Proceedings of the 6th World Congress on Momentum, Heat and Mass Transfer (MHMT'21)
~~Lisbon, Portugal~~ Virtual Conference – June 17 – 19, 2021
Paper No. ICMFHT 103
DOI: 10.11159/icmfht21.lx.103

Experimental Study on Electrified Micro-Jet Instability in Electrohydrodynamic Atomization (EHDA) Cone-Jet

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Extended Abstract

The cone-jet regime in EHDA has been widely applied into numerous important industrial fields because of generating highly charged, monodispersed and micro-sized drops. The reference liquid flow rate and the onset potential for a steady cone-jet are discussed, as well as the effect of liquid physical parameters, operating parameters and other conditions on cone-jet regime. However, there are relatively few studies on the jet instability breakup modes (varicose and whipping), and the jet instability transform also needs to be clarified.

In the present experiment, the cone-jet evolution and electrified jet breakup for the single capillary sheathed with quartz tube and the common metal capillary are visualized versus varied operating parameters (liquid flow rate and applied potential) and physical properties (conductivity). It was found that the range of electric potential and liquid flow rate range for a steady cone-jet with the sheathed quartz tube extends compared with the common metal capillary, as well as the minimum liquid flow rate. The typical instabilities including varicose and whipping instabilities in the steady cone-jet mode, and an electrified jet breakup mode from varicose to whipping instabilities are also captured in this experiment. The competition of the interfacial force determines the jet instability breakup mode, varicose instabilities occurs with low electric surface charges, and the whipping instabilities appears with an increase in electric normal stress. This breakup mode of steady cone-jet with different dimensionless liquid flow rate and applied potential are discussed.

The results show that Taylor cone angle decreases as liquid flow rate increasing, while increases with electric potential increasing. The jet breakup length decreases with an increase in liquid flow rate and conductivity, while increases as electric potential increasing. The diffusion angle increases with an increase in the liquid flow rate, while decreases as electric potential and conductivity increasing. Much more obvious whipping instability breakup is observed with an increase in "electro-Weber" number and conductivity, while much more indistinct is noticed as electric Bond number increasing. Meanwhile, for a large liquid flow rate, the transition from varicose instability to whipping instability is clearly found. The whipping instability is more clearly observed with an increase in conductivity due to much more free ions in liquid. For a high conductivity, the cone-jet appears intermittent states. In this mode, the end of the jet no longer maintains a whipping shape, showing an umbrella plume, and the breakup length sharply shortens due to the high free charge density. Besides, the generatrix of Taylor cone transforms from a straight to a curved one.