Characterization of Surface Barrier Discharge Source using Comb Electrode System Suitable for Seed Treatment

Hisashi Koga, Tsuyoshi Nomiyama, Tomohiro Kawashima, Takahiro Yamauchi, Hirofumi Takikawa
Toyohashi University of Technology
koga.hisashi.lc@tut.jp

Introduction

Seed germination requires the presence of environmental conditions such as temperature, water, and oxygen. However, even when living seeds are provided with appropriate environmental conditions, they may fail to germinate due to seed dormancy[1]. Regarding this cause of reduced yield, reports indicate that plasma and ozone exposure treatments can break seed dormancy and improve germination rates[2][3]. In this study, we evaluated the impedance changes and cumulative power of a comb-shaped electrode system during plasma generation, aiming to develop a surface discharge plasma device effective for seed treatment.

Experimental Procedures

A suitable filter (14 nF//1 kΩ) was connected in series with the plasma source, and the voltage across its terminals and the input signal were recorded at one-second intervals. Figure 1 shows the system configuration and the plasma source using a comb-shaped electrode system. Aluminum tape with 0.1 mm thickness was employed as electrodes. The comb-shaped electrode, with five teeth each, is 60 mm in length and 1 mm in width. It was attached to a 2 mm thick glass or vinyl chloride (PVC) plate on the high-voltage side. Additionally, another aluminum tape, serving as a ground electrode, was placed on the back of the comb electrode, covering the 50 mm long section completely, as shown in Figure 1. An AC high voltage of 10 kV and 20 kHz was applied to the comb-shaped electrode and creepage discharge characteristics was observed for 30 minutes.

Results and Discussion

Figure 2 shows the time variation of impedance and the cumulative generation power over 30 minutes. In the case of the comb-shaped electrode system using glass, the impedance and generation power values remain approximately stable from immediately after discharge begins. Conversely, when using PVC, the impedance profile exhibits nonlinearity, and its values stabilize at nearly the same level after 5 minutes of applying voltage. This trend is also seen in the generation power profile. It is suggested that the surface resistance of PVC results from plasma surface treatment. The results indicate that impedance measurements can be performed on the plasma source during discharge. Furthermore, it is suggested that substrates with high dielectric constants, which are less susceptible to surface modification by the plasma, are more suitable for use as surface discharge plasma sources for seed treatment.

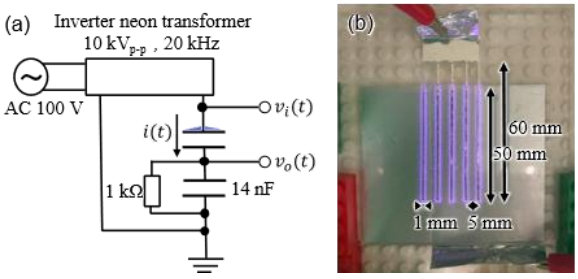

Figure 1 Test system. (a) Measurement system.
(b) Comb-shape electrode system.

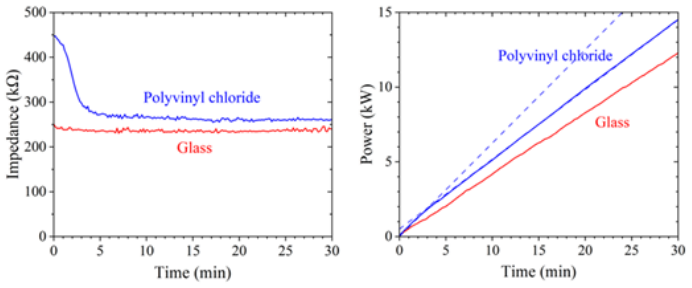

Figure 4 Characteristics of surface discharge plasma.
(a) Impedance. (b) Cumulative power.

References

[1] L. Taiz, E. Zeiger, Plant Physiology and Development, 513- 515 (2020)
[2] Yujuan Li et al.:Plasma Chem Plasma Process, 37, 1621–1634 (2017)
[3] N. Sudhakar et al.:American Journal of Plant Sciences, 2, 443-448 (2011)