Low temperature plasma interactions with in-flight liquid microdroplets

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Transport of micron-sized liquid droplets through a low temperature RF plasma\textsuperscript{1} at atmospheric pressure has demonstrated a number of remarkable and unexpected effects. After a short flight time, \( \sim 120 \mu s \), there is evidence that chemical reactions induced by the plasma and gas flux proceed at a rate that is significantly faster that observed in plasma – bulk liquid studies and many orders of magnitude faster than in standard bulk chemistry\textsuperscript{2}. Current theories of microparticle charging in a collisional environment is limited. While in-flight charge measurements represent a significant challenge, the relatively large size of the droplet (10 – 20 \( \mu m \) diameter) and the limited evaporation over the flight time, offer the prospect of using droplets as a spherical probe to develop enhanced collisional probe theories in the regime where the particle size is greater than Debye lengths or mean free paths. In-flight measurements indicate a minimum net charge of \( 10^5 \) electrons, considerably higher than that obtained by other charging methods. We report pulse charge measurements using a dual concentric micro-ring probe and compare results with numerical simulation.

There exists a large potential to develop new plasma-liquid processes for medical, chemical, biological, environmental and materials applications, among others and we can highlight some unique features of the plasma – microdroplet system that may provide opportunities for exploitation, namely: (i) a controlled ambient environment, (ii) a large surface area to volume ratio, (iii) small volume, (iv) low droplet temperature, (v) in-flight chemical synthesis and encapsulation, (iv) remote delivery. The droplet system also offers new possibilities for studying complex kinetic interactions between plasma species and a defined liquid surface with limited momentum transfer. We will report both experimental measurements and simulations of plasma-induced droplet chemistry and highlight the impact of specific species, namely solvated electrons and OH\textsuperscript{*} radicals on living bacterial cells carried in the droplet.

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\textsuperscript{2}PD Maguire et al. Nano Lett., \url{http://dx.doi.org/10.1021/acs.nanolett.6b03440}
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