DEVELOPMENT OF CONDUCTIVE AND BIODEGRADABLE NANOFIBROUS YARNS: STUDY OF ELECTRICAL AND MECHANICAL PROPERTIES

Puwakdandawe Vishakha Thilini Weerasinghe

(188058V)

Degree of Master of Science

Department of Textile and Clothing Technology

University of Moratuwa
Sri Lanka

January 2020

DEVELOPMENT OF CONDUCTIVE AND BIODEGRADABLE NANOFIBROUS YARNS: STUDY OF ELECTRICAL AND MECHANICAL PROPERTIES

Puwakdandawe Vishakha Thilini Weerasinghe

(188058V)

Thesis submitted in partial fulfillment of the requirements for the degree Master of Science in Textile and Clothing Technology

Department of Textile and Clothing Technology

University of Moratuwa
Sri Lanka

January 2020

Declaration

“I declare that this is my own work and this thesis does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Also, I hereby grant to University of Moratuwa the non-exclusive right to reproduce and distribute my thesis, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).”

Signature: …………………………… Date: …………………..

“The above candidate has carried out research for the Master’s thesis under my supervision.”

Name of the supervisor: ……………………………………………………………….

Signature of supervisor: …………………………… Date: …………………..

Name of the supervisor: ……………………………………………………………….

Signature of supervisor: …………………………… Date: …………………..

Abstract

Electrically conductive and biodegradable materials are desired for a vast array of applications in wearable and flexible electronic areas to address the growing ecological problem of e-waste. Herein, we report on the design and fabrication of all-organic, conductive and biodegradable yarn using polyaniline (PANi) and polycaprolactone (PCL). The process of PANi incorporation is achieved in two ways; i) electrospinning a blend of PANi and PCL solution ii) in-situ polymerization of PANi on the nanofibrous surface of PCL electrospun fibers. The electrospun PANi incorporated webs are cut into ribbons and twisted to develop twisted yarns. A customized setup was used to produce continuous electrospun yarns. The effect of different degrees of PANi blended into PCL was investigated. Moreover, the effect of an array of aniline concentrations in coated fibers were studied. PCL/PANi blended solution with 2% PANi resulted in nanofibers with resistance of 10 ± 4 MΩ/cm. Fibers coated with 1% aniline concentration resulted in the core-shell fibers with of 50 ± 8 kΩ/cm. Increasing the number of plies of yarn to 3 plies resulted in a 3-fold reduction of the resistance. The twisted plied yarns were incorporated into fabric by stitching or weaving to demonstrate the stability of conductivity over mechanical forces. Both PANi blended and PANi coated yarns were found to be biodegradable in controlled environmental conditions. The use of PANi blended yarn as a biomaterial for tissue engineering and PANi coated yarns as a wearable electrode for capacitive sensors were demonstrated. The electromechanical behavior of PANi coated yarn is expected to provide inspiration for the production of highly sensitive strain sensors. This approach presents an early step on the way to the realization of all organic conductive biodegradable nanofibrous yarns for sustainable smart textiles.

Key words: Conductive polymers, nanofibrous yarns, biodegradable, electrospinning, polyaniline

Dedication

I dedicate my thesis to all my professors and doctors and scientists for the extensive knowledge you share with me. Your unselfish guidance increased my passion for nanotechnology.

Acknowledgement

I wish to acknowledge who supported me in numerous ways to achieve my MSc. First, I am indebted to research supervisor Dr. N.D. Wanasekara, Senior Lecturer, Department of Textile and Clothing Technology, University of Moratuwa for invaluable support, and motivation he readily gave me to accomplish this research .His patience in guiding me, vast knowledge, advice and experience helped me in many ways to conclude my research.

I would like to express appreciation thanks to Dr. (Mrs.) D.G.K. Dissanayake, Senior Lecturer, Department of Textile and Clothing Technology, University of Moratuwa, insightful comments and encouragement from the start to the very end of the days I worked on this thesis and also, magnanimous way of educating me to the world of scientific publication, are very much appreciated.

Besides my supervisors, I am also thankful towards my progress review committee: Dr. Srimala Perera and Dr. T.S.S. Jayawardena for their motivation comments and encouragement in each progress review to make my focus to the strategical research plan.

Also, I wish to express gratitude to Sri Lanka Institute of Nanotechnology (SLINTEC) to give access to advanced laboratory facilities and scientists, Miss. Nadeeka Tissera, Mr. Ruchira Wijesena and Prof. Nalin de Silva who assisted and supported me while dedicating their valuable time.

I also express my sincere gratitude to the academic and nonacademic staff of Department of Textile and Clothing Technology, University of Moratuwa for the continuous support and guidance given throughout my undergraduate and postgraduate life. Furthermore, I thank Nilupuli Rathnayake from the 15^{th} batch and Sasini Weerasinghe from the 13^{th} batch, Department of Textile and Clothing technology for all the support given to accomplish this research without any stress.

The financial support for this research was provided through the SRC Grant (SRC/LT/2018/ 33) offered by the Senate Research Council, University of Moratuwa.

I would like to extend my sincere thanks to SRC for identifying the value of this research and approving the requested budget for this research. I would like to acknowledge Dr. (Mrs.) D.G.K. Dissanayake for appointing me as a research student to conduct this research under the above SRC grant.

Last but not least, it is with a heart laden with gratitude that I thank to my family for the tremendous support given me and who were always there to lift me up during hard times.

Table of contents

List of figures

List of tables

List of abbreviations

Abbreviation	Description
PANi	Polyaniline
PCL	Polycaprolactone
CBNY	Conductive and biodegradable nanofibrous yarn
NY	Nanofiber yarn
SEM	Scanning electron microscope
FTIR	Fourier transform infrared
DSC	Differential scanning calorimetry
TGA	Thermogravimetric
PBS	Phosphate-buffered saline
ASTM	American Society for Testing and Material

List of appendices