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Plasma-liquid interaction induced by atmospheric pressure plasma using liquid electrode

Naoki Shirai
Graduate School of Engineering, Hokkaido University, Japan

Atmospheric pressure non-thermal plasma in and in contact with liquids has been studied for a wide range of applications [1]. Previously we investigated characteristics of atmospheric pressure DC glow discharge using liquid electrode[2-4]. Using this type of plasma when liquid worked as cathode, the atomic lines of sodium dissolved in the solution appear in the spectrum emitted by the plasma[2]. Nanoparticles can be synthesized at plasma-liquid interface by using this plasma[3]. Although many researches have been reported about plasma with liquid electrode, the detail mechanism of the plasma-liquid interaction have not been understood completely. For example, optical emission mechanism of metal cation (such as Na^+) transported from liquid (NaCl aq.) electrode is still unclear. In this study, we focus attention on plasma-liquid interfacial behavior such as droplets generation at the liquid interface induced by plasma. We also investigate chemical reaction in liquid induced by plasma.

Figure 1 shows the experimental setup for obtaining electrolyte cathode discharges with a miniature helium flow. The concentration of the electrolyte cathode (NaCl aq. solution) is 0-15%. The stainless-steel nozzle anode has inner and outer diameters of 500 and 800 μm, respectively. The gap length is 1-4 mm. Helium gas is fed through the nozzle anode in open air. The gas flow rate is adjusted 200 sccm using a mass flow controller.
The glow discharge is generated by applying a dc voltage to the nozzle anode. The current from the power source is varied up to 120 mA. The electrolyte cathode is grounded via a platinum wire immersed in the electrolyte. The mist dynamics in plasma was observed by the scattering of laser light. The light source is He-Ne laser with wavelength of 633 nm. The mist dynamics along the laser sheet was observed with a high-speed camera or a digital camera.

Figure 2 shows visualization of the droplet emission from liquid surface induced by plasma liquid interface when plasma is generated using NaCl aq. with the concentration of 5 w%. With increasing concentration of NaCl aq., amount of droplet increased and distance of scattered droplet becomes longer. Namely, amount of droplet depend on the concentration of NaCl. When we use the NaCl aq. solution mixed with other electrolyte including metal cation such as CuSO4, intensity of spectral emission of Cu increases compared with the case of using only $CuSO_4$ aq. solution. These results indicate that plasma induced droplet generation which depends on concentration of NaCl is important factor for transport metal cation in solution to gas phase.
This droplet generation might relate to the explosion reaction of alkali metal with water.

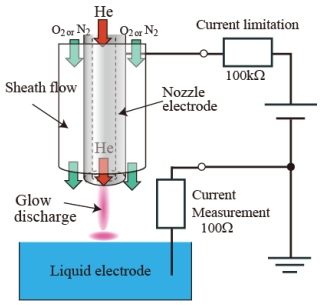

Figure 1 Experimental setup for generation of atmospheric pressure glow discharge with liquid electrode

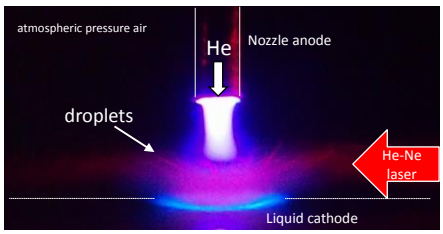

Figure 2 Observation of droplet emission from liquid surface induced by plasma-liquid interaction.

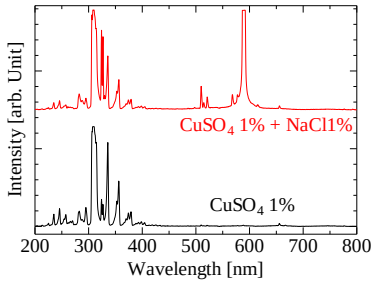

Figure 3 Atomic lines of metal dissolved in the solution appear in the spectrum emitted by the plasma

References

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