Evaluating the interaction of low temperature atmospheric pressure plasma with cells for wound healing and disinfection

Nazir Barekzi and Mounir Laroussi

Laser and Plasma Engineering Institute
Old Dominion Univ., Norfolk, VA, 23529, USA
E-mail: nbarekzi@odu.edu; mlarouss@odu.edu

Historically, thermal plasmas that generate high levels of heat have been used in certain medical procedures such as electrosurgery, including tissue ablation. Recent advances in plasma science and technology allowed for the generation of biologically tolerant non-thermal plasmas, which could be used in various novel medical applications. The use of nonequilibrium plasmas in diverse experiments ranging from material science to medicine have resulted in efficacious decontamination, wound healing, tissue regeneration, killing of cancerous cells and treating dermatological diseases [1]. However, the mechanisms of action of plasmas at the cellular and molecular level still need to be examined in order to define the general and specific effects of non-thermal plasmas in relation to healthy and diseased host cells.

In order to understand these relationships, our efforts at the Laser and Plasma Engineering Institute at Old Dominion University have focused on a multi-prong approach. The goal of our research is to optimize plasma treatment to effectively kill various bacteria by either inhibiting or destroying biofilm formation, without harming mammalian cells. The same approach has been undertaken to understand how non-thermal plasma affects the molecular machinery in mammalian cells, how these effects differ in disease states of the mammalian cells and ultimately how to modulate a desired cellular phenotype by changing the dose and parameters of non-thermal gas plasmas.

In our research efforts, we utilized the plasma pencil to generate low temperature atmospheric pressure plasma (LTAPP) [2] in order to determine the effect of LTAPP on decreasing or inhibiting bacterial adhesion, proliferation and persistence in different models of infection. The interaction between the reactive species (reactive oxygen species and reactive nitrogen species) generated by LTAPP and the downstream effects are fundamental in understanding how LTAPP decontaminates wounds and simultaneously heals damaged wound tissue. Studying the effects of LTAPP on the coordinated process of bacterial killing at the phenotypic and molecular level provides an important means to study different bacterial signaling pathways. Ultimately, our goal is to understand the effect of LTAPP treatment at the molecular level in both prokaryotic and eukaryotic systems in order to facilitate the subsequent development of LTAPP as a therapeutic against microbial infection of wounds and accelerate healing of damaged or diseased cells. The broad impact of the results from this effort will transform the concept of how low temperature atmospheric pressure plasma affects host-associated microbial infection at the molecular level and provide a model template for future investigations involving LTAPP.

References

[1] Weltmann K.D., and von Woedtke, T. IEEE Transactions on Plasma Science, 2011, 39(4): 1015-1025.
[2] Laroussi M., and Lu, X. Applied Physics Letters, 2005, 87(113902): 1-3.