Dedicated to

Dadu, Dumma,

Maa, Papa,

Jhu & Tupshi

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 "**Sustainable Waterborne Poly(ester amide) Nanocomposites and their Potential 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: 4/3/24

Annesha Kar

(Annesha Kar)

TEZPUR UNIVERSITY

(A Central University Established by an Act of Parliament)

Napaam, Tezpur-784028, Sonitpur, Assam, India

Dr. Niranjan Karak
Professor
Department of Chemical Sciences

Phone: +91-3712-267004 (O)
Fax: +91-3712-267005 (O)
Email: nkarak@tezu.ernet.in

CERTIFICATE

This is to certify that the thesis entitled "**Sustainable Waterborne Poly(ester amide) Nanocomposites and Their Potential 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 **Ms. Annesha Kar** 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.

Place: Tezpur University, Tezpur

Date: 16/10/23

(Dr. Niranjan Karak)
Professor
Department of Chemical Sciences
School of Sciences
Tezpur University

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

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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 pursuit of meeting the increasing demands of modern world's material science has led to significant focus on the development of sustainable as well as high-performance polymer nanocomposites. Poly(ester amide) nanocomposites, in particular, have garnered substantial interest due to their notable and distinct characteristics. The imperative of sustainability has further driven scientific research towards the creation of eco-friendly poly(ester amide)s. As a result, current endeavors are dedicated to the development of economically viable as well as industrially significant poly(ester amide) nanocomposites via environmentally friendly approaches. There is significant potential for carrying out exploration of different carbon-based nanomaterials as well as bio-based precursors for the fabrication of poly(ester amide) nanocomposites with practical applications. Thus, delving into this field, the initial section of this thesis demonstrated the synthesis of a waterborne bio-based poly(ester amide) material with strong performance characteristics. Subsequent sections of the thesis focused on developing another durable, elastomeric poly(ester amide urethane) material along with incorporating different reinforcing agents, viz., biochar particles with and without bentonite nanoclay particles, etc. The resulting polymeric materials as well as nanocomposites were evaluated for diverse potential applications, including poly(ester amide urethane) material as environmentally resilient structural material, biochar-integrated poly(ester amide urethane) nanocomposites as adsorbent material for removal of organic dyes from aqueous systems, and modified biochar/ bentonite nanoclay-infused poly(ester amide urethane) nanocomposites as adsorbents bearing high efficacy for removal of heavy metal ions from contaminated waste water.

Therefore, this research work provides the perspectives on the fabrication of sustainable as well as high-performance poly(ester amide) nanocomposites bearing unique multifunctional traits that render their applicability in diverse realms.

Date: 4/3/24

Place: **Tezpur University, Tezpur**

Annesha Kar

Annesha Kar

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Place: Tezpur University, Tezpur

Date: 4/3/24

Annesha Kar
(Annesha Kar)

LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
°	Degree
°C	Degree centigrade
Θ	Diffraction angle
δ	Chemical shift
λ	Wavelength
µL	Microliter
µm	Micrometer
0-D	Zero dimensional
1-D	One-dimensional
2-D	Two-dimensional
3-D	Three-dimensional
a.u.	Arbitrary units
A	Ampere
ACN	Acetonitrile
AFM	Atomic force microscopy
ASTM	American Society for Testing and Methods
ATR	Attenuated total reflectance
BC	Biochar
BET	Brunauer-Emmett-Teller
BJH	Barrett-Joyner-Halenda
BS	*Bacillus subtilis*
cm	Centimeter
CD	Carbon dot

CNFs	Cellulose nanofibers
COSY	Correlated Spectroscopy
DB	Degree of branching
DLS	Dynamic light scattering
DMAc	N,N-Dimethylacetamide
DMF	N, N-Dimethylformamide
DMSO	Dimethyl sulfoxide
DSC	Differential scanning calorimetry
eq	Equivalent
eV	Electron volt
EDX	Energy dispersive X-ray
ECH	Epichlorohydrin
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
HMDA	Hexamethylene diamine
HBPEA	Hyperbranched poly(ester amide)
H-bonding	Hydrogen bonding
IPDI	Isophorone diisocyanate

IM	Inverted microscopy
J	Joule
k	Rate constant
kg	Kilogram
kN	Kilo Newton
mg	Milligram
min	Minute
mm	Millimeter
mol	Mole
mmol	Millimole
mV	Millivolt
MHz	Mega Hertz
M_n	Number average molecular weight
M_w	Weight average molecular weight
MPa	Mega Pascal
MBC	Modified biochar
MG	Malachite green
MWCNT	Multiwalled carbon nanotube
nm	Nanometer
N	Newton
NMR	Nuclear magnetic resonance
OD	Optical density
OM	Optical microscopy
ppm	Parts per million
PA	*Pseudomonas aeruginosa*

PEA	Poly(ester amide)
PEAU	Poly(ester amide urethane)
PDI	Polydispersity index
PTSA	p- Toluene sulphonic acid
PVA	Poly(vinyl alcohol)
rpm	Rotations per minute
RGO	Reduced graphene oxide
s	Second
SEM	Scanning electron microscope
TZ	Tartrazine
TEA	Triethylamine
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
XPS	X-Ray photoelectron spectroscopy
XRD	X-ray diffraction

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