Instability of an electrified liquid jet focused by a coflowing gas stream

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ABSTRACT

Flow focusing (FF) is an effective technique to form droplets and particles down to micrometre dimension and below that are controllable and monodisperse[1,2]. In this paper, an axial electric field is further applied in the flow field region of FF and the instability behavior of the electrified liquid jet under both the hydrodynamic and electrical forces is studied experimentally and theoretically. It is shown that this method is available to enhance the atomization, widen the range of steady regimes and yield a reduction in droplet size. Consequently, it will be more useful in fields of extensive applications.

The experiments are conducted with a combined FF device. A round electrode is positioned facing the hole exit with an offset distance L and a high voltage direct current power supply is linked to the stainless steel capillary tube in FF device. The focused liquid mainly used is water and the focusing gas is air. A coflowing liquid-gas jet can be formed when the liquid of flow rate Q_l is continuously supplied and a pressure difference Δp_g between the inside and outside of the FF device is maintained. When the value of Δp_g increases with other parameters constant, the transition from dripping to jetting modes and that from axisymmetric to non-axisymmetric modes can be observed. Compared to the phenomena in single FF[3], the flow domains are changed and critical values for transitions between instability modes are distinct. For instance, higher voltage V_0 will result in smaller critical Δp_g for the transition between the axisymmetric and non-axisymmetric modes.

The breakup process is closely associated with the propagation of unstable disturbances at the interface between fluids. Therefore, a linear instability analysis based on the classic normal mode method is also implemented. The theoretical model is similar to that for the single FF problem[3,4]. The difference lies in that the voltage V_0 is imposed on the liquid surface and the governing equations and corresponding boundary conditions are modified to satisfy the current physical process. Effects of flow parameters on the growth rate of disturbances are performed to explore the characteristics of the jet instability and the breakup modes obtained in experiments are also predicted.

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