstream are shown in Fig. 1. This broad peak would be attributed to nitrogen oxide radical, and its height is maximum in the case of the mixture gas of N_2 : O_2 = 1 : 1. Preliminary experiment implies that the peak height and the sterilization period have a linear correlation. Therefore, the sterilization factor would be the nitrogen oxide radical with long lifetime.

Inactivation period of bacilli on silicone points with various populations is determined. Bacilli with the population of 10^1, 10^2, 10^3, 10^4 are inactivated with the treatment period of 30, 36, 50, 60 minutes, respectively, as shown in Fig. 2. The decimal reduction value (D value) evaluated from the survival curve of Fig. 2 is 9.6 min. Obtained D value is relatively large, which would be due to the surface roughness of the silicone points.

Dependence of sterilization period on sample materials are shown Table I. Sterilization of a vial-type biological indicator with bacilli with the population of 10^5 requires 25 min. On the other hand, the sterilization period of bacilli on silicone points with population of 10^4 is 60 min. The SEM image of surface of silicone point is shown in Fig. 3. Silicone gum and SiC form a microscopic fluctuations on the surface of silicone points. The detailed observation of the surface indicates that bacilli stack in the microstructure. Therefore, sterilization of tiny dental equipments is found to be difficult.

In the case of the RF plasma using air, the inactivation of bacilli on silicon points requires over than 3 hours. The sterilization period of silicone points with the population of 10^4 requires 60 min in this experiment. This fact suggests that the microwave torch plasma is suitable for the sterilization of dental equipments with high-speed.

4. Conclusion

The high-speed sterilization characteristics have been studied using bacilli on dental equipments as well as a biological indicator. The sterilization period, that is, sterilization ability depends strongly on the surface structure and materials of samples to be sterilized.

References

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