Prevention of infection by low-concentration ozone using an excimer lamp

Y. Takano, A. Koike, and I. Serizawa
ORC Manufacturing, Co., Ltd., 4896 Tamagawa, Chino, Nagano, 391-0011, Japan

***A**bstract* -- An excimer lamp is a mercury-free discharge lamp, which emits ultraviolet light to produce ozone. To utilize ozone gas produced by an excimer lamp for infection prevention, we evaluated the inactivation effect on SARS-CoV-2 and *Escherichia coli*. The ozone concentration was held constant at 0.05 while the exposure time was varied. The number of viruses or bacteria decreased with increasing treatment time, with the decrease rate after 6 h being > 99.9% in SARS-CoV-2 and 98.5% in *E. coli*. We found that ozone gas can be used to inactivate attached viruses and bacteria.

I. Introduction

Ozone gas is widely used for bacteria elimination, cleaning, and deodorization. The ozone gas generation system is roughly divided into discharge and UV type. In the UV system, three kinds of reactive oxygen species, singlet oxygen atom [O (^{1}D)], triplet oxygen [O (^{3}P)], and ozone molecule [O_3] are generated by the reaction shown in Equations 1 to 5 below [1].

$$O_2 + hv\ (\lambda \leqq 242\ nm) \rightarrow O\ (^3P) + O\ (^3P) \quad (1)$$
$$O_2 + hv\ (\lambda \leqq 176\ nm) \rightarrow O\ (^1D) + O\ (^3P) \quad (2)$$
$$O\ (^1D) + M \rightarrow O\ (^3P) + M \quad (3)$$
$$O\ (^3P) + O_2 + M \rightarrow O_3 + M \quad (4)$$
$$O_3 + hv\ (\lambda \leqq 320\ nm) \rightarrow O_2 + O\ (^1D) \quad (5)$$

In recent years, it was revealed that ozone gas generated by the excimer UV method was shown to contain no nitrogen oxide (NOx) and cause less corrosion of copper and iron plates, compared with ozone gas from the electrical discharge method at the same ozone concentration [2]. The ozone gas generation method using the excimer lamp is expected to be used as a spatial bacteria elimination method to reduce damage to metals and other materials. This study evaluated the inactivation effect of ozone gas produced by the excimer lamp on *Escherichia coli* and SARS-CoV-2.

II. Materials and Methods

A membrane filter dropped with 0.mL of *E. coli* (NBRC3301) solution was used as a test specimen. Specimens were installed in a sealed desiccator and exposed to ozone at concentrations of 0.05 ppm and 0.1 ppm for a fixed period of time. The ozone gas source was Smart Excimer® UV Lamp. Concentration control was performed using an ozone densitometer. After the action time, the filter was immersed in 10 mL of sterile water to collect. The collected solution was cultured on a standard agar medium, and the number of viable bacteria (CFU/mL) was determined.

The evaluation of virus inactivation was entrusted to the Department of Microbiology and Infectious Diseases at Nara Medical University. All operations were carried out under appropriate pathogen containment measures at biosafety level 3 experimental facilities.

Twenty microliters of the virus (SARS-CoV-2; 2019-nCoV JPN/TY/WK-521 strain) were coated on the dish and kept static for a certain time, and dried as test specimens. The ozone treatment method was the same as described above. After the action time, sodium thiosulfate-containing SCDLP medium was dropped onto 2 ml specimens, and the virus was recovered using a cell scraper. The recovered solution was used to infect Vero E6 cells. The virus infectivity titer (PFU/sample) was measured by the plaque method.

III. Results and Discussion

The number of viable *E. coli* decreased as ozone exposure time increased (Fig. 1). Also, the number of viable bacteria at equal exposure times was lower at 0.1 ppm than at 0.05 ppm ozone concentration.

In the inactivation assays of SARS-CoV-2, the infectivity decreased as treatment time increased (Fig. 2). At an ozone concentration of 0.05 ppm, the percentage reduction in infectivity after 2 h was 99.958 % and 99.996 % after 6 h.

The allowable ozone concentration in manned environments established by the Japan Society for Occupational Health is less than 0.1 ppm. The results revealed that *E. coli* and a novel coronavirus could be inactivated even at the low concentration (0.05 ppm) that is below manned environmental standards. The effects on floating viruses and bacteria have not been verified.

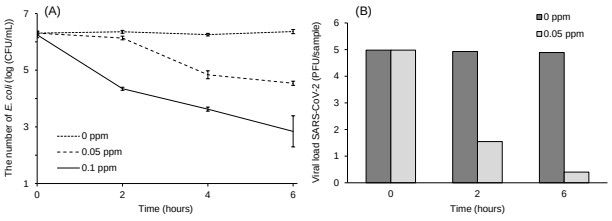

Fig. 1. Effects of duration for ozone gas treatments in *Escherichia coli* (A), and SARS-CoV-2 (B)

References

[1] H. Sugimura, J. Surf. Finish. Soc. Jpn. Vol. 69, p 58-64, 2018

[2] T. Hayakawa and I. Serizawa, Bull. Med. & Hyg. Ozone Res., vol, 28, p 27-28, 2021