April 3, 2014

Plasmacluster*[1] Technology Shown Effective in Controlling Effects of Bacteria and Fungi Adhering to Yellow Sand and in Removing Organic Chemicals Contained in PM2.5

Sharp Corporation has demonstrated the effectiveness of its Plasmacluster technology in suppressing bacteria and fungi adhering to airborne yellow sand particles and in removing organic chemicals contained in PM2.5.

Under testing that Sharp Corporation consigned to Shokukanken Inc.*[2], Plasmacluster technology was shown to suppressing more than 99% of yellow-sand-adhering *Bacillus cereus* (a bacterium that causes food poisoning) and *Bjerkandera adusta* (a type of allergy-causing fungi).

After conducting in-house tests, Sharp Corporation consigned analysis of test results*[3] to Sumika Chemical Analysis Service, Ltd.*[4]. This analysis revealed that Plasmacluster technology removed approximately 98% of aromatic carboxylic acid (benzoic acid)—which is contained in PM2.5 and which causes acid rain—and approximately 99% of the alkane (hexadecane) contained in such sources as car exhaust.

Testing carried out by Sharp and these third-party institutions confirmed the ability of Plasmacluster technology to suppress bacteria and fungi and remove organic chemicals under conditions simulating actual use (using rooms of 25 m^3 and 28.5 m^3 in size). The results indicate that Plasmacluster technology shows great promise for use as a countermeasure against environmental pollutants and as a means to assist users in achieving a healthy air environment.

Since introducing Plasmacluster technology in 2000, Sharp has conducted academic marketing*[5] in collaboration with some of the world's leading third-party scientific research organizations. So far, 23*[6] such organizations have demonstrated the effectiveness of Plasmacluster in not only suppressing harmful substances such as viruses, bacteria, and allergens, but also in beautifying people's skin and hair in a proven safe manner*[7].

Sharp will continue to pursue the creation of healthy environments by advancing Plasmacluster technology and conducting testing to show its effectiveness.

Table 1. Suppressing bacteria and fungi adhering to yellow sand

Type	Test space	Period	Suppress rate	Comments
Bacillus cereus	25 m^3	6 hours	More than 99%	Cause of food poisoning; occurs naturally in nature (soil, polluted water, etc.)
Bjerkandera adusta		8 hours		Fungi that triggers asthma and allergic symptoms

Table 2. Removing organic chemicals contained in PM2.5

Type	Test space	Period	Removal rate	Comments
Aromatic carboxylic acid (benzoic acid)	28.5 m^3	8 hours	Approx. 98%	Cause of acid rain
Alkane (hexadecane)		24 hours	Approx. 99%	Contained in things like car exhaust

1. Suppressing bacteria and fungi adhering to yellow sand

(1) *Bacillus cereus*

Verification Method

• Test institution: Shokukanken Inc.[*2]

• Test space: 25 m^3 test chamber

• Bacterium: *Bacillus cereus*

• Test sample: Sterile gauze coated in bacterial suspension

• Device tested: Plasmacluster ion generator

• Control test: Airflow without using Plasmacluster ion generator

• Test and analysis method: A Plasmacluster ion generator was placed in a 25 m^3 chamber. A gauze coated in *Bacillus cereus* was suspended and Plasmacluster ions were generated. After a set time period, the gauze was taken down. The *Bacillus cereus* bacteria was removed, and after bacterial culturing the number of colony-forming units (CFUs)*[8] was counted.

Results

After six hours the number of bacteria had decreased by more than 99% compared to the control test (airflow without using Plasmacluster ions).

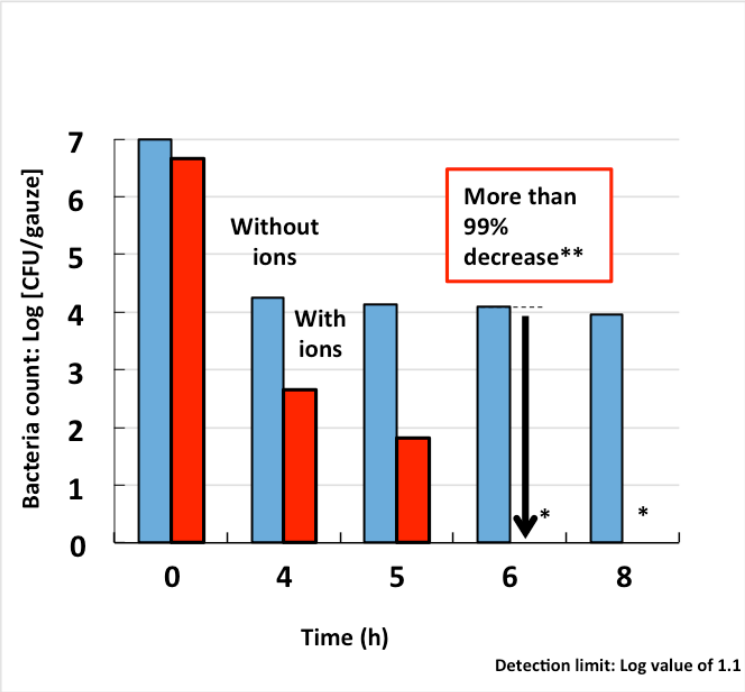


Figure 1. Control effect on adhered *Bacillus cereus*

* No bacteria were detected after six hours and eight hours in the tests using Plasmacluster ions.

** The log value is represented on the vertical axis of the graph. For example, if the log value difference between the ion test and the control test is 2.0, this equals a reduction of 99%.

(2) *Bjerkandera adusta*

Verification Method

• Test institution: Shokukanken Inc.[*2]

• Test space: 25 m^3 test chamber

• Bacterium: *Bjerkandera adusta*

• Test sample: Sterile gauze coated in fungal suspension

• Device tested: Plasmacluster ion generator

• Control test: Airflow without using Plasmacluster ion generator

• Test and analysis method: A Plasmacluster ion generator was placed in a 25 m^3 chamber. A gauze coated in *Bjerkandera adusta* was suspended and Plasmacluster ions were generated. After a set time period, the gauze was taken down. The *Bjerkandera adusta* was removed, and after fungal culturing the number of colony-forming units (CFUs)[*8] was counted.

Results

After eight hours the number of fungi had decreased by more than 99% compared to the control test (airflow without using Plasmacluster ions).

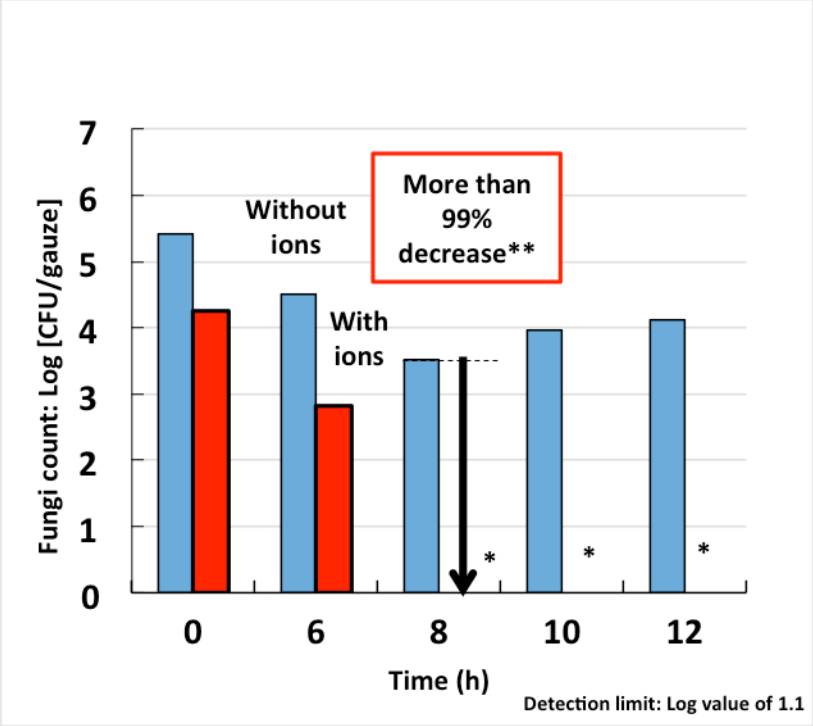


Figure 2. Suppressing effect on adhered *Bjerkandera adusta*

* No fungi were detected after eight hours, ten hours and twelve hours in the tests using Plasmacluster ions.

** The log value is represented on the vertical axis of the graph. For example, if the log value difference between the ion test and the control test is 2.0, this equals a reduction of 99%.

Comment from Shokukanken Inc.

The tests showed that Plasmacluster ions can inhibit the growth of *Bacillus cereus*, a bacterium that causes food poisoning, and *Bjerkandera adusta*, a type of fungi said to cause allergies. This holds promise for alleviating asthma and the symptoms of allergies as well as for reducing the incidence of food poisoning.

Overview of Shokukanken Inc.

Established in 1998. Specializes in research in food and food environments; work includes conducting academic inspection on microorganisms, analysis of food substances, and sanitary inspections.

2. Removing organic chemicals contained in PM2.5

Aromatic carboxylic acid (benzoic acid) and alkane (hexadecane)

Verification Method

• Test institution: Sharp Corporation

• Analysis institution: Sumika Chemical Analysis Service, Ltd.*4

• Test space: 28.5 m^3 test chamber

• Substances verified: Aromatic carboxylic acid (benzoic acid) and alkane (hexadecane)

• Test sample: Petri dish containing aromatic carboxylic acid (benzoic acid) and alkane (hexadecane)

• Device tested: Plasmacluster ion generator

• Control test: Natural environment (i.e., Plasmacluster ion generator not used)

• Test and analysis method: A Plasmacluster ion generator was placed in a 28.5 m^3 chamber. A petri dish containing 625 µg each of aromatic carboxylic acid (benzoic acid) and alkane (hexadecane) was placed in the chamber. This was exposed to Plasmacluster ions for a set time period. The remaining aromatic carboxylic acid (benzoic acid) and alkane (hexadecane) were collected and quantitatively analysed using gas chromatography mass spectrometry*9.

• Report: Order No. 8385697-00

Results

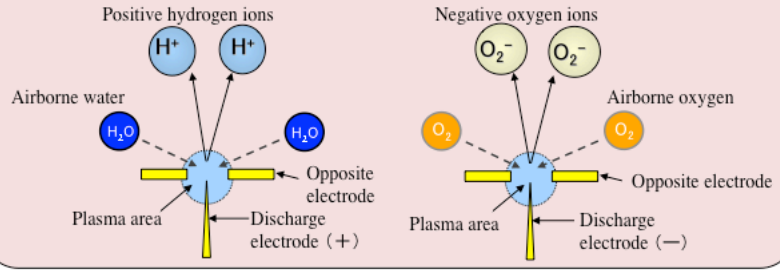
After eight hours the amount of aromatic carboxylic acid (benzoic acid) decreased by approximately 98%,and after 24hours the amount of alkane (hexadecane) decreased by approximately 99%, compared to the natural control environment.

About Plasmacluster Technology

In Sharp's proprietary air purification technology, positively charged hydrogen ions (H^+ $(H_2O)_m$) and negatively charged oxygen ions (O_2^- $(H_2O)_n$) are discharged simultaneously. These positive and negative ions instantaneously bond on the surface of substances such as bacteria, fungi, viruses, and allergens, becoming highly reactive OH radicals (hydroxyl radicals) that break down the proteins on the surface of these bacteria and other substances. By chemical reaction, the OH radicals work to suppress the activity of those substances.

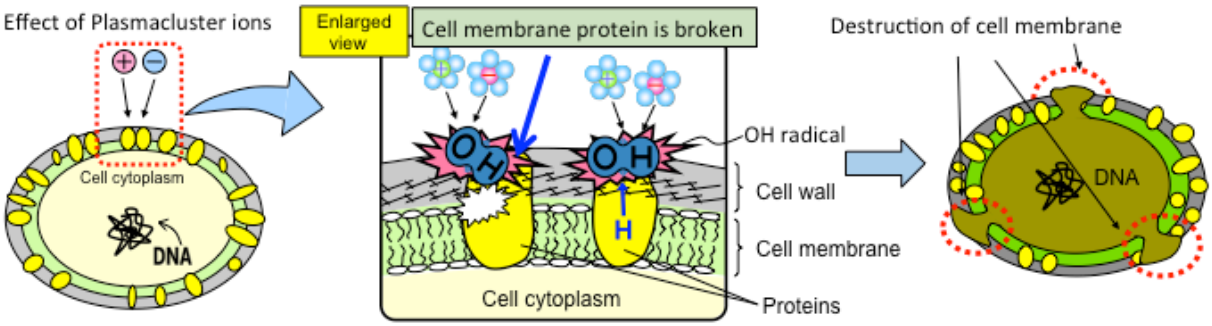
How Plasmacluster Ions Are Generated

Positive and negative voltages are applied to discharge electrodes to electrically split airborne water and oxygen molecules into hydrogen and oxygen. This creates positively charged hydrogen ions (H+) and negatively charged oxygen ions (O-).



The airborne water molecules cluster around ions like bunches of grapes, making each ion a stable cluster ion.

Mechanism for controlling bacteria



Cross-section of bacterium

Enlarged view of controlling mechanism using positive and negative ions

The cell membrane is rendered inactive, which inhibits proliferation

Comparison of Oxidation

Positive and negative ions bond on the surface of viruses and bacteria and react chemically to form OH radicals, which have high oxidation power (standard oxidation potential 2.81 V). These reduce the contagiousness of airborne viruses and the activity of bacteria.

Active substances	Chemical formula	Standard oxidation potential (V)
Hydroxyl radicals	OH	2.81
Oxygen atom	O	2.42
Ozone	O_3	2.07
Hydrogen peroxide	H_2O_2	1.78
Hydroperoxyl radical	OOH	1.7
Oxygen molecule	O_2	1.23

Source: "Fundamentals and Applications of Ozone"

23*[6] Research Institutes That Provided Data for Sharp's Academic Marketing*[5]

Target Substance	Testing and Verification Organization
Viruses	Kitasato Research Center of Environmental Sciences, Japan
	Seoul National University, Korea
	Shanghai Municipal Center for Disease Control and Prevention, China
	Kitasato Institute Medical Center Hospital, Japan
	Retroscreen Virology, Ltd., UK
	Shokukanken Inc., Japan
	Hanoi College of Technology, Vietnam National University, Vietnam
	Pasteur Institute of Ho Chi Minh City, Vietnam
	Public Health Research Foundation, Graduate School of Medicine, Tokyo University
Allergens	Graduate School of Advanced Sciences of Matter, Hiroshima University, Japan
	Department of Biochemistry and Molecular Pathology, Graduate School of Medicine, Osaka City University, Japan
	Soiken Inc., Japan
Fungi	Ishikawa Health Service Association, Japan
	University of Lübeck, Germany
	Professor Gerhard Artmann, Aachen University of Applied Sciences, Germany
	Japan Food Research Laboratories, Japan
	Shokukanken Inc., Japan
Bacteria	Ishikawa Health Service Association, Japan
	Shanghai Municipal Center for Disease Control and Prevention, China

	Kitasato Research Center of Environmental Sciences, Japan
	Kitasato Institute Medical Center Hospital, Japan
	Dr. Melvin W. First, Professor Emeritus, Harvard School of Public Health, US
	Animal Clinical Research Foundation, Japan
	University of Lübeck, Germany
	Professor Gerhard Artmann, Aachen University of Applied Sciences, Germany
	Japan Food Research Laboratories, Japan
	Shokukanken Inc., Japan
Organic Chemicals	Sumika Chemical Analysis Service, Ltd., Japan
Odors, pet smells	Boken Quality Evaluation Institute, Japan
	Animal Clinical Research Foundation, Japan
Skin beautifying effects	Soiken Inc., Japan
Hair beautifying effects	Saticine Medical Co., Ltd.
	C.T.C Japan Ltd.
Efficacy Analysis	
Inhibitory effects on viruses, fungi and bacteria	Professor Gerhard Artmann, Aachen University of Applied Sciences, Germany
Inhibitory effects on allergens	Graduate School of Advanced Sciences of Matter, Hiroshima University, Japan
Skin moisturizing (water molecule coating) effect	Research Institute of Electrical Communication, Tohoku University, Japan

In collaboration with 23 research organizations, Sharp has proven the efficacy of Plasmacluster ions against 29 types of harmful substances (viruses, allergens, fungi, and

bacteria) as well as their efficacy and working mechanism in neutralizing four types of odors, beautifying skin and hair, and controlling static electricity. The efficacy of Plasmacluster ions against two types of organic chemicals has also been demonstrated.

Please note that the information provided here is valid at the time of publication but may be subject to change at a later date.

Footnotes

*[1] Plasmacluster is a registered trademark of Sharp Corporation.

*[2] See an overview of Shokukanken Inc. on page 5.

*[3] Tests conducted at Sharp Corporation and analysis performed by Sumika Chemical Analysis Service, Ltd.

*[4] Japan's largest integrated analytical company.

*[5] Marketing method involving collaboration with leading third-party academic research institutions, whereby data on technical performance is gathered and analyzed in order to apply findings to new products.

*[6] As of April 3, 2014

*[7] According to testing by LSI Medience Corporation (inhalation toxicity test, eye and skin irritation test, and corrosivity test).

*[8] One colony is a clump of cultivated bacteria on the culture medium. One CFU (colony-forming unit) is the number of bacteria needed to form one colony.

*[9] Organic chemicals are separated into their individual substances, which are identified (for type) and then subject to instrumental analysis. Gas chromatography mass spectrometry is used in environmental observation analysis, such as of substances in the atmosphere. This analytical method is also used in fields such as quality control and safety confirmation; for example to measure substances that vaporize from plastics and building materials, and to test for the existence of substances that deteriorate the quality of surrounding materials or that are harmful to humans.