Modeling simple-jet mode EHDA droplets' trajectories and spray pattern for a single nozzle system

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Electro-Hydrodynamic Atomization (EHDA), or simply electrospraying, is a process of influencing the breakup of a liquid flowing through a capillary by the application of a strong electric field ($kV.cm^{-1}$) For a certain spray configuration and a specified liquid, there are different electrospraying modes depending on the applied electric potential and the liquid flow rate. Of these modes, the so called cone-jet mode is the most explored one, due to its ability to produce highly charged monodisperse droplets in the nano- and micro-meter size range. This mode has been highly investigated and much information about it can be found in literature. Another mode of interest, which also produces mono sized droplets, but more in the millimeter size range, is the simple-jet mode. This mode is less explored compared to the former. Agostinho *et al*, were, most probably, the first authors to carefully investigate and characterize this mode. In their work, the authors reported about the influence of the electric potential(ϕ) and the liquid flow rate(Q) on droplets' size and spray structure. They also pointed out that the charge of these droplets is a fraction of their Rayleigh limit.

This presentation describes the design and the implementation of a physical model for determining the droplet trajectories in the simple-jet mode. The model is done specifically for the situation of a nozzle to ring(up) configuration. It is a two-dimensional model, which solves the force balance equation for each droplet breaking up from the jet. It includes; initial droplet velocity, force of gravity, applied electric field, drag force and inter droplet coulombic force. Droplets' deformation and reorientation, which were observed to have a big influence on the droplets' dispersion, were simulated by implementing random displacements on the droplets' center of charge. These displacements had a maximum value, which was experimentally approximated.

In order to visualize the EHDA droplets, an imaging system consisting of a High speed camera (Photron ASX-2) and a backlight illumination (Dedocool light source) was constructed. After acquired, the images were analyzed by ImageJ® software. Calculation of the background electric field as a function of geometry was done with COMSOL® software. A self-made MATLAB® routine was used to solve the force balance equation and output the droplets' trajectories.

Validation of the results was done by comparing experimental results with model results for different combinations of electric potential (ϕ) and liquid flowrate (Q).

This model offers new possibilities of modelling the droplets' trajectories in complex geometries and of introducing additional forces, such as the ones due to secondary electric field and air movements.

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