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Transcutaneous plasma stresses: Fundamentals of atmospheric plasmas, Plasma-cell and plasma-tissue interactions

XinPei Lu

State Key Laboratory of Advanced Electromagnetic Engineering and Technology, Huazhong University of Science and Technology, Wuhan, Hubei 430074, PR China
E-mail: *luxinpei@hotmail.com*

Interaction of non-equilibrium atmospheric-pressure plasmas with biological objects has recently attracted strong attention owing to the many promising applications in health care and medicine. These studies involve diverse multidisciplinary approaches across physical, chemical, biological, medical and engineering sciences and are based on the physics of atmospheric-pressure plasma discharges and more recently, plasma interactions with materials and biological objects. Among the key fundamental questions in the plasma treatment of the surfaces of living tissues, the question about the depth of penetration of the plasma generated species into the tissue is of particular importance for practical applications in health care and medicine. Here the interactions of the plasmas with tissue models and real biological tissues are critically examined. The physical phenomena that occur during the penetration of plasma-generated reactive agents through tissues are introduced, and discussed in most typical cases ranging from in vitro water- and gel-based to in vivo animal models. A particular focus is on transport of reactive agents (reactive species, ions, heat, UV, electric fields) generated by non-equilibrium reactive atmospheric-pressure plasma through biological tissues, e.g., through the skin to the bloodstream[1]. The tissues are made of living cells and these cells form a highly-interactive, internetworked matrix. Even though plasma does not penetrate tissue, the effects of the plasma generated reactive agents can penetrate deep inside the tissues. Recent studies of physical (ions, electric charge, species diffusion, heat, radiation, etc.), physico-chemical (e.g., change in acidity, salinity of the media, reactions caused by the solvated reactive species, etc.) and biological (e.g., pore opening, intracellular processes, immunity, etc.) effects of the plasma are reviewed and examined, focusing on cancer cells and tumours. Other cases such as wound healing are discussed as well. This knowledge is essential to enable effective applications of the plasmas in cancer treatment and other areas.

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References

[1] X. Lu, M. Keidar, M. Laroussi, E. Choi, E. Szili, K. Ostrikov, Materials Science & Engineering R 138 (2019) 36–59