22a On the Process of Electrohydrodynamic Atomization under the Influence of Two Independent Electrical Field Sources

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It is known that Electrohydrodynamic Atomization can take many forms [1] [2]. Central to these various forms is the formation of what is now known as the Taylor Cone [3]. In most of the literature, only the nozzle is subjected to an electrical potential relative to the grounded needle which is placed directly below it. We present phenomenological evidence for the spray forms which are produced when an additional electrical field is applied to the system by a ring electrode that surrounds the nozzle. The two electrodes are connected to separate high voltage DC power supplies and the electrical potentials are varied independently. Ijsebaert [4] first used the ring electrode at a constant electrical potential to focus the Electrohydrodynamic Atomization spray.

We have found that, for solvents with conductivities between 1E-9 S/m and 1E-7 S/m, the ring electrode is able to change the form of the spray in ways that have not been reported before. Without the ring electrode, increasing the electrical potential of the nozzle from zero to progressively higher values will change the form of the spray from the Gravity Dripping mode, through the Single Taylor Cone/Single Jet mode, and finally to the Multiple Cone mode. With the ring electrode in place and with the spray in the Multiple Cone mode, an increase in the ring potential will cause the spray form to revert back to Single Taylor Cone/Single Jet mode, and finally to the Gravity Dripping mode. The range of ring electrical potentials for which the Single Taylor Cone/Single Jet mode is possible depends on parameters such as the solvent flow rate and the electrical potential applied to the nozzle.

We have shown that the interaction of the two electrical fields associated with the nozzle and the ring electrode is the main reason for this interesting observation. Simulation has shown that, in the vicinity of the nozzle where the spray is located, the various voltage settings which result in the formation of the Single Taylor Cone/Single Jet mode produce similar electrical fields, in both magnitude and form. This is due to the cancellation of the radial component of the electrical fields from the nozzle electrode and the ring electrode. So, with the various different voltage settings, we are able to get the Single Taylor Cone/ Single Jet mode.

Finally, we have also observed the formation of pulsating jets, for which the form corresponds to the Single Taylor Cone/ Single Jet mode, but the flow is intermittent. The frequency of the pulsation is above 100/s, the exact value depending on the solution properties and other experimental parameters such as solvent flow rate and the electrical potentials applied to the electrodes.

The above interesting observations, have, to our best knowledge, not previously been reported in the literature.

[1] Cloupeau, M., Prunet_Foch, B., Electrohydrodynamic spraying functioning modes: a critical review, J. Aerosol Sci., Vol. 25, No. 6, 1021-1036, 1994.

[2] Jaworek, A., Krupa, A., Forms of the multijet mode of electrohydrodynamic spraying, J. Aerosol Sci., Vol. 27, No. 7, 979-986, 1996.

[3] Taylor, G.I., Electrically Driven Jets, Proc. R. Soc. A, Vol 313, 453-475, 1969.

[4] Ijsebaert, J.C., Geerse, K.B., Marijnissen, J.C.M., Lammers, J.W.J., Zanen, P., Electrohydrodynamic Atomization of Drug Solution for Inhalation Purposes, J. Appl. Physiol., 91, 2735-2741, 2001.