

Biological effects of radical-free under-water plasma activated water

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Research on plasma-activated water (PAW) has been actively conducted in the 21st century. Most of the technologies adopted to produce PAW is a gas discharge cold plasma. While treating the water with plasma, reactive oxygen species and reactive nitrogen species of plasma are dissolved in water. As a result, biological efficacy observed in plasma-activated water is related to the sterilization effect of various kinds of free radicals. On the other hand, the presence of active species becomes an obstacle to the wide application of plasma-activated water.

In this paper, the production of radical-free plasma-activated water by utilizing under-water plasma generation is introduced. Ultrapure water having resistance 1.8 MΩ·cm was prepared by micro filtering and deionization process. A stable and continuous generation of under-water plasma was obtained by the chain reaction of nanobubbles collapse. Hydrogen gas was detected by gas chromatography from this PAW. The pH was around 4, and the oxidation reduction potential (ORP) was around +150 mV on average. No bactericidal effect was observed in this water due to the absence of reactive species. Quite interestingly, this water showed reduction capability which was confirmed by the free-radical scavenging effect. This effect is estimated to be from the hydrogen nanobubbles.

For the cell culture experiment, a cell culture medium was prepared using this PAW and it was observed that the proliferation rate increased by about ~50% on average in various cells including macrophage RAW 264.7 immune cell, pancreas cell, etc. In particular, a synergy effect of sterilization due to the acidity of PAW and promoting cell regeneration effect was observed for a patient having serious bed sore. By continuous spraying of PAW, secondary infection was prevented, and it was completely healed in about 2 months without leaving any scar.

On the other hand, an effect of inhibiting proliferation was observed for cancer cells including breast cancer cells and others. This result is presumed to be due to oxygen gas nanobubbles present in PAW. In order to observe the effect of drinking this water, an experiment on mice infected with influenza virus was carried out. It was found that weight loss was decreased, antibody formation was increased, and virus concentration was significantly reduced in the group fed with the PAW. Comprehensively, continuous drinking of PAW showed more than 90% inhibitory efficacy in the early stage of influenza virus infection. These results suggest that radical-free under-water PAW can be used in a wide range of areas such as wound healing, cell regeneration, recovery from cancer as well as prevention of flu and coronavirus disease (COVID-19).