Technologies for Improving Hygiene in Air Conditioners

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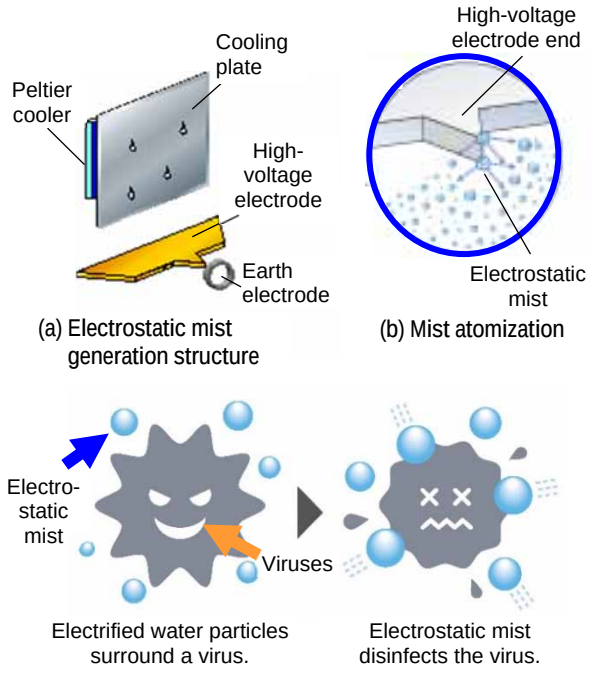
1. Introduction

There is increasing demand for better hygiene on the inside of products, in addition to better indoor air quality (IAQ) and indoor environmental quality (IEQ). Mitsubishi Electric Corporation has developed technologies for improving the hygiene of air conditioners that prevent substances whose safety has not been verified from being released to environments where humans are present, considering the potential impact on the human body. This paper introduces these technologies.

2. Hygiene Improvement Technology 1: Electrostatic Mist Treatment Technology

Mitsubishi Electric has developed an electrostatic mist treatment technology to sterilize and inactivate airborne microbes in indoor spaces to improve IAQ. Figure 1 illustrates the electrostatic mist generation structure and airborne microbial activity suppression mechanism, a Peltier cooler is used to condense moisture in the air into water on the cooling plate. The condensed water drips onto a hygroscopic high-voltage electrode. A high voltage is applied and the electrostatic atomization mechanism forms fine water droplets and releases them into the air. Porous formed titanium is used as the hygroscopic high-voltage electrode, enabling a large quantity of fine water droplets to form and improving the corrosion resistance. In addition, pure fine electrostatic water droplets with particle diameters of 10–40 nm are formed by controlling the applied voltage. Such water droplets do not contain ozone gas and radicals, which have high oxidizing power. Electrostatic mist absorbs airborne microbes by the charging effect and thereby suppresses their activity in the air. The mist does not affect the human body because it does not contain ozone gas or radicals.



(a) Electrostatic mist generation structure

(b) Mist atomization

(c) Airborne microbial activity suppression mechanism

Fig. 1 Electrostatic mist generation method and airborne microbial activity suppression mechanism

The inactivation effect of the electrostatic mist treatment against airborne influenza viruses (influenza A virus: A/Aichi2/68(H3N2)) was verified. It was found that there were fewer airborne viruses when electrostatic mist was released than in the case of natural decrease when no mist was released, and the number decreased by two orders of magnitude (99%) in 158 minutes. These results show that electrostatic mist can disinfect airborne viruses.

Mitsubishi Electric's room air conditioners that utilize this technology come under the name of "PURE MIST."

3. Hygiene Improvement Technology 2: Wet ozone Treatment Technology

The inside of air conditioners during air-cooling is humid and so mold tends to grow. Microorganism-based volatile organic compounds, which are created when mold propagates, cause offensive odors and also mold spores may cause allergies.(1) Therefore, there is a need for technologies to kill and prevent mold inside air conditioners. Because mold spores are protected by coating layers and cell walls composed of protein, the concentration-time value (CT) (ozone gas concentration (ppm) × exposure time (min)) necessary to kill 99% of mold by ozone treatment is large: approximately 5,400 ppm•min.(2) Therefore, it takes a long time to kill mold by ozone treatment with ozone gas at a concentration equal to or lower than the environmental standard value (0.05 ppm). Mitsubishi Electric, focusing on the fact that spores germinate under high humidity and that the coating layers and cell walls cleave, has developed a wet ozone treatment technology for treating ozone gas at high humidity.

Figure 2 shows the fungicidal effect against spores of *Aspergillus niger* NBRC 6341 applied to the inside of

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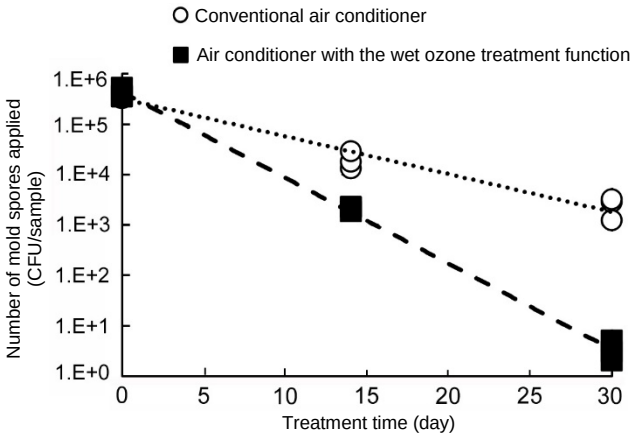
an air conditioner with the wet ozone treatment function. The number of mold spores on the air conditioner with this treatment function is less than that on a conventional air conditioner without the function: 99% or more of mold can be killed through exposure to wet ozone gas in 30 days (as in Figure 2, the CT is 30 ppm•min). These results show that the wet ozone treatment efficiently kills mold.

Mitsubishi Electric's room air conditioners feature this inside cleaning technology under the name of "FUNGICIDAL CLEAN SHOWER."

4. Hygiene Improvement Technology 3: Technology for Pulsed High-Voltage Discharge Treatment in Water

During cooling operation of air conditioners, water condenses on the heat exchangers in the indoor units. In packaged air conditioners, this condensed water is stored in drain pans and then discharged by pumps. If microorganisms breed in the stored water, the resulting offensive odors may be released or the air conditioner may malfunction due to the formation of biofilm. To prevent these problems, Mitsubishi Electric has developed a technology for pulsed high-voltage discharge treatment in water. For this technology, a discharge electrode and a rod-shape metal earth electrode are placed in water. The discharge electrode is a small-diameter metal wire whose circumference has been molded with resin. A pulsed high voltage is applied to the section between these electrodes, causing the formation of hydroxy radicals (OH•; "•" indicates an unpaired electron), hydrogen radicals (H•), and other radicals as shown in Fig. 3 in the water. These radicals oxidize and break the cell walls and cell membranes of

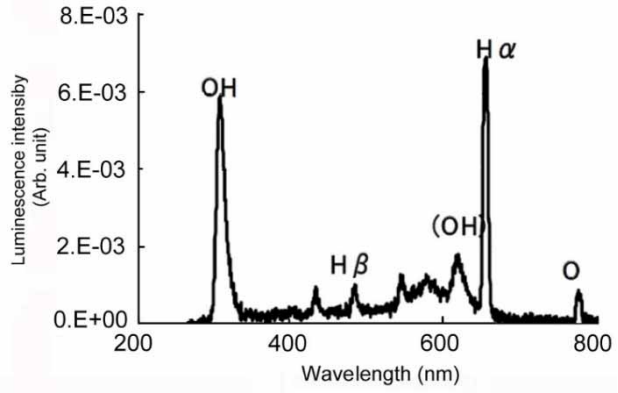


Conventional air conditioner operation: A cycle of 6-hour cooling operation and 6-hour stopped was repeated.

Wet ozone treatment (twice/day): When no cooling operation is performed, 10-minute ozone gas treatment (maximum ozone gas concentration in the air conditioner: 0.05 ppm) was performed.

Test period: 30 days, 5.5×10^6 CFU of mold spores applied

Fig. 2 Fungicidal effect of wet ozone treatment

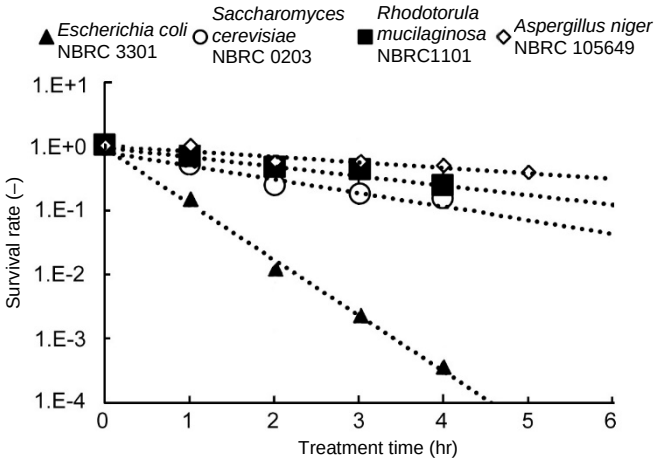


Discharge conditions: Applied voltage: −8kV, pulse frequency: 130 Hz, discharge electrode wire diameter: 0.3 mm, earth electrode wire diameter: 1 mm

Test water: Water imitating the components of actual drain water (imitation drain water: total organic carbon TOC: 40 mg/L, electrical conductivity: 130 µS/cm)

Measuring instrument: Discharge light spectrum analyzer (CSP-TSP-100MDN)

Fig. 3 Spectral characteristics using pulsed high-voltage discharge in water



Discharge conditions: Applied voltage: −4 kV, pulse frequency: 130 Hz, discharge electrode wire diameter: 0.3 mm, earth electrode wire diameter: 1 mm

Test water: Imitation drain water, water quantity: 50 mL

Fig. 4 Bactericidal effect of pulsed high-voltage discharge in water

microorganisms, thus inactivating them and achieving disinfection.

Figure 4 shows the bactericidal effect of the pulsed high-voltage discharge treatment in water against various types of microorganisms (bacteria, yeasts, and mold spores). The longer the treatment time, the lower the survival rates of all the microorganisms. The technology can kill *Escherichia coli*, which are prokaryotes (living things without a cell nucleus) under water, and also yeasts and molds (eukaryotes), demonstrating bactericidal effects. These results show that pulsed high-voltage discharge treatment in water can suppress the formation of biofilms, which are aggregates of multiple microorganisms. Mitsubishi Electric's packaged air conditioners feature this drain pan cleaning technology under the name of "PULSE CLEAN."

References

(1) K. Takashima: Mold in Living Environments and Health Disturbance, J. Natl. Inst. Public Health, 47, No. 1, 13–18 (1998)
(2) U. Yanagi, et al.: Research on the Actual Conditions of Contamination with Microorganisms in Air Conditioning Systems and Countermeasures 3, Collection of environmental academic papers issued by the Architectural Institute of Japan, 73, No. 632, 1197–1200 (2008)