

Plasma – Cell Interaction: Review and Update

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Abstract— Non-equilibrium plasmas are weakly ionized, low temperature plasmas. They generally contain charged particles (electrons and ions) with densities in the 10^9 - 10^{11} cm^{-3} range. The electrons are the energetic particles, which via collisions with background gas atoms and molecules, generate not only ions but excited neutral species and very reactive molecular fragments. It is the reactive oxygen species (ROS) and reactive nitrogen species (RNS) that are suspected to play the major role in the interaction of low temperature plasmas with biological cells [1]. These chemical species which include O, O_2^- , OH, NO, and NO_2 exhibit strong oxidative properties and/or trigger signaling pathways in biological cells. For example oxidation of the lipids and proteins that constitute the membrane of bacterial cells leads to the loss of their functions and eventually to the death of the cell. However, at low doses low temperature plasmas appear to cause little damage to healthy animal and plant tissues. For example, epithelial cells are found to remain viable under plasma conditions that can be lethal to bacterial cells. On the other hand, low doses of plasma were also found to induce apoptosis, or programmed cell death, opening the possibility to use plasma technology to kill cancerous cells. Charged particles can also affect biological cells. For example, the charging of the cellular membrane can result in an outward electrostatic force which exerts a substantial physical force on the cell. In bacteria it was found that if the tensile strength of the cell outer membrane is lower than the electrostatic force, the membrane can rupture. This mostly likely occurs at surface irregularities with a small radius of curvatures [2]. Rupture of the cellular membrane can result in cell death. In this presentation background knowledge as well as recent results on plasma-cell interactions, obtained in our laboratory, will be discussed. The need for developing in-depth understanding on the basic and fundamental levels in order to advance the applications of plasmas in medicine will be highlighted.

REFERENCES

- [1] M. Laroussi, "Low Temperature Plasmas for Medicine?", IEEE Trans. Plasma Sci., Vol. 37, No. 6, pp. 714-725, 2009.

- [2] M. Laroussi, D. A. Mendis, and M. Rosenberg, "Plasma Interaction with Microbes", *New Journal of Physics*, Vol. 5, pp. 41.1-41.10, 2003.