

*Dedicated*  
*to*  
*Maa, Deuta & Ba*



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## DECLARATION

I, do hereby declare that the thesis entitled “**Biobased superabsorbent hydrogels 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 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:** 12-12-2023

*Ashok Bora*  
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### CERTIFICATE OF SUPERVISOR

This is to certify that the thesis entitled “**Biobased superabsorbent hydrogels 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 **Mr. Ashok Bora** under my supervision and guidance.

All the help received by him 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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**Date:** 12-12-2023

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## CERTIFICATE OF EXAMINER

This is to certify that the thesis entitled “**Biobased superabsorbent hydrogels 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 has been examined by us on ..... and found to be satisfactory.

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

**Principal Supervisor**

**External Examiner**

**Date:**

**Date:**

## **PREFACE**

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In the past few decades, the development of bio-based hydrogel has received a lot of attention to reduce the extensive usage of hydrogels derived from conventional petroleum sources, which pose serious threats to the sustainability of the ecosystem. In this aspect, a high biobased content hydrogel was prepared using starch and itaconic acid as renewable resources for various application fields. The hydrogel showed various properties, including high water swelling as well as water holding capacity and slow fertilizer release ability. Further, the wastepaper-derived cellulosic micro-reinforcing agent was prepared by simply applying alkaline treatment only and incorporated into the hydrogel matrix, showing enhanced water swelling as well as slow-release fertilizer properties. In addition to these, cellulose nanofiber was isolated from wastepaper applying simple treatments and further modified for use as a nano-reinforcing agent. Moreover, zinc oxide nanohybrid was produced using modified cellulose nanofiber as supporting material via an eco-friendly approach. The prepared nanomaterial and nanohybrid were introduced into the hydrogel matrix to obtain hydrogel with improved characteristics, making them suitable for use in the removal of dyes and heavy metal ions from water as well as for drug delivery. Thus, the current research work in the entitled thesis may bring up new possibilities in developing bio-based hydrogels with enhanced properties for various potential applications.

*Ashok Bora*

**Place:** Tezpur University, Tezpur

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**Date:** 12-12-2023

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*Ashok Bora*

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## **LIST OF ABBREVIATION AND SYMBOLS**

AA	acrylic acid
AM	acrylamide
AN	acrylonitrile
ANOVA	analysis of variance
APS	ammonium persulfate
AUL	absorption under load
BD	bulk density
CAN	ceric ammonium nitrate
CFX	ciprofloxacin
cm	centimeter(s)
CNC	cellulose nanocrystal
CNF	cellulose nanofiber
CNW	cellulose nanowhisker
CR	cresol red
DMSO	dimethyl sulfoxide
EDX	energy dispersive x-ray
eV	electron volt
FESEM	field emission scanning electron microscope
FTIR	fourier transform infrared
g	gram(s)
h	hour(s)
HC	hydrogel composite(s)
HNC	hydrogel nanocomposite(s)
IA	itaconic acid
IPN	interpenetrating network



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KPS	potassium persulfate
MAA	methacrylic acid
MB	methylene blue
MBA	<i>N, N</i> -methylene bisacrylamide
mCNF	modified-cellulose nanofiber
MG	malachite green
min	minute(s)
mL	milli litre(s)
MV	methyl violet
NPK	nitrogen, phosphorous and potassium
NM	nanomaterials
nm	nanometer
NP	nanoparticle
PAA	poly(acrylic acid)
PAM	poly(acrylamide)
PD	particle density
PFO	Pseudo-first-order
PIA	poly(itaconic acid)
ppm	parts per million
PSO	Pseudo-second-order
PVA	poly(vinyl alcohol)
$q_{eq}$	dye adsorption capacity
$Q_{max}$	maximum water swelling capacity
RL	root length
SA	sodium acrylate
SAH	superabsorbent hydrogel
SAHNC	Superabsorbent hydrogel nanocomposite

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SEM	scanning electron microscope
SL	shoot length
SMCA	sodium monochloroacetate
SRF	slow-release fertilizer
t	time
TEM	transmission electron microscope
TGA	thermogravimetric analysis
USAH	urea encapsulated superabsorbent hydrogels
Vol	volume
WAC	water absorption capacity
WHC	water holding capacity
WP	wastepaper
WPP	wastepaper powder
XPS	X-ray photo electron spectroscopy
XRD	X-ray diffraction
Wt	weight
ZnO	zinc oxide
ZONH	zinc oxide/cellulose nanofiber nanohybrid
3D	three-dimensional
μL	micro litre(s)
%	percentage
°	degree
°C	degree centigrade
0-D	zero dimensional
1-D	one dimensional
2-D	two dimensional
a.u.	arbitrary unit

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