Air DC transient spark discharge inactivation of *E. coli* in water

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Positive transient spark discharge generated in air above a water electrode, or with water electro-sprayed through the discharge zone was used to treat water solutions contaminated with *Escherichia coli*. The chemical effects induced in water, i.e., changes of pH, conductivity, temperature, concentrations of hydrogen peroxide $\text{H}_2\text{O}_2$, and peroxynitrites ONOO$^-$, were evaluated and linked with the bactericidal effects.

1. Methodology

Two different setups of DC transient spark discharge have been used. The first setup for *water electrode* experiments consisted of needle electrode placed above an inclined plane with a narrow water channel and a water flow controlled by a peristaltic pump. The volume and the flow rate of water, the discharge power and the treatment time were varied. The second setup for *electro-spraying* consisted of hypodermic needle placed above a mesh electrode. The water was sampled through the needle and got atomized into small droplets by the DC electric field applied to the needle. The water droplets passed through the discharge zone and were collected under the mesh electrode. The water solutions of various initial pH and electrical conductivities were used: phosphate solution mimicking tap water, physiological saline solution, as well as their buffered counterparts. $\text{H}_2\text{O}_2$ and peroxynitrites were measured by absorption and fluorescence spectrometry, respectively, described in detail in [1].

2. Results

The results of water treatment in both systems were compared for a given volume of liquid treated at a constant discharge power and time. The acidity, conductivity and temperature of non-buffered solutions increased almost linearly with the discharge treatment time. After 10 minutes of treatment, the pH of tap water decreased from the initial $\approx 5.0-5.5$ to $2.5-3.5$, and of physiological solution from $\approx 6.2$ to $2.5-3.0$. The conductivity of water changed from $\approx 600$ $\mu$S/cm to 800-900 $\mu$S/cm, and of physiological solution from 6.0 to 5.7-6.4 mS/cm. The temperature of the solutions increased by $\approx 1.5^\circ\text{C}$. The relative changes in pH, conductivity and temperature in both systems were quite similar. On the other hand, the concentrations of $\text{H}_2\text{O}_2$ and ONOO$^-$ were found higher with the liquid electrode system. The bactericidal efficacy of the discharge expressed as logarithmic reduction of *E. coli* population showed up to $\approx 6$-log reduction both in water and saline solutions for electro-spray system. With the same discharge energy input and treatment time, logarithmic reduction of only $\approx 3-4$ logs was observed in the water electrode system. In buffered solutions, significantly lower (1-2 logs) bactericidal effects were obtained. The higher bactericidal efficacy of the electro-spray system is due to more effective contact of the discharge with water droplets. Synergistic effect of nitrates and peroxides in acidic conditions seems to be the most probable mechanism responsible for bactericidal properties of water treated by the air plasma.

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