Polymer solution electrospraying: A tool for engineering particles and films with controlled morphology

Eszter Bodnár, Jordi Grifoll, Joan Rosell-Llompart

www.elsevier.com/locate/jaerosci

PII: S0021-8502(17)30428-7
DOI: https://doi.org/10.1016/j.jaerosci.2018.04.012
Reference: AS5280

To appear in: *Journal of Aerosol Science*

Received date: 31 October 2017
Revised date: 30 April 2018
Accepted date: 30 April 2018

Cite this article as: Eszter Bodnár, Jordi Grifoll and Joan Rosell-Llompart, Polymer solution electrospraying: A tool for engineering particles and films with controlled morphology, *Journal of Aerosol Science,* https://doi.org/10.1016/j.jaerosci.2018.04.012

Polymer solution electrospraying: A tool for engineering particles and films with controlled morphology

Eszter Bodnár[a], Jordi Grifoll[a], Joan Rosell-Llompart[a,b]

[a]Department of Chemical Engineering, Universitat Rovira i Virgili, E-43007 Tarragona, Spain

[b]Catalan Institution for Research and Advanced Studies (ICREA), E-08010 Barcelona, Spain

Abstract

Polymer solution electrospray is a relatively new research field which has become increasingly active mostly due to its potential for engineering particle morphologies at the micro- and nanoscales, which can be useful for pharmaceutical applications, energy devices, and many other. Despite significant efforts in this research area, and the fact that electrospray (ES) theory for pure solvents is well-established, improved understanding is still needed on how polymeric structures form during electrospray to be able to predict the diversity of particle morphologies encountered. This situation is due partly to the complexity of the mechanisms involved, which combine the unique dynamic behavior of polymer solutions with the unique physics of ES (with disparate temporal and spatial scales). In this article, we start by reviewing which application fields have driven research in polymer solution electrospraying, and which morphologies matter. We then develop a theoretical framework on the mechanisms responsible for the transformation of a polymer solution droplet made by electrospray into a solid morphology. We discuss the applicability of a droplet drying model used in Spray Drying to the case of electrospray droplets. We further highlight the importance of Coulombic instabilities in developing polymeric structures. These structures include particles with pointed ends, sometimes with long nanofilaments, as well as other elongated shapes, and globular shapes with a broad size distribution. We identify the conditions necessary to prepare mono-sized globular particles (e.g. spheres). Finally, we analyze the roles played by the presence of non-solvent vapors during droplet drying. This includes ambient humidity when electrospraying non water-soluble polymers, whose effects on particle porosity have often been overlooked. We close with recommendations and clarifications of practical importance for practitioners.

1. Introduction

An electrospray (ES) is a dispersion of highly charged droplets which are released by electro-hydrodynamic (EHD) microjets into gas phase (Fig. 1). Therefore, electrospray is sometimes called *electro-hydrodynamic spraying* (EHDS), or *electro-hydrodynamic atomization* (EHDA). Specifically, we