Cold atmospheric pressure plasma in interaction with multiphase and reduced gravity environments

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Cold atmospheric pressure plasmas (CAP) are being intensively investigated for several applications ranging from biomedicine to agriculture. The very promising results achieved with CAP devices are often counterbalanced by the difficulties in achieving fine control over CAP processes. This is mostly due to their strong dependence on environmental conditions such as humidity, liquid contact or reduced gravity conditions. A deeper understanding is needed of the fundamental mechanisms of interaction between CAPs and substrate in conditions as close as possible to those encountered in the final application. CAPs are of particular interest for their potential to treat biological tissues and liquids. In this sense the interaction of CAP with water takes a prominent role since water is the main components in biological tissues and the liquid of choice for countless applications. The understanding of the resulting multiphase environment composed of plasma, water and gas (air) pose unique challenges but results essential for the development of CAP technology. In this work the interaction between CAP and water is investigated from a physical point of view in different CAP-water configurations ranging from common batch solutions to aerosol configurations. Additionally, the understanding of plasma interaction with liquid aerosols is simplified to its fundamental configuration investigating the interaction of CAP with a single droplet suspended by acoustic levitation. Important effects such as evaporation, temperature variation, surface morphology modification and electro fluid dynamic flows are investigated.

Furthermore, the prospect of CAP applications in reduced gravity conditions has recently raised new challenges and perspectives. Spacecrafts and the International Space Station are very special environments. Under low-gravity, confined and virtually isolated from the external world these places have a limited volume and resources. Multipurpose technologies with low energy consumption and waste production such as CAP could be extremely valuables during space missions. CAP technology could be successfully adapted in aerospace travels for important applications such as purification of recycled air and wastewater, disinfection of surfaces or tissues from drug resistant bacteria, viruses and potentially S-pathogens (i.e. organisms adapted for life in space). An essential step to develop such applications is to validate and characterize the operation of cold plasma devices at reduced pressures and in zero-gravity facilities. The presented work aims at exploring this uncharted area by performing experiments on a plasma jet device in zero gravity conditions (typical of space vessels) and/or at reduced pressure (typical of spacecraft cabins) or even for rarefied atmospheres associated with satellite or planetary probes conditions. A setup comprising plasma generation system and electrical and optical diagnostics (ex. OES, Schlieren) has been adapted to fit the requirements for parabolic flights organized by NOVESPACE and the french space agency CNES. Thus, experiments could be conducted both in zero-gravity (0G) conditions and in hyper gravity conditions (1.8G). Achieved results are an important first step to bring CAP technology in space applications.

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