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Numerical and Experimental Study on Interface Behavior for Electrohydrodynamic Flow

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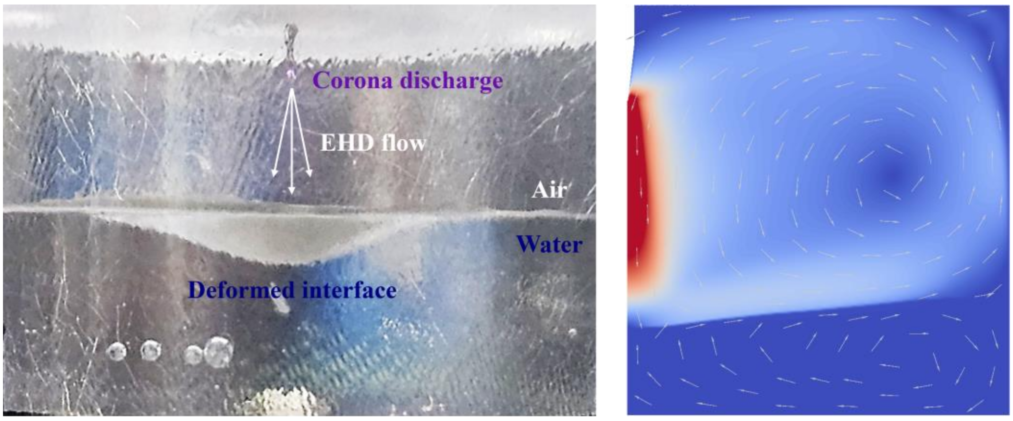
Abstract

Electrohydrodynamic (EHD) flow at gas–liquid interfaces offers a unique mechanism for inducing fluid motion and interface deformation using electric fields. This study investigates the dynamic interaction between corona discharge and the air–water interface through two-phase numerical simulations, complemented by experimental validation using a particle image velocimetry and current measurements. A fully coupled model was developed to capture charge transport, Coulomb force-driven flow, and the resulting interfacial deformation. The results reveal that stronger electric fields, created by reduced electrode-interface distance and increased voltage, enhance charge transport and generate more pronounced EHD flow, leading to greater interfacial displacement. A direct correlation was observed between discharge current and deformation depth, confirming current as a representative indicator of momentum transfer and interface behavior. Additionally, the interface exhibited unsteady behavior under strong electric fields, showing periodic deformation and dynamic coupling between flow and electrical characteristics.

Keywords: Electrohydrodynamic flow, Corona discharge, Gas-liquid interface, Interfacial deformation



(a) **(b)**

Figure 1. (a) Experimental visualization of corona-induced deformation and (b) Simulated velocity field and interface deformation

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