Structure and Process Parameter Relations of Electrospun Nanofibers

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Long Abstract

Introduction

Electrospinning has been a process of great interest due to its versatility and potential to be used in a wide range of applications. It is possible to produce nanofibers with diameters ranging between a few nanometers to a few nanometers thanks to the latest developments in electrospinning. Electrospun nanofibers promise diverse applications including biotechnology, drug delivery, wound healing, tissue engineering, microelectronics, environmental protection, energy harvest and storage due to their very large surface area to volume ratio, flexibility in surface functionalities and superior mechanical performance [1-3]. There is also the advantage to control nanofiber composition and electrospinning parameters to achieve the desired property and functionality [4]. This paper focuses on electrospinning process principles and relation of process parameters with electrospun polyurethane (PU) nanofiber structural properties.

1. Process

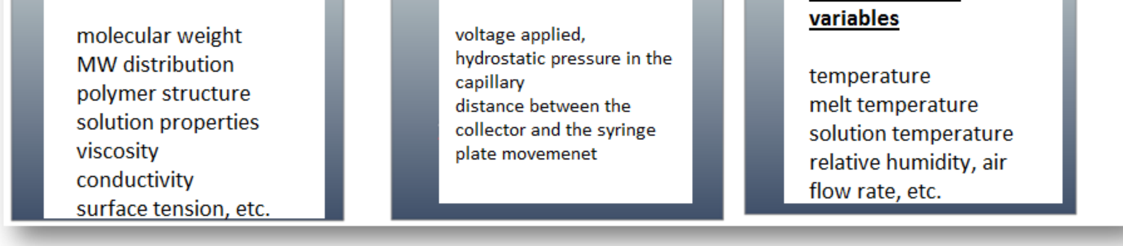
Electrospinning makes use of electrostatic forces to stretch the solution or melt as it solidifies. The fiber mat is collected as a distribution of continuous nanofibers [5]. A typical electrospinning set-up consists of mainly three components :

1. A syringe with a metal spinneret
2. A high voltage supplier
3. A rotating collector

A high voltage is applied to create an electrically charged jet of polymer solution or melt. The jet undergoes stretching before it reaches the collector and it solidifies on the collector in the form of nanofibers by the evaporation of the solvent [3, 6]. The process principle involves subjecting a polymer solution or melt held at its surface tension at the end of a capillary to an electric field. As the intensity of the electric field dis increased, the hemispherical surface of the solution at the tip of the capillary elongates and forms a conical shape known as the Taylor cone. The electric field reaches a critical value where the repulsive electric force overcomes the surface tension force. At this critical value, a charged jet of the solution is ejected from the tip of the Taylor cone. The solvent evaporates as the jet travels in air. The charged polymer fiber is randomly deposited on a collector [7].

A number of theories and simulated modelling techniques were used to explain the electrospinning process. Generally, it is agreed that there are four different regions within electrospinning process [8, 9] :

1. The base region: the charged surface of the solution at the nozzle end,
2. The jet region: where the solution travels along a straight line
3. The splay region : where the jet splits into many nanofibers
4. The collector region : where nanofibers eventually settle.



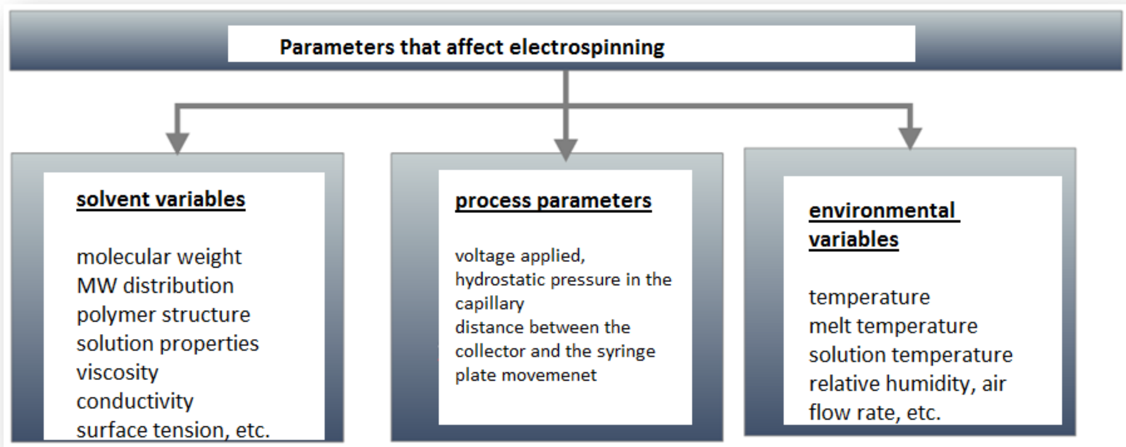


Figure 1. Electrospining process parameters

The characteristics of electrospun nanofibers are determined by electrospinning parameters and this has been widely investigated. In this paper, the process parameter and structure relation of polyurethane nanofibers are studied and the formation of jet is examined.

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