S4-6 Applications of Multi- Phase-Media Plasma for Agriculture and Fisheries

マルチフェーズプラズマの農水分野応用

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Multi-phase-media plasmas were produced using pulsed power technologies and were utilized in agricultural and fisheries applications. Magnetic pulse compression (MPC) type pulsed power generator was employed to produce a corona discharge plasmas in air-water mixture layers. Growth rate of B*rassica rapa var. perviridis* (Chinese cabbage) was improved by use of the water after the plasma treatment in the bed-soil cultivation. Nitric acid ions were produced in the water after the plasma treatment. Nitrogen content in the leaves increased by the plasma treatment based on chlorophyll content analysis. The non-thermal plasmas were also generated in gas-solid mixture using a Cockcroft-Walton circuit with small capacitance capacitor. The plasma ignition changes an electric field distribution in vicinity of the plasma. The electrostatic force around the solid material works as keeping freshness of agricultural and marine products owing to the collection of fungi spores and the structure change of albumin in the cell membrane. Fruit body formation of mushroom is also accelerated by the plasma ignition on the cultivation sawdust-bed. The high electric field is caused in the sawdust-bed and is worked as stimulation for the mushroom hypha. The response of the stimulation was confirmed by laccase analysis.

1. Introduction

Repetitively operated compact pulsed power generators with a moderate peak power were developed for the applications in several stages of agriculture and fishery. Types of pulsed power that have biological effects are caused with gas discharges, water discharges, and electromagnetic fields. The discharges yield free radicals, UV radiation, intense electric field, and shock waves. Biologically based applications of pulsed power are performed by selecting the type that gives the target objects the adequate result from among these agents. For instance, intense electric fields form pores on the cell membrane, which is called electroporation [1], or influence the nuclei. The radicals in water react with cell membrane of bacteria. These applications are mainly based on biological effects and can be categorized as germination of plant seeds; control of growth rate of the plants [2]; improvement of mushroom yield [3]; keeping freshness for a relatively longer period of perishables such as fish and shellfish [4]; decontamination of air and liquid to inhibit degradation of agricultural products [5]. These applications can contribute a food supply chain in Japan and the world.

2. Aqua-plasma for plant growth improvement

Figure 1 shows still photographs of the discharge generated in the gas and liquid phases. The distance from high-voltage wire to liquid layer is 9 mm. The streamer discharge initiates at vicinity of the center wire and propagates toward the water layer by applying 9kV pulse voltage generated with the MPC generator [6]. It is clear that the streamer propagates into the bubble through the tiny holes of the separator from the wire electrode.

Figure 2 shows photographs of *Brassica rapa var. perviridis* at 28 days of cultivation for various plasma treatment times [6]. The plasma was irradiated in the drainage water for 10 and 20 minutes each day. One group consisted of three cultivated pots. Another group (the control) was cultivated without plasma treatment. All plants grew by 28 days cultivation. The leaf size of the plants increased with plasma treatment time. The use of plasma in the water can supply many kinds of chemical species, such as OH, O, O_3, NO_2, NO_3, and H_2O_2, among others. Nitrate and nitrous species in

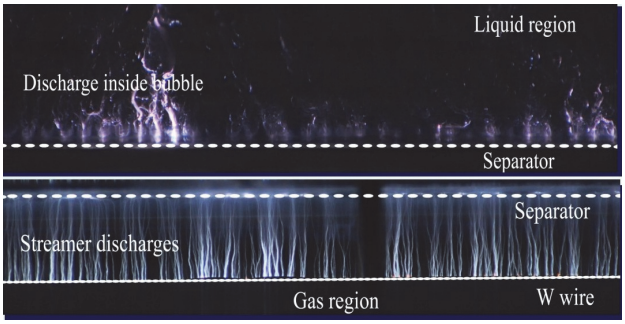

Fig. 1. Typical photograph of streamer discharges: upper is in liquid and lower in gas phases.

the drainage water were measured to clarify the effect of plasma irradiation on the plant growth rate because nitrous nitrogen typically works as a fertilizer in plant cultivation [2].

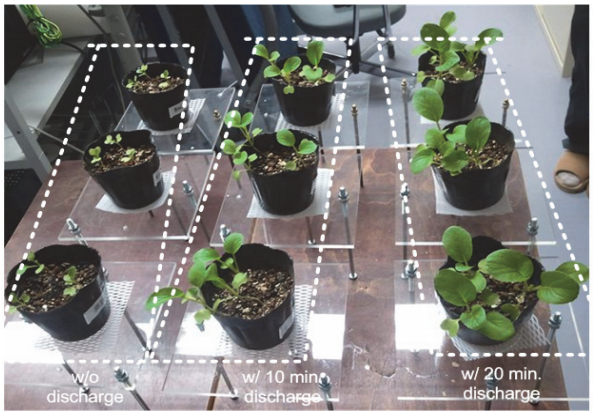

Fig. 3. Photographs of *Brassica rapa var. perviridis* cultivated for 28 days at (a) w/o plasma and with (b) 10 min. or (c) 20 min. treatment per day.

3. Gas-solid plasma for fruit body formation

Figure 3 shows a still photograph image of the discharge from high-voltage electrode to sawdust-bed for *L. edodes* cultivation. The distance from electrode to the sawdust-bed (solid layer) is 10 cm. The discharge plasma bridges between the high-voltage electrode and the sawdust-bed. As the result, the surface potential of the sawdust-bed changes from zero to the high-voltage. This potential change causes high electric field in the sawdust-bed. The hypha of the *L. edodes* are accelerated owing to the strong electrical field [3].

Figure 4 shows scanning electron microscope (SEM) images of hyphae before and after applying pulse voltage. It is confirmed that some parts of the hyphae are ruptured with force generated with the pulse electric field. The application of the pulse electric field generates the forces to the hyphae. Many parts of the hyphae are displaced by the force and some hyphae are ruptured. This is candidate of triggering fruit body formation.

Fig. 3. Photographic image of discharge from high-voltage electrode to the sawdust-bed for *L. edodes* cultivation.

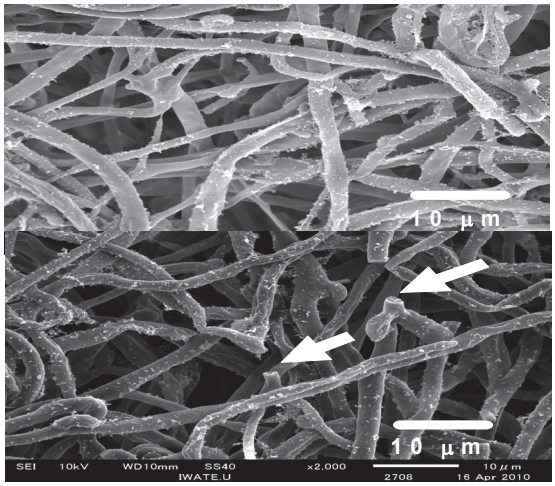

Fig. 4. SEM images of *Lentinula edodes* hypha before (top) and after (bottom) applying 10 kV pulse high-voltages.

4. Preservation of marine products

AC electric field was used to improve a freshness of perishable food such as purple sea urchin. **Figure 5** shows the gel electrophoresis profile obtained by the SDS-PAGE analysis. For the group which did not apply the AC electric field at the time of a freeze, the amount of molecules with the molecular weight of less than 70000 has increased, and the amount of molecules with the molecular weight of 150000~180000 has decreased. This indicates the protein decomposition which means digestion [6].

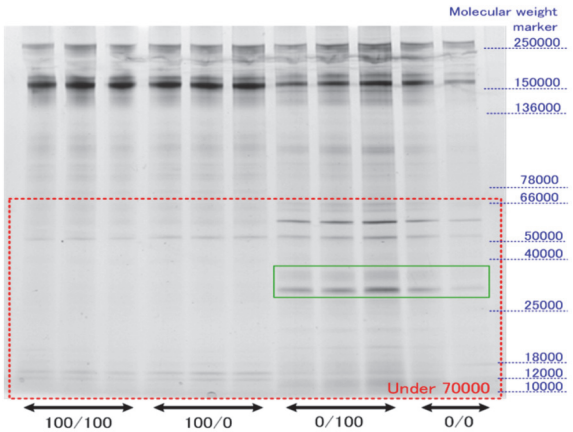

Fig. 5. Gel electrophoresis profiles. [Output voltage in freezing / in defrosting].

References

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