# Bio-decontamination of plastic and dental surfaces with atmospheric pressure air DC discharges

**Z. Šipoldová[1], Z. Machala[2]**
[1]Division of Biomedical Physics, Comenius University, Mlynska dolina, 84248 Bratislava, Slovakia
[2]Division of Environmental Physics, Comenius University, Mlynska dolina, 84248 Bratislava, Slovakia
**e-mail: sipoldovaz@gmail.com**

**Résumé**

In our experiments we have been exploring bio-decontamination effects of atmospheric pressure air discharges applied on plastic and dental surfaces contaminated by bacterial spores (*Bacillus cereus*). We found discharge regimes with good bactericidal effects and low energy requirements.

**Introduction**

Prions and numerous bacterial strains become resistant against commonly used chemicals disinfectants and antibiotics. Conventionally used techniques (autoclave and dry heat) cannot by applied for human tissues or some plastic materials, such as polypropylene and polyethylene. Therefore, searching for new methods in decontamination of heat-sensitive materials is crucial in medicine and food processing. Cold air plasmas at atmospheric pressure provide an alternative with great potential, because there are efficient and do not cause degradation of termo-sensitive materials [1,2]. Cold plasmas are capable to disinfect dental plaque and caries and so could become a good alternative to painful teeth drilling [3].

We used non-equilibrium air plasma at atmospheric pressure produced by DC discharges for bio-decontamination of plastic and dental surfaces with bacterial spores of *Bacillus cereus.* We treated spores on a smooth surface of polypropylene foil or on rough dental surfaces and in dental cavities of extracted human teeth. We tested the impact of corona discharge in both polarities and the effect of moisture. A detailed description of our discharges used can be found in [4,5].

Our discharge set-up contains hypodermic injection needle as high voltage (HV) electrode and a grounded copper plate. The gap between the HV electrode and the sample was 0.5 cm for both polarities. We placed circular plastic foils (2 cm diameter) or a tooth with 20 µl of spore suspension droped on the surface of the plate electrode. A spore suspension contained around $10^6$-$10^7$ colony forming units per ml.

At first we made experiments with polypropylene plastic foils under moist or dry conditions, with both polarities of corona. Each discharge regime was applied to at least 4 samples in 5 experimental series, and each sample was exposed to the discharge for 2 minutes. Positive corona was supplied with a HV ~11 kV, this formed streamers (current pulses) with frequency 7-12 kHz and maximum amplitude 30 mA. Negative pulsed corona was supplied with 8-9 kV, its amplitude was ~0.3 mA and frequency 1 MHz. When HV was further increased, negative corona established a pulseless regime with constant current 0.22 mA and constant voltage 9.4 kV. Under physiological conditions teeth surfaces are wet; therefore we treated the teeth as the moist plastic samples. So far we did 3 experiments with corona on 8 dental samples. Teeth were exposed to the plasma for 3 or 5 minutes.

Figure 1 shows the results of bio-decontamination of the spores on plastic and teeth surfaces in efficiency vs. energy graphs. On dry plastic samples, positive streamer corona is more effective and more energetic, whereas negative pulse corona is more efficient on moist ones with about the same energy consumption. Negative pulseless corona is largely more energetic and so it is not so convenient for bio-decontamination, despite it provided the best sporicidal efficiency. From the first few experiments with moist teeth surfaces we can see that the efficiency in 3 and 5 minutes exposure time is almost the same. Positive streamer corona was the most efficient and negative Trichel pulse corona slightly less efficient and less energetic.

Figure 2 shows the photographs taken by Olympus E410 camera with long exposure times. Each picture was made from the side of the discharge. The photos show discharges on plastic and teeth samples placed on the plate electrode and the needle (electrode above).

Our results from decontamination of bacterial spores on both plastic and dental surfaces are satisfying, taking into account that spores are extremely resistant to adverse conditions. The next step will be treatment of dental surfaces contaminated by *Streptococcus mutans* biofilms in tooth cavities representing a dental plaque.

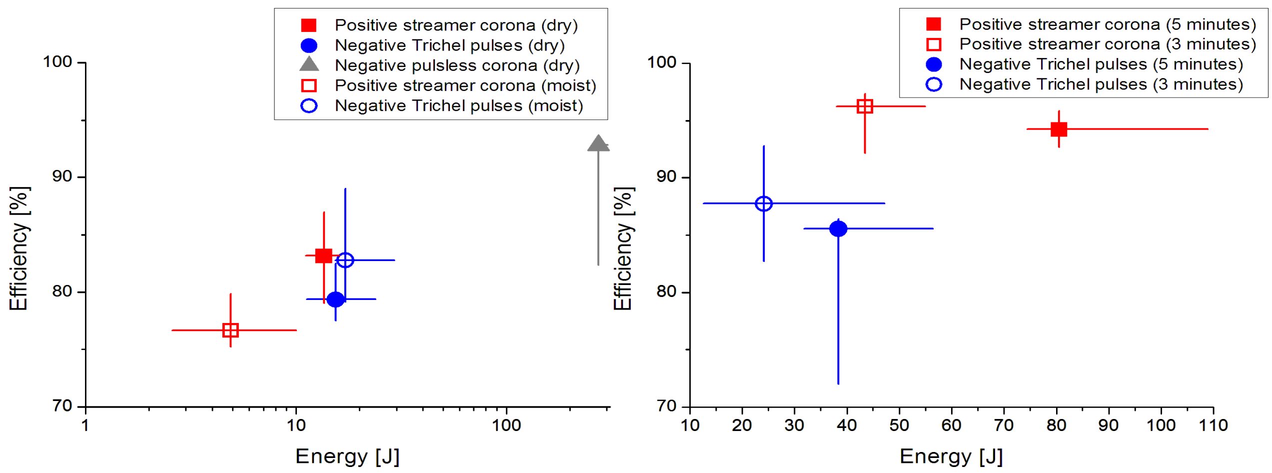


Fig. 1: Decontamination efficiency vs. energy (median with first and third quartile): plastic samples (left) and moist tooth samples (right)

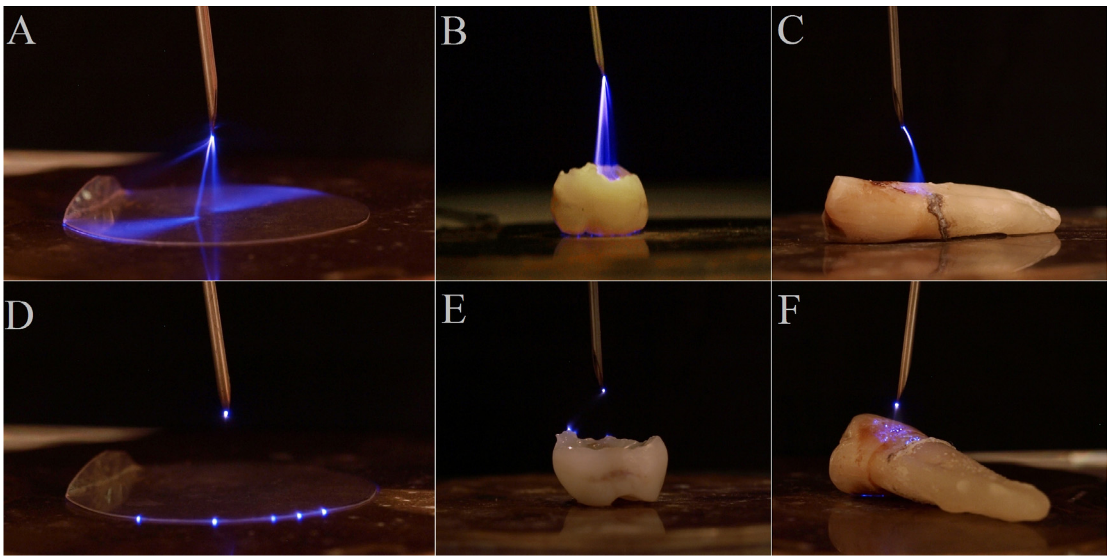


Fig. 2: Photographs of contaminated plastic (A, D) and tooth (B, C, E, F) samples with atmospheric pressure air DC discharges: 1st row (A, B, C) - positive stramer corona, 2nd row (D, E, F) - negative corona (Trichel pulses). (Exposure times [s]: A 5; B 1/2; C 2; D 3.2; E 1.3; F 2.5)


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