

 *Dedicated to*

মা আৰু দেউতা..



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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



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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.

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The committee recommends for the award of the degree of Doctor of Philosophy.

Principal Supervisor

External Examiner

Date:

Date:

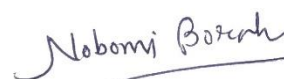
PREFACE

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.

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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 |
| 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 | Centimeter |
| 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 |
| <i>f</i> -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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