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高電場プラズマを用いた生鮮植物の長期保存

Prolonged Preservation of Fresh Plants using High Electric Field Plasma

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Abstract: “High Electric-Field Plasma (HEFP)” technique in an atmospheric pressure has been developed to control and keep the environmental atmosphere in clean state; such as sterilization, much longer sustenance of fresh states of such plants as vegetables, fruits and flowers, and deodorization of atmospheric air. Here the HEFP system means that there are no apparent discharges between electrodes and the electric field inside the system is as high as $3-4\times10^6$ V/m in the atmospheric pressure. This high field plasma can decompose harmful or poisonous materials for the fresh plants. This also kills bacteria. We have developed special refrigerator which has precise controlling system of temperature and humidity, equipped with HEFP system. In the new refrigerator, usage of harmful or poisonous materials such as ozone, OH radicals or UV light are suppressed. In this refrigerator the fresh plants are preserved much longer duration without increasing bacteria or mold on their surface, compared with conventional method employed so far.

1. Introduction

In the contemporary world many of the living life is faced to environmental hazardous circumstances, including air pollution, increasing CO_2 concentration, water pollution or stain and many others. For human life, it is important issues to supply the fresh foods stably. Therefore, it is necessary to develop preservation system of fresh plants for a long duration without consuming much energy. The plasma phenomena are employed as one of the possible tools for solving these problems.

For decomposing and sterilization of toxic gases using electrical discharges in atmospheric pressure harmful ozone are generated if corona discharge is employed, for example. In this situation new serious problems have taken place so far, such as change of color of crops, and poisonous for human body. When UV light is employed instead of discharge system, same kinds of problems have arisen such as color change of the stored materials, ozone production and seriously harmful to the human body with direct irradiation, in addition to the quite low energy conversion efficiency from electricity to the UV light.

We have developed new technique [1] named “High Electric-Field Plasma (HEFP)” system shown in Fig.1. In this system no apparent discharges such as corona or silent discharges within the electrodes appear, and the electric fields between electrodes keep as high enough as $3-4\times10^6$ V/m in the atmosphere pressure. In the present

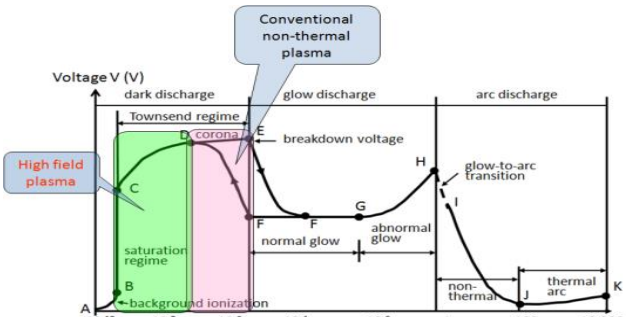

Fig.1. Typical example of I-V characteristic in the discharge system. The definition of HEFP area corresponds to “B-D” area in the “Townsend regime”.

technique, pulsed high voltages with sharp rise time are applied to the controlling electrodes and quite small amount of current less than about 50 μA flows with a present system, but no apparent discharges occur. In this system ozone generation was suppressed as small amount as possible, almost no production, and UV light generation is also suppressed. Thus, apparent effects from

ozone or UV light did not appear. This technique is applicable for decomposing harmful or poisonous chemical materials for the fresh plants and also for killing bacteria or mold in the air. Therefore, this technique has ability to be applied for the contaminated gas cleaning systems.

It is popularly known that plants are breathing to put off the ethylene gas even if they are taken out from the trees or from the farming ground. As ethylene gas has strong ripe effects on the fresh plants including vegetables, fruits and flowers, it is necessary to remove ethylene gas from the preservation spots in order to keep crops in fresh conditions for a long duration. Furthermore, for a long preservation of the fresh plants, the surrounding temperature and humidity are also another key factors and well controlled system of these parameters is required.

The present study includes carbon hydrate decomposition for long preservation of fresh plants and sterilization of bacteria in the surrounding area or on the surface of the plants, by using high field plasma system equipped in a special refrigerator. This refrigerator has shown quite effective results to keep fresh plants as they are for long durations, more than 4~5 times longer than the case used conventional one, although these durations depend on the kinds of plants.

2. Experimental apparatus

The present experiments were conducted with two different types of experimental apparatus: (1) well controlled refrigerator on temperature and humidity and (2) the clean view plastic boxes with no precise artificial control of temperature and humidity inside of the boxes left in the experimental room. In the experiments performed so far many kinds of fresh fruits, vegetables and flowers were tested, but in most of the cases only the data on the change of outside shape were photographed, and no precise data such as weight change, ethylene gas discharging rate and condition of bacteria avoidance were taken. However we have tried to take precise data using limited kinds of fruits and the results will be introduced.

The schematic structure of the refrigerator is shown in Fig.2. The typical sizes used in the present experiments are 2 m (W) x 2 m (D) x 2 m (H). The air is circulating within the refrigerator under well controlled conditions in temperature and humidity. The temperature can be adjusted within ± 1 °C accuracy and the humidity is ± 5 % to the set values. The high field system is set inside the air circulating duct. In order to monitor the ethylene gas contents in the refrigerator, a probe for ethylene gas detector is inserted.

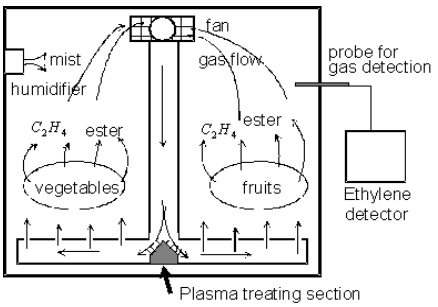

Fig.2. Advanced Refrigerator equipped with High-Electric Field Plasma generator and humidifier

When the plastic boxes are used, these boxes are left in the experimental room with room temperature of about 24 - 25 °C through the experimental duration. The sizes of the boxes are 68 (W) cm x 49 (D) cm x 39 (H) cm, and the top of the box is covered and tightly sealed while the experiments are undertaken. Therefore, ethylene gas amount and humidity within each box are kept as they are. In one box, only sample bananas on a weight scale were set, but in other boxes the HEFP system in addition to sample bananas on a scale were sealed together. Here, one of the high field systems was home-made, but the other one was made by IDX Co. in Japan by our specifications.

Our HEFP producing system is shown schematically in Fig. 3. The electrode size depends on the refrigerator size and several types are employed.

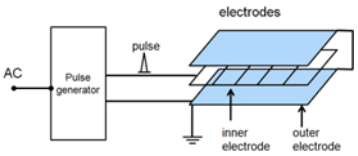

Fig.3. High Electric-Field Plasma system.

The outer electrodes are made of grounded copper mesh, while an inner electrode is made of copper wire folded with 3 cm separation. The gap distance between electrodes is about 1.0 mm. Between electrodes high voltage pulse with rise time of 0.5 μs and pulse width of 1.0 μs is applied. The pulse height is 2.0 kV in peak and the peak current is about 20 – 30 μA with repetition of ~ 150 Hz. These conditions, however, are variable depending on the conditions and sample materials. Precise experimental results will be shown in the conference.

Reference

1). C.M. Liu, Y. Nishida, K. Iwasaki, and K. Ting, IEEE Trans. on Plasma Sci., **39**, No.2, pp. 717-724. (2011).