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Atmospheric Pressure Glow Discharge with Liquid Electrode[1]

FUMIYOSHI TOCHIKUBO, Tokyo Metropolitan University

Nonthermal atmospheric pressure plasmas in contact with liquid are widely studied aiming variety of plasma applications. DC glow discharge with liquid electrode is an easy method to obtain simple and stable plasma-liquid interface. When we focus attention on liquid-phase reaction, the discharge system is considered as electrolysis with plasma electrode. The plasma electrode will supply electrons and positive ions to the liquid surface in a different way from the conventional metal electrode. However, the phenomena at plasma-liquid interface have not been understood well. In this work, we studied physical and chemical effect in liquid induced by dc atmospheric pressure glow discharge with liquid electrode. The experiment was carried out using H-shaped Hoffman electrolysis apparatus filled with electrolyte, to separate the anodic and cathodic reactions. Two nozzle electrodes made of stainless steel are set about 2 mm above the liquid surface. By applying a dc voltage between the nozzle electrodes, dc glow discharges as plasma electrodes are generated in contact with liquid [1]. As electrolyte, we used aqueous solutions of NaCl, Na_2SO_4, $AgNO_3$ and $HAuCl_4$. $AgNO_3$ and $HAuCl_4$ are to discuss the reduction process of metal ions for synthesis of nanoparticles (NPs). OH radical generation yield in liquid was measured by chemical probe method using terephthalic acid. Discharge-induced liquid flow was visualized by Schlieren method. Electron irradiation to liquid surface (plasma cathode) generated OH^- and OH radical in liquid while positive ion irradiation (plasma anode) generated H^+ and OH radical. The generation efficiency of OH radical was better with plasma anode. Both Ag NPs in $AgNO_3$ and Au NPs in $HAuCl_4$ were synthesized with plasma cathode while only Au NPs were generated with plasma anode. Possible reaction process is qualitatively discussed. The discharge-induced liquid flow such as convection pattern was strongly influenced by the gas flow on the liquid surface.

[1] N. Shirai et al., Plasma Sources Sci. Technol. 20 (2011) 034013.

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