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Air transient spark discharge vs. helium plasma jet: Their effects on water, bacteria, cells and biomolecules

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A DC-driven self-pulsing transient spark (TS) discharge operated in air and a pulse-driven dielectric barrier discharge plasma jet (PJ) operated in helium in contact with water solutions were used for the treatment of bacteria (*Escherichia coli*), mammalian cells (normal Vero and cancerous HeLa cells) and biomolecules (DNA, protein). Direct exposure to the TS was compared with indirect exposure to the TS activated gas flow and to the effect of the PJ. The direct exposure to the TS showed significant chemical effects in the treated water solutions: acidification and high concentrations of generated RONS, which were by one order of magnitude higher than those generated by the PJ [1]. The TS systems also showed strong bactericidal effects, both in non-buffered (3-5 log) and buffered solutions (1-2 log), as well as cytotoxic effects on HeLa and Vero cells. The maximum cytotoxicity of 94% was found with the frequency of 4 kHz and 10 min exposure time in the TS system. Small concentrations of active species generated by the PJ resulted in limited bactericidal activity (< 1 log reduction) and weak cytotoxic effects on cells (< 10%). The effect of the PJ was also smaller when compared with the indirect exposure to the TS. The discharges induced a cytotoxic effect by activation of apoptotic mechanism on both types of cells, however the effect was persistent only for HeLa (Fig. 1). The results of viability, apoptosis, and cell cycle clearly showed the plasma can selectively target cancerous cells. The potential of plasma systems for successful fragmentation of DNA and denaturation of protein was also investigated. The comparisons of the air TS and the He PJ show that the chemical, bactericidal, cytotoxic, fragmentation, and denaturation effects are stronger in the air plasma of the TS than in the He PJ (Fig. 1). In our comparison, even indirect exposure to TS resulted in stronger effects than direct exposure by the PJ, which indicates the dominant role of RONS. These results demonstrated a great potential of the TS as an efficient tool for biomedical applications.

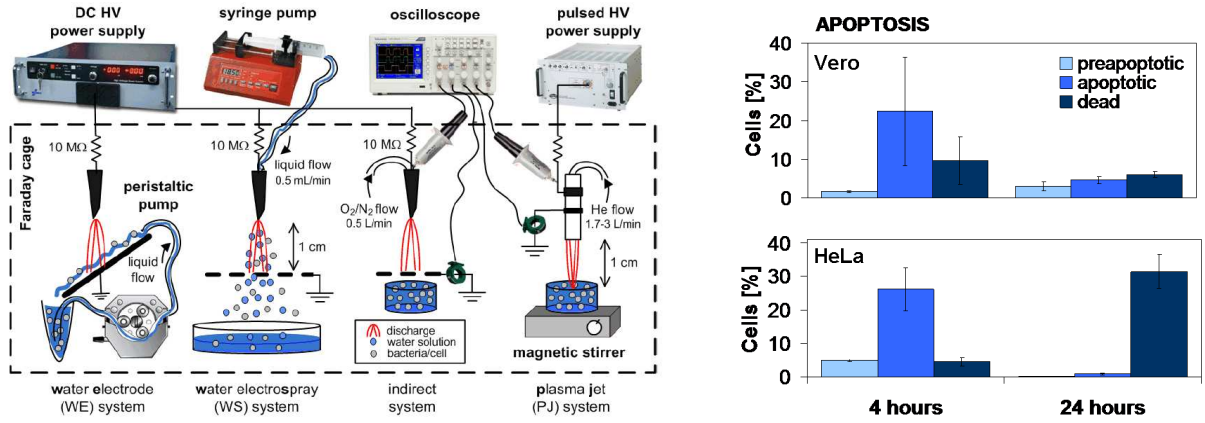

Fig. 1 Left: Experimental setup of the TS and the PJ systems; Right: HeLa and Vero cells exposed to the TS after 4 and 24 hours of incubation (cells in 100 µL of PBS, indirect exposure 4 min, U ~ 12.5 kV, f ~ 2 kHz)

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Reference

[1] K. Hensel, K. Kučerová, B. Tarabová, et al., *Biointerphases*, **10**, 029515 (2015).