GEC17-2017-000385

Abstract for an Invited Paper
for the GEC17 Meeting of
the American Physical Society

Understanding the Plasma-Liquid Interface: Progress and Challenges[1]

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The interaction of plasma with liquid water occurs at a phase boundary layer, which includes gas, a water vapor layer, and the liquid itself. A host of physical and chemical processes are active at this interface making it a rich multiphase physics problem. These processes ultimately give rise to changes in the bulk liquid. Such induced changes are the basis for a number of emerging technologies and applications such as plasma-based water treatment and plasma medicine. The nature of the physical processes and ensuing chemistry that "activates" the liquid water, which is believed to originate at the interface, is not well understood. Ongoing experimental and computational efforts however are making progress towards the formulation of a consistent picture of the role of the plasma liquid interface in driving chemistry in solution. Here we survey the current state of understanding regarding the interfacial region including electrohydraulic forces that can lead to fluid dynamical effects resulting in enhanced radical distribution as well as chemistry driven by direct plasma interaction with liquid water. In particular, we review recent results from single and 2-D bubble studies that have yielded insight into mechanisms of radical transport into solution as a function of discharge type present in the bubble. Complex mass transport and induced chemistry generated in DC atmospheric pressure glows with liquid electrode resulting from plasma self-organization is also not well understood. Insight into the physical mechanism underlying both self-organization and its role in radical transport in these systems as inferred from recent experiments is also discussed. The implications of these findings, the understanding gaps along with measurement and modeling needs for continued progress, and the connection of this understanding with technologies with a plasma liquid underpinning are also commented upon.

[1]DOE DE-SC 0002588, NSF CBET 1336375, and NASA Glenn