Influence of Ozone on Suspended Microorganisms caused by DBD Treatment: A Comparison with Ozone Gassing

Katrin Oehmigen[1], Ronny Brandenburg[1], Klaus-Dieter Weltmann[1], Thomas von Woedke[1]

[1] *INP - Leibniz Institute of Plasma Science and Technology, D-17489 Greifswald, Germany*
E-mail: oehmigen@inp-greifswald.de

The treatment of liquid with a surface dielectric barrier discharge (DBD) under atmospheric pressure in air results in pH decrease and generation of nitrate (NO_3^-), nitrite (NO_2^-) and hydrogen peroxide (H_2O_2) in water. As well as, suspended microorganisms were inactivated within a few minutes [1] [2]. Furthermore, ozone (O_3), dinitrogen oxide (N_2O), carbon dioxide (CO_2) and nitric acid (HNO_3)/peroxynitrous acid (ONOOH) were detected by FT-IR in the gas gap between the plasma and the liquid surface [2].
Ozone is known for its antimicrobial effects [3] [4] but other active species from the plasma are candidates for biological decontamination, too. In order to resolve the role of O_3 in the plasma-liquid interaction a comparing study has been performed. Using an ozoniser and a FT-IR spectrometer different ozone concentrations as reached during direct plasma treatment of liquids (145 – 1900 ppm) were generated in a separate discharge chamber (without liquid sample) and the ozonized gas was blown over the liquid surface in a downstream petri dish. The pH and the H_2O_2 concentrations were estimated in 5 ml ozone treated water, as well as, antimicrobial effects on *E. coli* and *S. aureus* (10^7- 10^8 cfu · ml^{-1}) suspended in physiological saline were investigated.
It was found a pH decrease to 4.7, but lower generation of H_2O_2 than in direct DBD treated water. Inactivating effects on the microorganisms are weaker in case of ozone gassing. Consequently, the observed effects of the DBD treatment were not caused by ozone alone.The generation of protons (H^+) and H_2O_2, as well as, the antimicrobial effects may result from reactions of ozone with water. Presumably, $HO^\bullet$ and $HOO^\bullet$ radicals were produced and may cause the inactivating effects of the microorganisms. Also the pH decrease could be explained as given in equation (1). The H_2O_2 generation is a result of radical recombination as given by equation (2) and (3) [5] [6].

$$HOO^\bullet \leftrightarrow H^+ + O_2^{\bullet-} \qquad (pKa = 4.8) \qquad (1)$$

$$2\,HO^\bullet \leftrightarrow H_2O_2 \qquad (2)$$

$$2\,HOO^\bullet \leftrightarrow H_2O_2 + O_2 \qquad (3)$$

Additionally, other presumably nitrogen-based reactive species may play a role in the effects of plasma-liquid interaction. Therefore, further investigations have to be done.

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References

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