

Visualization of the transient spark discharge in contact with water supplied through the anode

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1. Motivation

Direct contact of electrical discharges with water leads to the formation of a plasma-activated water (PAW). PAW contains a mixture of reactive oxygen and nitrogen species (RONS) and has a wide range of applications in the health, agriculture, and food sectors [1].

Efficient transfer of these reactive species from the plasma to the liquid phase can be achieved by maximizing the plasma-water interface. One effective method involves converting bulk water into microdroplets via an electrospray (ES) process [2].

An electrospray is initiated when a sufficiently high voltage is applied between a nozzle (anode) and a grounded electrode. Within this same configuration, transient spark (TS) discharges can be generated, interacting directly with the incoming water, hence producing PAW with high concentrations of RONS [3].

2. Methodology and Results

An ultrafast camera (Fig. 1) and a Schlieren imaging method (Fig. 2) were used for visualization of the transient spark with and without a water inlet to the reactor, to better understand the interaction between the TS and microdroplets.

Our observations show that the presence of the transient spark significantly distorts the electrospray process due to both electrical forces and turbulent gas mixing. Taylor cone is not formed and the microdroplets are released from irregular water structures. Moreover, microdroplets are also created by two different mechanisms: ablation from the point where the spark channel touches the water surface or the Coulomb fission of relatively large water volumes.

Schlieren imaging reveals that even in the absence of external gas flow, TS discharges induce a relatively fast flow toward the grounded cathode. When the cathode is covered by bulk water, this effect significantly enhances the solvation of gaseous RONS into the liquid phase.

Time-resolved optical emission spectroscopy was also used to study the influence of the water incoming to the reactor through the nozzle on the discharge characteristics. A significant increase in the intensity of H α , Fe and Fe⁺ lines was observed.



Fig. 1: An illustrative image of the transient spark interaction with water, captured by an ultrafast camera.

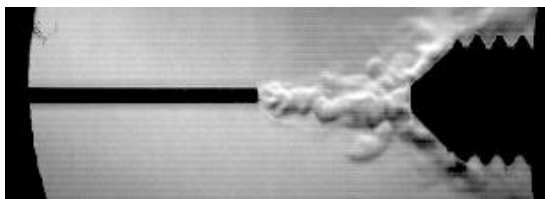


Fig. 2: An illustrative image from Schlieren imaging of the transient spark discharge.

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References

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