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Production of Nanofibers by Using Electrospinning Method

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Opinion Article

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DESCRIPTION

Nanofibers are fibres that range in diameter from one nanometer to one millimetre. Collagen, chitosan, Poly Urethane (PU), and other polymers can be used to create nanofibers, which have a variety of physical characteristics and possible uses of bonds. Nanofibers are utilised in a wide range of processes, including seed coating, medication delivery, tissue engineering, and cancer diagnostics. Nanofibers can be produced using a wide range of techniques, including as drawing, electrospinning, self-assembly, template synthesis, and thermally induced phase separation. The most popular technique for creating nanofibers is electrospinning, which has a simple setup, the capacity to mass-produce continuous nanofibers from a variety of polymers, and the ability to create ultrathin fibres with adjustable diameters, compositions, and orientations.

In the electro hydrodynamic process that makes up electrospinning, a liquid droplet is electrified to create a jet, which is then stretched and lengthened to create fibre(s). Since the fundamental setup for electrospinning is so straightforward, practically every laboratory may use it. The main parts are a high-voltage power supply, a syringe pump, a spinneret (often a blunt-tipped hypodermic needle), and a conductive collector. Either Direct Current (DC) or Alternating Current (AC) can be used as the power source. Due to surface tension, the liquid during electrospinning is forced out of the spinneret and forms a pendant droplet. A charged jet is released from the droplet when it becomes electrified because of the electrostatic attraction between surface charges with the same sign.

A solid fibre or fibres are deposited on the grounded collector as the jet is stretched to smaller dimensions and solidifies fast. Typically, there are four sequential processes that make up the electrospinning process:

Formation of taylor cone upon charging a liquid droplet

It is important to comprehend the electrohydrodynamic concepts involved in order to comprehend how a Taylor cone forms during electrospinning from an electrically charged liquid droplet. Rayleigh jets are created when ethylene glycol droplets are levitated in an electric field. This is a classic example. The droplet's radius was 58 m when it was injected into the levitator, giving it a spherical shape. Approximately 3.3 pC of charge was present on the surface. The droplet's size decreased over time due to the evaporation of neutral molecules. The droplet then started to take on an ellipsoidal shape, and the poles started to acquire two sharp tips.

Stretching of the charged jet

An electrically charged jet is released from the top of the Taylor cone and then is accelerated by the electric field. As it approaches the collector, the jet will be stretched in the direction of the electric field. It was thought of as if the jet were a series of interconnected, viscoelastic dumbbells. The Three-Dimensional (3D) trajectory of the jet was predicted using a linear Maxwell equation, and the calculation outcomes agreed with the experimental measurements.

Thinning of the Jet

The surface tension and viscoelastic force in the jet work to slow down its forward motion as it accelerates in a straight line. The acceleration consequently progressively decreases. In the meantime, as the jet is constantly stretched, the diameter of the jet in the straight section falls monotonically with distance from the tip. Any slight disturbance can stop a straight movement once the acceleration reaches zero or becomes constant.

Solidification of the jet

The jet solidifies to form fibres during the elongation phase, which is brought on by either the solvent evaporating or the melt cooling. The elongation of the charged jet can last for a longer duration to produce fibres with a narrower diameter when the solidification process is gradual. According to one study, stretching and solvent evaporation led to a dry fiber's cross-sectional radius being just 103 times less than that of the initial jet. Charges may remain trapped on the dry fibres' surface even after they have solidified.

Formation of fibres

Depositing fibres on a grounded collector completes the electrospinning procedure. The degree of bending instability at which the fibres are deposited primarily determines their morphologies. The fibres in the initial bending instability's loop zone are easily collected into a nonwoven mat and placed on a stationary or moving collector.

Managing an electrospinning process

The processing factors, such as the applied voltage, the liquid flow rate, and the separation between the spinneret tip and the collector, have a significant role in the creation of electrospun fibres and the regulation of their diameters.