

Development of UV/Ozone Sterilization Method

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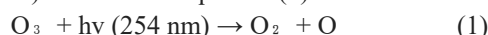
1. Introduction

The ultraviolet(UV)/ozone cleaning method is an effective way to remove a variety of contaminants from the material surfaces[1]. In this method, atomic oxygen produced by dissociation of ozone with the absorption of UV, react with contaminant molecules on the material surfaces and remove it effectively. In this research, surface cleaning method is applied for the surface sterilization. We previously reported that spore-forming bacteria (*B.atrophaeus*) of 8×10^6 CFU was successfully inactivated in treatment time of 30 min using UV/ozone method[2]. On the other hand, a water vapor was reported to be an effective processing gas for plasma sterilization at atmospheric pressure.

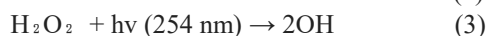
The purpose of this study is to confirm the influence of humidity in UV/ozone method on sterilization effect.

2 Ozone / UV method

When ozone is irradiated with UV light at 254 nm, it is dissociated into atomic oxygen (O) and oxygen molecule (O₂) as shown in equation (1).



It is known that the oxygen atoms react with the cell walls of bacteria and destroy it. On the other hand, UV light around 254 nm gives great damage to bacterial DNA. Therefore, by using the two in combination, it is possible to kill bacteria efficiently. Moreover, the oxygen atom produced from the dissociation of ozone react with a water molecule included in the processing gas and a hydrogen peroxide (H₂O₂) is produced (equation (2)). It is dissociated by the irradiation of UV light and a hydroxyl radical (OH) is produced (equation (3)).[3]



Hydroxy radicals have the highest oxidizing power among reactive oxygen species. We used this reaction to improve sterilization effect.

3. Experimental setup

Figure 1 shows a schematic diagram of the experimental setup. Both ozone produced by surface barrier discharge with Ar/O₂ gas mixtures and UV light emitted from a low pressure mercury lamp were introduced into the process chamber (H45mm×W156mm×L195mm). Moreover, moist air produced by atomization unit was introduced into the process chamber in order to control the humidity. It is consider that reactive species are produced in the chamber by the irradiation of UV light and they contribute to sterilization of bacteria. In this study, we used ozone concentration of 750[ppm], UV light

intensity of 2.5[mW/cm²], and relative humidity of 99.9%.

Ability of sterilization was investigated using biological indicators. *G.stearotherophilus*, 3A63251 of a population of 2.3×10^6 CFU/carrier adhered on a small stainless plate (7mm × 33mm). The biological indicator was placed in the center of the process chamber as shown in Fig.1. For comparison, we treated with ozone only, UV only, UV + water, ozone + UV, ozone + UV + water.

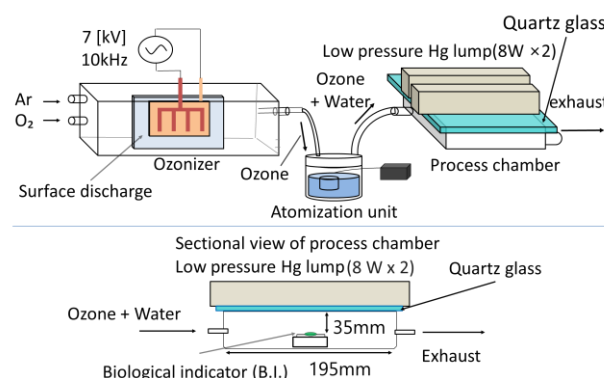


Figure.1 the outline of experiment device

4. Experimental results and discussions

Table 1 shows the results of sterilization test using biological indicators. The treatment time was fixed at 15 minutes. Results of using ozone singly, UV singly, UV + Water, and UV/ozone without moist air were indicated in Table 1 for comparison.

Table 1 Results of sterilization experiment

Ozone singly	UV singly	UV + Water	Ozone + UV	Ozone UV + Water
×	×	×	×	○

As shown in the table, spore-forming bacteria was inactivated only in the case of UV/ozone with moist air. This result suggested that hydroxyl (OH) radicals dissociated from H₂O molecules by UV light irradiation played an important role in the sterilization process.

References

- [1] John R. Vig: J. Vac. Sci. A3, 1027 (1985).
- [2] Y. Akata et al. "Surface sterilization using UV/ozone method" APSPT-9/ SPSM28(2015), P1-36.
- [3] S. Patil et al./ Journal of Hospital Infection 88 (2014) 162-169.