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The Reactive Species Produced by Transient Spark Discharge in Gas and Liquid Phase and Its Effect on *Escherichia coli*

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Low temperature plasma generated at atmospheric pressure in contact with water induces numerous reactive species in the gas phase, which diffuse into liquid phase and induce chemical and biological changes. Despite many studies, the exact mechanism of plasma interaction with living organisms is still not enough clear. The main objective of the study was to put into correlation the chemical changes in gas and liquid phase and bactericidal inactivation induced by the plasma generated in various gas mixtures above various water solutions and to get more information on the reactive agents responsible for the biocidal effects. We used the self-pulsing transient spark (TS) discharge driven by positive DC power supply generated in various gas mixtures of O_2/N_2 (~ 2 L/min) above the circulating water solutions (~ 14 mL/min) - non-buffered solution of monosodium phosphate (NaH_2PO_4, pH 5, 600 ε S/cm, W) and 2 mM phosphate buffer solution (Na_2HPO_4/KH_2PO_4, pH 7, 550 ε S/cm, PB) - to explore the impact of pH on chemistry. The gas phase species were analyzed by FTIR measurements. UV-VIS absorption spectroscopy was used to measure concentrations of H_2O_2 and NO_2^-. By UV-VIS fluorescence spectroscopy we evaluated the concentration of $^{\bullet}OH$ radical via hydroxylation of terephthalic acid. Standard colony counting method was used to evaluate the effect of the TS on Gram-negative bacteria *E. coli*. In the gas phase, in gas mixtures containing both O_2 and N_2 molecules, NO and NO_2 were detected as main products. Their concentrations increased with $O_2/(O_2+N_2)$ ratio up to 50%, where NO and NO_2 concentrations achieved maximum of 264 ppm and 60 ppm, respectively (Fig. 1). In the case of the TS generated in pure O_2 only O_3 (~ 110 ppm) was detected. The concentrations of H_2O_2, NO_2^- and $^{\bullet}OH$ radical in water solutions depended also on O_2/N_2 ratio in gas mixture. For the TS generated in pure O_2 or N_2, the NO_2^- concentration was low, while H_2O_2 was relatively high (Fig. 2). In the case gas mixtures contained both O_2 and N_2, the most significant pH decrease and balanced concentrations of reactive species (0.4-0.5 mM) resulted into the strongest bactericidal effect due to the formation of $ONOO^-$ from reaction of H_2O_2 with NO_2^- [1].

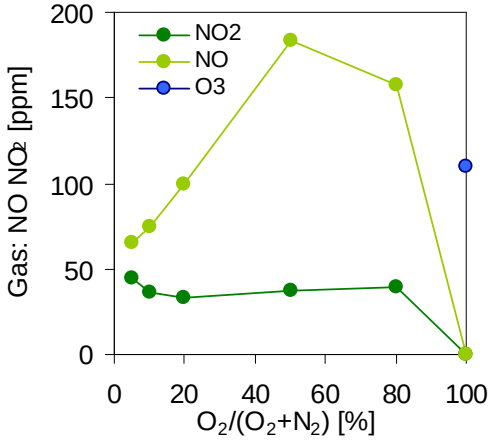

Fig. 1 Concentrations of NO and NO_2 in the gas phase generated by TS discharge.

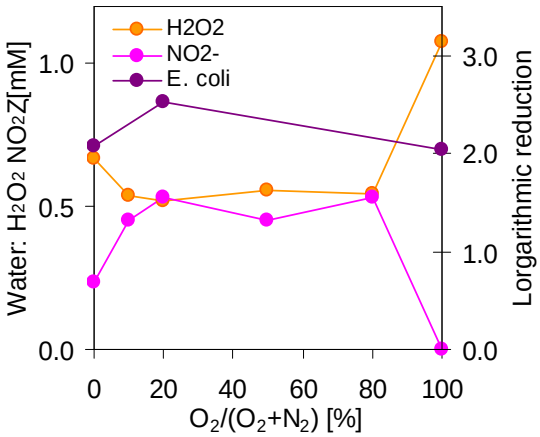

Fig. 2 Concentrations of H_2O_2, NO_2^- and inactivation of *E. coli* in water (W).

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References

[1] P. Lukes, E. Dolezalova, I. Sisrová, M. Clupek, *Plasma Sources Sci. Technol.* **23**, 15 (2014).