UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE of ENGINEERING
Industrial Solutions Laboratory

Department Project Information

Department Name	*Mechanical Engineering*	**Date Submitted**	
Project Title	*Controllable Degradable nanofiber for axon growth* **(BIO_NIR)**	**Planned Starting Semester**	*Fall/ 2022*

Funding

What is the source of funds that will be used to cover all direct costs of this project? ___Grant_____

Is this source of funds already secured? Yes__ __ No x ____

Work Space

Have you secured a lab/work space for the project to be built? Yes__x__ No____

Faculty Mentor/Grading Instructors *

	Name	Email	Phone
1	In-Hong Yang	Iyang3@uncc.edu	
2			
3			

*List any graduate student that will be working on the project as a grading instructor so that they may be added to Canvas.

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	4	Electrical	
Computer		Systems	
Other ( )			

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Project Overview:

Provide background information about your research and an overview about the context for the project.

Peripheral nerve injuries are common due to increasing traffic accidents, and industrial accidents. Although peripheral nerves have regenerative capability, the regenerative outcome is not satisfactory for the large nerve defects. Functional impairment of the peripheral organs due to nerve defects results in a negative impact on the personal lifestyle, function, and work and will eventually increase the social and economic burden on the healthcare system. Thousands of peripheral nerve repair procedures are conducted annually in the US [1]. The surgical intervention such as suture of the two nerve ends is employed for the nerve gap lesser than 5 mm. The nerve graft is a gold standard model and is used commonly to resume the connection between affected axonal ends if the defect is less than 2 cm and the patient is young (<25 years) [2]. However, the increased risk for the ailment of the donor sites, neuroma formation in both donor and primary injured sites are the major complications that come along with it. There are other approaches to using biomaterials grafts in order to get functional recovery through axon guidance and regeneration. Axon guidance approach is considered a substitute for nerve transplantation and avoids the limitations and damage caused by nerve transfer and nerve grafting. The functional nerve guidance materials were reported to have shown enhanced nerve guidance and regeneration. However, there is a chance of causing inflammation of the surrounding tissues and compression of the nerves [3]. This results in deteriorating the defect area and leading to cause for chronic neuropathic pain. This effect is increasing when guidance material resides for a longer period. The negative consequences that come along with implant guidance materials following axon regeneration have not been discussed widely. Considering these backgrounds, fabricating a smart nerve guidance material that can degrade on-

demand following axon regeneration while overcoming the pitfalls of conventional nerve conduits is highly appealing. The goal of the proposed study is to fabricate the on-demand degradable fibrous matrix for improved axon guidance. This study aims to engineer a controllable fibrous matrix that is degradable in a response to mild heating (~40-42ºC) where normal neuron cells are unharmed [4]. It is hypothesized that degradation of the nerve conduit controllably after nerve regeneration will enhance neuronal activities such as myelination and neuronal maturation.

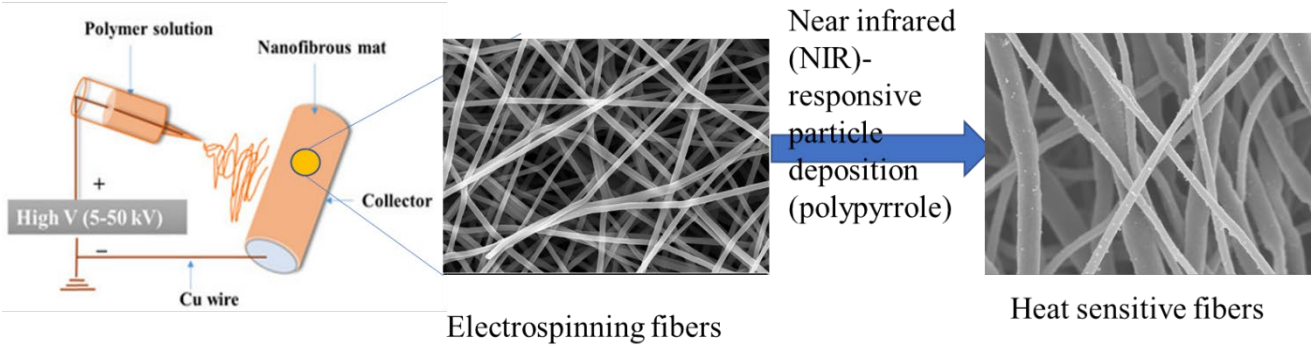

Figure 1. *Schematic of fabrication process of NIR responsive degradable electrospinning nanofibers.*

Project Requirements:

This is a more detailed description of the design problem, project objectives and the desired output – describing the scope and specifications for what the project team will actually be designing and producing.

Design problem:

Synthetic grafts have slow degradation kinetics and stay longer in the grafting region even after the axons grew over them. On the other hand, the biopolymers have a higher dissolution rate. For example, gelatin constructs can dissolve at physiological temperature (~37 ºC) conditions prior to

the accomplishment of nerve guidance. As far as we know, there are not any reports which are showing a fabrication of fully focally controlled degradable matrix for the axon regeneration to date.

The proposed project will establish a strategy for making a nerve conduit with a property of focal degradation which may have more advantages than contemporary conduit materials.

Objectives:

The following objectives are set to be achieved with the proposed study.

1. Fabrication of controllable degradable fibers matrix
2. Removal of nanofibers by controllable degradation after the axon's growth using mild heating (40-42 ^{o}C) leaving axons behind.
3. Assess the myelination after degradation of nerve guidance fibers and neuronal maturation.

Description about fabrication

The electrospinning fibers will be received from the collaborative laboratory from another institution on request. Upon receipt of the nanofibers, these will be transformed into the near-infrared (NIR) responsive nanofibers by embedding NIR responsive polypyrrole nanoparticles by chemical modification [5]. Polypyrrole is an organic polymer with biocompatible properties. It produces the heat (photothermal properties) dependently on an irradiated NIR power density. Controlled degradation of the fiber will be achieved by modulating the heat produced by the nanofiber under NIR light. The NIR light irradiation of temperature range ~40-42 ^{o}C may be expected fibers to disassemble at the region of interest. This NIR-therapy is a FDA approved non-invasive that uses red light of the NIR region and approved for various treatment purposes including hyperthermia, osteoporosis, bone injuries and peripheral neuropathy [6-8].

The project team will work as follows.

1. Fabricating the fibers with NIR properties by embedding polypyrrole particles.
2. Characterizing physical and chemical properties of the fibers before and after modification.

3. Performing the in-vitro degradation of fibers in simulated body fluid conditions under NIR light exposure.
4. Preparing the fiber material ready for the neuron cell culture.
5. Participating in the neuron culture and assessing the microscopic study for the cell's adhesion and growth.
6. Measuring the length of the axons grown over the nanofibers.
7. Imaging of the growth of axons and changes of the nanofibers in terms of morphology.
8. Evaluating the degradation of the nanofibers and the fate of axons following the NIR light.

Expected Deliverables/Results:

Bullet list of all deliverables that the team is to provide to the mentor at the end of the project. Be specific here to avoid misunderstandings.

- The focally degradable nanofibrous material.
- Results obtained with proposed material.

Succeeding this project may be expected to have the potential to neuronal functional recovery following the axon damages that are associated with injuries, CIPN, diabetic induced neuropathy etc.

Disposition of Deliverables at the End of the Project:

Hardware developed is the property of the mentor and department. Typically, the work product is displayed at the last Expo then immediately handed over to the mentor. Please confirm your expectation in this section.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

These resources are needed if possible

- NIR light source
- NIR light camera

References

[1] G.R. Evans, Peripheral nerve injury: a review and approach to tissue engineered constructs, The Anatomical Record: An Official Publication of the American Association of Anatomists 263(4) (2001) 396-404.

[2] M.S.U. Sahar, M. Barton, G.D. Tansley, Bridging larger gaps in peripheral nerves using neural prosthetics and physical therapeutic agents, Neural Regen Res 14(7) (2019) 1109-1115.
[3] B. Battiston, S. Geuna, M. Ferrero, P. Tos, Nerve repair by means of tubulization: literature review and personal clinical experience comparing biological and synthetic conduits for sensory nerve repair, Microsurgery 25(4) (2005) 258-267.
[4] Z. Vujaskovic, S.M. Gillette, B.E. Powers, S.M. Larue, E.L. Gillette, T.B. Borak, R.J. Scott, T.P. Ryan, T.A. Colacchio, Effects of intraoperative hyperthermia on peripheral nerves: Neurological and electrophysiological studies, International Journal of Hyperthermia 10(1) (1994) 41-49.
[5] A.P. Tiwari, T.I. Hwang, J.-M. Oh, B. Maharjan, S. Chun, B.S. Kim, M.K. Joshi, C.H. Park, C.S. Kim, pH/NIR-Responsive Polypyrrole-Functionalized Fibrous Localized Drug-Delivery Platform for Synergistic Cancer Therapy, ACS Applied Materials & Interfaces 10(24) (2018) 20256-20270.
[6] A. Swislocki, M. Orth, M. Bales, J. Weisshaupt, C. West, J. Edrington, B. Cooper, L. Saputo, M. Islas, C. Miaskowski, A randomized clinical trial of the effectiveness of photon stimulation on pain, sensation, and quality of life in patients with diabetic peripheral neuropathy, Journal of pain and symptom management 39(1) (2010) 88-99.
[7] L. Burkow, The use of near infrared light emitting diodes in treating sports-related injuries: a review, Research (2014).
[8] E.M. Nuijs-Beems, J.A. Oosterhuis, E.H. Verburg-van der Marel, D. de Wolff-Rouendaal, J.L. van Delft, J.A. van Best, Tumor destruction by intermediate level hyperthermia, Current eye research 9(8) (1990) 771-780.