DERIVATION OF NANOFIBRILLATED CELLULOSE FROM LOCALLY AVAILABLE RICE STRAW

Abirami Ratnakumar

(159493E)

Degree of Master of Science

Department of Materials Science and Engineering

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July 2020

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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.

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Name of the Supervisor: Mr. A.M.P.B Samarasekara

Signature of the supervisor: Date:

Name of the Supervisor: Dr. D.A.S Amarasinghe

Signature of the supervisor: Date:

ACKNOWLEDGEMENT

Time flies! The days one after the other in the lab, the days prepared for the publications day and night; the days participated in the lectures and the days I received guidance and strength from the supervisors will never be forgotten.

Foremost, I would like to express my sincere gratitude to my supervisors Mr. A.M.P.B Samarasekara and Dr. D.A.S Amarasinghe for their patience, immense guidance, ample time spent and continuous advices and support that helped me in carrying out this research. I could not imagine having better supervisors and mentors for my study.

I would like to express my sincere gratitude to Professor A.A.P de Alwis and Mr. V.S.C Weragoda for their encouragement, insightful comments and valuable suggestions which have contributed greatly for the improvement of the thesis.

I am deeply thankful to the Director, Rice Research and Development Institute, Bathalagoda, Sri Lanka and Director, Provincial Agriculture Department, Jaffna, Sri Lanka for their generous support in providing the rice straw to carry out this research.

I would like to extend my special thanks to Head of the Department/ Mr. V. Sivahar, Course Coordinator/ Dr. (Mrs.) A.S. Galhenage, Project Coordinator/ Mr. S.V. Udayakumara and the staff members of Department of Material Science and Engineering, University of Moratuwa, Sri Lanka for their kind assistance. I am also grateful to Mr. S.D. Karunarathna, Mr. M.T.M.R. Jayaweera, Mr. M.A.P.C. Gunawardana, Mr. R.R.P. Perera, Mr. H. Amal and Mr. G.D. Chandrakumara of Department of Materials Science and Engineering, University of Moratuwa, Sri Lanka for providing facilities and technical support in conducting this research.

I would like to thank my mother, whose love and guidance was with me in whatever I pursue. She is my pillar of support and the ultimate role model who provides unending inspiration.

I'm really grateful. I want to thank everyone who helped me!

ABSTRACT

Cellulose has become a wonder material in the present context of research and development since it is fibrous and tough, hence biodegradable, biocompatible, and renewable natural polymer. Nowadays, rice straw as a cellulose source has gained momentum as rice is one of the major crops grown in most of the tropical and subtropical countries of the world where half of the world population consuming it as the major food source. Rice straw is the agricultural production residue from rice cultivation which is considered as an agricultural waste and cause decay related issues in the plantation. This biological waste material if utilized can be a renewable feedstock for the production of value added products for special applications. Sri Lanka being an agricultural country holds twentieth position in the worldwide rice production. However, a large amount of rice straw is generated per annum as a by-product of rice production in the country. Even though rice straw is utilized in various ways, there is a possibility for a value addition by extracting its constituents such as nanofibrillated cellulose from this commercially underutilized waste material and thereby embracing a bioeconomy approach in the country.

In this study, nanofibrillated cellulose (NFC) was extracted from Sri Lankan rice straw varieties BG352, Murunkan, Pachchaperumal and Moddaikaruppan in two distinct stages. Initially, rice straw was subjected to a series of chemical traetments to eliminate the non-cellulosic constituents. Then the obtained chemically extracted cellulose fibers were separated into nanofibers *via* high-intensity ultrasonication (HIUS) treatment. Structural, thermal and morphological characteristics of nanofibers and their intermediate products were determined. FTIR analysis confirmed that the chemical composition of nanofibers was mainly cellulose where amorphous natured hemicellulose and lignin were effectively removed during chemical treatments. Study revealed that around 25 - 38 percent cellulose was extracted from the four rice straw varieties *via* chemical process. From these chemically extracted cellulose fibers around 17 - 45 percent of nanofibrillated cellulose were extracted *via* high-intensity ultrasonication process. Morphology of rice straw during the extraction process was distinct when the non-cellulosic components were removed. Results indicated that the efficient multi-step treatment process yielded nanofibers with potential advanced applications.

Chemical extraction method is found to be the most efficient method for cellulose extraction from lignocellulosic biomass. Therefore, it is of paramount important to investigate the influence of parent materials on the synthesis process and the properties of the yield. Effect of particle size distribution of locally available traditional rice straw Murunkan on cellulose extraction was studied. Study revealed that after the series of chemical treatments rice straw with particle size distribution below 75 µm (Mu-75) yielded 27.19 ± 0.98 percent and rice straw with particle size distribution between 150 µm to 250 µm (Mu-250) yielded 38.31 ± 0.86 percent. Out of these cellulose fibers, around 63 percent of NFC was extracted from Mu-75 and around 55 percent of NFC from Mu-250. SEM images showed that the diameters of the extracted nanofibres from Mu-250 ranged from 75 to 200 nm whereas nanofibers from Mu-75 ranged between 27 – 104 nm. These findings will have profound influence upon extracting nanofibrillated cellulose from agricultural biomass.

Key words – Rice Straw, Nanofibrillated Cellulose, Chemical Extraction, High Intensity Ultrasonication, Bioeconomy

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List of Abbreviations

Abbreviation	Description
BC	Bacterial Cellulose
CPC	Chemically Purified Cellulose
CNC	Cellulose Nanocrystals
CNF	Cellulose Nanofibrils
DTA	Differential Thermal Analysis
DTG	Derivative Thermogravimetry
ECNF	Electrospun Cellulose Nanofibers
EDS	Energy-dispersive X-Ray Spectroscopy
FTIR	Fourier transform infrared spectroscopy
HIUS	High-Intensity Ultrasonication
HPH	High Pressure Homogenization
MFC	Microfibrillated Cellulose
NC	Nanocellulose
NCC	Nanocrystalline Cellulose
NFC	Nanofibrillated Cellulose
RRDI	Rice Research and Development Institute
RS	Rice straw
RSA	Rice straw ash
SEM	Scanning Electron Microscopy
TGA	Thermogravimetric Analysis
XRD	X-Ray Diffraction

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