Bio-relevant NO_x generated by transient spark in atmospheric dry air and air with water electrospray

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Generation of nitrogen oxides (NO_x) was studied in a DC-driven self-pulsing transient spark (TS) discharge in atmospheric pressure air. The precursors of NO_x production and the TS characteristics were studied by nanosecond time-resolved optical diagnostics. Thanks to the short (~20–50 ns) high current (~1 A) spark pulses, highly reactive non-equilibrium plasma is generated. The NO_x production rate of ~7×10^{16} molecules/J was achieved in dry air, dependent on TS repetition frequency, i.e. power, which is related to the complex frequency-dependent discharge properties and thus NO_2/NO generating mechanisms. With water electrosprayed through the TS, gaseous NO_x formation was lowered but induced chemical changes in water make it of biomedical importance.

1. Introduction

Nitrogen oxides (NO_x) are typical by-products of air plasmas that have important bio-relevant properties, e.g. as antimicrobial (NO_2), physiological (NO), and anesthetics (N_2O) agents. We studied the generation of NO and NO_2 in the transient spark (TS) discharge in atmospheric pressure air, using optical emission spectroscopy combined with the post-discharge gas composition analysis by FTIR.

The TS is a DC-driven repetitive self-pulsing discharge with 20-50 ns short spark current pulses initiated by streamers, with the pulse repetition frequency 1-10 kHz [1]. It has been successfully applied for flue gas cleaning and bio-decontamination of water [2]. The air TS can be combined with the electrospray of water, which induces formation of nitrites, nitrates, hydrogen peroxide and peroxynitrites and demonstrates strong antibacterial properties of such plasma activated water [2].

2. Results

Generation of NO_x in the gas phase was studied in dry air, and in the air humidified by water electrosprayed through the discharge. The dominant stable gas phase products in dry air were nitrogen oxides, while ozone was not detected (<10 ppm detection limit). NO formation steeply increases with the discharge power, as shown in Fig. 1. The sum of NO and NO_2 concentration >400 ppm was achieved with power input below 6 W. The highest NO_x (NO + NO_2) generation rate achieved was around 7×10^{16} molecules/J [3]. Due to their easy dissolution in the water and possibly also due to the discharge cooling by water and thus decreased NO_x formation, the NO_x densities were found lower in air humidified by the water electrospray (Fig. 1).

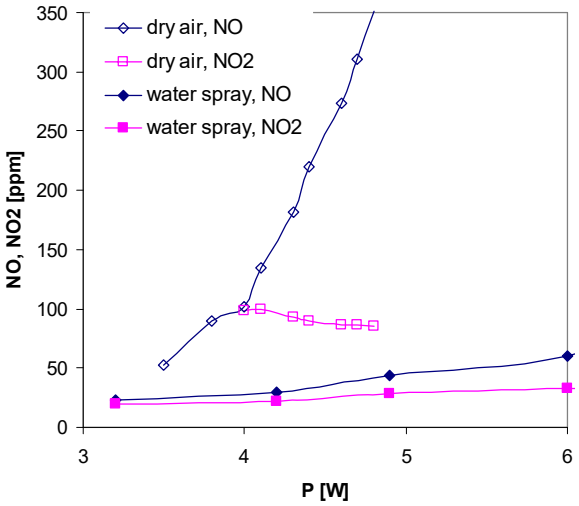

Fig. 1: NO and NO_2 generation in TS in dry air vs. air with water electrospray for increasing dicsharge power.

3. Summary

TS in atmospheric air provided high production rates of NO_x. With sprayed water, gaseous NO_x formation was lowered but induced chemical changes in water make it of biomedical importance.

3. References

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This work was supported by Slovak Research and Development Agency APVV-0134-12 and Slovak grant agency VEGA 1/0918/15.