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Nanofiber Technology – Synthesis and Application

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Abstract: *Present era trying to use numerous ways for the development of technology. Nanoscience and nanotechnology are the most important field of technology. Nanoscience is the study of structure and materials on an ultra small scale or 1000 times smaller than the width of human hair. Nanotechnology is the best development for future, concerned with the behaviour of material at these small dimensions. It create new products which are highly porous and having large surface area. Nanotechnology protect and develop environment by detecting, preventing and removing pollution. It has potential to develop all sectors from disease diagnosis and treatment to environmental remediation. The paper based on the potential of nanotechnology for the preparation of nanofibers and its applications. Nanofibers can be prepared from different polymers hence posses different physical properties and application potentials. They create products with new properties via physical and chemical processes. All polymer nanofibers are unique to their surface area to volume ratio, high porosity, flexible in functionalization and mechanical strength. Nanofibers has application in various fields such as energy conservation, medical .They are prepared by so many techniques. Electrospinning is most widely used technique to produce nanofibers.*

Keywords: Nanotechnology, Nanofibers, Electrospinning Technology

I. INTRODUCTION

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales. Where properties differ significantly from those at a larger scale. Nanotechnology are the design, characterisation, production and application of structures, devices and systems by controlling shape and size at nanometre scale. The appealing materials said to be nanomaterials. The term "nano" means one billionth of meter i. e. 1nm= 10^{-9} m, human hair is about 50,000-100,000nm wide. Atoms posses below nm size whereas many molecules ranges from a nanometre upwards. Nanomaterials have great potential application as nanofibers.

1.1 Nanofibers

Nanofibers are defined as fibers with diameters of about 100nm.They can be synthesised by natural polymer, synthetic polymers, carbon-based materials etc. The synthetic polymer nanofibers are made from nylon, acrylic, polycarbonate, polysulfones, and fluoropolymers among other polymers. The biological polymer nanofibers are made from materials such as polylactic acid, polycarpolactum and copolymer of polylactic acid among other biopolymers. The purpose of this paper is to gave the development of nanofiber technology, its synthesis and application. We introduce briefly the various techniques for synthesis such as electrospinning, self-assembly and phase separation. Among all the technologies electrospinning is most widely used for synthesis of nanofibers. Because electrospinning is of low cost, high rate production, high porosity, and ability to control nanofiber morphology and diameter

1.2 Major Applications of Nanofibers

The important areas of application of nanofibers are energy, health care and, water treatment and environmental remediation

- **Cosmetic Skin Mask:** Skin cleansing, Skin healing, Skin therapy with medicine.
- **Application in Life Science:** Drug delivery carrier, Wound dressing ,Haemostatic devices

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- **Tissue Engineering Scaffolding:** Porous membrane for skin, Tubular shapes for blood vessels and nerve regeneration, Three dimensional scaffolds forchemical, bone and cartilage regeneration
- **Nano Sensors:** Thermal sensor, Biochemical sensor, Piezoelectric sensor, Fluorescence optical sensor
- **Filter Media:** Liquid filtration, Gas filtration, Molecule filtration
- **Other industrial applications:** Micro/nanoelectronic devices, LCD device, Higher efficient and functional catalyst Ultra light weight space craft materials, Electromagnetic interference shielding, Photo voltaic devices

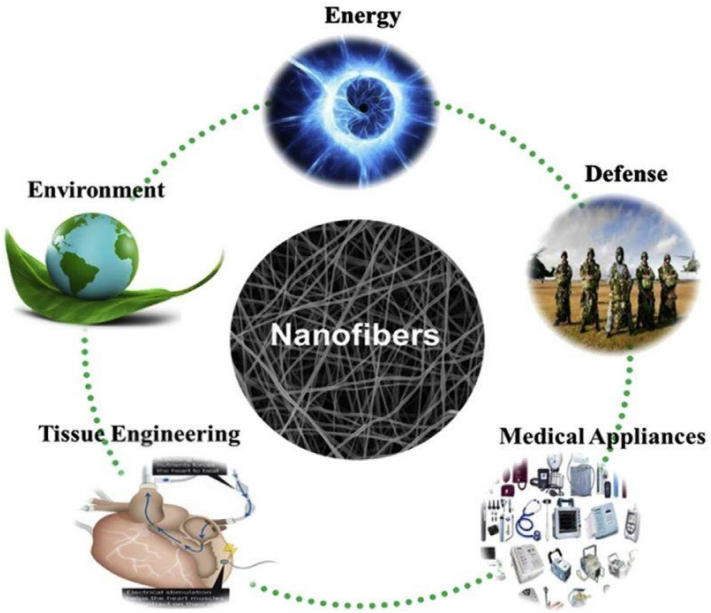

Figure: Applications of nanofibers

II. ELECTROSPINNING TECHNIQUE

Electrospinning is an attractive technique for processing of polymeric bio materials into nanofibers. Electrospinning method can be defined as a process of drawing continuous polymeric fiber from either a polymer solution or polymer melt, based on an electro hydrodynamic phenomenon, using electrostatic force in a liquid – jet form to fabricate polymer composite. During electro hydrodynamic process a liquid droplet is electrified to generate jet, followed by stretching and elongation fibers. The fibers having diameters from nanometer to micrometer.(50nm to 1000nm or higher).A general electrospinning setup consists of three primary components1.a high voltage power supply (kV), 2.a syringe with a metallic needle, and 3.grounded collector. As shown in fig. In a typical electrospinning process, high voltage is applied on solutions or melts., hence a pendant droplet forms. When the electrostatic repulsion starts to overcome the surface tension of the fluid, the pendant droplet will deform into a conical droplet known as the Taylor cone at the tip of the needle. As the electrostatic force overcomes the surface tension of the conical droplet, a fine, charged jet of polymer solution is ejected from the tip of the needle. The interaction between the electric field and the surface tension of the fluid stretches the jet stream and makes it undergo a whipping motion leading to the evaporation of the solvent. This causes the jet stream to be continuously elongated as a long and thin filament and then this filament solidifies and is eventually deposited onto a grounded collector, resulting in the formation of a uniform fiber. This technique also offers the opportunity for control over thickness and composition of the nanofibers along with porosity of the nanofiber meshes using a relatively simple experimental setup.

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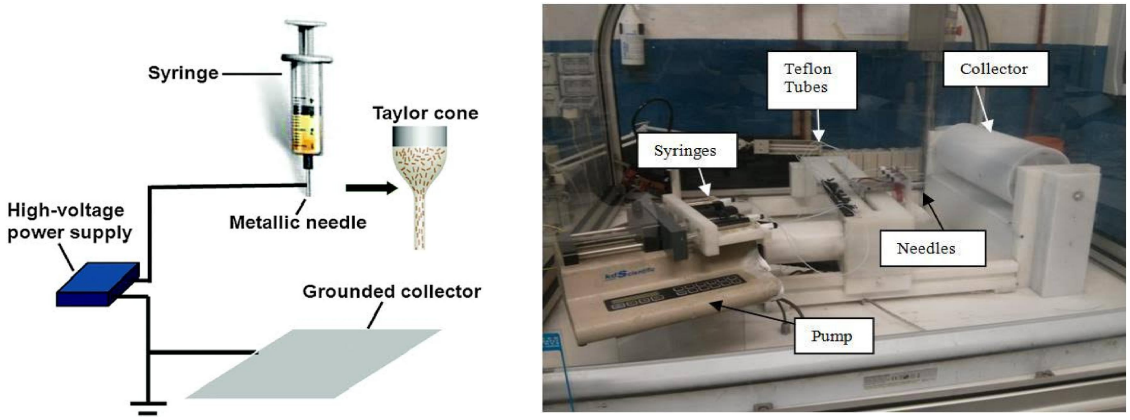

Figure: Electrospinning setup

2.1 Parameters Affecting on Electrospinning

There are two parameters that affects electrospinning

1. System parameters
2. Process parameters

A. System Parameters

System parameters such as polymer molecular weight and distribution determine the rate of degradation of nanofibers. System parameters such as polymer solution properties i.e. viscosity, surface tension and conductivity determines the nanofiber diameter and reduce the possibility of bead formation.

B. Process Parameters

Process parameters such as orifice diameter, flow rate of polymer, and electric potential that influence fiber diameter. Process parameters such as distance between capillary and metal collector determine the extent of evaporation of solvent from the nanofibers, and deposition on the collector, whereas motion of collector determines the pattern formation during fiber deposition. The systemic and process parameters vary with different polymeric systems. Conventional electrospinning produces nanofibers that are randomly oriented. Recent studies on nanofibers explore the possibility of providing an orientation to the nanofibers.). Some of the recent studies have tried to achieve nanofiber alignment by making use of a rotating disc with sharpened edges for deposition of nanofibers. The sharpened edge provides concentrated amounts of electrostatic force that causes the attraction of ions and deposition of the nanofibers along the edge of the rotating disc to produce aligned nanofibers demonstrated that several other parameters can influence the alignment of nanofibers, such as reduction in inter electrode distance, higher polymer concentration, and use of single sharp pin as a collecting electrode. In another recent study, developed a method for collecting electrospunnanofibers using patterned electrodes. They demonstrated that by introducing insulating gaps on the conductive collector, uniaxial aligned nanofibers can be obtained. These studies indicated that alignment and assembly of nanofibers can be altered by varying the design pattern of the collecting electrode. Along with the advantage of producing nanofiber meshes with high porosity and surface area, the electrospinning technique can be applied to a wide variety of natural and synthetic polymers, making it a very versatile technique. However, this technique is also associated with limitations such as broad range of fiber thickness, random orientation of nanofibers, and low mechanical properties of the fiber meshes. Overall, electrospinning is a simple technique to produce nanofibers from a wide variety of polymers.

III. Conclusion

This paper clarify the nanofibers its synthesis and major applications in different field of life. The nanofibers are synthesised by natural polymer, synthetic polymers, carbon-based materials etc. The important areas of application of nanofibers are energy, health care and, water treatment and environmental remediation. There are so many technologies

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for preparation of nanofibers. Such as electrospinning, self-assembly and phase separation. Most widely used technique is electrospinning. The reason is that electrospinning technique is a versatile, efficient, and low cost method. Electrospinning has originated from electrospraying, where an electric charge is provided to a conducting liquid and produces a jet which splits into fine particles that resemble a spray, hence the name electrospraying However, when a polymer is used in place of a low-molecular-weight substance for the electrospraying process, the long-chain nature of polymers does not allow the splitting of the jet into particles. Instead, the jet undergoes instabilities and thins to form nanofibers. Therefore, one has to use polymers (natural or synthetic) to form nanofibers using the electrospinning/electrospraying technique. Wide range of polymers has been used to electrospin nanofibers. This technique also offers the opportunity for control over thickness and composition of the nanofibers along with porosity of the nanofiber meshes using a relatively simple experimental setup.

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