
To my loving family
Maa, Deuta, Kapila
&
Appan

**TEZPUR UNIVERSITY**

(A Central University established by an Act of Parliament)

**Napaam-784028, Tezpur, Sonitpur, Assam, India**

## DECLARATION BY THE CANDIDATE

I, **Ms. Sangeeta Kalita**, hereby declare that the thesis entitled **"Study of Acidic Organic Salts in Catalysis and Nanomaterial Synthesis"** has been submitted to Tezpur University, Assam, in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy in Chemical Sciences**, is a record of original research work carried out by me under the guidance of **Prof. Ruli Borah,** Department of Chemical Sciences, Tezpur University.

The contents of the thesis, in full or in part, have not been previously considered for the award of any degree, diploma, or any other similar title or recognition from any University/Institute. I further declare that I have duly acknowledged all sources of assistance and any text, figures, results or design that are not of my own are appropriately referenced in order to give credit to the original author(s).

**Date:** 30/06/2025 Sangeeta Kalita

**Place:** Tezpur University **(Sangeeta Kalita)**

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(सर्वोत्तम विश्वविद्यालय के लिए कुलाध्यक्ष पुरस्कार,2016 औरभारत के 100श्रेष्ठ उच्च शिक्षण संस्थानों में पंचम स्थान प्राप्त विश्वविद्यालय)
(Awardee of Visitor's Best University Award, 2016 and 5th among India's Top 100 Universities, MHRD-NIRF Ranking, 2016)

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## *Certificate from the Supervisor*

This is to certify that the thesis entitled "**Study of Acidic Organic Salts in Catalysis and Nanomaterial Synthesis**" submitted to the School of Sciences, Tezpur University in partial fulfilment for the award of the degree of Doctor of Philosophy in Chemical Sciences, is a record of research work carried out by **Ms. Sangeeta Kalita** under my supervision and guidance. She has been duly registered, completed her Ph.D. coursework and the thesis presented is worthy of consideration for the award of Ph.D. degree.

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

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

R. Borah

**Date**: 30/06/2025
**Place**: Tezpur University

**(Prof. Ruli Borah)**


**TEZPUR UNIVERSITY**

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**Napaam-784028, Tezpur, Sonitpur, Assam, India**

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## *CERTIFICATE OF THE EXTERNAL EXAMINER AND ODEC*

This is to certify that the thesis entitled **"Study of Acidic Organic Salts in Catalysis and Nanomaterial Synthesis"** submitted by Ms. Sangeeta Kalita to Tezpur University in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Chemical Sciences has been examined by us on ..... and found to be satisfactory.

The committee recommends **Ms. Sangeeta Kalita** for the award of the degree of **Doctor of Philosophy in Chemical Sciences.**

**Principal Supervisor** **External Examiner**

**Date:** **Date:**

# *Acknowledgements*

*This thesis is a satisfying reward for the determination and dedication that was put into completing the goals, set in the beginning of this journey. This work would not have been possible without the guidance and support of many individuals who contributed valuable assistance during the preparation and completion of this study. I take this opportunity to extend my appreciation to all those who have been part of this journey.*

*First and foremost, I am highly indebted to my supervisor Prof. Ruli Borah, Department of Chemical Sciences, Tezpur University, for her guidance and unwavering support throughout my PhD journey. Her wisdom and expertise in the subject helped shape this work into its current form. Her constant encouragement and positive attitude, from the initial stages of this journey to the final submission of this thesis, inspired me to continue ahead.*

*I would like to thank my DRC members, Prof. Utpal Bora and Dr. Bipul C. Sarma, Department of Chemical Sciences, Tezpur University, for their insightful comments and suggestions during progress meetings. Their scientific inputs and encouragement helped me improve the quality of my work.*

*I would like to extend my sincere thanks to all the faculty Members and non-teaching staff of the Department of Chemical Sciences, Tezpur University, for offering me valuable feedback and needful advice throughout my research period. I am grateful to the Head of the Department of Chemical Sciences, Prof. Panchanan Puzari (Present), Prof. Ruli Borah (former) and Prof. Ashim Jyoti Thakur (former) for providing access to the various departmental resources and facilities, to carry out my research work in an amiable environment. I offer my deep gratitude to the technical staff (present and former) of the department Mr. Sankur Phukan, Dr. Nipu Dutta, Mr. Biplob Ozah, Mr. Manoranjan Sarma, Dr. Raju Kumar Borah, Dr. Biraj Jyoti Borah and Dr. Dhrubajyoti Talukdar for their immense help and cooperation during the technical analyses of my work.*

*I am sincerely grateful to Prof. Shambhu Nath Singh, Vice-Chancellor, Tezpur University and Prof. Vinod Kumar Jain, (former VC, Tezpur University), Tezpur University for giving me the opportunity and facility to carry out my research work inside the university campus.*

*I would like to thank SAIC, Tezpur University; IIT Guwahati and Guwahati Biotech Park, Amingaon for providing the instrumentation facilities.*

*I express my sincere gratitude to Dr. Nand Kishor Gour for helping me with the computational studies included in this thesis.*

*I offer my heartfelt gratitude to my labmates Niharika, Sukanya, Debanga, Subham and Prapti. Their endless help, support and companionship made the difficult days endurable. I wholeheartedly thank them for being my core unit of strength during this journey. A special thanks to all my labmates (present and former) Jita Morang, Minmoy Dutta, Dr. Susmita Saikia and Dr. Kabita Boruah for their valuable insights, encouragement and support. Special thanks to the former project students of our lab, Pallabi Borah and Mrityunjoy Dey, for working with me.*

*A special mention to my dear friend Dr. Munmi Sarma for her love and companionship, especially during the last phase of this journey. Special thanks to my batchmates, juniors and seniors, Subir, Suranjana, Debabrat, Asfi, Nishant, Prantika, Sudhangshu, Hiya, Gorismita, Dikshita, Bijoy, Dipika, Dimpee, Debasish, Ranjit, Annesha, Rakhee ba, Raktim, Arzu, Dibyashree, Surangana, Raju, Barsha, Priyanka, for their help, love and support.*

*Special thanks go to my family, whose constant encouragement fuelled my perseverance during the completion of this thesis. My PhD journey would not have been possible without the endless help and support from my dear husband Dr. Appan Roychoudhury. His passion and dedication towards research inspired me to work hard and overcome the obstacles. I offer my heartfelt appreciation to him for helping me in every possible way. I would like to sincerely acknowledge my pillars of strength, my parents Mrs. Nirala Kalita and Mr. Mukul Kalita, and my brother Dr. Nilkamal Kalita, for their unconditional love, support and belief on me. Words would fall short to describe the effect their presence and soothing words did to me on the sunny/gloomy days. I would also like to thank my parents-in-law, Mr. Asish Roychoudhury and Mrs. Sipra Roychoudhury, for their immense love and continuous support towards me. I will forever remain indebted to them.*

*Lastly, I praise the almighty, for giving me strength to endure this journey.*

*Sangeeta Kalita*

# List of Figures

## List of Schemes

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# List of Abbreviations

| | |
|---|---|
| ILs | Ionic liquids |
| RTILs | Room temperature ionic liquids |
| NPs | Nanoparticles |
| TSILs | Task-specific ionic liquids |
| DFT | Density functional theory |
| POMs | Polyoxometalates |
| IL-POMs | Polyoxometalate hybrids of ionic liquids |
| MDSIM | 2-Methyl-1,3-disulfoimidazolium |
| DEDSA | N,N'-Diethyldisulfoammonium |
| DSPZ | 1,4-Disulfopiperazinium |
| REMILs | Rare-earth metal ionic liquids |
| DSIL | Double salt ionic liquid |
| PET | Poly(ethylene terephthalate) |
| BHET | Bis(hydroxyethyl) terephthalate |
| amim | 1-allyl-3-methylimidazolium |
| DMAP | 4-(N,N-dimethylamino) pyridine |
| Hmim | 1-methylimidazolium triflouroacetate |
| bmim | 1-Butyl-3-methylimidazolium |
| TBAP | Tetrabutylammonium permanganate |
| CTAP | Cetyltrimethylammonium permanganate |
| BTAP | Benzyltriethylammonium permanganate |
| MTBAP | Methyltributylammonium permanganate |
| DCM | Dichloromethane |
| CTAB | Cetyltrimethylammonium bromide |
| TBAB | Tetrabutylammonium bromide |
| DMSO | Dimethyl sulfoxide |
| HDS | Hydrodesulfurization |
| DBT | Dibenzothiophene |
| AOP | Advanced oxidation process |
| eV | Electron volt |
| MB | Methylene blue |
| MO | Methyl orange |

| | |
|---|---|
| CV | Crystal violet |
| UV | Ultraviolet |
| GO | Graphene oxide |
| FT-IR | Fourier Transform Infrared |
| NMR | Nuclear Magnetic Resonance |
| ppm | Parts per million |
| TGA | Thermo-gravimetric analysis |
| PXRD | Powder X-Ray Diffraction |
| SAED | Selected area electron diffraction |
| DRS | Diffuse Reflectance Spectroscopy |
| SEM | Scanning Electron Microscopy |
| EDX | Energy Dispersive X-Ray |
| TEM | Transmission Electron Microscopy |
| BET | Brunauer -Emmett-Teller |
| XPS | X-Ray Photoelectron Spectroscopy |
| HPLC | High-Performance Liquid Chromatography |
| GC-MS | Gas Chromatography-Mass Spectrometry |
| TLC | Thin layer chromatography |
| $CH_3CN$ | Acetonitrile |
| EtOAc | Ethyl acetate |
| $H_2SO_4$ | Sulfuric acid |
| NaOH | Sodium hydroxide |
| TO | Transverse optical |
| LO | Longitudinal optical |
| VB | Valence band |
| CB | Conduction band |
| DMSO-$d_6$ | Deuterated dimethyl sulfoxide |
| $CDCl_3$ | Deuterated chloroform |
| UV-Vis | Ultraviolet-visible |
| OTf | Triflate |
| TFA | Trifluoroacetate |
| $^1H$ | Proton |
| $^{13}C$ | Carbon-13 isotope |

| | |
|---|---|
| JCPDS | Joint Committee on Powder Diffraction Standards |
| CHN | Carbon Hydrogen Nitrogen |
| i.e. | That is |
| J | Coupling Constant in NMR |
| s | Singlet in NMR |
| d | Doublet in NMR |
| t | Triplet in NMR |
| mg | Milligram |
| mL | Millilitre |
| mmol | Millimole |
| mol | Mole |
| M.p. | Melting Point |
| No. | Number |
| R.T. | Room temperature |
| h | Hour |
| min | Minute |