CHARACTERIZATION AND INTERACTIONS OF ATMOSPHERIC PRESSURE PLASMA JET (APPJ) WITH DNA AND HUMAN CELLS

Abstract

by

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Recent advances in plasma technology have realized the formation of controllable plasmas under ambient conditions, including atmospheric pressure plasma jets (APPJs). Due to vast production of reactive species at room temperatures, APPJs reveal promising capabilities in treating heat-sensitive biological surfaces, particularly serve as a potential tool for cancer therapy. Since the interactions of APPJs with living systems involve physio-chemical processes in the gas and liquid phases which initiate biological processes in cells, lack of comprehensive knowledge of these processes impede the further development of APPJs for clinical usages. Therefore, my research is focused on the understanding of the mechanisms underlying these interactions tackled by physical, chemical, and biological approaches.

In the first stage of my experimental work I characterize gas phase species in APPJs using optical emission spectroscopy. Varieties of reactive oxygen and nitrogen species are observed, which can propagate towards aqueous targets for further

interactions. Liquid-phase reactive species formed after plasma treatment are quantified mainly by a chemical dosimetry method. The plasma-induced chemistry is found to occur at the liquid surface and depends on the liquid surface area, suggesting the plasma treatment is superficial. The first biological sample applied in my study is isolated DNA in an aqueous solution, which is a relatively simple system for investigating the plasma's effects on genetic biomolecules comparing to the complex cellular system. By using gel electrophoresis, a significant level of DNA strand breaks are detected after APPJ treatment with longer exposures at closer locations to the jet. Next, a layer of cells in an aqueous solution is applied for probing the effective area, effectiveness, and selectivity of plasma treatment. The effective area is found enlarged with longer plasma exposures with high DNA damage levels for cancer cells but not for normal cells. Severely damaged cancer cells undergo cell death after long post-treatment times. The damage of cancer cells is further identified to be prominently induced during DNA synthesis phase of the cell cycle.

These results reveal crucial information of physical, chemical, and biological changes during multiphase plasma-cell interactions, and thus contribute to the further development of APPJs as an effective and safe therapeutic tool for cancer treatment.