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ESR study of plasma irradiated seeds

Masaharu SHIRATANI, Yosuke WADA, Ryoya SATO,
Daisuke YAMASHITA, and Kazunori KOGA
Department of Electronics, Kyushu University
siratani@ed.kyushu-u.ac.jp:

1. Introduction

One of the biggest challenges that humankind is facing is improving the sustainability of agriculture while reducing its environmental impact, to meet the food demands of the rapidly growing global population. Such agricultural sustainability needs to develop novel technologies with no adverse effects on environments but still leading to improvements in food productivity. Despite contemporary agriculture largely uses chemical compounds, the use of low temperature plasma might represent a good alternative to raise the yield of agricultural production while improving plant protection and storage [1-6]. Low temperature plasma methods for seed invigoration offer several advantages over conventional treatments. First, they reduce the use of fertilizers, thus decreasing pollution of agricultural products. Another advantage is that low temperature plasma methods can be used for seed disinfection before sowing and during the storage. So far, we have shown several remarkable effects of plasma irradiation to seeds [1]. Here, we report the ESR analysis on the biochemical changes induced in radish sprout seeds upon irradiation with increasing irradiation time (dose) of low temperature plasma.

2. Experimental

Experiments were carried out using a scalable dielectric barrier discharge (DBD) device which consisted of 20 electrodes of a stainless rod of 1 mm in outer diameter and 60 mm in length covered with a ceramic tube of 2 mm in outer diameter [1-4]. The electrodes were arranged parallel with each other at a distance of 0.2 mm. The discharge voltage and frequency were 7.96 kV and 9.2 kHz, respectively. The discharge power density was 3.05 W/cm^2. The dishcarge plasma was irradiated to seeds of radish sprouts. the biochemical changes induced in radish sprout seeds upon plasma irradiation were detected by ESR.

3. Results and Discussion

Figure 1 shows plasma irradiation time dependence of ESR signal (g=2.03) intensity normalized with control. This signal corresponds to stable radicals generated in seeds. The intensity increases with increasing the irradiation time from 0 to 3 min, then it becomes nearly constant. Plasma irradiation induces little intensity change of other ESR signals, corresponding to transition metal ions in seeds. We have also identified most stable radicals, typically semiquinone and tyrosyl character, are generated in seed coats.

We cultivated the plasma irradiated seeds together with control. The fastest growth rate was obtained for 3 min. plasma irradiated seeds. Then the growth rate decreases

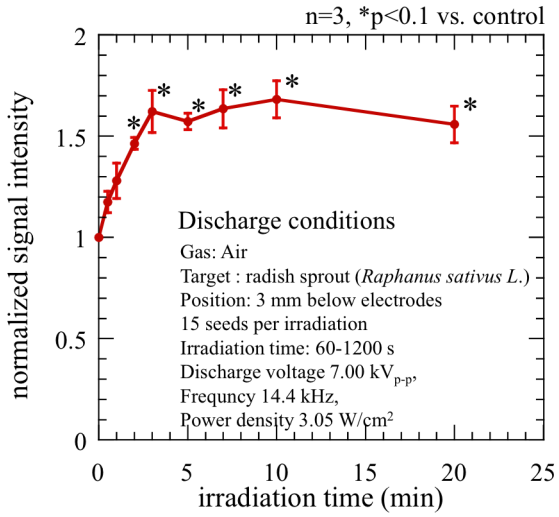

Figure 1. Plasma irradiation time dependence of ESR signal (g=2.03) intensity normalized with control.

with increasing the plasma irradiation time above 3 min.

The results suggest that ESR spectrometry is a relatively fast and simple technique to measure free radicals generated upon plasma irradiation. This has an enormous potential on a seed technology context, since ESR can be used to monitor seed invigoration treatments and identify the best suitable plasma irradiation time or time-point to stop the treatment.

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