USE OF NEURAL NETWORKS IN OPTIMIZATION OF ELECTROSPUN DERIVED SCAFFOLDS

Marko N Živanović[1, 2], Dalibor Nikolić[1, 2], Katarina Virijević[1], Nenad Filipović[2, 3]

[1] Laboratory for Bioengineering, Institute of Information Technologies, University of Kragujevac, Jovana Cvijića bb, 34000 Kragujevac, Serbia
e-mail: marko@kg.ac.rs
[2] Bioengineering Research and Development Center – BioIRC, Prvoslava Stojanovića 6, 34000 Kragujevac, Serbia
[3] Faculty of Engineering, University of Kragujevac, Sestre Janjić 6, 34000 Kragujevac, Serbia

Abstract:

Electrospinning is a highly used technique in the tissue engineering field, particularly for the development of various scaffolds [1]. Currently there is research in improving many biomedical methods for tissue engineering. This paper is focused on the electrospinning process and its ideal conditions for producing scaffolds for cell seeding with use of neural network approach for prediction of the most optimal chemical composition of used polymers. With use of a series of biocompatible polymers and solvents, solutions were tested in various electrospinning settings in order to produce microscale fibers. The production of these fibers is directly related to the electrospinning parameters in use, hence the importance of optimizing this process. Upon simple fiber optimization, the electrospinning setup was progressed to include rotational collection for scaffold development. A series of scaffold samples were built from various solutions in different parameter conditions. The scaffolds were analyzed with microscope images for fiber diameter measurement.

Keywords: Electrospinning, polymers, scaffolds, neural networks

1. Introduction

Tissue engineering is an evolving field which has the potential for creating new biomedical methods for the improvement of patient-affected tissue function. The development of a biocompatible scaffold for cell seeding and tissue engineering would be highly beneficial for possible implantation of a constructed tissue. In order to produce a tissue with such complexity and required properties, the early-stage production of the scaffolds needs to be perfected. It is essential that the scaffold produced meets desired characteristics and is a capable surface for cell-seeding [2]. Using electrospinning as the development method, this paper focuses on improving this process for ideal scaffold production. As polymer-based fibers are the product of electrospinning, the aim is to optimize the fiber formation for the best possible scaffold development. Microscopic analysis will be carried out to determine the success rate of the fibers produced, while the neural networks method will be used to prognose and predict the most optimal chemical combination for polymer preparation. Jos teksta o neural networs ovde. The fiber response depends heavily on the materials used and the parameter settings in the electrospinning stage, thus the optimization of this process is necessary. The aim is to find through experimental testing, connections between the material properties of the scaffold and the parameter settings of the test. It is expected that the experimental findings from this paper will progress the research in the field of bioengineering that utilizes Artificial Intelligence and that eventually, It is expected that the experimental findings will offer research progression in this area for the bioengineering research and use of

Artificial Intelligence in that sense and eventually the wider tissue engineering research community.

2. Results

Initially, polycaprolactone (PCL) and polyethylene glycol (PEG) compounds were tested alone along with the compounds of dimethyl formamide (DMF) and chloroform (CHL) which has a higher molecular weight and is more responsible for the viscosity of the solution. Steadily, the concentration was increased from 13 to 30%, as well as the fiber response analysis for each test. Each compound was tested twice, while alternating between the 25:75 solvent ratio. The lengths of the experiment were purposely diversified in order to assess how well the fibers build up with extended durations. The tests were done in 5-, 10-, 20- and 30-minute timeframes with a 26G needle, which has an inner diameter of 0.260 mm. When applying voltage, it was necessary to consider the distance. Both applied voltage and flow rate were generally increased with the increase in polymer concentration, with testing ranges from 0.4 to 2.4 mL/h for flow rate, and 9 to 15 kV for applied voltage.

In order to gain better insight on the structure of the scaffolds based on the fiber types, a portion of each scaffold sample was analyzed using an optical microscope to see whetherethere were any obvious visible imperfections impacting the sample. Each image contains a micrometer scale which can be used to interpret the average fiber diameter (Fig. 1).

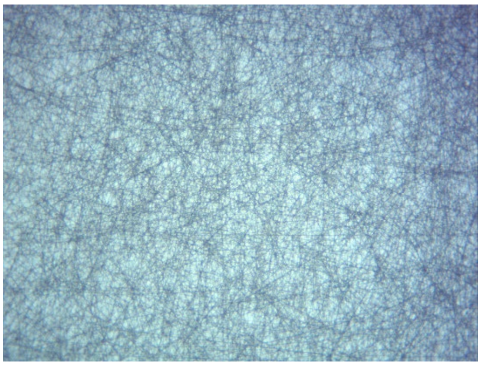

Fig. 1. Example of optical microscopy result on obtained electrospun microfiber scaffold.

Polymer Ratio (22%)	Flow rate (mL/h)	Voltage (kV)	Time (minutes)	Rpm	Diameter Mean (µm)
PCL1:PEG1	0.3	11	100	90	0.498
PCL1:PEG1.2	0.5	12	60	110	0.357
PCL1:PEG1.4	0.5	13	70	115	0.427
PCL1:PEG1.6	0.6	15	110	120	0.459
PCL1:PEG1.8	0.8	18	150	120	0.488
PCL1.2:PEG1	0.5	14	60	80	0.316
PCL1.2:PEG1.2	0.5	12	60	75	0.308
PCL1.2:PEG1.4	0.4	11	60	70	0.301
PCL1.2:PEG1.6	0.5	10	60	70	0.287
PCL1.2:PEG1.8	0.4	9	50	60	0.255

Table 1. Solution and fiber parameter summary

The obtained results are used as inputs for the neural network analysis.

3. Conclusions

It was found that the best fibers ranged in concentrations between 21% and 23%, with chloroform being the larger portion of the ratio. Fiber flow in this range was easiest to manage as it was the most consistent throughout the duration of the testing. Occasionally the flow would be discontinuous and intermittent which still allowed for fiber formation only with some variation from time to time. Based on these findings, the 22% polymer concentration was used with varying ratios of PCL and PEG. Solvent ratios were kept consistent with DMF 25: CHL 75. The Flow rates were diversified to suit the viscosity of the solution. Solutions with a significantly larger PEG ratio were too thin for testing, thus the even or PCL heavy solutions were tested. From this, multiple tests managed to create sufficient fibers.

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