INTERACTIONS OF COLD ATMOSPHERIC PRESSURE PLASMA JETS WITH PLASMID DNA

Deborah O'Connell, Laura Cox, Wendy Hyland,
Stephen McMahon, Bill Graham, Timo Gans, Fred Currell

Centre for Plasma Physics, Queen's University Belfast, Northern Ireland, UK

Cold atmospheric pressure plasmas offer a unique environment for treatments of soft materials, including bio-materials and living tissue. Single plasma devices can be as small as micro-meters allowing very precise treatments reducing damage to surrounding healthy living cells. It is essential to correlate direct plasma parameters with effects on bio-materials. There are various energy carrying species in the plasma such as charged particles, excited neutrals, radicals, and photons. In particular radical oxygen species ROS e.g. O, OH, have been identified as important.

Little is known of the influence the plasma has on DNA, this is vital to quantify before any potential application on living tissue can be realized. In this study we quantify the influence a cold plasma has on plasmid DNA and simultaneously measure absolute densities of ground state atomic oxygen (Diagnostic based Modelling) and helium metastables (laser absorption spectroscopy) for direct correlation.

An RF atmospheric pressure plasma jet configuration, operated in helium and oxygen, is used for application on plasmid DNA to determine the nature of the influence on DNA. The effluent of the plasma interacts with pCDNA3.1 plasmid DNA for varying treatment times and various plasma conditions. Three different buffers - water, phosphate buffered saline (PBS), and Tris-EDTA are used. After irradiation an electrophoresis technique is used to separate out the different DNA constituents supercoiled, open circular and linear. A rate equation model is used to fit the experimental data and determine the rate of single strand breaks (SSBs) and double strand breaks (DSBs). This allows for greater understanding of the processes involved in DNA damage. While SSBs are easily repaired since the damaged strand can replicate the undamaged strand, DSBs are more serious and incorrect repair can lead to DNA mutations or even cancer.

Absolute atomic oxygen densities and helium metastable densities are measured in the plasma bulk for correlations to the influence on DNA. Double strand breaks require more energy or a second single strand break within 10 DNA base pairs of the first (where a typical strand of the DNA used has 5400), and so there are significantly fewer linear breaks. With increasing power, and increasing atomic oxygen densities and helium metastables, an increase in both single and double strand break rates are observed. Significantly less damage is observed in the Tris-EDTA solution, indicating the role of radicals in damage.