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Item	**Details**
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Research Area:	Experimental Condensed Matter Physics ➢ Metal-Organic Framework (MOF)-Based Materials for Supercapacitor and Energy Storage Applications ➢ Emerging Materials for Anti-Icing and Superhydrophobic Surface ➢ Engineering Nanostructured Functional Materials for Sustainable Energy Storage Technologies
Publications (Past 5 years)	*1.* "Tailoring the structure and electrochemical properties of CuO via Manganese doping for supercapacitor applications".Indu Deswal, **Nirmal Manyani**, Avinash Kumar, and S.K. Tripathi. *Ionics, (2026)*. DOI: 10.1007/s11581-026-07192-w *2.* "Thermal annealing induced multifold enhancement in thermoelectric power factor of β-Zn4Sb3 thin films." Avinash Kumar,**Nirmal Manyani**, Janpreet Singh, and S.K. Tripathi. *Current Applied Physics, (2025). DOI: 10.1016/j.cap.2025.09.014* *3.* "Optimization of nickel cobalt sulphide nanostructures for supercapacitors application." Poonam Siwatch, Kriti Sharma, **Nirmal Manyani**, Yamini Gupta, and S. K. Tripathi. *Ionics (2025). DOI: 10.1007/s11581-025-06534-4* 4. "Synthesis and Characterization of Zirconia-Based Oxide (ZrO2) Nanoparticles for Photocatalytic Degradation."Simranjeet Kaur, **Nirmal Manyani,** and S.K. Tripathi. *Springer Nature Conference Proceedings ,July (2025)*

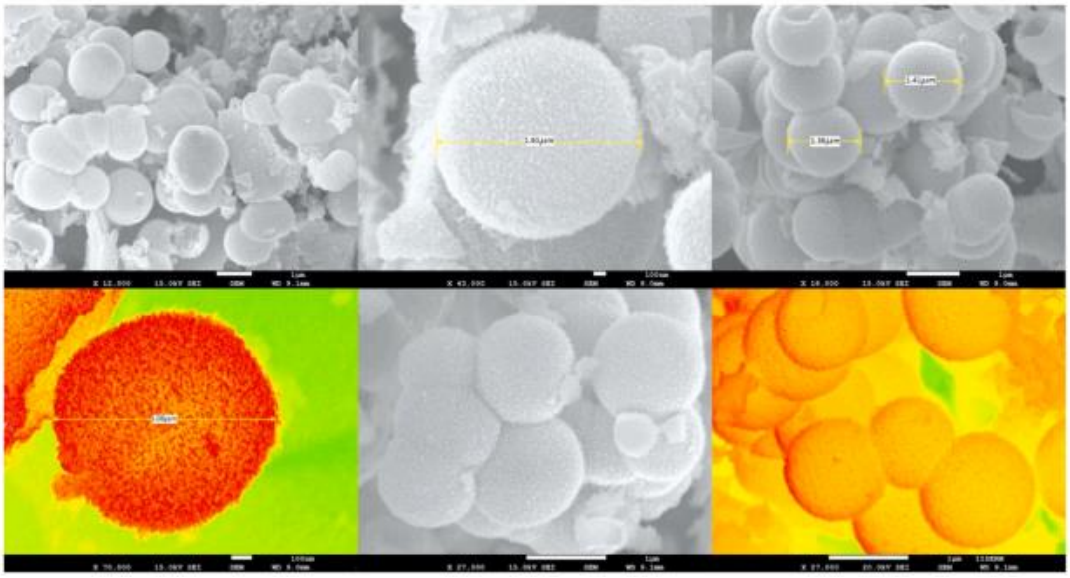
Publications (Past 5 years)	

5. "Bimetallic Metal-Organic Framework Derived by Organic Linker Benzene-1,4-Dicarboxylic Acid for Supercapacitor Electrode"**Nirmal Manyani**, Kriti Sharma, Poonam Siwatch, and S. K. Tripathi. *Materials Chemistry and Physics Vol. 337,(2025).DOI*: *10.1016/j.matchemphys.2025.130562***.**
6. "Synthesis and characterization of thermoelectric material Bi2Te3 – A potential alternative for power generation." Avinash Kumar, **Nirmal Manyani** , S.K.Tripathi. *Springer Nature Conference Proceedings,* November 2023. DOI: 10.1007/978-981-99-4878-9_40
7. "Investigating the temperature and frequency dependence of dielectric response using AC Impedance spectroscopy on tin oxide." Shweta Dhiman, Ram Charan Meena , **Nirmal Manyani,** S.K. Tripathi. *Surface and Interfaces, September 2023***.** DOI:10.1016/j.surfin.2023.103362
8. "Role of grain boundaries governing the giant dielectric constant in bulk SnO2" Shweta Dhiman, **Nirmal Manyani,** S.K. Tripathi. *ICNOC 2022 Springer Proceedings in Materials, vol 28.* DOI: 10.1007/978-981-99-4685-3_70
9. "Three dimensional hollow sulphide nanocomposites for supercapacitor electrodes." Poonam Siwatch, Kriti Sharma, **Nirmal Manyani**, Ravneet Kaur, and S. K. Tripathi. *Current Applied Physics 53* (2023): 25-38. DOI: 10.1016/j.cap.2023.05.019
10. "Study of electrochemical behaviour of binder-free nickel metal-organic framework derived by benzene-1, 3, 5- tricarboxylic acid for supercapacitor electrode**."** **Nirmal Manyani**, Poonam Siwatch, Shweta Rana, Kriti Sharma, and S. K. Tripathi. *Materials Research Bulletin* 165 (2023): 112320. DOI:10.1016/j.materresbull.2023.112320
11. "Tuning band gap, structural and optical properties of tin selenide nanoparticles by alkali metal doping." Diksha, **Nirmal Manyani**, and S. K. Tripathi. *Materials Today: Proceedings* (2023).DOI: 10.1016/j.matpr.2023.02.273
12. "Synthesis of Nickel Cobalt Oxide-Reduced Graphene Oxide Nanocomposite Using Ammonia for Supercapacitor." Poonam Siwatch, Kriti Sharma, **Nirmal Manyani**, and S. K. Tripathi. *ECS Transactions* 107, no. 1 (2022): 11697**.** DOI:10.1149/10701.11697ecst
13. "Characterization of nanostructured nickel cobalt oxide-polyvinyl alcohol composite films for supercapacitor application." Poonam Siwatch, Kriti Sharma, **Nirmal Manyani**, Jasmeen Kang, and S. K.Tripathi.*Journal of Alloys and Compounds* 872 (2021): 159409**.**DOI: 10.1016/j.jallcom.2021.159409
14. "Enhanced supercapacitive performance of reduced graphene oxide by incorporating NiCo2O4 quantum dots using aqueous electrolyte." Poonam Siwatch, Kriti Sharma, Navjot Singh, **Nirmal Manyani,** and S.K.Tripathi. ***Electrochimica Acta* 381 (2021):138235.** DOI:10.1016/j.electacta.2021.138235

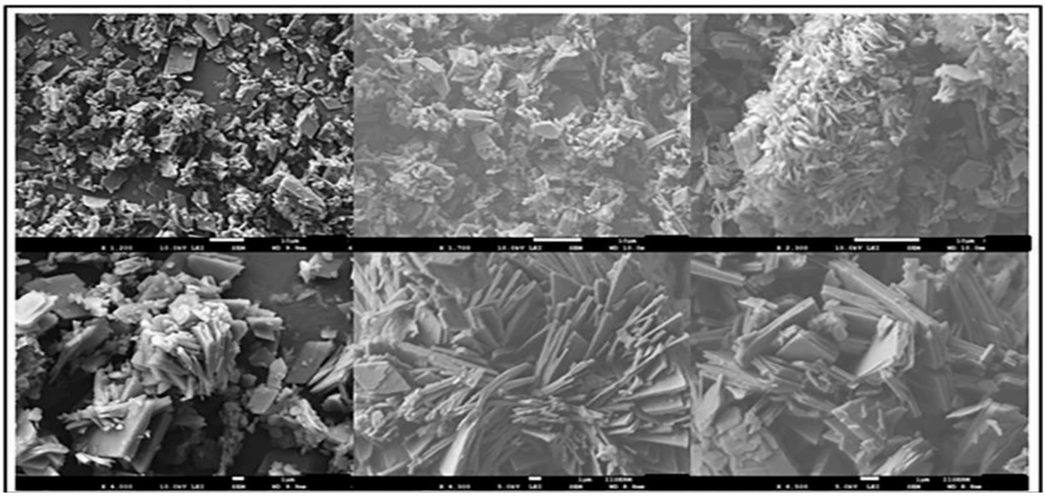
Publications (Past 5 years)	15. "Study of electrochemical performance of Ni-BTC MOF as a supercapacitor electrode." **Nirmal Manyani**, Kriti Sharma, Poonam Siwatch, and S. K. Tripathi. *AIP Conference Proceedings*, vol. 2352, no. 1. *AIP Publishing, 2021*. DOI: 10.1063/5.0052486 16. "Electrochemical study of nanocomposite of nickel cobalt oxide with reduced graphene oxide." Poonam Siwatch, Kriti Sharma, **Nirmal Manyani**, and S. K. Tripathi. *AIP Conference Proceedings*, vol. 2352, no. 1. *AIP Publishing, 2021*. DOI: 10.1063/5.0052496
Sponsored Projects (Past and Ongoing)	**Project Title: Green Synthesis of robust surfaces for sustained drop condensation and anti-icing applications : Experiments and data-driven modelling.** **Mentor : Prof. Pallab Sinha Mahapatra (IIT Madras)** **Awardee : Scheme and Sponsored Agency: SERB Funding**
Profile Links : Scopus and Orcid	https://scholar.google.com/citations/NirmalManyani **Scopus ID :** 57189995763 **Orcid :** https://orcid.org/0000-0001-7643-3783
Research Activities (Write about your best research results max of 2-3 pages including diagrams)	My research focuses on the design, synthesis, and development of **Metal–Organic Frameworks (MOFs)** as advanced electrode materials for next-generation electrochemical energy storage devices. The growing demand for clean and sustainable energy technologies has created an urgent need for electrode materials that simultaneously exhibit high energy density, rapid charge–discharge capability, excellent cycling stability, and environmental compatibility. In this context, my research aims to develop **cost-effective, binder-free MOF-based electrodes** with tailored morphology, high porosity, and enhanced electrochemical performance for supercapacitor applications. The foundation of my research lies in understanding the relationship between **chemical composition, crystal structure, pore architecture, surface area, morphology, and electrochemical behavior** of MOFs. By systematically modifying the metal centers, organic linkers, and synthesis parameters, I investigate how these factors influence charge storage mechanisms and overall electrochemical performance. My work began with the synthesis of **Nickel-based Metal–Organic Frameworks (Ni-BTC MOFs)** using **benzene-1,3,5-tricarboxylic acid (BTC)** as the organic linker through a simple one-step hydrothermal synthesis route. The hydrothermal method was selected because it provides precise control over crystal growth, morphology, and particle size while offering a scalable and economical synthesis strategy. The synthesized binder-free Ni-BTC MOF exhibited a well-defined porous framework and demonstrated excellent electrochemical performance when evaluated using cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS). A comparative investigation using three aqueous alkaline electrolytes (LiOH, NaOH, and KOH) revealed that the Ni-BTC MOF delivered its highest electrochemical performance in **1 M KOH**

Research Activities (Write about your best research results max of 2-3 pages including diagrams)

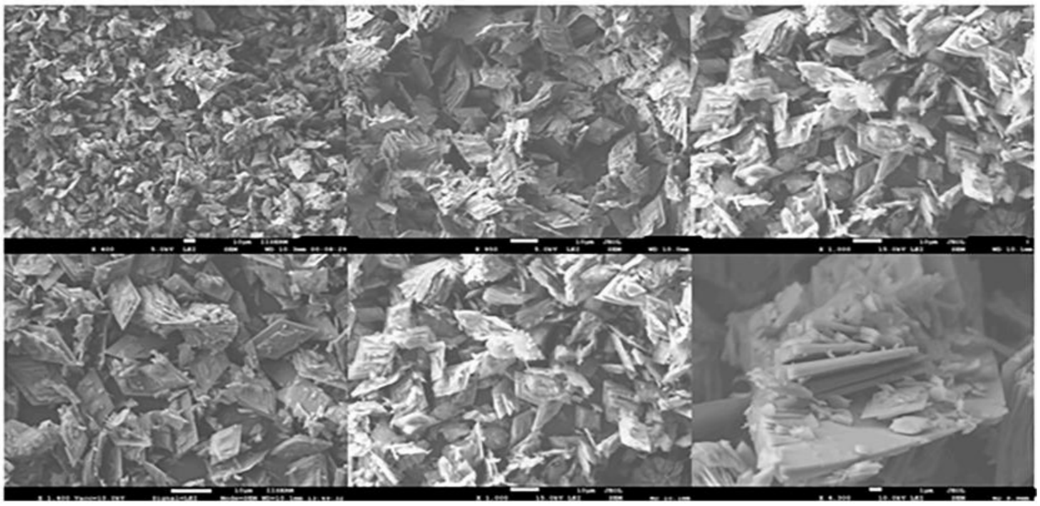
electrolyte, achieving a specific capacitance of **573 F g^{-1}** with excellent cycling stability. This study demonstrated the significant role of electrolyte selection in improving charge storage performance and established the feasibility of binder-free MOFs as efficient supercapacitor electrodes.



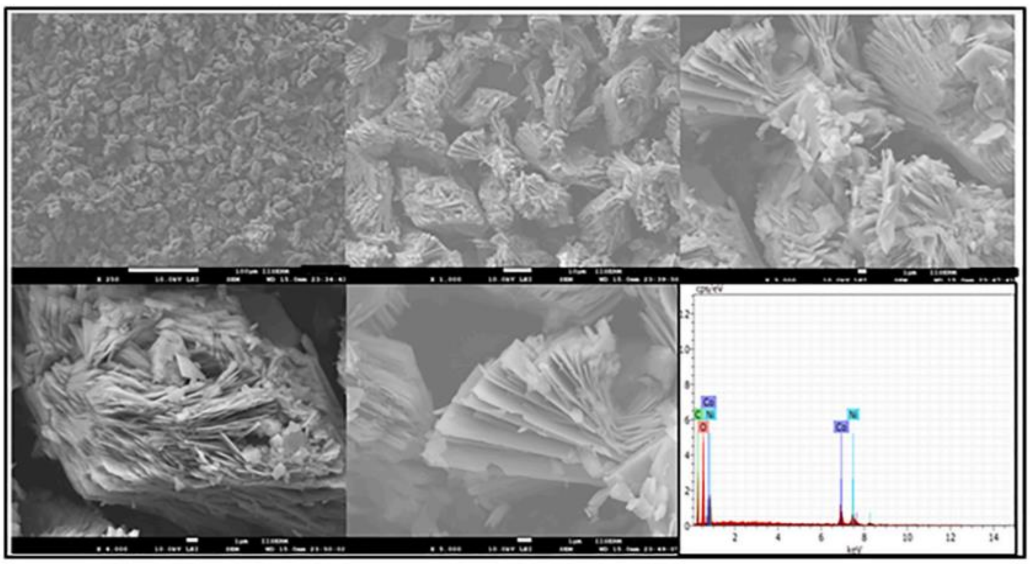
Building on these findings, I expanded my research towards the development of **benzene-1,4-dicarboxylic acid (BDC)-based MOFs**, including **Ni-BDC, Co-BDC, and bimetallic NiCo-BDC MOFs**. The objective was to investigate the influence of different transition metals and mixed-metal coordination on the structural, optical, and electrochemical properties of MOFs. These materials were synthesized through hydrothermal processing under optimized reaction conditions to obtain highly crystalline porous frameworks.



The monometallic Ni-BDC and Co-BDC MOFs exhibited distinct structural and electrochemical characteristics, whereas the incorporation of nickel and cobalt into a single framework resulted in remarkable improvements in material properties. The synthesized **NiCo-BDC MOF** possessed a unique **flower-like hierarchical nanosheet morphology**, significantly higher specific surface area, reduced optical band gap, and enhanced electrical conductivity compared to the monometallic counterparts.



The synergistic interaction between nickel and cobalt ions generated a greater number of electrochemically active sites while facilitating faster electron transport and electrolyte ion diffusion throughout the porous framework. Consequently, the bimetallic NiCo-BDC MOF exhibited a significantly enhanced specific capacitance of **640 F g^{-1}** in 1 M KOH electrolyte, demonstrating superior electrochemical performance over both Ni-BDC and Co-BDC MOFs. A key aspect of my research has been establishing the relationship between **structure, morphology, porosity, and electrochemical performance**. Advanced characterization techniques including X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Field Emission Scanning Electron Microscopy (FESEM), UV–Visible spectroscopy, Thermogravimetric Analysis (TGA), and Brunauer–Emmett–Teller (BET) surface area analysis were employed to investigate the structural and physicochemical properties of the synthesized MOFs. Electrochemical characterization using cyclic voltammetry, galvanostatic charge–discharge, and electrochemical impedance spectroscopy enabled a detailed understanding of charge storage kinetics, ion diffusion behavior, internal resistance, and cycling stability.



	These investigations demonstrated that optimizing pore architecture, nanoscale morphology, and mixed-metal composition substantially enhances electrochemical performance. An important contribution of my research is the successful demonstration of **binder-free MOF electrodes**. Conventional electrode fabrication often relies on polymeric binders that reduce electrical conductivity by blocking active sites and increasing interfacial resistance. By directly depositing MOF materials onto conductive substrates without insulating binders, my work improves electron transport pathways and maximizes the utilization of electrochemically active sites, leading to enhanced charge storage efficiency and improved cycling stability. My research also emphasizes the importance of **rational materials design** in developing high-performance supercapacitor electrodes. The progression from monometallic Ni-BTC MOFs to Ni-BDC and Co-BDC MOFs, followed by the development of bimetallic NiCo-BDC MOFs, demonstrates how systematic modification of metal composition and organic linkers can effectively tailor structural and electrochemical properties. This strategy provides valuable insight into designing multifunctional porous materials for advanced energy storage applications. Currently, my research is extending beyond energy storage towards the development of **MOF-based multifunctional coatings** for **superhydrophobic and anti-icing applications**. By integrating porous MOF architectures with functional polymers and surface modification techniques, I aim to engineer hierarchical micro/nanostructured surfaces exhibiting excellent water repellency, reduced ice adhesion, and enhanced environmental durability. These multifunctional coatings have potential applications in aerospace, renewable energy systems, transportation, and power infrastructure, where efficient ice mitigation is essential for operational reliability. Overall, my research combines **materials chemistry, nanotechnology, electrochemistry, and surface engineering** to develop innovative functional materials for sustainable technologies. My long-term research vision is to design hierarchical porous MOFs and hybrid nanocomposites with improved electrical conductivity, enhanced structural stability, and multifunctional properties that address emerging challenges in clean energy storage and smart surface engineering. Through fundamental understanding of structure–property relationships and advanced materials design, my work aims to contribute to the development of efficient, environmentally friendly, and scalable technologies for future energy and environmental applications.

Collaborations	IIT Madras (Chennai) Panjab University (Chandigarh) DCRUST (Murthal)
Invited Talks	