22P075-P

Long Preservation and Sterilization of Fresh Plants
生鮮植物の長期保存法と殺菌法

C.M. Liu[1], Y. Nishida[1,2,3], K. Iwasaki[4], and K. Ting [1]
劉　沖明、西田　靖、岩﨑憲一、丁　鯤

[1]*College of Engineering, Lunghwa University of Science and Technology*
300 Wan-Shou Rd., Gueishan, Taoyuan 33306, Taiwan
[2]*Plasma and Space Science Center, National Cheng Kung University.*
1, Ta-Hsueh Road, Tainan 70101, Taiwan,
[3]*Research Center for Biomedical Devices, Taipei Medical University,*
Taipei 110, Taiwan
[4]*Daikoh Shoji Corporation, Takaraki-cho, Utsunomiya, Tochigi 320-0075, Japan*

"High-field plasma" technique in an atmospheric pressure has been developed to control and keep the environmental atmosphere in clean state. Here the "high-field plasma" system has no apparent discharges between electrodes and the electric field inside the plasma area is high as $3-4\times10^6$ V/m in the atmospheric pressure. It is demonstrated that fresh fruits are preserved for much longer duration without apparent bacterial contamination compared with the conventional method. In order for this purpose special refrigerator has been developed, equipped with high-field plasma system. In the present refrigerator, usage of harmful or poisonous materials such as ozone, OH radicals or UV light is suppressed.

1. Introduction

In the contemporary world, it is important requirement to supply the fresh foods stably. Therefore, it is necessary to develop the preservation system of fresh plants including foods for a long duration without consuming much energy. The plasma phenomena are employed as one of the possible tools for solving these problems and many new techniques are under developing.

The corona or glow plasma is one of the useful candidate for the present purpose due to its easy operation at atmospheric pressure, and this is applied to many industrial field such as electrostatic precipitation, generation of ozone, sterilization of bacteria and many others [1]-[4]. In reforming or decomposing and/or sterilization of gases by using electrical discharges in atmospheric pressure, however, harmful ozone was generated, and new serious problems were taken place so far, such as change of color of crops, poisonous for human body and so on. When UV light is employed instead of discharge system, the same problems were arisen. In addition, more important thing is quite low energy conversion efficiency from electricity to UV lights.

We have developed new technique [5]-[9], named "High-Filed Plasma" system. This means that the plasma has no apparent discharges, such as corona or silent discharges, and the electric field inside the plasma area is as high as $3-4\times10^6$ V/m in the atmospheric pressure. From now on we wish to use the terminology of "high-field plasma" instead of just "plasma" or "discharges". The precise mechanism on high-field plasma has been explained in Ref.[9]. In the present system the ozone generation and/or UV light related effects were suppressed and no apparent effects appeared.

The plants are breathing to put off the ethylene gas. As ethylene gas has strong ripe effects on the fresh plants, it is necessary to remove it from the preservation spots in order to keep crops in fresh state for a long duration. The purposes of the present study include carbon hydrate decomposition by using high-field plasma system.

2. Experimental setup

The experimental apparatus have been shown in Ref.[10]. In the refrigerator, the air circulating system with high field plasma is set 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.

2-1 The case of grape preservation test;

The grapes were kept in two refrigerators; one with high-field plasma system and the other without it, both were kept under the temperature 2±1ºC and humidity 90%±5 % through the experimental duration.

2-2 The case of banana preservation test;

The bananas were kept in two refrigerators with clear glass windows. The measured parameters were ethylene gas amounts, weight changes and apparent changes. All bananas were kept at 12±1ºC

and humidity at 85%±5%.

2-3 The case of peach preservation test;

In the case of peach preservation, one refrigerator was employed without high field system; instead activated carbon (charcoal) was installed within an air flow duct for absorbing ethylene gas under the temperature 2±1ºC and humidity 80%±5%.

3. Preservation results

In the present paper, only the results on banana preservation results are shown only because of space limitation. Figure 1 shows the result how the ethylene gas exhausted from the bananas inside of the refrigerator was treated by the high-field plasma system. In the case shown by the "blue" color, plasma system was turned off or on in the way of the experiments. When the high-field plasma was turned-off, ethylene gas amount increases, but once the high-field system was turned-on, the gas concentration quickly went done.

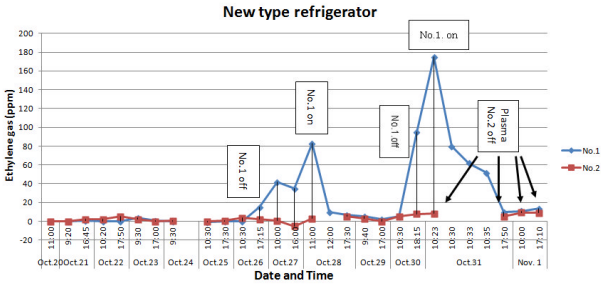

Figure 1. Exhausted ethylene gas amount vs. time. Here, high-field plasma system was turned-on or off while running the system (blue colored case).

The preservation results are shown in Fig.2 by sample photographs, where the photos of bananas with starting days and week later are shown. As clearly seen the bananas stored in the refrigerator with high-field plasma system shows much smaller damage (color change) than the case without high-field system. This is resulted from the fact that the high-field system decomposes ethylene gas and ripe effects on bananas from ethylene gas were weak.

4 Discussions

In the present system, no corona or silent discharges occurs at all, rather high electric-field is built between electrodes. For the present purpose the electric field between electrodes should be strong enough to accelerate electrons in the ambient atmospheric air. The field strength is uniform over most of the electrode area with $0.6-3\times10^{6}$, $(\mathrm{V/m})$ depending on the applied voltages.

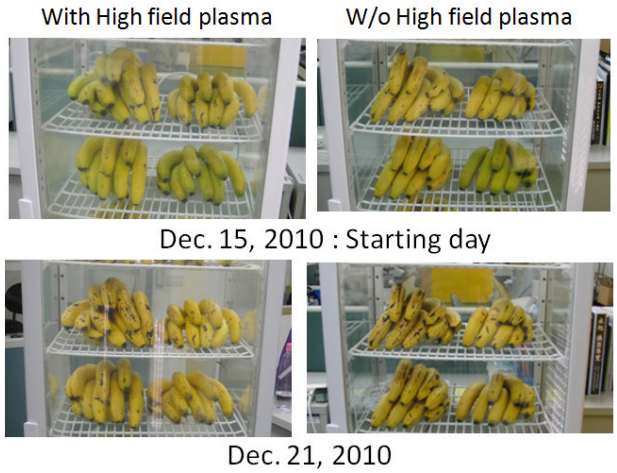

Figure 2. Sample photos of experimental results.

The bonding energy of O-H is about 4.74 eV, that of H-H is 4.44 eV, and that of C-H is 4.22 eV [11]. Therefore, electrons with energy more than 5 eV could decompose these bonding, and as a result oxygen, hydrogen and carbon could be produced as final products.

These processes can decompose many kinds of chemical bonding including the origin of polluted materials in the air, bacteria, and drying action of the air. This technique is extended to apply for the contaminated gas cleaning system or for sterilization devices of contaminated air with bacteria [10].

References

[1] J.S. Chang, P. A. Lawless, and T. Yamamoto, IEEE Trans. Plasma Sci. **19**, 1152 (1991).

[2] M. Sato, N. Ishida, Miho Neide, A.T. Sugiarto, T. Ohshima, and H. Taniguchi, IEEE Trans. Ind. Appl., **37**(6), 1646 (2001).

[3] T. Ohshima, T. Ono, and M. Sato, J. Electrostatics, **46**(2/3), 163 (1999).

[4] L. Zhou, B. Xue, U. Kogelschatz and B. Ellassson, Energy Fuels, **12,** 1191 (1998).

[5] T. Nagasawa, Y. Nishida, and T. Miyazaki, T. IEE of Japan, **119-A**, pp. 1429-1435 (1999) (in Japanese).

[6] T. Nagasawa, Y. Nishida, Y. Uda, and T. Kawatsu , T. IEE of Japan, **121-D**, pp. 526-527 (2001) (in Japanese).

[7] Y. Nishida and K. Iwasak, *Proc. of The 5th Asia-Pacific Int. Symp. on the Basic and Appl. of Plasma Tech.* pp.-151-152, Dec.10-12, (2007), Kaohsiung, Taiwan.

[8] Nihon Hosen System Co, Apr. 20, 1993 (jp 2733470) (Japanese patent). , Jul. 17, 1991 (jp 12047013) (Japanese patent). T. Nagasawa , Y. Nishida and K. Iwasaki., Nov. 22, 2001 (jp 3650932) (Japanese patent)

[9] C.M. Liu, Y. Nishida, K. Iwasaki, and K. Ting:, IEEE Trans. Plasma Sci. **39**, 717 (2011).

[10] Y.Nishida and K.Iwasaki,(JP2009-165183) (Applied for the Japanese patent).

[11] Table 9.123 and others, Chemical Handbook vol.3, 2 (June, 1984). The chemical Society of Japan, Maruzen (in Japanese).