Electrospinning: A Versatile Method for Producing Nanofibers

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Commentary

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DESCRIPTION

A technique for creating fibres called electrospinning uses electric force to extract charged threads from polymer melts or solutions up to fibre sizes of a few hundred nanometers. Electrospinning and traditional solution dry spinning of fibres share properties with electrospraying. The method can create solid threads from solutions without the use of coagulation chemicals or high temperatures. Because of this, the method is especially well suited for the manufacture of fibres from large, complicated compounds. Additionally, electrospinning from molten precursors is used to assure that no solvent enters the finished product. A liquid droplet is stretched when a sufficiently high voltage is given to it; at a critical point, a stream of liquid bursts from the surface as a result of the liquid's body becoming charged and electrostatic repulsion counteracting surface tension.

The Taylor cone is the name of this eruption site. If the liquid's molecular cohesion is high enough, stream breakage won't happen, and a charged liquid jet will instead form. The charge migrates to the surface of the fibre as the jet dries while in flight, and the current flow mode switches from ohmic to convective. The jet is then extended by an electrostatic whipping process that is started at tiny bends in the fibre and concludes with it being deposited on the grounded collector.

Uniform fibres with nanometer-scale widths are formed as a result of the elongation and thinning of the fibre caused by this bending instability. Without changing the spinneret, emulsions can be utilised to make core shell or composite fibres. However, due to the increased number of variables that must be taken into account when generating the emulsion, these fibres are often more challenging to create than coaxial spinning. The emulsion is created by combining a water phase and an immiscible solvent phase while using an emulsifying agent. Any substance that helps to keep the immiscible phases' interface stable can be applied.

It has proven successful to use surfactants such sodium dodecyl sulphate, Triton X-100, and nanoparticles. A version of this technology that makes use of the fact that polymers often are not miscible with one another and can phase segregate without the addition of surfactants is electrospinning of blends. The use of a solvent that dissolves both polymers will simplify this process even more. Volatile solvents are not required while electrospinning polymer melts, unlike solution electrospinning. Solution spinning enables the production of semi-crystalline polymer fibres, such as PE, PET, and PP, which are otherwise impossible or highly challenging to produce. The system, which uses a syringe or spinneret, a high voltage supply, and the collector, is very similar to that used in traditional electrospinning.

Typically, resistive heating, circulating fluids, air heating, or lasers are used to heat the polymer melt. The fibre sizes are typically a little bit greater than those obtained from solution electrospinning because of the high viscosity of polymer melts. When stable flow rates and thermal equilibrium are reached, the fibre uniformity usually improves greatly. Due to the poor melt conductivity and high viscosity of the melt, the whipping instability, which is the primary stage in which the fibre is stretched for spinning from solutions, can be absent from the process.

The feed rate, polymer molecular weight, and spinneret diameter are often the most important variables that have an impact on fibre size. When compared to macroscale materials, electrospun fibres can interact with other materials in ways that are distinct due to their nanoscale size and potential nanoscale surface texture. Additionally, it is anticipated that the electrospun ultra-fine fibres will have two key characteristics: a very high surface to volume ratio and a largely defect-free molecular structure.