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Transport processes in Plasma Activated Droplets

Fredrik Green, Aaron Dickenson, and Mohammad I Hasan[1]

[1] Department of Electrical Engineering and Electronics, the University of Liverpool, L69 3GJ, Liverpool, the United Kingdom

e-mail (speaker): mihasan@liverpool.ac.uk

Despite the great promise shown by Plasma Activated Liquids (PAL)-based technology in agriculture, environmental applications and medicine. The use of PAL in practical applications is still far off due to multiple challenges. One of the key factors impeding the maturing of PAL-based technologies is the interfacial transport, which is a relatively slow process that requires extended plasma treatment time and high plasma power for high levels of activation. A potential solution to overcome this barrier is to activate droplets of the liquid instead of bulk treatment, which maximizes the surface area of the treated liquid and thus increases the dose of reactive species to be solvated in the treated liquid.

When a droplet is subject to mechanical perturbations it experiences a resonant vibration at a frequency dictated by its diameter and density. The vibrations are associated with complex variation in the fluid flow pattern in the droplet. In a plasma environment, multiple processes can trigger such vibrations including the background gas flow induced by the plasma, the electric field stresses exerted at the boundaries of the droplet by the sheath surrounding it, and the pressure exerted by the bombarding ions at the surface of the droplet. While the response of a droplet to a generic mechanical force has been investigated by lord Rayleigh in 1879 [1], and the response of a spherical drop to electric field stresses at the interface has been investigated by Torza et al in 1971[2], the droplet's response in a plasma environment remains unknown.

Based on an earlier computational model developed in our group [3], this work presents an upgraded 2 - dimensional validated model which is used to analyze the induced flow pattern and its associated vibrations experienced by water droplets in a plasma environment. The analysis aims to examine the impact of the droplets diameter on the induced flow and thus on the transport of the reactive species in the liquid phase and across the interface, which is examined in light of surface renewal model of interfacial transport.

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References

[1] L. Rayleigh, Proceedings of the Royal Society of London 29, 71 (1879).
[2] S Torza et al, Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences Vol. 269, No. 1198 (1971), pp. 295-319
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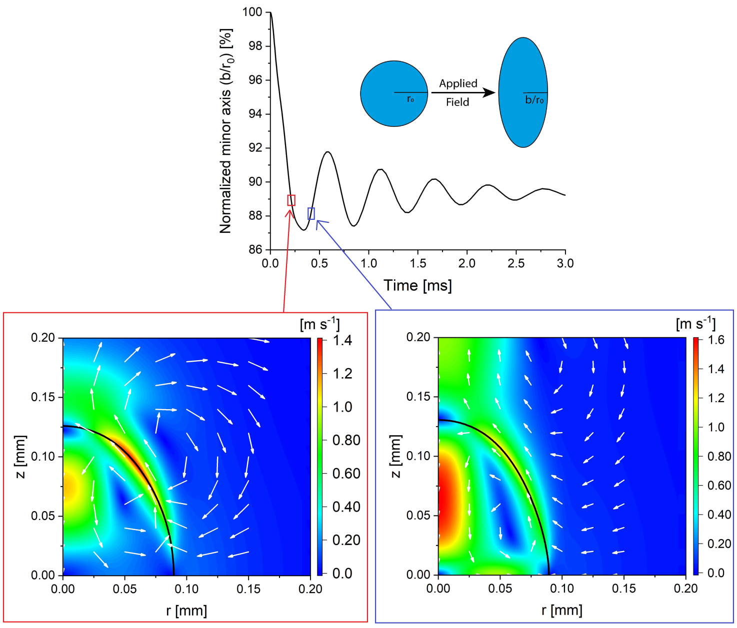

Fig-1. Oscillation of the velocity field at the edge of a water droplet in air as a response to an applied electric field