Chemical Modifications in Non-Thermal DBD Plasma Treated Water and Antimicrobial Effects

Utku K. Ercan[1,3], Arben Kojtari[2], Hai-Feng Ji[2], Greg Fridman[1], Ari D. Brooks[3], Suresh G. Joshi[3]

[1] *School of Biomedical Engineering, Science & Health Systems, Drexel University, Philadelphia PA, 19104, USA*
[2] *Department of Chemistry, College of Arts and Science, Drexel University, Philadelphia PA, 19104, USA*
[3] *Department of Surgery, Drexel University College of Medicine, Philadelphia PA, 19102, USA*

utkuercan@gmail.com

Plasma medicine is an emerging area of biological and medical applications, and non-thermal atmospheric plasma is a major focus of it. Most literatures are pertinent to direct plasma treatment. Previously our laboratory has reported that antimicrobial effect of non-thermal dielectric-barrier discharge plasma using floating electrode (FE-DBD) is much more effective than other traditional methods, and able to inactivate bacterial pathogens in both the planktonic and biofilm forms [1]. We also reported that FE-DBD technique of plasma application generates reactive oxygen species (ROS) that are significantly responsible lipid peroxidation, and eventual DNA damage, and that the known antioxidant was able to prevent these changes significantly [2]. The aim of present study is to characterize non-thermal DBD plasma treated water for its chemical properties which are playing major role on antimicrobial effect Among the possibilities are decreased pH, ROS and RNS that are generated in plasma treated water, and comprehend possible mechanisms responsible for making plasma treated water stable for extended period of time. Our findings suggest that non-thermal DBD plasma treatment of water generates ROS, acidified nitrates, and strong antimicrobial effect. Our findings also showed that non-thermal DBD plasma treated water (for 3 minutes), inactivates all the pathogens to 10^8/mL as well as in biofilm forms. The pH was dropped to ~2.00. The plasma treated water could sustain its antimicrobial property for weeks at normal atmospheric conditions. Amount of H_2O_2, HNO_3 and HNO_2 in water that are generated by 3 minutes of non-thermal DBD plasma treatment were determined as 50 mg/L, 3.86 mM, 0.26 mM respectively by using UV-vis spectroscopy, GC-MS and hydrogen peroxide assay kit (National Diagnostics, Atlanta, GA). In conclusion, non-thermal DBD plasma treatment of water generates strong oxidative species, which contribute microbial inactivation. Low pH and generation of nitric acid and nitrous acid might be responsible for chemical stabilization of generated species or their products. For the better understanding of underlying mechanisms of antimicrobial effect, and stabilization of non-thermal DBD plasma treated water, studies are underway.

References

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