ROS and RNS formed in water sprayed through transient spark in air and their bactericidal effects

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Recent studies show that the bactericidal effects of atmospheric pressure cold air plasmas in contact with water are dominantly due to reactive oxygen and nitrogen species (ROS, RNS). We investigated the chemical effects induced in water electro-sprayed through DC-driven positive transient spark discharge at a constant flow rate of 0.5 mL/min.

The chemical effects induced in the plasma treated water were measured by pH and conductivity probes, spectrophotometrically for peroxides (OO^{2-}), and by high resolution ion chromatography for nitrites (NO_2^-) and nitrates (NO_3^-). Aqueous solutions of various initial conductivities were used: deionized water (σ=1 μS/cm), NaH_2PO_4 solutions of σ=500-700 μS/cm mimicking tap water, and physiological saline solutions (σ=7 mS/cm). The initial pH was 5-7. After spraying the solutions through a positive transient spark, conductivity and acidity increased (pH dropped down to ~3).

Bacterial suspensions of *E. coli* (CCM3954) and other bacteria (*S. typhimurium, B. cereus*) were sprayed through the discharge. Up to 7 log reduction in the number of bacteria was obtained in water or in saline solution. Acidity itself is not the main bactericidal agent, as confirmed by the tests with the nitric acid solution of the same pH. Acid environment in synergy with plasma agents leads to the bacterial inactivation. To elucidate the pH effect on the plasma induced water chemistry we tested aqueous solutions buffered with dilute phosphate buffer (PB) that did not decrease their pH after plasma treatment. Non-acidic environment resulted in higher nitrites, slightly lower peroxides and nitrates, and strongly reduced bactericidal effect (about 1 log bacteria reduction). Fig. 1 shows bactericidal effect (log reduction) and NO_2- concentrations as functions of pH after treatment.

Air plasma water treatment produces nitrites, nitrates and peroxides. It seems that the acidified nitrites are the dominant bactericidal agents in water treated by air plasma.

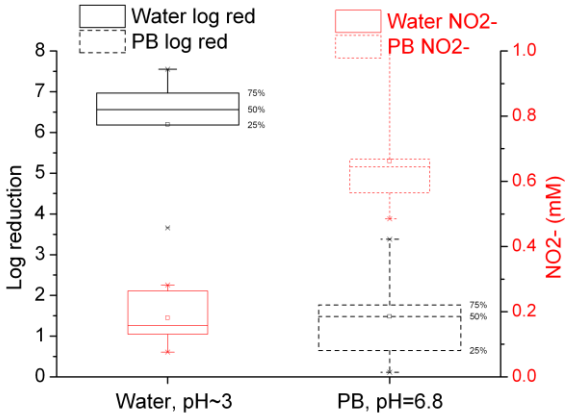

Figure 1: *Bacteria log reduction and nitrite concentration in water and phosphate buffered solutions depending on pH after plasma treatment.*

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