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Direct spray of solution containing short-lived reactive species for plant pathogen control

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Non-equilibrium atmospheric-pressure plasmas in contact with liquid, which are defined as "gas-liquid interfacial plasmas", are widely used in material, environmental, and biological fields. Especially, in the gas-liquid interfacial plasmas for medical and agricultural applications, various kinds of stimuli such as electrical [1], chemical [2], pressure [3], temperature stimuli, are generated and delivered to biological cells and tissues, and affect the biological responses. Among these stimuli, reactive species as the chemical stimuli are particularly important factors. Therefore, we have experimentally investigated the generation and reaction of the reactive species [4,5], especially short-lived reactive species, using several lab-build gas-liquid interfacial plasma devices for agricultural applications.

First, we have developed an air plasma exposed solution (PES) spray device (Fig. 1) for plant pathogen control [6] and induction of pathogen resistance [7]. The direct contact with the plasma in the PES spray device is expected to yield high concentration of the short-lived reactive species, which is transported to target objects in a short time. Five seconds PES spray is found to significantly suppress germination of a fungal conidium of strawberry pathogen (*C. gloeosporioides*). In addition, the germination suppression efficacy is not monotonically modulated by the gas and solution flow rates for PES generation. It is suggested that several short-lived reactive species, generated with control of the solution flow rate, contribute to germination suppression.

In order to detect decay of the OH radical (one of important short-lived reactive species in PES), we try to introduce high-speed (~ 10 m/s) liquid flow in He plasma. This system gives the resolution of sub-milliseconds in the decay measurement of short-lived reactive species. Our preliminary result shows that the half-life of OH is estimated to be 55 μs in our experimental system.

Second, an air plasma-effluent-gas dissolved solution (PEGDS) spray device (Fig. 2) has been developed [8]. The PEGDS spray device relies on the dissolution of the plasma effluent gas into the distilled water for practical use in the farming field. Its performance is characterised by the conidium germination suppression effect on the plant pathogen and the reactive species generated in both gas and liquid phases. The results suggest that O_3 can be responsible for the germination suppression effect under the given operating condition, whose life-time is found to be shortened by the co-dissolved reactive species. This suggests that the O_3 dependent anti-bacterial effect can be tuned by the co-dissolved reactive species, which can balance the anti-bacterial effect, environmental release of the generated species, and plant responses.

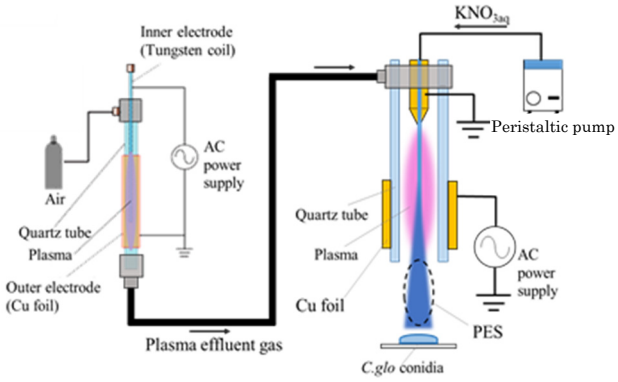

Figure 1. Schematic of an air PES spray device.

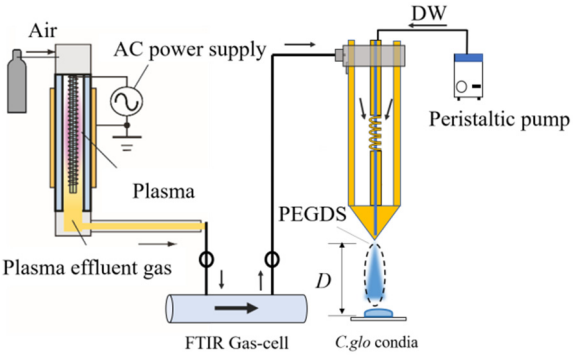

Figure 2. Schematic of an air PEGDS spray device.

References

1. S. Sasaki, Y. Hokari, A. Kumada, M. Kanzaki, T. Kaneko: Plasma Process. Polym., **15**, e1700077 (2018).
2. S. Sasaki, Y. Zheng, T. Mokudai, H. Kanetaka, M. Tachikawa, M. Kanzaki, T. Kaneko: Plasma Process. Polym., **17**, e1900257 (2020).
3. R. Honda, S. Sasaki, K. Takashima, M. Kanzaki, T. Sato, T. Kaneko: Jpn. J. Appl. Phys., **59**, 040904 (2020).
4. Y. Kimura, K. Takashima, S. Sasaki, and T. Kaneko: J. Phys. D: Appl. Phys., **52**, 064003 (2019).
5. K. Shimada, K. Takashima, Y. Kimura, K. Nihei, H. Konishi, T. Kaneko: Plasma Process. Polym., **17**, e1900004 (2020).
6. S. E. Hanbal, K. Takashima, S. Miyashita, S. Ando, K. Ito, M. M. Elsharkawy, T. Kaneko, H. Takahashi: Arch. Virol., **163**, 2835 (2018).
7. A. Ochi, H. Konishi, S. Ando, K. Sato, K. Yokoyama, S. Tsushima, S. Yoshida, T. Morikawa, T. Kaneko, H. Takahashi: Plant Pathology, **66**, 67 (2016).
8. K. Takashima, Y. Hu, T. Goto, S. Sasaki, T. Kaneko: J. Phys. D: Appl. Phys., **53**, 354004 (2020).