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REVIEW ON SCAFFOLD FORMATION BY ELECTRO SPINNING TECHNIQUE IN BIOMEDICAL FIELD

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Abstract: Electrospun nano fibres have increasingly attracted attention to be used as new generation tissue Engineering scaffolds since they have the nano fibrous structure. This paper gives the review of research on electrospun nano fibres for tissue engineering. In this paper it is shown that scaffold can be form by electrospinning technology which may use in medical applications. The tissue engineering strategy is to facilitate the regrowth of nerves by combining an appropriate cell type with the electrospun scaffold. Electrospinning can generate fibrous meshes having fibre diameter dimensions at the nano scale and these fibres can be non woven. The nano fibre scaffolds have been used for skin, nerve and blood vessel tissue engineering.
Keywords: - Scaffold, Electrospinning, nanofibres,Tissue Engineering,Nanotechnology .

I. INTRODUCTION

Electrospinning is a very efficient method for tissue scaffold manufacturing to produce a nonwoven mesh of micron-sized to submicron-sized fibers. Many researchers have generated various types of scaffolds for human tissue and organ regeneration, including bone, dentin, collagen, liver, cartilage, and skin. electrospun nanofibres have been used in making these scaffolds. These electrospun nano fibres are used to repair, replace and enhance the properties of the tissues. The electrospun nanofibers, which are used in the scaffold, need to be well designed and must have uniformity of dimension. In addition, other requirements such as high porosity large surface area, biodegradability, the ability to maintain structural integrity with tissue, good mechanical properties, non-toxicity to cell and biocompatibility are also important in tissue engineering while using electrospinning Central and peripheral nervous system injuries may benefit from the use of neural tissue engineering strategies that use scaffolds to facilitate the regrowth of nerves.Each individual nano-scale fiber has a high surface to volume and aspect ratio allowing for more surface area contact of the scaffold with the cell. The physical and biological properties of the scaffold are dependent on the material used for electrospinning and its properties such as density, molecular weight, temperature, The overall goal the public distribution system.

II. .ELECTROSPINNING TECHNOLOGY

In the electrospinning process, an electrostatic force is applied to a polymeric solution to produce nanofibre with diameter ranging from 50 nm to 100 nm or greater .Due to surface tension the solution is held at the tip of syringe. Polymer solution is charged due to applied electric force. In the polymer solution, a force is induced due to mutual charge repulsion that is directly opposite to the surface tension of the polymer solution. Further increase in the electrical potential leads to the elongation of the hemispherical surface of the solution at the tip of the syringe to form a conical shape known as Taylor cone. The electric potential is increased to overcome the surface tension forces to cause the formation of a jet, ejects from the tip of the Taylor cone. Due to elongation and solvent evaporation, charged jet instable and gradually thins in air primarily .The charged jet forms randomly oriented nanofibres that can be collected on a stationary or rotating

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III. Electrospinning Setup

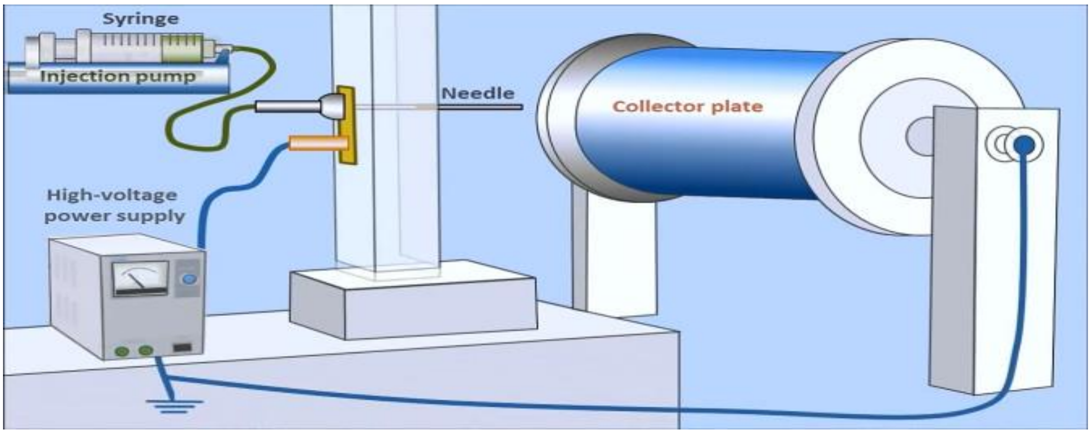

Fig. 1 Elecrto Spining Set Up

A] Basic Component:

a. Syringe pump
b. Syringe
c. Needle
d. Collector plate
e. High voltage DC power supply

IV. WORKING PRINCIPLE

In electrospining process, high voltage is used to create an electrically charged stream of polymer solution. One end of High voltage electrode is linked with the needle and other end to ground plate collector. Solution is filled in syringe pump. Syringe pump is hydraulically operated. Solution is spray with high pressure with help of syringe pump through needle by setting flow rate and time in syringe pump. Electrostatic force is created between solution coming out from needle and ground plate collector. Taylor cone is formed at the tip of needle producing fibers in micron. Fiber solidifies as the polymer solvent evaporates and creates fiber particles on the surface of collector.

Electro spinning process can be explained in 5 steps, such as:
1) Charging of polymer fluid:
The syringe is filled with an polymer solution, the polymer solution is charged with a very high potential around i.e. 10-30kV. The nature of the fluid and polarity of the applied potential free electrons, ions or ion-pairs are generated as the charge carriers form an electrical double layer. This charging induction is suitable for conducting fluid, but for non-conducting fluid charge directly injected into the fluid by the application of electrostatic field.The syringe is filled with an polymer solution, the polymer solution is charged with a very high potential around i.e. 10-30kV. The nature of the fluid and polarity of the applied potential free electrons, ions or ion-pairs are generated as the charge carriers form an electrical double layer. This charging induction is suitable for fluid, but for non-conducting fluid charge directly injected into the fluid by the application of electrostatic field.
2) Formation of cone jet (Taylor Cone):
The polarity of the fluid depends upon the voltage generator. The repulsion between the similar charges at the free electrical double layer works against the surface tension and fluid elasticity in the polymer solution to deform the droplet into a conical shaped structure i.e known as Taylor-cone. Beyond a critical charge density Taylor-cone becomes unstable and a jet of fluid is ejected from the tip of the cone.
3) Thinning of jet in the presence of electric field:
The jet travels a path to the ground; this fluid jet forms a slender continuous liquid filament. The charged fluid is accelerated in the presence of electrical field. This region of fluid is generally linear and thin.
4) Instability of the jet:

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Fluid elements accelerated under electric field and thus stretched and succumbed to one or more fluid instabilities which distort as they grow following many spiral and distort path before collected on the collector electrode. This region of instability is also known as whipping region.

5) Collection of the jet:

Charged electro spun fibers travel downfield until it impact with a lower potential collector drum. Orientation of the collector affects the alignment of the fibers.

V. ELECTROSPINNING TECHNIQUE IS AFFECTED BY DIFFERENT PARAMETERS

A Polymer solution parameters:
1) Molecular weight and solution viscosity
Higher the molecular weight of the polymer, increases molecular entanglement in the solution, hence there is increase in viscosity. The electro spun jet eject with high viscosity during it is stretched to collector electrode leading to formation of continuous fiber with higher diameter but very high viscosity makes difficult to pump the solution and also lead to the drying of the solution at the needle tip. As very low viscosity lead to bead formation in the resultant electro spun fiber, so the molecular weight and viscosity should be acceptable to form nanofibre.
2) Surface tension:
Lower viscosity leads to decrease in surface tension resulting bead formation along the fiber length because the surface area is decreased, but at higher viscosity effect of surface tension is nullified because of the uniform distribution of the polymer solution over the entangled polymer molecules. So, lower surface tension is required to obtain smooth fiber and lower surface tension can be achieved by adding of surfactants in polymer solution.
3) Solution conductivity:
Higher conductivity of the solution followed higher charge distribution on the electrospinning jet which leads to increase in stretching of the solution during fiber formation. Increased conductivity of the polymer solution lowers the critical voltage for the electro spinning. Increased charge leads to the higher bending instability leading to the higher deposition area of the fiber being formed, as a result jet path is increased and finer fiber is formed.
4) Dielectric effect of solvent:
Higher the dielectric property of the solution lesser is the chance of bead formation and smaller is the diameter of electro spun fiber. As the dielectric property is increased, there is increase in the bending instability of the jet and the deposition area of the fiber is increased. As jet path length is increased fine fiber deposit on the collector.
B. Processing condition parameters:
1) Voltage:
Taylor cone stability is depends on applied voltage, at higher voltage greater amount of charge causes the jet to accelerate faster leading to smaller and unstable Taylor cone. Higher voltage lead to greater stretching of the solution due to fiber with small diameter formed. There is greater tendency to bead formation at high voltage because of increased .It is observed that better crystalline in the fiber obtained at higher voltage, because with very high voltage acceleration of fiber increased that reduced flight time and polymer molecules do not have much time to align themselves and fiber with less crystalline formed.
2) Feed rate:
As the feed rate is increased, there is increase in the fiber diameter because greater volume of solution is drawn from the needle tip.
3) Temperature:
At high temperature, viscosity of the solution is decreases and there is increase in higher evaporation rate which allows greater stretching of the solution and a uniform fiber is formed.
4) Effect of collector:
In electro spinning, collector material should be conductive. Collector is grounded to create stable potential difference between needle and collector. a non-conducting material collector reducing the amount of fiber being deposited with lower packing density Porous collector yields fibers with lower packing density as compared to non-porous collector plate. In porous collector plate the surface area is increased so residual solvent molecules gets evaporated fast as compared to non-porous.
5) Diameter of needle:

Needle with small diameter reduces the clogging effect due to less exposure of solution to the atmosphere and leads to the formation of fibers with smaller diameter. However, very small needle has the disadvantage that it creates problem in extruding droplet of solution from the tip of the needle.

VI . APPLICATION OF SCAFFOLD FORM BY ELECTROSPINNING TECHNOLOGY

1) Nanofibres for bone tissue engineering:

The design of scaffolds for bone tissue engineering is based on the physical properties of bone tissue such as mechanical strength, pore size, porosity, hardness, and overall 3D architecture. For bone tissue engineering, scaffolds with a pore size in the range of 100–350 μm and porosity greater than 90% are preferred for better cell/tissue in-growth and hence enhanced bone regeneration.

2) Nanofibres for ligament tissue engineering:

Ligaments are bands of dense connective tissue responsible for joint movement and stability. Ligament ruptures result in abnormal joint kinematics and often irreversible damage of the surrounding tissue leading to tissue degenerative diseases, which do not heal naturally and cannot be completely repaired by conventional clinical methods . In particular, aligned nanofibres enhanced cell response and hence were explored as scaffolds for ligament tissue engineering.

3) Nanofibres for skeletal muscle tissue engineering:

Skeletal muscles are responsible for voluntary movement of the body and once damaged are difficult to regenerate in adult. Tissue engineering of skeletal muscle, although challenging, is an exciting alternative to surgical techniques for skeletal muscle regeneration .The use of electrospun microfibers made from degradable polyester urethane as scaffolds for skeletal muscle tissue engineering.

4) Nanofibres for neural tissue engineering:

In the nervous system, degeneration of neurons or glial cells or any unfavorable change in the extracellular matrix of neural tissue can lead to a wide variety of clinical disorders. Neural tissue repair is a daunting challenge because almost all neural injuries lead to an irreversible loss of function .Neural tissue engineering aims to repair neural tissue by employing biological tools such as normal or genetically engineered.

VII. CONCLUSION

In biomedical field, the electrospun nanofibres have a wide range of applications, from tissue engineering. These applications are made possible due to the characteristics of the nano fibers such as its high porosity and high surface area-to-volume ratio. Although there are other methods of generating nano scale materials, such as drawing, template synthesis, phase separation, self-assembly. Only the electrospinning process has the flexibility and ease of fiber production in both in the lab and in the production plant.

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