

**DERIVATION OF NANOFIBRILLATED CELLULOSE
FROM LOCALLY AVAILABLE RICE STRAW**

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Degree of Master of Science

Department of Materials Science and Engineering

University of Moratuwa

Sri Lanka

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Thesis submitted in partial fulfillment of the requirement for the Degree of Master of
Science

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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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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 treatments 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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