

Antibiotic-Resistant and Non-Resistant Bacteria Display Similar Susceptibility to Dielectric Barrier Discharge Plasma

Electron spin resonance (ESR) spectroscopy detected radicals generated during DBD plasma torch operation.

Materials and Methods

ESR

OH radicals ($\text{OH}\cdot$) and H radicals ($\text{H}\cdot$) generated in water by plasma irradiation were detected using an electron spin resonance meter (TE-100, JEOL Ltd., Tokyo, Japan). DMPO (5,5-dimethyl-1-pyrroline *N*-oxide) purchased from Kyoto-Spinlabo CO., Ltd. (Kyoto, Japan) was used as a radical trapping agent. The concentration of DMPO was 100 mM in distilled water (DMPO solution). After bubbling with nitrogen gas for 5 min (flow rate: 1.0 L/min) to remove dissolved oxygen from the DMPO water, 1.0 mL of DMPO solution in a 2.0 mL-microtube was subjected to 5 min plasma irradiation using a DBD plasma torch. The distance between the DBD discharge plasma and the surface of the DMPO water was 10 mm. An aliquot of the solution was then collected using a hematocrit tube and placed in a quartz tube for ESR measurements. All ESR measurements were carried out at a microwave frequency of 9.4280 GHz, with a 60 s sweep time and an acquisition frequency of 1 time. Measurement conditions for the ESR device included a magnetic field of 335.6 ± 5.0 mT, modulation width of 0.10 mT, modulation frequency for the magnetic field of 100 kHz, time constant for detection of 30 ms and a gain for the detector of 125–500. Estimations of g values were performed using the signal of Mn^{2+} in MgO matrix as a secondary standard.

Results

ESR was used to investigate the reaction process of gas plasma in a DBD plasma torch. The radical scavenger DMPO was used to detect free radicals by ESR. The main component of the ESR spectrum was a strong signal of four lines, giving a signal strength ratio of 1:2:2:1, together with several weaker signals. The strong signal is derived from a DMPO/OH radical in which an OH radical reacts at the 2-position of DMPO, and the weak signal can be attributed to a DMPO/H radical in which a hydrogen atom reacts at the 2-position of DMPO. These results suggest that OH radicals and H radicals were generated by plasma irradiation.

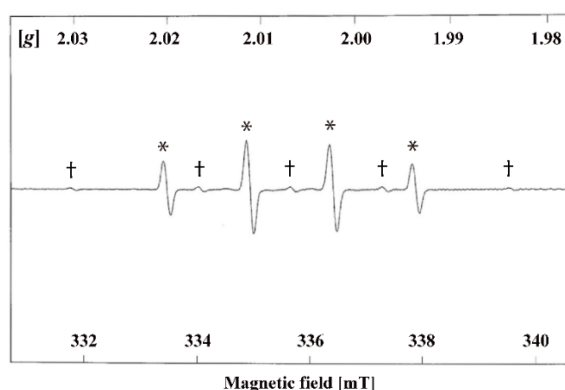


Figure S1. ESR detected radicals generated during operation of a DBD plasma torch. ESR spectra of spin adducts in aqueous solution irradiated using a DBD plasma torch with nitrogen at a flow rate of 1.0 L/min for 10 min after bubbling with nitrogen gas. ESR spectrum of DMPO shows a 1:2:2:1 quartet of DMPO-OH (*) and several other smaller peaks due to DMPO-H (†).