Liquid Mediated Effects on Cells, Bacteria, and Model Membranes by Plasma-born Reactive Species

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The recently developed cold atmospheric pressure plasma sources opens the possibility to treat thermosensitive living tissue in a non-destructive beneficial way. One successful application is the plasma treatment of wounds including stimulation of cell growth, killing of bacteria, and endotoxin inactivation. For all applications stable and controlled plasma-parameters are essential for reproducibility and optimized effects. By development of an shielding attachment for a non-thermal plasma-jet, kinpen, fluctuating environmental influences can be eliminated and plasma chemistry can be controlled. This attachment produces a shielding gas curtain that isolates the plasma effluent from ambient air including all its impurities. As a result, plasma-treatment leads to different concentrations of active species (e.g. reactive oxygen or nitrogen species (ROS or RNS, respectively), nitrate/nitrite, or peroxides.

Even if the effects of plasma treatments are well known, the deeper understanding of molecular mechanisms still needs improvement. The cell-surrounding liquid, an interface between plasma/gas-phase and biological object, is mediating these effects and gets more and more into focus of interest recently. In these liquids, reactive species are either introduced directly by the plasma phase into the liquid phase or are created within the liquid.

Because every externally applied substance that creates a cellular effect, has to interact with the envelope of the cell -the membrane. Lipids and proteins are the constituents of it; the first mainly responsible for the structure, the last mainly responsible for membrane function. Normally protein interaction requires a high specifity in binding. Due to the unspecific interaction of radicals, it is unlikely that they interact specifically with any biological molecule. The externally applied agent can either overcome the membrane to get access to intracellular targets or interact directly with the membrane. This direct interaction can result in activation of a cellular signal path (e.g. intrinsically apoptosis pathway) or in direct lipid interaction like lipid peroxidation. Lipid interaction can result in pore or lesion forming which allows a "self-promoted uptake" into intracellular space. The intracellular concentration of the agent depends therefore of its ability to form pores. If the pores are big enough, this can result in depolarization of cells and therefore cellular death. Furthermore, the lipid reorganization can result in fusion processes. Therefore, the membrane is the primary target of plasma-treatment of cells (pro- and eukaryotic).

Here we are presenting models to verify if the observed effects are directly membrane related. For this we use different liposome models to measure membrane effects (e.g. fusion). Neutral lipids and lipopolysaccharides (LPS) are used to mimic eu- and gram-neg. eukaryotic membranes. Because LPS aggregates are the active form of Gram-negative endotoxin, it is tested, if this disordering ability results in LPS inactivation preventing a septical shock.