Direct Optical Measurements of Solvated Electrons at a Plasma-liquid Interface

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Abstract—Electrical discharges, or plasmas, are capable of producing a wide variety of reactive chemical species, and have been used to deliver species to aqueous media, with applications in medicine, water treatment, and material synthesis. For example, plasmas in humid air produce nitric oxide (NO) and hydroxyl radicals (OH), which will dissolve in aqueous solution to yield nitrous acid (HNO_2) and hydrogen peroxide (H_2O_2) [1] and [2]. Additionally, free electrons from a discharge have been used to drive standard electrochemical reactions such as water electrolysis [3] and the reduction of metallic cations [4]. In this work, we use optical absorption spectroscopy to directly probe the plasma-liquid interface and demonstrate that electrons from the plasma briefly solvate before initiating electrochemical reduction reactions. We determine the average penetration depth of the solvated electrons to be 2.5±1.0 nm and measure their reaction kinetics with other chemical species. We also measure the optical absorption spectrum of the electrons near the interface and find it to be blue-shifted from previously reported bulk measurements [5]. Overall, we have discovered a unique system for studying solvated electrons with many potential chemical applications.

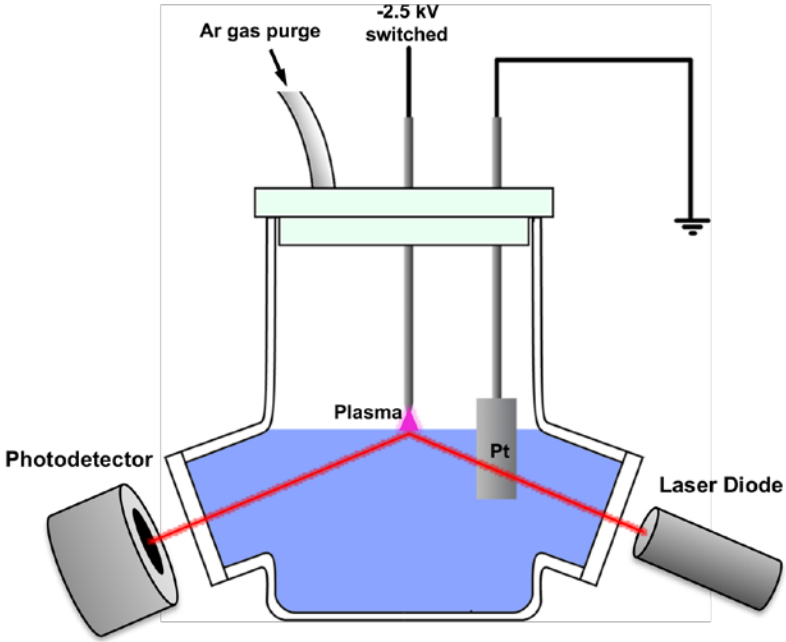

Fig. 1 Shown above is a schematic of the experimental setup for optically measuring solvated electrons. A laser diode is focused onto the plasma-liquid interface. The angle of incidence is greater than the critical angle for total internal reflection, so the beam is entirely reflected into the detector sans the small amount absorbed by solvated electrons.

References

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