Plasma-liquid interface: importance of bulk liquid composition and electrohydrodynamic flow in controlling rates of chemical reactions

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Plasmas formed directly in and contacting a liquid are powerful sources of reactive radicals, ions and high-energy electrons and have been successfully used to sterilize water and fruit juices, purify water, synthesize materials and nanoparticles, and for applications in plasma medicine, electrical transmission, and polymer surface treatment. Nevertheless, despite the obvious versatility in processing capabilities, the optimization and broader application of electrical discharge plasmas in and contacting a liquid have been limited due to a general lack of understanding of the underlying physical and chemical processes occurring at the plasma-liquid interface. Despite the significant progress that has been made towards understanding interfacial chemistry of plasmas in the last decade or so (especially for air plasmas contacting water), relative contributions of plasma processes such as formation and diffusion of reactive species and bulk liquid processes such as electrohydrodynamic flow to interfacial dynamics have not been yet determined.

This work investigates the extent to which bulk liquid processes, primarily bulk liquid composition and plasma-induced electrohydrodynamic flow control the rates of chemical reactions at a plasma-liquid interface. Experiments with different initial bulk liquid concentrations of non-surfactant and surfactant compounds (up to critical micelle concentration, CMC) have been performed to investigate how different interfacial compound concentrations affect their removal rates. Particle Image Velocimetry has been used to visualize the plasma-induced flow and quantify the velocity in the bulk liquid. The magnitude and the direction of the plasma-induced flow appear to be dependent on the chemical composition of the bulk liquid and surface concentration gradients.