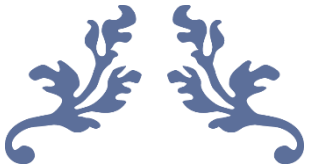

Dedicated to my most beloved,

Maa and Papa,

The strengths of my soul and the wings of my dreams.

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DECLARATION

I solemnly declare that the thesis entitled **'Study of the Electrochemical Behaviour of Creatinine towards Selected Transition Metal Ions and Electro-Active Materials for Sensor Application,'** submitted to the Department of Chemical Sciences, under the School of Sciences, Tezpur University, India, is an authentic record of original research undertaken by me. Following the standard scientific reporting protocols, due acknowledgements have been made wherever the work described is based on the findings of other investigators. I have also acknowledged all sources of support and assistance. Neither this work as a whole nor any part of it has been submitted to any other University or Institute for any degree, diploma or award.

Date: 20-03-2025

Place: Tezpur University, Tezpur.

(Nayab Hussain)

TEZPUR UNIVERSITY

(A Central University Established by an Act of Parliament)

Napaam, Tezpur-784028, Sonitpur, Assam, India

Dr. Panchanan Puzari
Professor
Department of Chemical Sciences

Tell(O): +91 (3712) 267007
Fax: +91 (3712) 267005/6
Email: pancha@tezu.ernet.in

CERTIFICATE FROM THE SUPERVISOR

This is to certify that the thesis entitled "**Study of the Electrochemical Behaviour of Creatinine towards Selected Transition Metal Ions and Electro-Active Materials for Sensor Application**" 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. Nayab Hussain** under my supervision and guidance.

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

Date: 20.03.2025

Place: Tezpur University

(Dr. Panchanan Puzari)
Professor
Department of Chemical Sciences
School of Sciences
Tezpur University

TEZPUR UNIVERSITY

(A Central University Established by an Act of Parliament)

Napaam, Tezpur-784028, Sonitpur, Assam, India

CERTIFICATE FROM THE EXTERNAL EXAMINER AND ODEC

This is to certify that the thesis entitled "**Study of the Electrochemical Behaviour of Creatinine towards Selected Transition Metal Ions and Electro-Active Materials for Sensor Application**" 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 the award of the degree of Doctor of Philosophy to Mr. Nayab Hussain.

Signature of:

Supervisor

Date: 20.03.2025

External Examiner

Date:

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"Setback, despair, lesson, success, joy and growth" – these are what we can randomly find as we embark on any journey and I believe, I found all of those in this PhD journey of mine. However, wearing a smile at the end wouldn't have been possible without the significant contributions from many that my endeavour has received in different forms. Let me take this opportunity to count the blessings and express my sincere thanks.

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Date:

Place: *Tezpur University, Tezpur.* ***(Nayab Hussain)***

Abbreviations and symbols used in this thesis

%	Percent
$\|Z\|$	Magnitude of electrochemical impedance
°	Degree
°C	Degree Celsius
µA	Microampere
µL	Microlitre
µS/m	Microsiemens per meter
2-NBA	2-nitrobenzaldehyde
A	Ampere
A	Electrode surface area
Å	Armstrong
a.u.	Arbitrary unit
ACN	Acetonitrile
AKI	Acute kidney injury
aMRDR	Abbreviated Modification of Diet in Renal Disease
ASN	American Society of Nephrology
B2M	β_2-microglobulin
BSA	Body surface area
BTP	β-trace protein
BUN	Blood urea nitrogen
BW	Body weight
C/mol	Coloumb per mole
CA	Chronoamperometry
CB	Carbon black
C_c	Coating capacitance
CCS	Cobalt chloride solution
C_{dl}	Double layer capacitance
CE	Counter electrode
CIP	Creatinine imprinted polypyrrole
CIP/Pt	Platinum electrode modified with creatinine imprinted polypyrrole
CKD	Chronic Kidney Disease
CKD-EPI	Kidney Disease Epidemiology Collaboration
CL_{cr}	Creatinine clearance
cm	Centimetre
$cm^2\ s^{-1}$	Square centimetres per second

CNT	Carbon nanotube
COPD	Chronic obstructive pulmonary disease
CP	Chronopotentiometry
CPE	Constant phase element
CRS	Creatinine solution
CV	Cyclic voltammetry/ Cyclic voltammogram
CVs	Cyclic voltammograms
D	Diffusion coefficient
DMSO	Dimethyl sulfoxide
DPV	Differential pulse voltammetry/ Differential pulse voltammogram
DPVs	Differential pulse voltammograms
DRS	Diffuse Reflectance Spectra
EDX	Energy dispersive X-Ray
eGFR	Estimated Glomerular Filtration Rate
EIS	Electrochemical impedance spectroscopy
E_{onset}	Onset potential
EPR	Electron Paramagnetic Resonance
Eq.	Equation
Et al.	*et alli*
Etc.	Et Cetera
F	Faraday's Constant
f	Frequency
FTIR	Fourier Transform Infrared Spectroscopy
g/mol	Gram per mole
GCE	Glassy carbon electrode
GEIS	Galvanostatic electrochemical impedance spectroscopy
GFR	Glomerular Filtration Rate
HBS	Human blood serum
Ht	Height
IHD	Ischaemic heart diseases
i_p	Peak current
i_{pa}	Anodic peak current
i_{pc}	Cathodic peak current
IUPAC	International Union of Pure and Applied Chemistry
$J\ K^{-1}\ mol^{-1}$	Joule per kelvin per mole
KDIGO	Kidney Disease: Improving Global Outcomes
kg	Kilogram

LICs	Low-income countries
LMICs	Lower-middle-income countries
LMWPs	Low Molecular Weight Proteins
LOD	Limit of detection
LOQ	Limit of quantification
LRI	Lower respiratory infections
m	Meter
M	Molar
m^2	Square meter
mg	Milligram
mg/day	Milligrams per day
mg/dL	Milligrams per decilitre
mg/L	Milligrams per litre
mGFR	Measured Glomerular Filtration Rate
MHz	Megahertz
mHz	Millihertz
min	Minute
MIP	Molecular imprinted polymer
mL	Millilitre
mL/min	Millilitres per minute
mM	Millimolar
MRDR	Modification of Diet in Renal Disease
ms	Millisecond
mV	Millivolt
mV s^{-1}	Millivolt per second
n	Number of electron transfer
NADPH	Nicotinamide adenine dinucleotide phosphate
ng	Nanogram
NIP	Non-imprinted polypyrrole (co-deposited polypyrrole and creatinine)
NIP/Pt	Platinum electrode modified with non-imprinted polypyrrole
NKF	National Kidney Foundation
nm	Nanometer
P_{adj}	Adjusted creatinine production rate
PANi	Polyaniline
PBS	Phosphate buffer saline
PEIS	Potentiostatic electrochemical impedance spectroscopy
pH	Potential of hydrogen

POCT	Point-of-care-testing
PPy	Polypyrrole
P-XRD	Powder X-Ray Diffraction
Py	Pyrrole
R	Gas constant
R_{ct}	Charge transfer resistance
RE	Reference electrode
rGO	Reduced graphene oxide
R_p	Polarization resistance
R_s	Solution resistance
s	Second
SCr	Serum creatinine concentration
SEM	Scanning Electron Microscope
T	Time
T	Temperature
UCr	Urinary creatinine concentration
UV-vis	Ultraviolet-visible
V	Volt
V s^{-1}	Volt per second
V_U	24-hours urine volume
WE	Working electrode
YLLs	Years of life lost
Z	Electrochemical impedance
Z_w	Warburg resistance
σ	Warburg coefficient
φ	Phase difference
ω	Radial frequency

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