Connecting the Dots: Understanding the Nature of Plasma and Liquid Interactions

David B. Go

University of Notre Dame, Notre Dame, Indiana, United States

Plasma-liquid systems are one of the most exciting, and promising, areas of emerging plasma science and reflect and new direction for plasmas in multiphase systems. However, the multiphase nature of the system adds additional complexity that makes it challenging to not only isolate and discern specific behaviors but understand how all the phenomena are connected – physically, chemically, and across broad length and time scales. Plasma electrolysis can be roughly described as replacing one of the solid electrodes in a conventional electrolytic cell with a plasma (i.e., gas discharge) such that charge transfer oxidation or reduction reactions occur at a plasma-liquid interface rather than a solid-liquid interface. One of the most promising aspects of these systems is the chemistry induced in the liquid by the plasma, ranging from the reduction of metal cations to produce colloidal nanoparticles to the oxidation of organic compounds for water remediation. From a plasma science perspective, these are also exciting systems because the liquid is a part of the plasma circuit and thus the plasma-liquid interfaces is inherently linked to plasma operation. Ultimately, the physics and chemistry of both the plasma and liquid are tightly coupled and mutually dependent, and unraveling these interactions is important for understanding, designing, and optimizing these systems. This talk will overview the efforts of our team to unravel these roles using a variety of experiments, theory, and simulations [1]. Topics will include the in situ detection of the solvated electron injected by a plasma, the efficiency of those electrons in driving chemistry, and a recent theoretical description of plasma self-organization on the liquid surface, among others.

[1] Elg, D.T., Delgado, H.E., Martin, D.C., Sankaran, R.M., Rumbach, P., Bartels, D.M. and Go, D.B., 2021. Recent advances in understanding the role of solvated electrons at the plasma-liquid interface of solution-based gas discharges. Spectrochimica Acta Part B: Atomic Spectroscopy, vol. 186, p.106307.