Antibacterial Activity of Plasma-Activated Water and Ultraviolet Radiation in a Coupled System

Bernard Gitura Kimani[1], Ramin Mehrabifard[1], Oleksandr Galmiz[1], and Zdenko Machala[1]
[1]Division of Environmental Physics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Mlynská dolina, 842 48 Bratislava, Slovakia
E-mail: kimani1@uniba.sk

Cold atmospheric plasmas (CAP) generated in the ambient air have found applications in diverse fields such as agriculture, biomedicine, and food processing [1]. Plasma-activated water (PAW) is produced by treating water using plasma-generation devices and it contains various reactive oxygen and nitrogen species (RONS), such as hydrogen peroxide, ozone, superoxide radicals and nitrite ions, among others [1]. Ultraviolet radiation (UVA 315-400 nm, UVB 280-315 nm, UVC 120-280 nm) is also a versatile tool with a wide range of practical applications [2]. Combining PAW and UV radiation as an antibacterial strategy offers a synergistic and effective approach for disinfection and steriliza t ion purposes with potential benefits in terms of efficacy, versatility, and environmental sustainability. This study investigated the antimicrobial properties of plasma against planktonic *E. coli* CCM 3954. The UVA radiation as a supporting system in generating RONS and its subsequent effects on planktonic bacteria was characterized [3]. The concentration of gaseous plasma species, namely H_2O_2, O_3 and (H)NO_x (HNO_2, NO_2, and NO), was determined. Further, their dissolution in water as H_2O_2(aq), O_3(aq), NO_2^-(aq), and NO_3^-(aq) was also investigated. Different modalities of plasma-UVA antimicrobial treatment were tested in our study including direct plasma treatment, UVA exposure, and a combination of plasma and UVA. In addition, plasma water treatment followed by UVA exposure and vice versa was also investigated. The efficacy of the PAW and UVA radiation coupled system was assessed by determining the number of viable bacteria present in the microbia l suspension after plasma treatment through agar plating as compared to the untreated control samples. The results of our investigation show that the PAW-UVA radiation coupled system is a feasible antimicrobial strategy that can be used in microbial decontamination of water and surfaces.

Acknowledgment: This work was supported by Slovak Research and Development Agency APVV-22-0247 and Comenius University grant UK. O. Galmiz was supported by Marie S. Curie Action Postdoctoral Fellowship under Horizon Europe with grant agreement number 101066764.

References

[1] Zhang, H. *et al. Front. Nutr.* 11, (2024)

[2] Zhang, H. *et al. Appl. Microbiol. Biotechnol.* 107, 5301–5316 (2023)

[3] Pavlovich, M. J. *et al. Plasma Process. Polym.* 10, 1051–1060 (2013)