Dedicated to

my beloved parents

DECLARATION BY THE CANDIDATE

I hereby declare that the thesis entitled **"*Developing facile plasmonic nanostructures and their application in sensing prominent adulterants in cattle milk*"**, submitted to the **School of Sciences, Tezpur University**, Tezpur, Assam in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Physics, is a record of original work carried out by me at **Department of Physics, Tezpur University**, Assam, under the supervision of **Dr. Rajib Biswas**, Associate Professor, **Department of Physics, Tezpur University**. Any text, figures, theories, results or designs that are not my own devising are appropriately referenced in order to give due credit to the original author(s). All sources of assistance are duly acknowledged. I also declare that neither this work as a whole nor a part of it has been submitted to another university or institute for any degree, diploma, associateship, fellowship, or any other similar title or recognition.

Upama Das.

Date: 22/08/2025

(Upama Das)

Place: Tezpur University, Assam

Registration No. **TZ203794** of **2021**

TEZPUR UNIVERSITY

(A Central University by an Act of Parliament)

Department of Physics

Tezpur-784028, ASSAM, INDIA

Dr. Rajib Biswas **Ph. +91-3712-275564 (O)**

Associate Professor **+91-9954313970 (M)**

Department of Physics **Email: rajib@tezu.ernet.in**

Tezpur University, Tezpur

CERTIFICATE OF THE SUPERVISOR

This is to certify that the thesis entitled **"Developing facile plasmonic nanostructures and their application in sensing prominent adulterants in cattle milk",** submitted to the **School of Sciences, Tezpur University**, in partial fulfilment for the award of the Degree of Doctor of Philosophy in Physics is a record of research work carried out by **Ms. Upama Das** under my supervision and guidance.

All help received by her from various sources have been duly acknowledged.

No part of this thesis has been submitted elsewhere for any award or any other degree.

Date: 22/08/2025

Place: Tezpur University, Assam

(Dr. Rajib Biswas)
Associate Professor
Department of Physics
Tezpur University, Assam

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(*"Knowledge is power"* — Francis Bacon)

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Place: Tezpur University, Assam

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
NPs	Nanoparticles
0D	Zero dimensional
LSPR	Localised surface plasmon resonance
NSs	Nanostructures
NMs	Nanomaterials
HM	Heavy metal
Hg	Mercury
As	Arsenic
Cd	Cadmium
Pb	Lead
LOD	Limit of detection
AgNPs	Silver nanoparticles
UV-Vis	UV-Visible
PVA	Poly-vinyl alcohol
AuNPs	Gold nanoparticles
ITO	Indium tin oxide
CV	Cyclic voltammetry
PEG	Polyethylene glycol
PVP	Polyvinyl pyrrolidone
FDA	Food and Drug Administration
FSSAI	Food Safety and Standard Authority of India
WHO	World Health Organization
BHA	Beta hydroxy acid
GC	Gas chromatography
MS	Mass spectrometry
HPLC	High-performance liquid chromatography
SPR	Surface plasmon resonance
NRs	Nanorods
NWs	Nanowires
NCs	Nanocages
NSPs	Nanospheres
NPRs	Nano prisms
NPLs	Nanoplates
NSHs	Nanosheets
SERS	Surface-Enhanced Raman scattering
XRD	X-ray diffraction
FCC	Face centred cubic
$NaBH_4$	Sodium borohydride
TSC	Trisodium citrate
$AgNO_3$	Silver nitrate
Ag^+	Silver ion
SeNPs	Selenium nanoparticles
rGO	Reduced graphene oxide

RIU	Refractive index unit
GCE	Glassy carbon electrode
SPCE	Screen printed carbon electrode
SPE	Screen printed electrode
PLA	Polylactic Acid
Au-Pt NPs	Gold platinum nanoparticles
APTES	(3-Aminopropyl)-triethoxysilane
Cu^{2+}	Copper ions
AuNCs	Gold nanoclusters
EDA-GO	Ethylenediamine-graphene oxide
$HAuCl_4$	Chloroauric acid
GT	Green tea
CT	Cotton tree
WR	Watermelon Rind
BRB	Banana root bulb
MA	Maleic acid
CA	Citric acid
TCA	Trichloroacetic acid
NaOH	Sodium hydroxide
SA	Salicylic acid
DW	Distilled water
DI	Deionized water
TEM	Transmission Electron Microscope
FESEM	Field Emission Scanning Electron Microscope
FTIR	Fourier Transform Infrared Spectroscopy
AFM	Atomic Force Microscopy
EGCG	(-)-epigallocatechin gallate
EC	(-)-epicatechin
ECG	(−)-epicatechin gallate
GC	(+)-gallocatechin
EGC	(-)-epigallocatechin
BSA	Bovine Serum Albumin
Ag^0	Silver atoms
DMAB	Dimethylaminobenzaldehyde
CuO/Co_3O_4@MWCNTs	Copper oxide/Cobalt oxide multi-walled carbon nanotubes
DPV	Differential pulse voltammetry
PBS	Phosphate buffered saline
KCl	Potassium chloride
PE	Paper electrode
AgNPsOA	Silver nanoparticles capped with octylamine
MTT	1-(2 mercaptoethyl) 1,3,5-triazinane 2,4,6-trione
SFA	Sulphanilic acid

AA	Ascorbic acid
CHT	Chitosan
TPP	Tripolyphosphate
GA	Gallic acid
β-CDT	β-cyclodextrin
DP	Dopamine
JG	*Jatropha gossypifolia*
TA	Tannic acid
CA	Caffeic acid
PH	*Parthenium histerophorus*
CW	Cellulose nanowhiskers
SC	Sericin
SB	*Sargassum Boveanum*
BH	*Benincasa hispida*
TL	Tollen's reagent
4-ATP	4-aminothiophenol
RSC	Resorcinol
L-Cyst	L-Cysteine
GE	Garlic extract
CA	Cysteamine
PP	*Papain*
L-Glu	L-Gutamine
p-NA	p-Nitroaniline
NFs	nanoflowers
AI	Artificial Intelligence

LIST OF SYMBOLS

Symbol	Meaning
ppm	Parts per million
ppb	Parts per billion
RGB	Red Green Blue
HSV	Hue Saturation Value
NH_2	Amine group
C=O	Carbonyl group
COOH	Carboxyl group
OH	Hydroxyl group
Hg^{2+}	Mercury (II)
As^{3+}	Arsenic (III)
As^{5+}	Arsenic (V)
Cd^{2+}	Cadmium (II)
Pb^{2+}	Lead (II)
σ	Standard deviation
μ	Micro
β	Beta
º	Theta
SH	Thiol group
h	hour
min	minute
sec	second
ºC	degree Celsius
rpm	rotation per minute
mL	millilitre
mg	milligram
g	gram
M	Molarity
dL	decilitre
a.u.	Absorbance unit
nm	nanometre
mm	millimetre
cm	centimetre
mA	Milli ampere
V	Volt