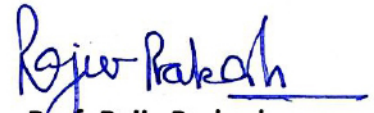



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It is certified that the work contained in the thesis titled “**Understanding Redox Mediated Intercalation and its Relation to Safety and Stability of Rechargeable Na-Ion Battery**” by “**SAURABH KUMAR**” has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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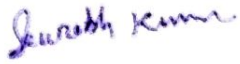

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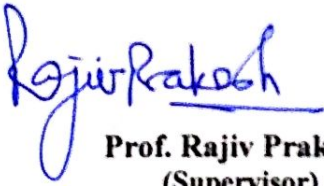
I, SAURABH KUMAR certify that the work embodied in this thesis is my own bonafide work and carried out by me under the supervision of Prof. Rajiv Prakash and Dr. Preetam Singh from January 2019 to December 2022, at the School of Materials Science & Technology and Department of Ceramic Engineering, Indian Institute of Technology (Banaras Hindu University), Varanasi. The matter embodied in this thesis has not been submitted for the award of any degree/diploma. I declare that I have faithfully acknowledged and given credits to the person/researcher/scientist/institute wherever their works have been cited in my work in this thesis. I further declare that I have not willfully copied any other's work, paragraph, text, data, results, image, etc., reported in journals, books, magazines, reports, dissertations, thesis, etc., or available at websites and have not included them in this thesis and have not cited as my own work.

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(Saurabh Kumar)

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Abbreviations/Symbols

AC – Alternating Current

BSE – Back Scattered Electron

Btu – British Thermal Unit

GCD – Galvanostatic Charge Discharge

CE – Coulombic Efficiency

C_{sp} – Specific Capacity

DC – Direct Current

DEC – Diethylene Carbonate

EC – Ethylene Carbonate

EDS – energy dispersive X-ray spectroscopy

EIS – Electrochemical Impedance Spectroscopy

ESS – Energy Storage System

EV – Electric Vehicle

GW – Giga Watt

HEV – Hybrid Electric Vehicle

FEC – Fluoroethylene Carbonate

FT-IR – Fourier Transform Infrared

GITT – Galvanostatic Intermittent Titration Technique

LIB – Lithium-ion Battery

LMCT – ligand to metal charge transfer

MOP – $\text{Mo}_2\text{P}_2\text{O}_{11}$

mAh/g – milli Ampere Hour per gram

MWh – Mega Watt Hour

NASICON – Natrium Super ionic Conductor

NCS – $\text{NaCr}(\text{SO}_4)_2$

NFPS – $\text{Na}_3\text{Fe}_2\text{PO}_4(\text{SO}_4)_2$

NIB – Sodium-ion Battery
NMC – Nickel Manganese Cobalt
NMP – N-methyl-2-pyrrolidinone
OCV – Open circuit Voltage
PC – Propylene Carbonate
P_{sp} – Specific Power
PV – Photo Voltaic
PVDF – Polyvinylidene Fluoride
RES – Renewable Energy Sources
RFB – Redox Flow Battery
SHE – Standard Hydrogen Electrode
SIB – Sodium ion Battery
SE – Secondary Electrons
SEI – Solid-Electrolyte Interphase
SEM – Scanning Electron Microscopy
TGA – Thermogravimetric Analysis
UV-Vis – Ultraviolet-Visible Spectroscopy
Wh/Kg – Watt Hour per Kilogram
XPS – X-ray Photoelectron Spectroscopy
XRD – X-ray Diffraction
ZEBRA – Zeolite Battery Research Africa
μ_a – Anode Electrochemical Potential
μ_c – Cathode Electrochemical Potential