An electric current-based monitoring system for electrohydrodynamic atomization

F. Kariithi[1, 2], M. J. Gatari[1], J. C. M. Marijnissen[1], L. L. F. Agostinho[2]

[1] University of Nairobi, Institute of Nuclear Science and Technology, P.O. Box 30197-00100, Nairobi, Kenya

[2] NHL University of Applied Sciences, Water Technology Research Group, 8917 DD Leeuwarden, the Netherlands

Introduction

Electrohydrodynamic atomization (EHDA), or simply electrospray, is an atomization technique that uses a strong electric field to influence the break-up of a liquid into droplets[1]. In this technique, the strength of the applied electric field and the flow rate can be varied to achieve different electrospraying modes for the same liquid. These modes include the cone-jet and the simple-jet modes, for example. The cone-jet mode can be said to be a dripping regime mode while the simple-jet mode a jetting regime mode. More about dripping and jetting regime modes can be found in the literature[2]. High-speed imaging and laser techniques are the most commonly used monitoring techniques to evaluate the droplet size, size distribution and which operational mode is taking place. However, such techniques may not always be practical in industrial processes due to the fact that some setups do not readily allow visual access.

Another viable way to determine the operational mode, as proposed by Verdoold *et al.* (2014), is monitoring via electric current values and signal shape[3]. Their method was however investigated only for the dripping regime modes. In this project, this method will be further explored to include possible signals which are common to the simple-jet mode. For that, the electric current values were investigated inside the dripping regime modes and the jetting regime modes, to provide a first indication of whether such method could be simply based on those values. The results are presented in sequence.

Method

A nozzle to ring (1,5cm) configuration was used. An EFD (blue) nozzle was used for all the flow rates (OD = 0.72mm, ID = 0.41mm). The experiments were performed in both dripping and jetting regimes using ethanol (99%). For each regime, the electric potential was varied in such a way as to allow the appearance of all the modes. For each mode, the electric current values were monitored, in the ground line, for a few minutes and averaged. Figure 1 is a representation of the setup used for the experiments.

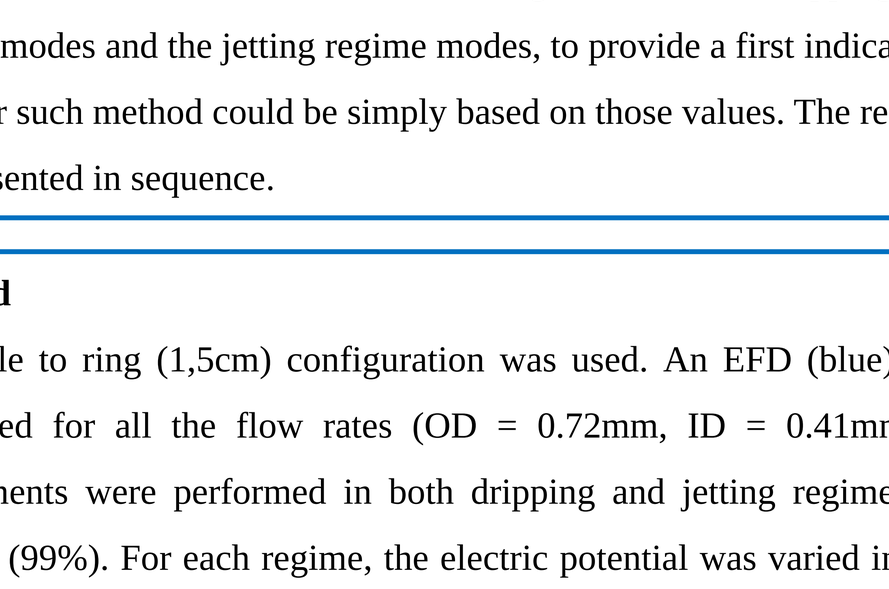
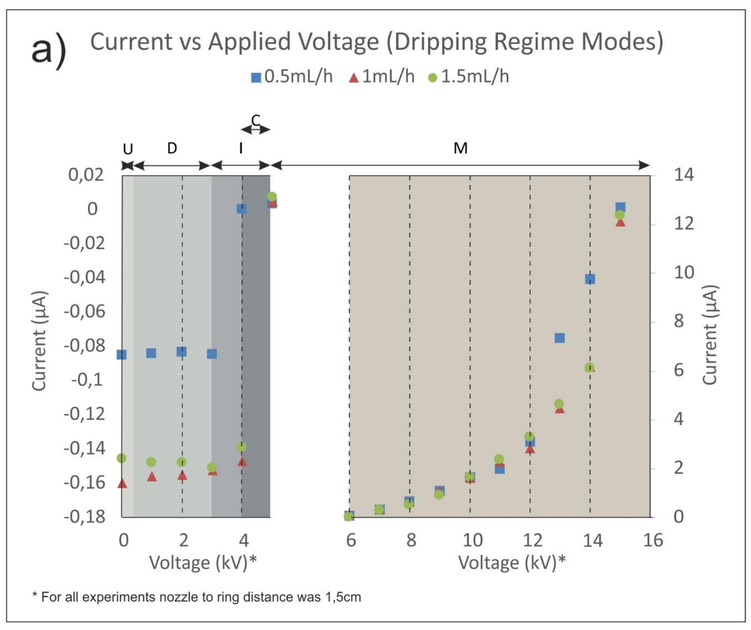


Figure 1. Experimental setup

Results



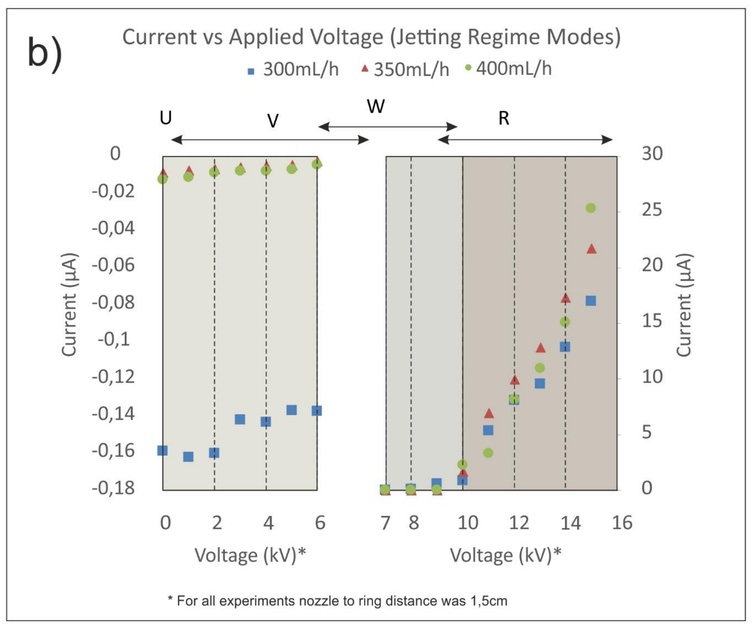


Figure 2. Graphs of the electric current versus voltage for dripping regime modes (a) and jetting regime modes (b). The different break-up mechanisms are represented by the grey zones using the following acronyms: uncharged (U), dripping (D), intermittent cone-jet mode (I), cone-jet mode (C), multijet mode (M), simple-jet with varicose break-up (V) simple-jet with whipping break-up (W) and simple-jet with ramified break-up (R).

Conclusions

Results have shown that the current versus voltage behavior for all the dripping regime modes and the transition regime (300mL.h^{-1}) is rather similar. Also, it was observed that the multijet mode, the simple-jet mode with whipping break-up and the simple-jet mode with ramified break-up, function in a much higher current level.

References

[1] Grace, J. M. & Marijnissen, J. C. M. (1994). A review of liquid atomization by electrical means. *Journal of Aerosol Science, 25*(6), 1005-1019.

[2] Agostinho, L. L. F., Bos, B., Kamau, A., Brouwer, S. P., Fuchs, E. C., & Marijnissen, J. C. M. Simple-jet mode electrosprays with water. Description, characterization and application in a single effect evaporation chamber (2018). *Journal of Aerosol Science*

[3] Verdoold, S., Agostinho, L. L. F., Yurteri, C. U. & Marijnissen, J. C. M. (2014). A generic electrospray classification. *Journal of Aerosol Science, 67*, 87-103.

Acknowledgement

The authors would like to acknowledge Gas Unie b.v. for the technical and financial support given to this project, as well as the Oranjewoud vonds for the financial support which allowed the participation of Kenyan students and professors in the project.