Tailored Collector Design For Optimization Of Nanofiber Alignment In Electrospining

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Abstract

Here we demonstrate a unique design of a collector for an Electrospining setup which produces scaffold with majority of aligned nanofibers. Previous researchers[1,2] have shown that the scaffold with aligned nanofibers gives maximum cell proliferation and enhances cell adherence. Also, the geometry of collector influences the alignment of fibers. We develop custom integrated Electrospining setup, build in laboratory, to make scaffold with aligned nanofibers. We use SEM to characterize the structural and morphological aspects of scaffold thus produced.

Introduction

•Electrospining uses an electrical charge to draw a very fine fibers from a liquid polymeric solution.
•Sufficient High Voltage is applied to a solution droplet which is then subjected to electrostatic repulsion and subsequent stretching.
•It causes eruption of a charged liquid jet which dries during the flight. Convection of charge along the fiber surface causes it to undergo whipping process which elongate the fiber to the diameter ranging from micro- nano size.
•Finally, The Fiber get deposited on the collector which is kept at lower potential with respect to the syringe.

Previous research have shown that,

•The Morphology of fibers in scaffold determines the cell adherence and proliferation.
•The Scaffold with aligned nanofibers shows high cell density than the one with randomly aligned.
•The geometry of the collector relatively effects the structure and morphology of fibers.
•Stationary collector gives randomly scattered fibers where as the Rotating collector Gives uniquely spaced fibers.
•Till the date researchers have come up with several collector designs such as Wired Drum Collector, Disc Edge Collector, etc. which gives sufficient alignment.
•We devised a Rotating Disc Collector which gives maximum alignment and minimum solution wastage.

Rotating Disc Collector

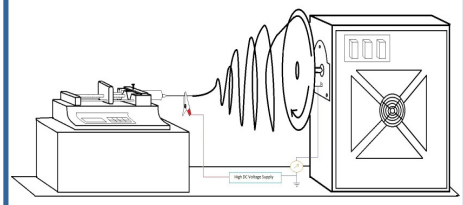


Figure : Schematic of Rotating Disc Collector and fiber deposition

Methodology

The setup was developed using Aluminum Plate (disc), a disposed Computer cabinet and 3speed 120Volt AC Motor. Number of experiments were carried out to calculate the optimum disc dimensions needed to obtain uniform scaffold with uniformly aligned nanofibers. Several collector designs were fabricated and Modified to ensure the design was viable. The whole setup was assembled and tested on real time electrospinning apparatus.

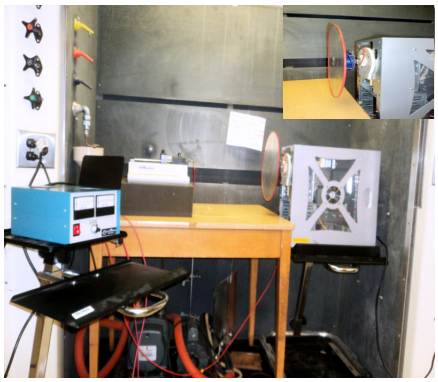


Figure: Electrospining setup with rotating disc collector with Disc in inset.

Design

Certain design parameters were provided so that this collector could be used in a type of setup it was intended. The collector should:
•Rotate without generating air turbulence.
•Be flexible, low maintenance, corrosion resistant and safe to handle
•Be relatively inexpensive to manufacture.

Our team approached these goals by keeping the design simple. The collector
• is made up of 6061-t6 Aluminum (to resist corrosion) , 3speed 120Volt AC motor and a computer cabinet
•Has simple holder-coupling for ease of maintenance.
•Has PVC coating on the edge to decrease air turbulence and to ensure user safety.

Results

After assembly, collector is tested on setup. Experiments were carried out to optimize the assembly to get the optimum value for each parameter. The parameters such as Solution concentration, Flow rate, Distance between syringe and collector, DC Voltage, Disc RPM and Grounding mechanism were kept fixed within the same experiment and were different for different experiments. Finally the following values found to be optimize the assembly.

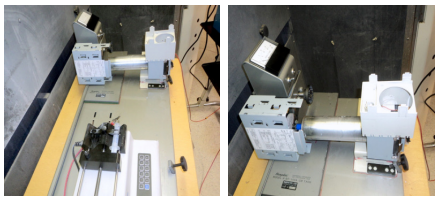
Concentration- 10% PVA
Flow Rate- 0.5ml/hour
Distance- 15 centimeters.
Voltage- 15 KV.
RPM- 1500.

Setup running with above parameters produces a scaffold with majority of aligned nanofibers. The texture of scaffold shows the fiber stretches are concentrically aligned with respect to the center of a disc. We use SEM to characterize the morphology of fibers thus produced. It shows that the fiber diameter ranges from 100nm-200nm and they aligned in cluster. Beside this achievement we found some drawbacks that disc provide sufficient air turbulence. The productivity is little lower than our goal. The grounding mechanism interferes with the fiber deposition.

CONCLUSION

Rotating disc collector gives unique fiber alignment. The largest problem we faced in designing rotating disc collector was meeting the goal of increased productivity. Failing short of this goal was primarily due to grounding mechanism, air turbulence due to manufacturing inconsistencies such as tolerance , issue with linearity of the space on the disc and vibrations caused by disc spinning at high RPM.

Current and Future work



Figur: Rotating Drum Collector

Currently working to modify the Rotating Disc Collector setup to meet all aspects of productivity. We are fabricating different grounding mechanism to ensure maximum percentage of fiber deposition. Maximum attention should be given to a method of balancing the disc to ensure that the vibrations are kept to minimum. We are developing a drum collector based combined technique which would make scaffold with much improved aligned nanofibers .

References : 1. Electrospinning of nano/micro scale poly(L-lactic acid) aligned fibers and their potential in neural tissue engineering ,F. Yang, R. Murugan, S. Wang S. Ramkrishna, *Biomaterial 2004.06.051, Elsevier.*
2. Continuous Electrospinning of Aligned Polymer Nanofibers onto a Wire Drum Collector, P. Katta, M. Alessandro, R. D. Ramsier, and G. G. Chase, *2004 American Chemical Society.*