✍ *Dedicated to*

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TEZPUR UNIVERSITY

(*A Central University Established by an Act of Parliament*)

Napaam, Tezpur-784028, Sonitpur, Assam, India

DECLARATION

I, do hereby declare that the thesis entitled "**Bio-based Epoxy Thermosets and Their Nanocomposites**", 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 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

Nobomi Borah

Nobomi Borah

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CERTIFICATE

This is to certify that the thesis entitled "**Bio-based Epoxy Thermosets and Their Composites**" 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 **Ms. Nobomi Borah** under my supervision and guidance.

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

Niranjan Karak

Place: Tezpur University, Tezpur
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The committee recommends for the award of the degree of Doctor of Philosophy.

Principal Supervisor **External Examiner**

Date: **Date:**

PREFACE

The advent of science and technology has bestowed upon humanity some amazing innovations that cannot be overlooked in the present times. Synthetic polymers, especially epoxy resins, are a prime example of such inventions whose impact can be realized in every facet of material science. In the contemporary world, there is a substantial consumption of commercial epoxy for preparing daily commodities, often without an awareness of the hazardous outcomes associated with the overuse of these petro-based commercial epoxies. However, to ameliorate the toxicity issues and circumvent the inherent brittleness of commercial epoxy systems, significant research interest has been concentrated on exploring replenishable resources as ingredients for producing epoxy. With regard to this instance, polyhydric phenols, especially tannins which are exclusively harvested from plant components, emerge as viable candidates for developing eco-friendly epoxy systems. The initial part of this thesis exemplified the same by using tannic acid to synthesize a bio-based epoxy with strong performance capabilities. The subsequent sections of the content delve into the fabrication of sustainable and robust composite systems, embracing bio-based epoxy and exciting nature-derived additives including microfibers, cellulose nanofibers, and iron oxide-decorated cellulose nanofibers. The biocomposites and nanocomposites thus fabricated were examined for some aspiring applications, for example, microfiber-containing biocomposites as environmentally durable structural materials, functionalized cellulose nanofiber-fused nanocomposites as anticorrosive coatings, iron oxide-cellulose nanofiber-based nanocomposites as pH sensitive antibacterial drug-releasing systems, etc.

Therefore, this work unveils new insights into the development of sustainable, high-performance epoxy composites, encompassing some exclusive multifunctional features that render their engagement in a wide array of scenarios.

Nobomi Borah

Date: 05/10/2023

Place: **Tezpur University, Tezpur** **Nobomi Borah**

ACKNOWLEDGEMENTS

With the divine grace of Almighty God, I have been blessed with the strength and wisdom to embark on this academic journey, and at this stage, as my vessel ultimately arrives at the coastline, I am earnestly grateful to all.

A profound sense of gratitude binds me to my supervisor and guiding light, Prof. Niranjan Karak, Department of Chemical Sciences, Tezpur University, for his unwavering guidance, mentorship, and invaluable insights throughout the course of this research. His hard work, punctuality, and commitment imparted lessons that I will carry with me throughout my life. I am truly grateful for his limitless efforts shown toward my research, his patience, and his motivational words during the time of crisis. His words were instrumental in shaping the direction of my research and inspired me to think outside the box.

I would like to extend my sincere gratitude and respect to my doctoral committee members, Prof. Ruli Borah and Dr. Sajal K. Das, Department of Chemical Sciences, Tezpur University, for their expertise and constructive feedback, which greatly enriched the quality of this work.

I would also like to appreciate the pleasant efforts and corporation extended to me by the entire fraternity of the Department of Chemical Sciences for facilitating me with all the basic technical and administrative necessities required for my research work.

My deepest gratitude goes to the present and former Heads of the Department, Prof. Panchanan Puzari and Prof. Ruli Borah, respectively, for all the opportunities provided, from sophisticated instrumental facilities to basic amenities in the department, that aided me to conduct my research work smoothly.

I am indebted to my collaborators, Prof. Manabendra Mandal, Department of Molecular Biology and Biotechnology, Tezpur University, and Prof. Biman B. Mandal, Department of Bioscience and Bioengineering, IIT Guwahati, for allowing me to perform all the biological experiments in their laboratory.

My sincere thanks go to all the faculty members of the Department of Chemical Sciences for their valuable suggestions and advice. I am indebted to all the official and other staff of the department for their priceless efforts and assistance. I also like to thank all the scholars of the department for their friendly and supportive demeanor.

I am wholeheartedly appreciative of the technical staff of the Department of Chemical Sciences, SAIC, Department of Physics, Tezpur University; NEIST-SAIF, CSIR-NEIST, Jorhat for all the instrumental and analytical assistance provided for my research.

My heartfelt appreciation goes to all the members of the APNL family: Dr. Aditi Saikia, Dr. Geeti Kaberi Dutta, and Dr. Dimpee Sarmah, for offering their valuable suggestions and guidance with the utmost affection. I can't thank enough my colleagues and friends, Samiran Morang and Annesha Kar, for their camaraderie, moral support, and for always sharing their knowledge with me, which enriched my academic experience. I am extremely grateful to Ashok Bora, Kalyan Dutta, Raghav Poudel, and Kriti Yadav for showing dynamic corporation, affection, and care during my Ph.D. work. The family I have discovered here has bestowed blessings and countless memories to treasure forever.

I would also like to thank my friends Shilpa Neog, Suranjana Patowary, Bikash Ch. Mushahary, Raju Chouhan, Nayab Hussain, Gautam Gogoi, Mohendra Tahu; my respected seniors Dr. Anirban Garg, Dr. Raktim Abha Saikia, Dr. Rakhi Saikia, Sudhamoyee Kataky, and Dr. Julie Bora; and my beloved wing-mates for their help and support. My joy knows no bounds in expressing my cordial gratitude to my friends Jahnobi Gogoi, Sumana Sharma, Parishmita Arandhara, Nabajyoti Rajowar, Ashim Baruah, and all my dear friends and well-wishers for their support during this journey.

I would like to acknowledge Mrs. Susmita Karak for her love and care that made my stay here more enjoyable and cherishable.

I am happy to take this opportunity to acknowledge my family members, Maa, Baba, Bhonti, Nanu, and Dehmon for their unconditional love and care. I owe everything I am today to the dedication and aspirations for knowledge that my parents instilled in me. Their sacrifices, efforts, and encouragement have brought me to this point in my life. I am always grateful to all my cousins and relatives for their affection and inspiration, which pushes me to exceed my boundaries and soar to new heights.

Lastly, a heartfelt thanks to Lord Krishna for his blessings and guidance that have illuminated my path.

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Nobomi Borah

Date: 05/10/2023 **(Nobomi Borah)**

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
°	Degree
℃	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
AC	Ampicillin
AEJO	Acrylated epoxidized jatropha oil
AESO	Acrylated epoxidized soyabean oil
AFM	Atomic force microscopy
ASTM	American society for testing and methods
ATR	Attenuated total reflectance
BN	Boron nitride
BPA	Bisphenol A
cm	Cenitmeter
CNFs	Cellulose nanofibers
DGEBA	Diglycidyl ether of bisphenol A

DLS	Dynamic light scattering
DMAc	N,N-dimethylacetamide
DMSO	Dimethyl sulfoxide
DPPH	2,2-Diphenyl-1-picrylhydrazyl
DSC	Differential scanning calorimetry
eq	Equivalent
eV	Electron volt
E_{corr}	Corrosion potential
EDA	Ethylene diamine
EDX	Energy dispersive X-ray
EEW	Epoxy equivalent weight
f-CNFs	Functionalized cellulose nanofibers
FESEM	Field emission scanning electron microscope
FTIR	Fourier transform infrared
g	Gram
g-CN	Graphitic carbon nitride
g/mol	Gram per mole
GO	Graphene oxide
GPa	Giga pascal
GPC	Gel permeation chromatography
h	Hour
I_{corr}	Corrosion current
IONPs	Iron oxide nanoparticles
J	Joule
kg	Kilogram

kN	Kilo Newton
mg	Milligram
min	Minute
mm	Millimeter
mV	Millivolt
MHz	Mega hertz
M_n	Number average molecular weight
M_w	Weight average molecular weight
MAH	Maleic anhydride
MPa	Mega pascal
nm	Nanometer
N	Newton
NMR	Nuclear magnetic resonance
OD	Optical density
ppm	Parts per million
PDP	Potentiodynamic polarization
PE	Protection efficiency
PTC	Phase transfer catalyst
rpm	Rounds per minute
RGO	Reduced graphene oxide
s	Second
SEM	Scanning electron microscope
SPR	Surface plasmon resonance
TA	Tannic acid

TDA	Toluene diisocyanate
TEM	Transmission electron microscope
T_g	Glass transition temperature
TGA	Thermogravimetric analyser
T_{ON}	Onset degradation temperature
T_p	Peak degradation temperature
THF	Tetrahydrofuran
UTM	Universal testing machine
UV	Ultraviolet
VOC	Volatile organic compounds
wt%	Weight percent
WTFs	Waste tea fibers
XPS	X-Ray photoelectron spectroscopy
XRD	X-ray diffraction
ZOI	Zone of inhibition

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