Environmental Businesses Effectively Using Ozone

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The etymological meaning of the term ozone is “ozein” or “to smell” and indeed ozone has a unique grassy odor. Although it is an allotrope of oxygen, it is an extremely unstable substance that tends to disintegrate and become oxygen in nature. The oxygen atom generated through disintegration of ozone is called active oxygen, which has an oxidizing power that is about six times that of chlorine used as a disinfectant in our water supply. Furthermore, since ozone has a very short half life, it disintegrates naturally and reverts to oxygen in a short time. Therefore, it has no highly toxic residual reactants, as is the case with oxidizing agents made of chlorines, and no toxic secondary byproduct materials are generated either. In other words ozone is considered to be a “friendly to humans” chemical substance that does not cause any secondary pollution, since it disintegrates rapidly into nature and its residual properties cause no problems.

This paper introduces business solutions that effectively use ozone by taking advantage of its superior features for ordinary homes and various industrial fields.

Summary of ozone

The ozone layer (10 to 20 ppm) is located 20 to 30 km above the earth. This ozone layer is generated through the action of solar energy (ultraviolet rays) on the oxygen in the atmosphere. Although very minute, ozone is naturally generated in areas with strong ultraviolet rays, such as seashores and it is not necessarily generated in the sky above. Therefore, the concentration of ozone on the ground is generally considered to be about 0.005 ppm, whereas along seashores and forests it is considered to be about 0.02 to 0.1 ppm. The fact that sea bathing and walking in forests are considered to be beneficial for health, while sanatoriums are generally built on seashores and highlands, is said to be due to the large amounts of air cleansing ozone generated in nature within those areas. This means that the cleansing effects of ozone generated in nature is being utilized in our daily lives.

The Industrial Safety and Health Standards in Japan stipulates 0.1 ppm (on any eight-hour working day) for ozone (**Table 1**).

This means that it is possible to use ozone in places occupied by humans at all times provided that the concentration is 0.1 ppm or lower, however, once the concentration becomes larger than this, it can generally only be used in locations where humans are not present. So far there has been no report of any incidence of ozone exposure at a work environment anywhere in the world.

Table 1 Effects of ozone exposure on humans

Ozone concentration (ppm)	Effects
0.01 to 0.03	Hardly detectable odor
0.03 to 0.06	Slightly detectable odor
0.06 to 0.1	Definitely identifiable odor of ozone
0.1	Permissible concentration for work environment (Japan Society for Occupational Health)
0.2 to 0.5	Strong odor, causing headaches and throat aches
0.5	Clearly stimulating upper respiratory tract

This is due to the fact that even when humans are present in locations where the concentration of ozone is about 20 ppm, there are no negative effects to the human body as long as their exposure is short term. The fact that even a low concentration of about 0.02 ppm is detectable due to its peculiar odor, which makes it identifiable, is also considered to be a relevant factor as well.

Generation and utilization of ozone

A plasma discharging method, photochemical action method (ultraviolet lamp method) and radiation methods are the principal methods for artificially generating ozone. The plasma discharging method and photochemical action method are the common methods used in the industry. Since oxygen in the air is the raw material for ozone the material costs are low. Electrical energy is also required for the generation of ozone, which means that ozone is generally generated with low running costs.

The plasma discharging method, however, is not suitable for the generation of highly concentrated ozone, but it is the most effective method for economically manufacturing ozone and is also the method commonly used. The silent discharging method (**Fig. 1**) and surface discharging method (**Fig. 2**) are in practical use.

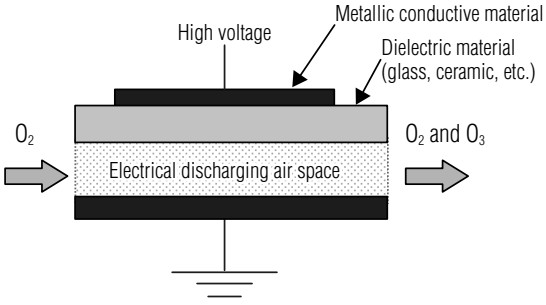

Fig. 1 Conceptual diagram of silent discharging[1)]

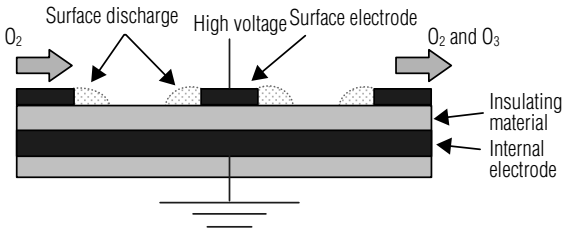

Fig. 2 Conceptual diagram of surface discharging[2)]

The silent discharging method is a generating method that utilizes a discharging phenomenon, which occurs in the spacing between two electrodes when an alternating current high voltage is applied via dielectric material, such as glass. A large amount of current resulting from the discharge will not flow between electrodes if dielectric material is inserted between the electrodes. Unlike thunder and lightning, no intense flash of light or loud thundering occurs for this reason, therefore, this method is called the silent discharging method. Ozone is generated after a certain amount of oxygen is poured into the silent discharging section and the voltage in the space between electrodes, which measures only a few millimeters, reaches 8,000 to 12,000 volts.

The surface discharging method involves covering electrodes in the planar form with insulating material and installing another electrode on the surface of the insulating material. High voltage is applied between these electrodes to cause a discharge on the surface of the insulating material to generate ozone. Ozone generators using the surface discharging method can be manufactured easily, therefore, an overwhelming number have been adapted as ozonizers for producing smaller capacities on a smaller scale. Almost all cheaper ozone deodorizing units adopt this method.

In general, ozone is used as a gas and in water. Ozone is a gas in room temperature and under normal pressure, so ozone in a gas form is primarily used for effectively disinfecting and deodorizing applications. When ozone is used in water, on the other hand, it is mixed in water as microscopic bubbles, which is known as ozone water, since ozone does not dissolve easily in water. Ozone water is mainly used effectively for applications, such as disinfecting or cleansing food, for which a liquid form is a more effective mode of application.

Ozone not only has a strong oxidizing power but its properties do not cause any secondary pollution, therefore, in recent years it has been widely used in a variety of industries for the purpose of disinfecting, deodorizing, bleaching and for water treating applications.

Environmental businesses effectively using ozone

We have been implementing deodorizing solutions and disinfecting solutions for a variety of environmental businesses, who utilize the many effects and benefits offered by ozone, a substance that has a very low level effect on the environment. A summary of these is provided below.

Elemental technologies and ozonizers are being provided by a venture business in Okayama Prefecture, Ozone Environmental Business Partner. Two types of ozonizers are used, “Low-temperature Plasma Generator” and “Lotus-type Generator”.

The low-temperature plasma generator, shown in **Fig. 3**, applies the silent discharging method and is in the low concentration ozone segment.

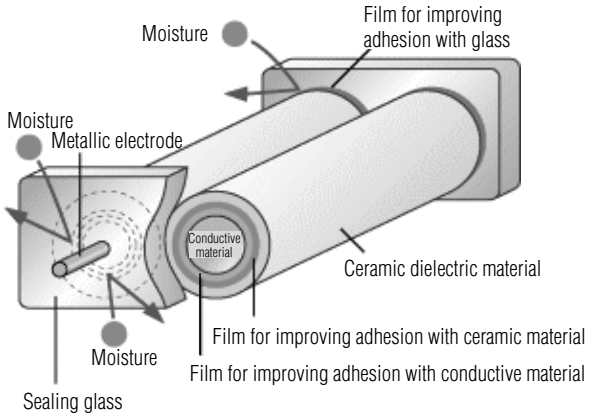

Fig. 3 Low-temperature plasma generator

The spacing between the two parallel electrodes, with which conductive materials are not exposed, is used for electrical discharging by a low-temperature plasma generator. It is possible to realize silent discharging that inhibits a reduction in the amount of ozone generated to a minimum with this method, making it possible to generate stable ozone at all times. Electrodes made of tungsten are sealed inside ceramic tubes and are not exposed to the outside with this low-temperature plasma generator. Therefore, the generator can be operated over a long period of time and used almost indefinitely, since the electrodes incur no wear and tear due to age deterioration. Furthermore, the generator is also capable of generating quantities of ozone in an extremely stable manner.

By changing the number of generators and adjusting the concentration of oxygen, which is the raw material for ozone, as well as by adopting a generator known as the lotus-type generator, shown in **Fig. 4**, the amounts of ozone required in accordance with the purpose of providing for the high concentration ozone segments were attained.

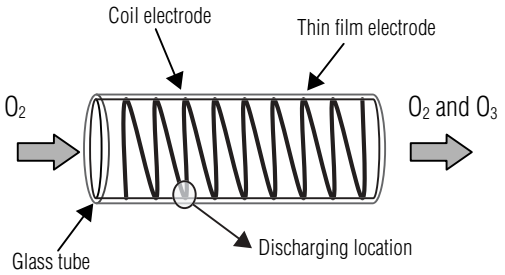

Fig. 4 Lotus-type generator

The lotus-type generator is the combination of a glass tube, made of a dielectric material, and other electrodes. The surface discharging method is the basic principle used for generating ozone with this generator.

Deodorizing solutions

Deodorizing solutions are the largest ozone business for this industry. Since ozone is in a gas form at room temperature and under normal pressure, this featured property enables it to deodorize a room with a strong oxidizing power, even into the edges of corners. Furthermore, substances that cause bad odors are directly oxidized and decomposed. Odor occurs when molecules, the source of an odor in a gaseous form, are dispersed into the air. Ozone strongly oxidizes such odor molecules changing and decomposing them into odorless molecules.

As an ozone deodorizing solution we provide large-size deodorizing systems for spaces on a large scale, such as municipal garbage recycling plants and biomass plants. We also offer compact deodorizing systems for spaces on a smaller scale, such as for ordinary homes or passenger cars.

Systems utilizing multiple number of ozonizer units for the high concentration ozone segments are provided as “a wide area deodorizing system” used for spaces on a larger scale. These systems use oxygen gas as the raw material and are capable of generating highly concentrated ozone of about 1 g/Hr. In order to deodorize large-scale spaces highly concentrated ozone is diffused by atomization with the use of air blowers.

The Offensive Odor Control Law, which applies to municipal garbage recycling plants and biomass plants, has been amended and the “offensive odor strategy” has become a critical issue that has had an impact on the continued existence of businesses in recent years. Municipal garbage recycling plants and biomass plants have been promoting the construction of sealed spaces to prevent offensive odors from escaping their premises in order to eliminate complaints from neighboring residents regarding offensive odors. When sealed spaces are made, however, the environment in which workers at such places are exposed deteriorates, making it necessary to install a deodorizing system to cover large-scale spaces in the facility. In the past, chemical reaction processes using chemical agents and physical absorption processes using activated charcoal were primarily utilized whenever deodorization was needed. Since the targeted spaces were large in scale, however, an enormous expenditure was required to construct localized exhaust systems that used ventilation fans and the like. Furthermore, when chemical agents or activated charcoals were used for deodorization, more chemical agents and energy were required to process the secondary byproducts.

The wide area deodorizing systems we provide utilize the natural oxidization decomposition reactions with the ozone gas that is sprayed and supplied in appropriate amounts to spaces with offensive odors using blower fans for the ozonizers to disperse it. These systems can be built quite easily and since no secondary byproducts are generated once deodorization takes place, there is no need for chemical agents or energy to process any secondary byproducts. For this reason these systems have been incorporated into numerous municipal garbage recycling plants and biomass plants as they can be built economically, are considerate of the environment and deodorize spaces on a large scale (**Photo 1**).

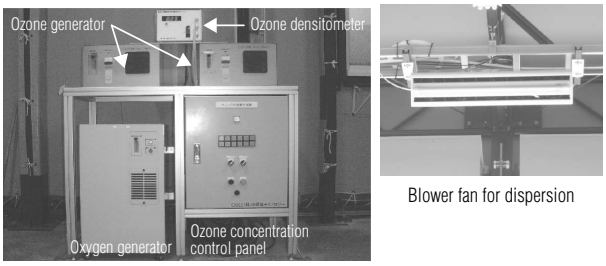

Photo 1 Wide area deodorizing system

Compact deodorizers that utilize ozonizers for low concentration ozone segments are provided for use in small-scale spaces. Compact deodorizers deodorize with an estimated ozone concentration of about 0.02 ppm, which is the threshold value for odor perception by ordinary persons, therefore, it is possible to use them at all times in environments occupied by people.

The most compact vehicle mounted-type compact deodorizer we offer has a maximum ozone generation of 1.0 mg/Hr (**Photo 2**).

Photo 2 Compact ozone deodorizer for vehicle mounting

The transformer used for discharging, in order to generate ozone, was made as compact as possible for this device, enabling us to realize a thin, card-size unit.

In the past aromatic agents and absorbing agents were primarily used to deodorize car interiors. The use of aromatic agents involves a masking effect by utilizing odors stronger than the offensive odors so that the offensive odors can no longer be perceived. Furthermore, the absorbing agents physically absorb the components that cause bad odors using chemical agents, such as activated charcoal. Aromatic agents and absorbing agents are extremely economical and are widely available in a diverse range of products at car accessory stores and volume sales stores. Unlike ozone deodorizing, however, these require the use of chemicals to eliminate odors and their affect on the environmental is significant.

We also offer a line of ozone deodorizers that are optimally suited for eliminating pet and cigarette odors in the home (**Photo 3**).

Generated amounts of ozone can reach a maximum of 2 to 4 mg/hr for each unit. A suitable generating capacity is selected for the space in which they are used. Furthermore, these units use the movement of air arising from ion generation to disperse ozone, making them quiet in design but also capable of deodorizing larger areas.

Photo 3 Compact ozone deodorizer for home use

The systems we offer are products that have very little impact on the environment since they use natural air as the raw material and minute amounts of electrical energy. Although they are slightly more expensive in comparison with products using aromatic agents or absorption agents, the recent eco boom has brought about a positive impact and many of these products have been adopted, with the taxi industry leading the trend.

Disinfecting solutions

The second group of products for ozone businesses in the industry employs disinfecting solutions. Ozone destroys and decomposes the nucleus of viruses and bacteria. This means that the strong oxidizing effect of ozone oxidizes the membranes of microbes, changing and decomposing them to trigger bacteriolysis, which in turn kills off the microbes. Furthermore, since ozone molecules also oxidize the interior of cells at the same time, they destroy the cell's functions and, therefore, are able to kill off even viruses with a simple structure. These actions are all physiochemical in nature and are thus different from action that involves killing microbes by inhibiting their metabolic process. A feature of this solution is that there is no risk of triggering a secondary disaster that can result from the generation of resistant strains of microbes for the above reason.

For our disinfecting solutions we adopted a lotus-type generator intended for high concentrated ozone segments. The resulting product is not only a high performance unit but has also been miniaturized to the extent that the main unit weighs about 5.5 kg (**Photo 4**).

Photo 4 Compact ozone disinfecting unit

One feature of this unit includes its ability to disinfect in a relatively short contact time. High concentrations of ozone are sprayed at room temperature and in normal humidity, in environments when no persons are present. **Table 2** shows the disinfecting effects of the compact ozone unit we offer, primarily against major microbes that cause food poisoning. As the results indicate, adequate disinfecting effects were achieved with exposure for a short period of time.

Table 2 Disinfecting effects of ozone (number of colonies per plate)

Test microbe	No exposure	With exposure (0.1 ppm)	
	Four hours	Two hours	Four hours
Bacillus cereus	200	37	36
Staphylococcus aureus	390	3	2
Vibrio parahaemolyticus	380	0	0

Source: Japan Chemical Analysis Center

Since ozone is an autolytic substance, there is no need for any neutralizing processes that would be required for other disinfecting methods that utilize chemical agents. Furthermore, since ozone disinfecting does not use heat or water and leaves no residue, its application is possible in a broad range of fields. It has recently been used at many locations for disinfecting kitchens in restaurants during the night and periodical disinfecting of medical facilities.

Future developments

We are providing various solutions that utilize the effects of ozone, which are “environmentally friendly” as described so far. We also believe that the oxidizing power of ozone can be used as an effective means for the environmental improvement technologies of the 21st Century and also for fields other than those that use ozone's deodorizing and disinfecting features.

We are currently promoting the application of ozone in water treatment systems that combine new technologies, such as microbubbles, to maximize the effects of ozone in the water. Furthermore, we are also proceeding with various studies and commercializing products relating to the utilization of ozone for building slime (microbe) eradication systems that use no chemicals.

References

1) Yasuo Ito, “Wonders of Ozone”, First Printing, Kodansha, pp. 69, 1999.
2) Yasuo Ito, “Wonders of Ozone”, First Printing, Kodansha, pp. 71, 1999.

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