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Growth promotion characteristics of bread yeast by atmospheric pressure dielectric barrier discharge plasma irradiation

大気圧バリア放電プラズマ照射による酵母の成長促進特性

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We have investigated growth promotion of bread yeast (Saccharomyces cerevisie) by atmospheric pressure dielectric barrier discharge plasma irradiation. NO of 70 ppm and O_3 above 200 ppm are produce by the DBD plasmas. DBD discharge plasma irradiation of 50 and 100 s enhances the growth of yeast in the lag phase. At t = 1000 min in the lag phase, the absorbance of yeast with 50 s plasma irradiation is 3 times higher than that without plasma irradidation. There is an optimum duration of plasma irradiation for the growth promotion.

1. Introduction

Nonthermal atmospheric pressure plasmas have been employed for biomedical processing applications, because they provide high density radicals at a low gas temperature [1-7]. Recently, nonthermal atmospheric pressure plasmas as well as low pressure plasmas have been employed for growth promotion of plant cells [8-12]. Such enhancement of cell proliferation by plasma irradiation is useful in many fields of cancer therapy, regenerative medicine, fermentation industry, and so on. In this study, we have developed a scalable atmospheric pressure dielectric barrier discharge (DBD) device for biomedical processing in a large area and have employed the device to growth promotion of bread yeast for fermentation applications.

2. Experimental

Figure 1 shows a schematic of the DBD discharge device. The device 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. The electrodes were arranged parallel with each other at a distance of 0.2 mm. The discharge voltage and frequency were 10 kV and 10 kHz, respectively. Optical emission spectra from the discharge plasmas were obtained with a spectrometer to obtain information on the radicals generated in the plasmas.

We employed dry yeast (Saccharomyces cerevisie) for the plasma irradiation experiments. The yeast of 0.01 g was placed 1 mm below the electrodes. The discharge voltage and frequency were 10 kV and 10 kHz, respectively. The plasma irradiation was carried out in the air. The irradiation duration T_{on} was 50, 100 and 150 s. After the irradiation, yeast was suspended in 1 ml yeast extract peptone dextrose (YPD) medium and agitated with a vortex mixer. 1 µl of sample was mixed with 199 µl YPD medium in a micro well plate and cultivated using a shaking incubator at 30 ^{o}C. To obtain growth curve of yeast time evolution of 660 nm light absorbance of the samples was measured with a micro plate reader.

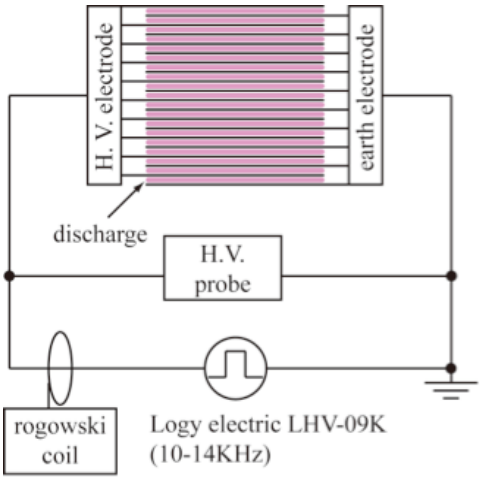

Fig. 1. Schematic of atmospheric pressure dielectric barrier discharge device.

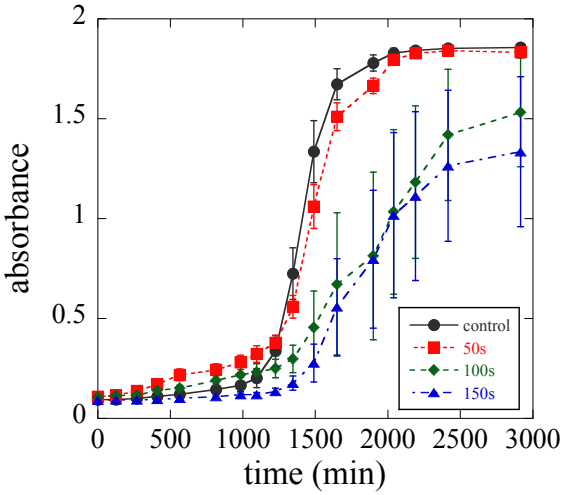

Fig. 2. Growth curve of dry yeast.

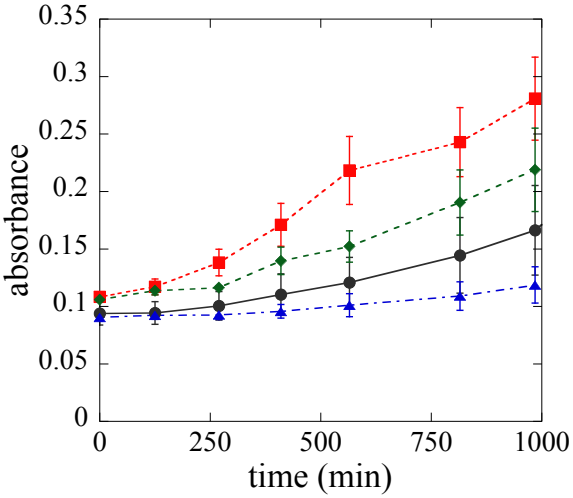

Fig. 3. Growth curve of dry yeast in lag phase.

3. Results and Discussion

Optical emission measurements show emission NO-γ at 200 - 250 nm. Gas detector tube experiments show NO of 70 ppm and O_3 above 200 ppm at 10 mm below the electrodes produced by the DBD discharge plasmas.

Figure 2 shows the growth curve of dry yeast. For the control, the absorbance is almost constant until t = 1000 min. after the beginning of the cultivation, which corresponds to the lag phase, and then it exponentially increases with t, the exponential growth phase. For yeast with the plasma irradiation of 50 and 100 s, the absorbance increases from t = 0 min. At t = 1000 min., the maximum absorbance for T_{on} = 50 s is 3 times as high as that for the control (see Fig. 3). After t = 1000 min., the absorbance increases exponentially with t. For longer T_{on} of 100s and 150s, the yeast is inactivated and hence it growth is suppressed compared to the control. These results suggest that the DBD plasma irradiation reduces the lag phase of yeast cell division and there is an optimum duration of plasma irradiation for the growth promotion.

4. Conclusions

We have investigated growth promotion characteristics of bread yeast by atmospheric pressure dielectric barrier discharge plasma irradiation. We obtained the following conclusions:

1) NO of 70 ppm and O_3 above 200 ppm are produce by the DBD plasmas.
2) DBD plasma irradiation of 50 and 100 s enhances the growth of yeast in the lag phase.
3) At t = 1000 min in the lag phase, the absorbance of yeast with 50 s plasma irradiation is 3 times higher than that without plasma irradiation.
4) There is an optimum duration of plasma irradiation for the growth promotion.

Acknowledgment

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