

A TECHNOLOGY UPDATE: ELECTRO SPRAY TECHNOLOGY

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ABSTRACT

Electro spraying is a method of liquid atomisation by electrical forces. Recently, the electro spraying entered in microfluidic devices and nanotechnology. Spraying solutions or suspensions allows production of fine particles, down to nanometer size, which can be used in industrial processes or for research purposes. It is a process when electrostatic forces are the only energy source leading to the atomization of liquid. In the most general sense, electro spraying is a method of generating a very fine liquid aerosol through electrostatic charging, rather than the more familiar gas (pneumatic) methods.

Keywords: Electro spray, automisation, atomisation

INTRODUCTION

Since last many decades in the field of pharmacy many technologies have been grown up. They all influence the field of pharma anyhow. In current scenario electro spray technology as one of such influencing technology, attracting for upgradation of ease and fast development. Fast and valuable development is the key of success in industry as well as market. So electro spray technology is one of those having characteristics impact. From the moment when first human eyes saw lighting we were fascinated by electrostatics and started to investigate and explore electrostatics. One of the applications of electrostatics is atomization of liquids. Electro spraying is a method of liquid atomisation by electrical forces. Remember those old perfume bottles with the little bulb attached in which you squeeze the bulb and a fine mist of perfume would effuse from the nozzle. In the form of air pumped through a tube by squeezing the bulb, you are using gas to generate droplets. Electro spray, as the name implies, uses electricity instead of gas to form the droplets. Droplets produced by electro spraying are highly charged, that prevents their coagulation, and promotes self-dispersion. When a droplet of liquid is subjected to strong electric field, due to mutual repulsion of electrical charges inside the droplet, it change its shape to conical. If the electric field is strong enough, from the cone apex a thin liquid jet emerges, which quickly breaks up into the mist of fine droplets. Droplets can be extremely small, in special cases down to nanometers, and the charge and size of the droplets can be controlled to some extent by voltage and flow rate. Electro spraying is applied in many industrial processes such as painting, microencapsulation, electroemulsification, fine powder production, or micro- and nano thin film deposition prepared from solutions or colloidal suspensions. Recently, the electro spraying entered in microfluidic devices and nanotechnology. Spraying solutions or suspensions allows production of fine particles, down to nanometer size, which can be used in industrial processes or for research purposes [1-2].

DEFINITION

It is a process when electrostatic forces are the only energy source leading to the atomization of liquid. In the most general sense, electro spray is a method of generating a very fine liquid aerosol through electrostatic charging,

rather than the more familiar gas (pneumatic) methods. Definition of Electro Hydro Dynamic Atomization (EHDA) method that employs only electrostatics is recommended. This name covers the process of the atomization of a moving (*dynamic*) liquid (*hydro*) in an electric (*electro*) field. [1] & [9]

DIFFERENT SPRAYING MODES

Electro spray cone doesn't always looks like that in the Figure 1. Depending on the electric field strength, liquid properties, and flow rate we can observe different cone and jet behaviour – different spraying modes. Various forms of the modes of electro spraying are schematically shown in figure. These modes can be grouped into two principal categories

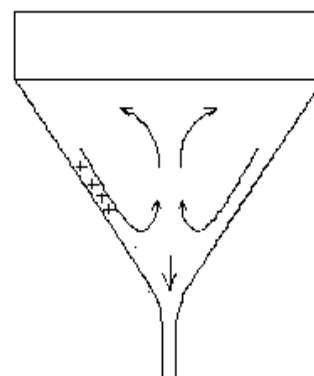


Figure 1: Circulation of the liquid inside the cone

Dripping modes:

These modes are characteristic in that only fragments of liquid are ejected directly from the capillary nozzle; these fragments can be in the form of regular large drops (dripping mode), fine droplets (microdripping mode), elongated spindles (spindle or multispindle modes), or sometimes irregular fragments of liquid. At some distance from the nozzle outlet, however, these fragments contract into spherical droplets in Micro dripping mode when slowly increase a voltage connected to the nozzle and keep a constant liquid flow first, an acceleration of free dripping process, droplets became smaller and a frequency increases occurs– this is *micro dripping mode* (bigger

particles lower frequencies; from single Hz up to few kHz).

Jet modes:

In this case, the liquid is elongated into a long, fine jet, which can be smooth and stable (cone-jet mode) sometimes called **Taylor cone** or can move in any regular way. For example, it may rotate around the capillary axis (precession mode) or oscillate in its plane (oscillating mode). Sometimes, a few fine jets on the circumference of the capillary can also be observed. This specific mode is

known as the “multi-jet” mode. In each case, the jet disintegrates into droplets due to electrostatic forces. Droplets produced by the breakup of the jet are small and are produced at frequencies from few MHz up to GHz. The most important mode of spraying is the cone-jet mode. In this mode, the liquid meniscus assumes the form of regular, axisymmetric cone with a thin jet (<100 μm in diameter) at its apex, stretching along the capillary axis. Various modes of electro spraying can be seen in Figure 2.

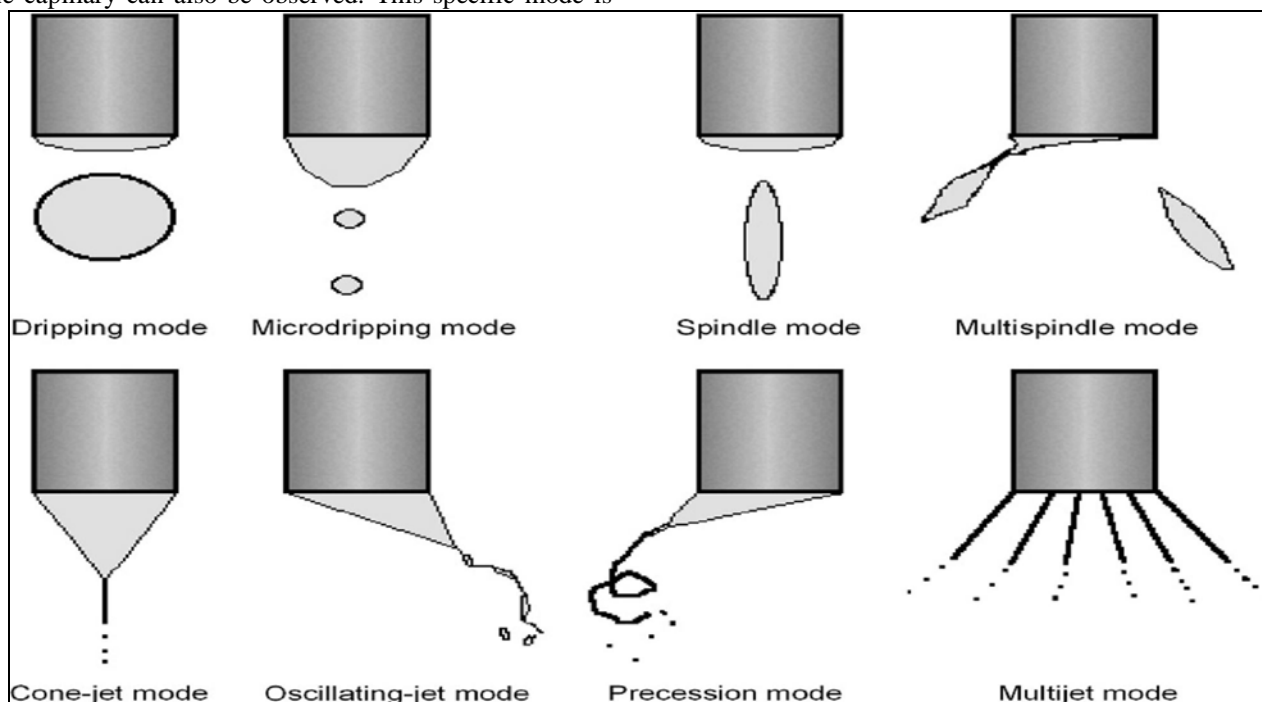


Figure 2: Various modes of electro spraying

Cone jet mode and Micro dripping mode these two modes are most frequently applied in the particle production for medical applications. Other modes like **multi jet mode, ramified, pulsating** and others, but due to the instability of these modes and wide size distribution of droplets they are rarely applied in research [1]& [8]

ADVANTAGES

- The electro spray has an advantage of uniform particles generation. An equipment used for electro spraying is inexpensive, can operate at atmospheric conditions, and the rate of particle production is easy to control by adjusting voltage and flow rate [2]
- Electro-hydro-dynamic atomization is a versatile technique to produce small monodisperse particles for drug delivery purpose. It allows for an influence on drug release rate either by manipulation of particle internal structure or by chemical additives. This technique has high encapsulation efficiency in comparison to wet, emulsion-based methods. [3]
- Because the flow rates and compositions of the sprayed liquids are controlled independently, and both of these are independent of the composition of the collection liquid, the process is very flexible.

- An advantage of using the electro spraying method is that the emulsion exhibits long-term stability, due to a residual charge remaining on the particles.
- The electro spraying has some advantages over conventional mechanical spraying systems with droplets charged by induction:
 - ⇒ Droplets have size smaller than those available from conventional mechanical atomisers, and can be smaller than 1 μm
 - ⇒ The size distribution of the droplets is usually narrow, with low standard deviation; droplets can be of equal size only for dripping and microdripping modes, or for Rayleigh jet breakup due to varicose wave instability.
 - ⇒ Charged droplets are self-dispersing in the space those results in absence of droplet agglomeration and coagulation.
 - ⇒ The motion of charged droplets can be easily controlled (including deflection or focusing) by electric fields.
 - ⇒ The deposition efficiency of charged spray on an object is much higher than for uncharged droplets. [2]

LIMITATIONS

- Low throughput of electrospraying process.
- Another issue is a control of a mode of spraying.
- Electrospray is very sensitive to the liquid physical properties and the electric field in the vicinity of the emitter tip [2]
- One drawback to electrospray is that highly conductive solutions, such as salt solutions, may be too conductive (and thus will not hold a charge) to reach the target droplet size. [10]

APPLICATIONS

- Fibre production [1]
- Controllable porous polymer particles generation [4]
- Generation of Monodisperse Protein Nanoparticles. [5]
- Electrospray as Aerosol-based clinical therapies for pulmonary diseases [2]
- Application in Wound management devices [7]
- As Photonic crystal production
- For the local delivery of anticancer drug to treat C6 glioma in vitro [6]
- Production of Nanoparticles for Drug and Gene Delivery [11]

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