✍ Dedicated to

Nan

Papa

My Family

My Neighbours

All Teachers

&

God

DECLARATION

I, do hereby declare that the thesis entitled "**Smart Waterborne Polyurethane Nanocomposites for Multifaceted Advanced Applications**", submitted to the Department of Chemical Sciences, Tezpur University, under the School of Sciences is a record of original research work carried out by me. All sources of support and assistance have been assigned with due acknowledgment. I, also declare that neither this work as a whole nor any part of it has been submitted to any other University or Institute for any kind of degree, diploma or award.

Place: Tezpur University, Tezpur

Date: 05/10/2023

Samiran Morang

(**Samiran Morang**)

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CERTIFICATE

This is to certify that the thesis entitled "**Smart Waterborne Polyurethane Nanocomposites for Multifaceted Advanced Applications**" submitted to Tezpur University, in the Department of Chemical Sciences, under the School of Sciences, in partial fulfillment for the award of the degree of Doctor of Philosophy in Science is a record of research work carried out by **Mr. Samiran Morang** under my supervision and guidance.

All help and assistance received by his from various sources have been duly acknowledged. No part of this thesis has been reproduced elsewhere for award of any other degree.

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PREFACE

In the pursuit of addressing the continuously growing needs in the field of polymer science and technology, extensive research is conducted on waterborne polyurethanes (WPUs) and their nanocomposites (WPUNCs) to assess their adaptability and usefulness across a wide range of applications. Among these endeavors, the creation of smart WPUs and WPUNCs by judicial molecular engineering and incorporating carbon-based nanomaterials demonstrate significant promise for high-performance applications, thanks to their exceptional and distinctive properties. Again, contemporary circumstances have underscored the importance of "going green" and embracing "sustainability" in scientific research, in response to the global ecological challenges linked to the polymer industry. Hence, current endeavors are dedicated to the development of environmentally friendly, economically feasible, and industrially robust WPUs and WPUNCs by utilizing renewable resources such as vegetable oil, glycerol, etc. These materials are suitable for a wide range of advanced applications with smart features like shape memory, self-healing, photoluminescence, and so forth.

Hence, this work introduces a novel perspective on the development of environmentally friendly, high-performance WPUs and WPUNCs derived from renewable resources, exhibiting unique properties and holding significant potential for various contemporary applications.

Date: 03/10/2023

Place: **Tezpur University, Tezpur**

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Place: ***Tezpur University, Tezpur***

Samiran Morang

Date: 05/10/2023 ***(Samiran Morang)***

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
°	Degree
°C	Degree centigrade
δ	Chemical shift
λ	Wavelength
ζ	Zeta potential
μL	Microliter
μm	Micrometer
0-D	Zero dimensional
1-D	One-dimensional
2-D	Two-dimensional
a.u.	Arbitrary units
A	Ampere
AFM	Atomic force microscopy
ASTM	American society for testing and methods
ATR	Attenuated total reflectance
cm	Cenitmeter
CNFs	Cellulose nanofibers
DLS	Dynamic light scattering
DMAc	N,N-dimethylacetamide
DMA	Dynamic mechanical analysis
DMSO	Dimethyl sulfoxide
DSC	Differential scanning calorimetry
Eq	Equation

eqv	Equivalent
eV	Electron volt
EDA	Ethylene diamine
EDX	Energy dispersive X-ray
FESEM	Field emission scanning electron microscope
FTIR	Fourier transform infrared
g	Gram
g-C_3N_4	Graphitic carbon nitride
GECA	Glycerol ester of citric acid
g/mol	Gram per mole
GO	Graphene oxide
GPa	Giga pascal
GPC	Gel permeation chromatography
h	Hour
HDF	Human dermal fibroblasts
HMDA	1,6-Heamethylene diamine
IPDA	Isophorone diamine
IPDI	Isophorone diisocyanate
J	Joule
kg	Kilogram
kN	Kilo Newton
mg	Milligram
MG_{CO}	Monoglyceride of castor oil
min	Minute
mm	Millimeter

mV	Millivolt
MHz	Mega hertz
M_n	Number average molecular weight
M_w	Weight average molecular weight
MPa	Mega pascal
nm	Nanometer
N	Newton
NMR	Nuclear magnetic resonance
OD	Optical density
PCL	Polycaprolactone
ppm	Parts per million
RBC	Red blood cell
rpm	Rounds per minute
RGO	Reduced graphene oxide
s	Second
SEM	Scanning electron microscope
SPR	Surface plasmon resonance
TCP	Tissue culture plate
TDA	Toluene diisocyanate
TEM	Transmission electron microscope
T_g	Glass transition temperature
TGA	Thermogravimetric analyser
T_{MAX}	Maximum degradation temperature
T_{ON}	Onset degradation temperature

T_p	Peak degradation temperature
THF	Tetrahydrofuran
UTM	Universal testing machine
V	Volume
UV	Ultraviolet
VOC	Volatile organic compounds
wt%	Weight percent
XPS	X-Ray photoelectron spectroscopy
XRD	X-ray diffraction

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