



 *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

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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*

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In the pursuit of addressing the continuously growing needs in the field of polymer science and technology, extensive research is conducted on waterborne polyurethanes (WPU) and their nanocomposites (WPUNCs) to assess their adaptability and usefulness across a wide range of applications. Among these endeavors, the creation of smart WPU and WPUNCs by judicious 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 WPU 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 WPU and WPUNCs derived from renewable resources, exhibiting unique properties and holding significant potential for various contemporary applications.

Date: 05/10/2023

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## ACKNOWLEDGEMENTS

Guru Brahma Guru Vishnu Gurudevo Maheshwara I  
Guru Sakshaat Parabrahma, Tasmae Shri Guruve Namaha II

*The journey from a state of innocence, through dreams of youthful adventure, to obtaining a Ph.D. would not have been fulfilling without acknowledging all those individuals who have actively contributed to its realization.*

*Above all, I extend my heartfelt gratitude to my Ph.D. supervisor, Prof. Niranjana Karak of the Department of Chemical Sciences at Tezpur University, for dedicating his full efforts to guide me in achieving my academic goals. From providing hands-on experimental training to encouraging critical thinking and the expression of ideas, his mentorship has left an indelible mark on my academic journey that I will carry with me throughout my life. His counsel to embody the determination of Arjuna from the Mahabharata echoed within me countless times, undoubtedly serving as a wellspring of motivation that propelled me forward and encouraged me to tackle fresh challenges throughout my Ph.D. expedition. Thank you Sir for everything.*

*I would like to extend my sincere gratitude and respect to my doctoral committee members, Prof. Ashim J. Thakur and Prof. Kusum K. Bania, Department of Chemical Sciences, Tezpur University, for their expertise and constructive feedback, which greatly enriched the quality of this work.*

*I extend my deepest gratitude to both the present and former Heads of the Department, Prof. Panchanan Puzari and Prof. Ruli Borah, respectively. Their unwavering support and provision of opportunities, ranging from*

---

*access to advanced instrumental facilities to fundamental departmental amenities, have played a pivotal role in facilitating the smooth progress of my research work.*

*I am profoundly grateful to my collaborators, namely Prof. Biman B. Mandal and Ashutosh Bandyopadhyay from the Department of Bioscience and Bioengineering at IIT Guwahati, Prof. Ramesh C. Deka and Nishant Biswakarma from Tezpur University, and Dr. Atharva Poundarik and Jay H. Rajput from IIT-Ropar, Punjab. Additionally, my thanks extend to Dr. Bodhisatwa Das and Anwasha Mukherjee, also from IIT-Ropar, Punjab. Their generosity in allowing me to conduct various biological experiments in their laboratories has been invaluable to my research.*

*I would like to extend my heartfelt gratitude to all the esteemed faculty members of the Department of Chemical Sciences for their invaluable suggestions and guidance. My sincere appreciation goes out to the dedicated official and support staff of the department for their indispensable efforts and assistance. Additionally, I would like to express my thanks to all the fellow scholars within the department for their friendly and supportive interactions.*

*I am wholeheartedly appreciative of the technical staff within the Department of Chemical Sciences, as well as those from SAIC (specially, Prakash da and Tridip da) and the Department of Physics at Tezpur University. Furthermore, my gratitude extends to CIF and NECBH, IIT-Guwahati for their invaluable support in offering instrumental and analytical assistance for my research.*

*I am deeply grateful to CSIR-HRDG, India, for their financial support, which has been instrumental in the progression of my research.*

---

*I extend my heartfelt appreciation to all the members of the APNL (Advanced Polymer and Nanomaterial Laboratory) family, including Dr. Geeti Kaberi Dutta, Dr. Tuhin Ghosh, Dr. Rajarshi Bayan, Dr. Rituparna Duarah, Dr. Deepshikha Hazarika, Dr. Aditi Saikia, and Dr. Dimpee Sarma. Their valuable suggestions and guidance, delivered with genuine affection, have been of immense help in my academic journey.*

*I cannot express enough gratitude to my dearest colleagues and closest friends, Nobomi and Annesha, for their unwavering companionship, moral support, and for generously sharing their knowledge, which greatly enriched my academic journey. I am deeply appreciative of Kriti Yadav (affectionately known as "little one"), Raghav Poudel (for videography assistance), Kalyan Dutta, and Ashok Bora for their dynamic cooperation, affection, and care throughout my Ph.D. journey. The close-knit family I have found here has showered me with blessings and countless memories that I will cherish forever.*

*I would like to extend my heartfelt thanks to my dear friends, including Raju Chouhan, Pinku Saikia, Gautam Gogoi, Suranjana Patowary, Rashmi Chetry, Bikash Ch. Mushahary, Dolly Saikia, Bedanta Thakur, Mahari Basumatary, Raktim Gogoi, Surya K. Borah, Mahesh Dubey, and Debajit Bora. Additionally, my gratitude goes to my respected seniors Raktim Abha Saikia, Nishant Biswakarma, Rakhi Saikia, Chiranjita Goswami, and Sudhamoyee Katakya, for their invaluable assistance and support. I also want to express my thanks to all my well-wishers for their encouragements and supports.*

*I would like to extend my acknowledgment to Mrs. Susmita Karak for her love and care, which contributed to making my time here more enjoyable and memorable.*

---

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*I want to convey my sincere gratitude to the Badminton Club at Tezpur University and my fellow game partners, such as Rahul, Manithoi, and Subham, for helping me stay physically active and fit.*

*I am delighted to seize this moment to express my heartfelt appreciation to my family members: Nan, Papa, Sumi, Mon, Dhunda, Horunan, Aita, and Pehi, for their unwavering love and care. I attribute everything I have achieved today to the dedication and thirst for knowledge that my parents instilled in me. Their sacrifices, hard work, and unwavering support have brought me to this stage in my life. I am forever grateful to all my cousins and relatives for their affection and inspiration, which continually motivates me to surpass my limits and reach new heights.*

*Finally, I offer my heartfelt gratitude to Lord Krishna for His blessings and guidance, which have illuminated my path throughout my journey. I just want to say “god gives me everything”.*

*Place: Tezpur University, Tezpur*

*Date: 05/10/2023*

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*(Samiran Morang)*



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## *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	Centimeter
CNFs	Cellulose nanofibers
DLS	Dynamic light scattering
DMAc	N,N-dimethylacetamide
DMA	Dynamic mechanical analysis
DMSO	Dimethyl sulfoxide
DSC	Differential scanning calorimetry
Eq	Equation

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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 <sub>3</sub> N <sub>4</sub>	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-Hexamethylene diamine
IPDA	Isophorone diamine
IPDI	Isophorone diisocyanate
J	Joule
kg	Kilogram
kN	Kilo Newton
mg	Milligram
MG <sub>CO</sub>	Monoglyceride of castor oil
min	Minute
mm	Millimeter

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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

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T <sub>p</sub>	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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