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IMPACT OF PARAMETERS INVESTIGATION IN ELECTROSPINNING TECHNIQUE TO PREPARE NANOFIBER

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Abstract

Nanotechnology relies to a large extent on the creation of nano fibres with significant application coverage. Applications-based nano meter generation nanofiber range is imposed with the growth contribution of several fields of exploitation. Many techniques are used to produce nanofibers, including electrospinning. The electrospinning technique is used to create fibres using a polymer solution. Due to their exceptional qualities, remarkable performances, and diverse applications, nanomaterials have received a lot of attention in recent years. The easy and most adaptable method for creating nanoscale fiber materials is electrospinning. Electrospinning has several input parameters which impact the diameter of nanofiber. The primary purpose is to investigate the parameters of electrospinning and how it influences the yield of nanofiber. In addition, nanofibers are in various applications, and the research extends too.

Keywords: nanofiber; electrospinning; parameters;

1. Introduction

Nanofibers are nanostructures can be produced using a variety of polymers, providing them a range of physical characteristics and various applications. The fabrication of the fibres utilising various processing techniques, has been the focus of research on the production of nanofibers. Nanofibers diameters range from tens to hundreds of nanometers, and with one-dimensional nanomaterials. Nanofibers can be categorised into two groups, (a) organic, inorganic, carbon, and composite fibres are based on the type of primary material which they are made of, and (b) nonporous, mesoporous, hollow, and core-shell fibres are depending on their configuration. [1] Using a variety of techniques nanofibers are prepared, some of the methods are drawing, self-assembly, thermal-induced phase separation, template synthesis and electrospinning. However, the electrospinning approach, which employed high-molecular-weight polymers, is thought to be simple and easy to utilise for the fabrication of nonwoven nanofibers. [2] [3]

able 1.1 Advantages and Disadvantages of Nanofiber Fabrication Method [3, 4]

Nanofiber Fabrication Methods	Advantages	Disadvantages	Processing Units / Sections
Drawing	simple, easy, inexpensive	Time consuming process, limited polymer usage, poor shape fiber as outcome.	Polymer Solution drop, Micropipette
Self-Assembly	Simple, easily process, mass production possible	poor loading efficiency and difficult to maintain its porosity for longer duration of period	Individual, pre-existing components organize, finally nanofiber obtain.
Thermal-induced Phase Separation	simple, inexpensive	Time consuming process, laboratory scale production, lack of structural stability, difficult to maintain porosity	Dissolution, gelation, and extraction
Template Synthesis	Ability to manage fiber diameter	Time consuming process, laboratory scale production,	Pressurized Water, Polymer solution, Membrane, Extruded Nanofibers, Solidification solution.
Electrospinning	cheap, simple, efficiency in set-up, control over pore geometry, high surface area,	requirement of electrospinning machine, not sufficient for cell seeding as well as cell infiltration.	High voltage supply, needle with a syringe, a nanofiber collector unit (flat / cylinder)

Compared with all other nanofiber techniques, the electrospinning method has more advantages and gives the best outcome in the production of nanofiber. Some of the techniques also have limitations with the usage of solvents based on the preparation step and applications. [4]

2. Basic Apparatus and working of Electrospinning

The most extensively used and effective method for creating nanofibers is electrospinning. In this method, a high voltage (kV) unit is optimized also to create fine nanofibers. The electrospinning technique involved three main blocks, (i) High Voltage unit, (ii) syringe, holder and needle unit, (iii) collector unit (nanofiber can be collected in flat surface or roller surface). These are the fundamental or primary sections involved in the electrospinning technique. Figure (1) explains the basic working concept of electrospinning to generate nanofiber.

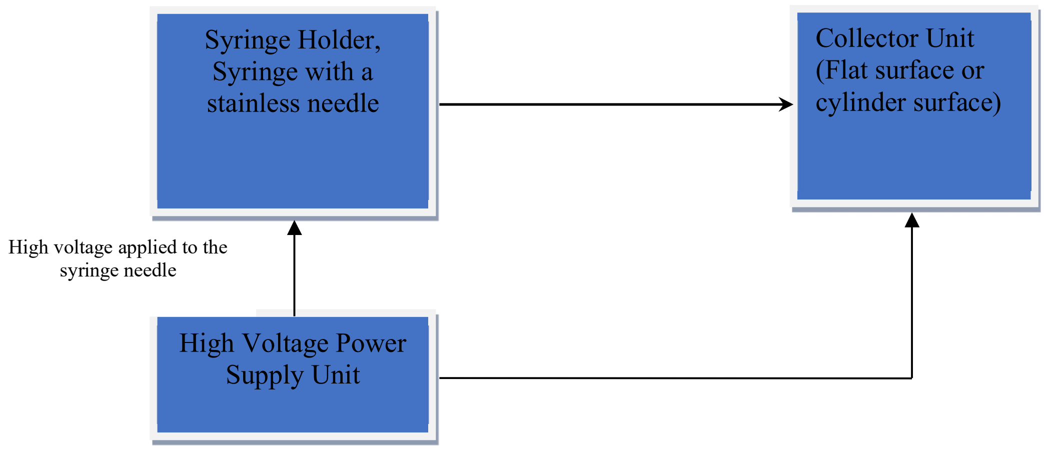

Figure (1) shows the basic block model of electrospinning working concept

Nanofiber properties are mostly influenced by the parameters; some are the type of polymer used, concentration used, the voltage used, needle size, etc. This method creates a powerful electro-negatively charged jet of polymer solution by connecting a syringe to a high-voltage potential. The syringe needle and the collector unit are as two electrodes, which is situated at a short distance in centimetre (cm). An electronegative drop molecule is created when a high voltage (kV) is applied and then the electric field is put across the syringe needle's tip. After increasing the applied field, the drop's surface assumes a hemispherical shape and starts to extend into the shape of a cone. This method holds number of key benefits, they are low cost, ease of use, high binding efficiency, control over porosity shape, fine nanofiber generation, etc. The limitations are requirement of electrospinning unit setup and space, used for selected applications which depend on the polymer solvent. [4] In a Syringe, polymer solvent is filled in order to produce nanofiber. With the help of a high-voltage power supply unit, the high voltage is passed to the syringe needle then a high electric field is formed between the needle and the collector unit. Initially, a fluid droplet starts to come out, by increasing the voltage a Taylor cone shape will be formed and the fiber starts to generate and is collected in the collector unit. Due to the electrostatic force, the formed fluid jets are propelled toward the grounded collection.

3. Effects of parameters in nanofiber generation

In the electrospinning method number of parameters are involved in nanofiber generation, and these parameters are influences the diameter of the nanofiber. Some of the important parameters which impact the generation of nanofiber are; applied voltage, solution viscosity, nozzle diameter, collector distance, surface tension, solution concentration, etc. Figure (2) shows the some of the parameters of Electrospinning method.

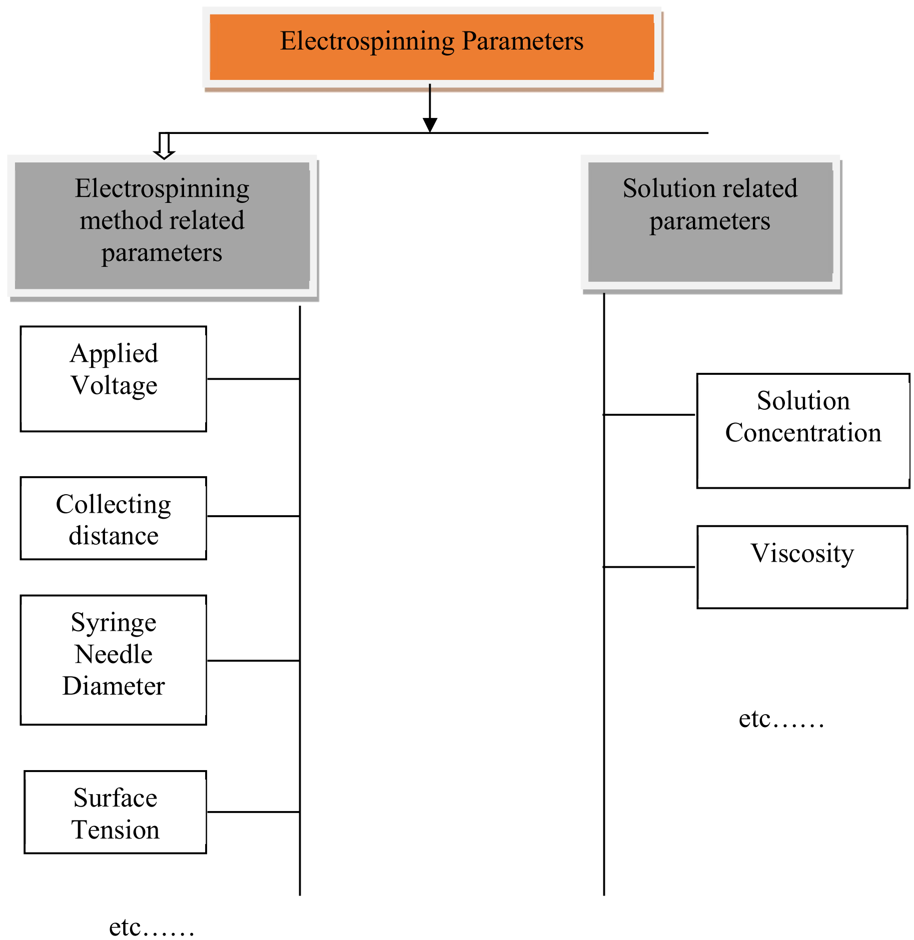

Figure (2) shows some of the parameters of Electrospinning method.

3.1 Applied voltage

In order for jet initiation to occur during electrospinning, significant voltage must be applied. No jet is stretched out and leaking occurs when the applied voltage is minimal because the electrostatic force is inadequate to overcome the surface tension of the solution droplet. The electrostatic force grows with increasing applied voltage, eventually leading to jet initiation and the beginning of the electrospinning process. In general, the diameter of the fibre decreases as the voltage rises due to the increased stretching stress [5, 6]. In contrast to nozzle electrospinning, applied voltage is significantly more crucial in needleless electrospinning. High voltage can increase the number of jets on a spinneret's free solution surface and speed up their flow, which can reduce the diameter of the fibre and enhance fibre production rate [7, 8]. Applying high voltage plays a vital role in the generation of nanofiber. A certain level of high voltage impact in the production of nanofiber, very less voltage, and also at very high voltage will not provide a continuous long nanofiber and a perfect standard nanofiber with a uniform diameter.

3.2 Collecting distance

The ideal distance for electrospinning should be sufficient to allow for both solvent evaporation and fibre stretching. When the applied voltage is constant, the electric field and fibre diameter will change in accordance with the change in distance between the nozzle and collector. Changes in fibre morphology and structure are a significant additional effect of shifting distance. The solution jet needs enough time for the solvent to evaporate, converting the jets to dry nanofibers. Interconnected nanofibers are frequently gathered when the collecting distance is relatively short. [7, 8, 9] Because numerous solution jets are instantly generated during needleless electrospinning, this event occurs more frequently. Additionally, it has been discovered that interconnected nanofibers gathered nearby could increase the mechanical strength of nanofiber mats, leading to better and more long-lasting performance in energy harvesting applications [9]. The distance between the syringe needle tip and the collector end also gives impacts the nanofiber preparation.

3.3 Solution Viscosity

Solution viscosity is also able to change the nanofiber dimensional characteristics. To produce best quality nanofibers this parameter plays a major role; when viscosity is low, fine fibres are formed with a beads, if the viscosity is high, smooth and similar range of nanofibers will be formed. In order to obtain a good and strengthen nanofiber, solution concentration is important.

4. Conclusion

In this analysis, some of the parameters are discussed related with the electrospinning method. The solution characteristics, high voltage power supply unit, and the function of the syringe unit were among the electrospinning processes and parameters are covered. Overall it is concluded that the high voltage unit had a substantial impact on the long, continuous & smooth diameter. All parameters are having an impact in diameter, crystalline structure, solubility, and mass production of nano fibres. The fibre morphology and quality changed as a result of changes to each of the parameters. Additionally, there are many different disciplines where this technique is applied.

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