TIET - VT CENTER OF EXCELLENCE IN EMERGING MATERIALS (CEEMS)

NEWSLETTER

VOL. VI SEPTEMBER 2026





CEEMS

A platform for the new materials age

A platform for the new materials age

PROF. ROOP L. MAHAJAN,
CHAIR PROFESSOR, CEEMS

Message from Prof. Roop L. Mahajan



Dear Friends of the TIET–VT Center of Excellence in Emerging Materials (CEEMS),

Greetings from Virginia Tech!

During my recent visit to TIET in August 2026, I had the pleasure of interacting with our faculty members, doctoral students, research faculty, and postdoctoral fellows and reviewing their ongoing research. I came away encouraged by their enthusiasm, commitment, and growing sense of ownership of CEEMS. Our extended CEEMS family continues to make impressive strides in advancing interdisciplinary research, strengthening TIET's reputation, and developing emerging materials with the potential to impact diverse sectors of the economy and society. During this visit, Professor Kamaldeep Paul, CEEMS new joint director, and I had a chance to review the overall progress of CEEMS since its inception with members of TIET's senior management. During this review, I thought it would be worthwhile to reflect briefly on what we mean by ***emerging materials*** and how this concept is shaping our research philosophy and future directions.

Emerging materials encompass both physical and biological materials, including those at the interface of the two.

- **Emerging physical and materials-science materials:** These include the now-familiar family of two-dimensional (2D) materials, such as coal-derived graphene oxide and reduced graphene oxide, MXenes, MoS_2 and other transition-metal dichalcogenides, hexagonal boron nitride, phosphorene, and newer 2D compounds. The broader landscape also includes metamaterials and engineered surfaces, quantum materials, and high-entropy materials and alloys.
- **Emerging biological and bio-derived materials:** These include materials derived from biological sources, inspired by biological systems, or engineered to interact with living systems. Examples include cellulose nanofibers and nanocrystals, bacterial nanocellulose, chitosan, alginate, lignin-derived materials, silk fibroin, collagen, keratin, and polymers and carbon materials derived from agricultural and other biological waste. They also include living or biohybrid materials incorporating bacteria, fungi, algae, or engineered cells that can sense, respond, or even repair themselves, as exemplified by bacteria-based self-healing concrete.

Emerging physical and biological materials are like two peas in a pod. Rather than pursuing these two classes independently, CEEMS has explored their integration to create multifunctional materials with properties and capabilities that neither can provide alone.

An excellent example from CEEMS is our research on bacterial nanocellulose (BNC)–coal-derived graphene oxide wound-healing systems. BNC provides a biocompatible, three-dimensional scaffold, while coal-derived GO contributes functional surface chemistry, mechanical reinforcement, and antimicrobial properties. Their integration offers promising opportunities for advanced wound dressings and, potentially, drug delivery, sensing, and other biomedical applications.

This is precisely the kind of interdisciplinary research that we encourage: bringing together different scientific disciplines, exploiting complementary material properties, and pursuing applications that address important societal needs.

CEEMS 2.0: Broadening Our Horizons

We are now in the second phase of CEEMS (July 1, 2024-June 30, 2029). Building on the foundation established during our first five years, we are broadening our research portfolio while maintaining our commitment to scientific excellence, innovation, and societal impact. Our four original scineering thrusts-integrating science and engineering remain central to our mission: (i) 2D Materials and **nano-composites**, including X-Graphene+ and other advanced functional materials, (ii) **Sustainable Construction and Eco-friendly Infrastructure,** with an emphasis on resource efficiency, durability, and waste valorization, (iii) **Cancer Detection and Treatment,** integrating materials science, engineering, and biomedical research, and (iv) **Smart Sensors** for healthcare, industrial, agricultural, and environmental applications.

We have now included two increasingly important domains - **Rare Earth Elements, and Integrated Waste and Pest Management** to complement our four scineering areas discussed above. AI-enabled discovery of new emerging materials is on the horizon.

Strategic Priorities: As we advance CEEMS 2.0, our strategic priorities extend beyond producing high-quality research. We must also strengthen our ability to translate scientific discoveries into technologies, products, and processes that benefit society. This calls for a concerted effort to strengthen industry partnerships, expand national and international research collaborations, compete successfully for government and industry funding, and pursue impactful scholarly publications and intellectual property.

Equally important is fostering a culture that encourages intellectual curiosity, unconventional thinking, and calculated risk-taking. In this context, I would particularly like to emphasize our commitment to **high-risk, high-reward research,** which we refer to as Black Swan research. These are investigations that challenge prevailing assumptions, explore unconventional scientific pathways, and have the potential to produce disruptive advances. They are distinct from conventional seed-funded projects, which generally seek to establish feasibility or generate preliminary evidence for promising research directions.

I would like CEEMS to become known not only for the quality of its research but also for its willingness to explore uncharted territory and translate promising discoveries from Bench to Bazaar.

As we look to the future, I am optimistic about what we can accomplish together. The talent, enthusiasm, and collaborative spirit of our faculty, students, and researchers provide a strong foundation. With the continued support of TIET and Virginia Tech, our industry partners, collaborators, and well-wishers, I am confident that CEEMS can emerge as a nationally and internationally recognized hub for emerging materials research and innovation.

With warm regards and best wishes,

Roop L. Mahajan, Virginia Tech

Innovating for Impact, Collaborating for the Future

CEEMS
A platform for the new materials age

PROF. KAMALDEEP PAUL
JOINT DIRECTOR

Message from Prof. Kamaldeep Paul



It is a privilege to serve as Joint Director of CEEMS and to contribute to the next phase of this exciting journey. Since its inception, CEEMS has evolved into a vibrant platform for interdisciplinary research, bringing together researchers from diverse scientific and engineering backgrounds to address complex challenges through emerging materials, innovative technologies, and collaborative problem-solving. As we advance through CEEMS 2.0, our focus extends beyond individual research achievements towards building a connected ecosystem in which fundamental science, engineering innovation, and real-world applications reinforce one another. Emerging materials offer extraordinary opportunities to address challenges in healthcare, sustainable infrastructure, environmental protection, energy, and industrial development.

Realizing this potential requires us to move beyond conventional disciplinary boundaries and encourage collaborations that combine complementary expertise, perspectives, and capabilities.

Our four core research thrusts-**2D Materials and composites, Sustainable Construction, Cancer Detection and Treatment, and Smart Sensors**-provide a strong foundation for this vision. The addition of **Rare Earth Elements and Integrated Waste and Pest Management** further broadens our opportunities to address strategic national priorities. By integrating materials science with chemistry, biology, engineering, computation, and emerging artificial intelligence tools, we can develop innovative solutions with scientific significance and practical relevance.

An important priority is to strengthen the collaborative spirit of CEEMS. Our faculty members, research faculty, postdoctoral fellows, doctoral scholars, and students bring diverse expertise and creative ideas to the Center. We must continue to create opportunities for meaningful interaction, interdisciplinary project development, shared access to expertise and facilities, and mentorship across research groups. The **Black Swan research initiative** represents an important opportunity to support high-risk, high-reward ideas with the potential to generate transformative outcomes. Alongside our regular and Seed Money projects, which help establish feasibility and generate preliminary evidence, we should encourage bold, application-driven research that opens new scientific and technological pathways.

Equally important is translating research discoveries into tangible outcomes. Through stronger partnerships with industry, government agencies, hospitals, research institutions, and entrepreneurial ecosystems, we can accelerate the journey from laboratory discoveries to prototypes, technologies, intellectual property, and commercially viable solutions. Our guiding aspiration should be to take promising innovations from **"Bench to Bazaar,"** ensuring that our research contributes meaningfully to society and the economy.

I look forward to working closely with Prof. Roop L. Mahajan, the leadership of TIET and Virginia Tech, our research community, and external partners to strengthen CEEMS as a nationally and internationally recognized center for emerging materials research and innovation.

Together, let us build a culture of collaboration, scientific excellence, creativity, and responsible risk-taking-one that empowers our researchers to pursue ambitious ideas and transforms knowledge into meaningful impact.

With warm regards and best wishes,

Kamaldeep Paul

Joint Director

TIET–VT Center of Excellence in Emerging Materials (CEEMS)

RESEARCH HIGHLIGHT

Title: "Automated CAD System Utilizing Deep Learning Models for Identifying Brain Lesions on MR Imaging"

Supervisors: Dr. Ashima Singh, Dr. Jainy Sachdeva, Dr. Amrita

Junior Research Fellow: Mr. Varunpreet Singh

Key Contributions and Outcomes

Automating lesion segmentation reduces the heavy workload of manual annotation, which is slow, labor-intensive, and often inconsistent between experts. This speeds up clinical workflows and makes advanced imaging analysis more accessible, especially in settings where expert radiologists are limited. In addition, the explainability features of deep learning model using the attention module and Grad-CAM visualization help build trust, which is important for clinical adoption. This work directly complements the overarching goals of CEEMS in advancing healthcare technologies, for early cancer detection.

However, the task is incredibly challenging due to lesion heterogeneity, tiny lesion size, and low contrast with surrounding tissue. A deep learning based multiscale residual V-Net with attention gating is developed for automatic brain lesion segmentation. The network expands the standard V-Net framework by including multiscale residual blocks with receptive fields of different kernel sizes, allowing joint extraction of fine-grained lesion boundaries and broader contextual features. To further improve lesion localization, attention gates are integrated into skip connections to suppress irrelevant background activations and selectively highlight lesion-relevant features.

To ensure model interpretability, Grad-CAM–based explainable AI is further integrated, which visualizes the discriminative regions contributing to lesion segmentation, thereby providing transparency and helping radiological validation.

The method was evaluated on the benchmark dataset, comparing against baseline U-Net and V-Net as well as a hybrid U-Net with ConvMixer architecture.

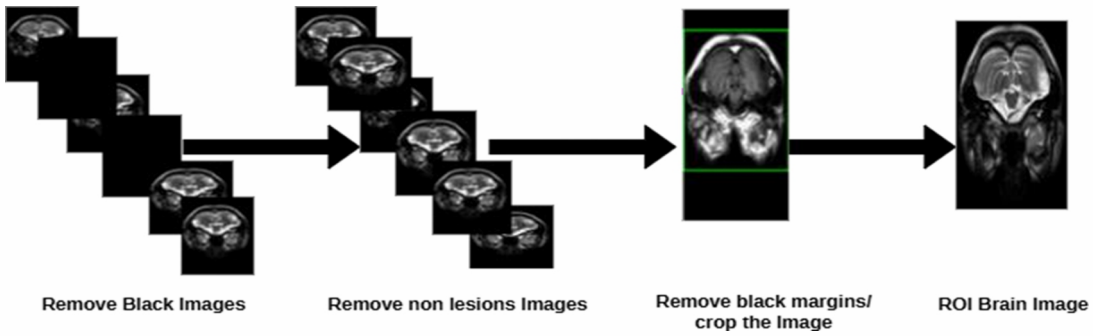


Fig. 1: Data Pre-processing

Our network's primary goal is to learn about the lesions. The full black masks, which don't provide any information on lesion features. Therefore, removing the scans with no brain lesions and full black masks is the first step in the pre-processing unit.

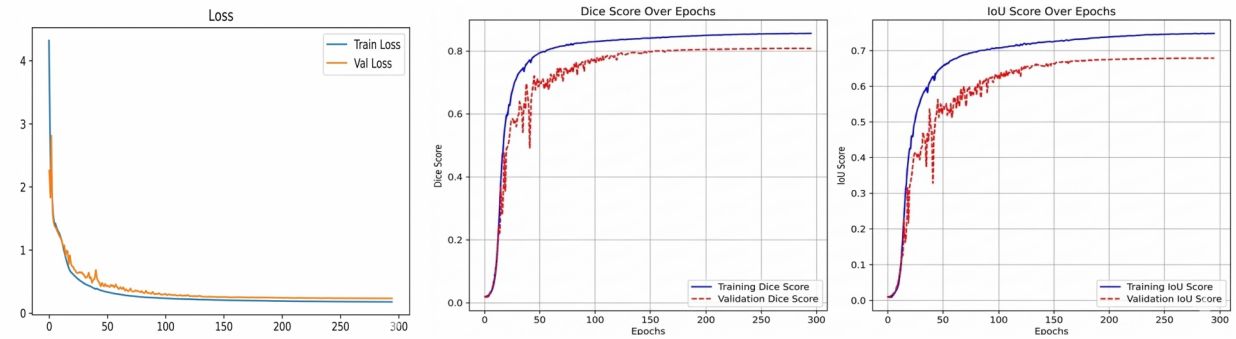


Fig. 2: Performance evaluation of Loss, Dice, IOU for training and validation

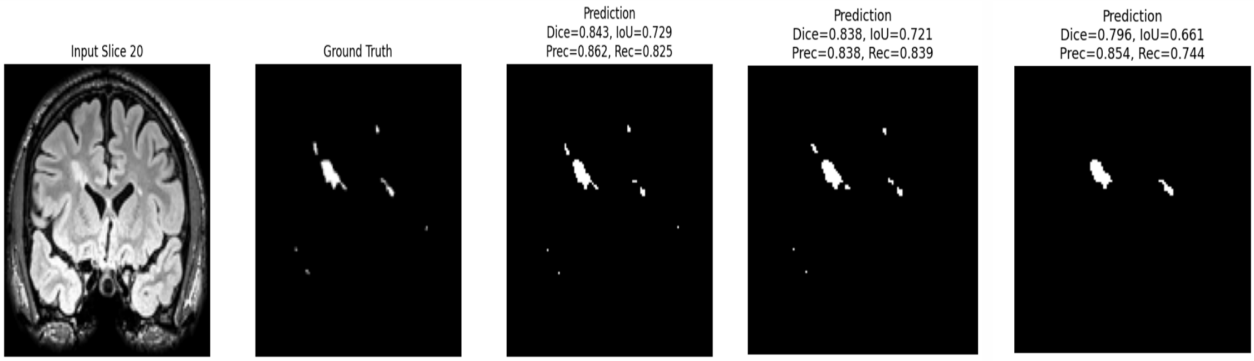


Fig. 3: Comparison among different deep learning based model: multiscale residual V-Net, baseline U-Net and hybrid U-Net with ConvMixer architecture.

Experimental results show that multiscale residual V-Net attains higher Dice coefficient (80.67), IoU (67.73), precision (80.03), and recall (81.42), particularly outstanding in the detection of white matter lesions.

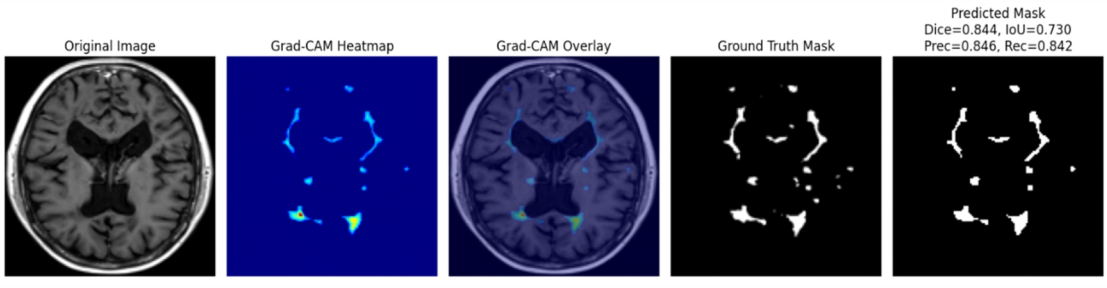


Fig. 4: XAI based Grad CAM visualization

Our findings show that the integration of multiscale representation, attention modules, explainability, and adaptive optimization improves robustness in demyelinating lesion segmentation, providing a valuable tool for clinical research and patient monitoring.

Title: Functionalized magnetic graphene for hydrolase enzyme immobilization as heterogeneous biocatalyst for catalyzing organic transformations

Senior Research Fellow: Ms. Anuva Mondal

Supervisors: Dr. Amjad Ali (Department of Chemistry & Biochemistry), Dr. Vikas Tyagi (Department of Chemistry & Biochemistry), Dr. B. N. Chudasama (Department of Physics & Material Science)

The study focuses on the immobilization of enzymes and the creation of synthetic enzymes for the valorization of plastic waste and environmental assessment. While natural enzymes provide catalytic precision and efficacy in moderate environments, their application in unbound form may be constrained by inadequate operational stability, challenging recovery, and limited reusability. Immobilization tackles these issues by attaching the enzymes to appropriate substrates, enabling their isolation and reusability while potentially enhancing their stability under varying reaction circumstances. In this study, covalent immobilization has been utilized to create heterogeneous biocatalysts for the depolymerization of PET. This methodology seeks to incorporate the catalytic benefits of enzymes with the realistic advantages of recoverable catalysts, presenting possibilities to lower enzyme usage and investigate gentler processing settings compared to certain traditional chemical pathways.

Simultaneously, synthetic enzymes have been created and utilised for the colorimetric identification of phenolic substances. These catalysts replicate specific properties of natural enzymes and provide enhanced storage stability, simplified handling, and diminished reliance on expensive enzyme isolation and purification. Their adjustable catalytic characteristics offer prospects for producing quantifiable colorimetric responses for the identification of pollutants. This method integrates enzyme-mimicking reactivity with the durability of synthetic catalysts to create functional analytical systems.

Together, these research programs investigate complementary ways for addressing the constraints of free enzymes and producing catalysts suitable for environmental applications. CEEMS has significantly contributed to this research by offering financial support for experimental endeavors and access to characterization facilities crucial for assessing the created catalysts. Its multidisciplinary direction has facilitated the integration of enzyme catalysis, materials science, and environmental applications, enhancing both the formulation and analysis of the study. This assistance has facilitated my progress in enzyme immobilization and the development of artificial enzymes for PET depolymerization and phenolic chemical detection, while also expanding my experimental capabilities and scientific outlook.

Title: Evaluation of Functional Efficacy of Selenium Nanoparticle-Coated Matrices for Enhanced Diabetic Wound Healing

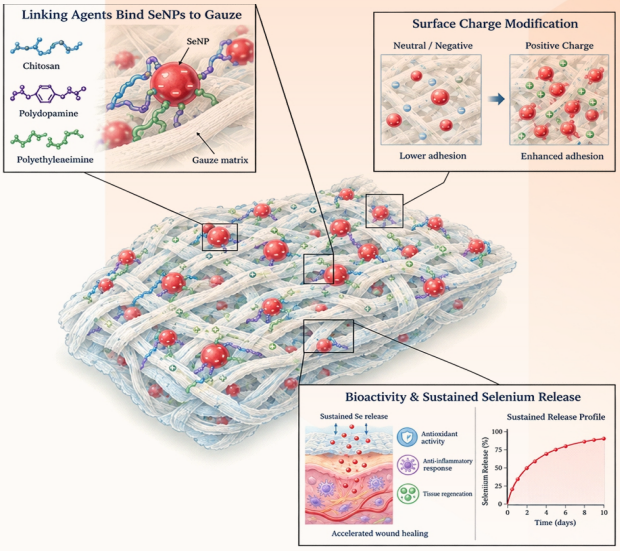
Researcher: Dr. Anmol Singh, Post-doctoral Fellow (PDF)

Project Supervisors: Prof. N. Tejo Prakash and Dr. Priyankar Dey

Research Overview

Diabetic wounds are a major healthcare challenge because persistent oxidative stress, chronic inflammation, impaired angiogenesis, and microbial infections delay tissue regeneration. Conventional wound dressings primarily provide physical protection and may not adequately address these underlying complications. The CEEMS-funded project, "Evaluation of Functional Efficacy of Selenium Nanoparticle-Coated Matrices for Enhanced Diabetic Wound Healing," aims to develop multifunctional, bioactive wound dressings by integrating selenium nanoparticles (SeNPs) into biocompatible matrices.

Selenium is an essential trace element involved in antioxidant defence and cellular redox regulation. In nanoparticle form, selenium offers potential antioxidant, antimicrobial, and inflammation-modulating properties. The project focuses on developing stabilized, fucose-capped selenium nanoparticles (Fu-SeNPs) and investigating their physicochemical characteristics, biological activity, and influence on microbial communities. The long-term goal is to translate these findings into advanced wound dressings capable of supporting tissue repair while reducing the risk of wound-associated infections.



Key Research Progress and Findings

A major component of the work has been the synthesis and physicochemical characterization of fucose-capped selenium nanoparticles. Preliminary transmission electron microscopy (TEM) observations revealed predominantly spherical or quasi-spherical nanoparticles, with a faint surrounding layer consistent with the presence of a fucose-associated surface coating. Fourier-transform infrared (FTIR) spectroscopy indicated changes in characteristic hydroxyl, C–H, and carbohydrate-associated vibrational bands following nanoparticle formation, supporting interactions between fucose and the selenium nanoparticle surface. These observations provide an initial basis for investigating the role of surface capping in nanoparticle stabilization.

The project has also progressed towards understanding the interactions of SeNPs with microbial communities. An optimum concentration was selected for preliminary microbiome experiments to investigate microbial modulation without completely eliminating the microbial population. DNA extraction and quality assessment were followed by 16S rRNA gene sequencing targeting the V3–V4 region. The sequencing workflow generated approximately 1.2–1.4 million reads per sample, providing a foundation for microbial community analysis.

Preliminary taxonomic profiling revealed distinct community structures between skin- and gut-associated microbiomes. Differences were observed in microbial composition at the phylum, order, and genus levels.

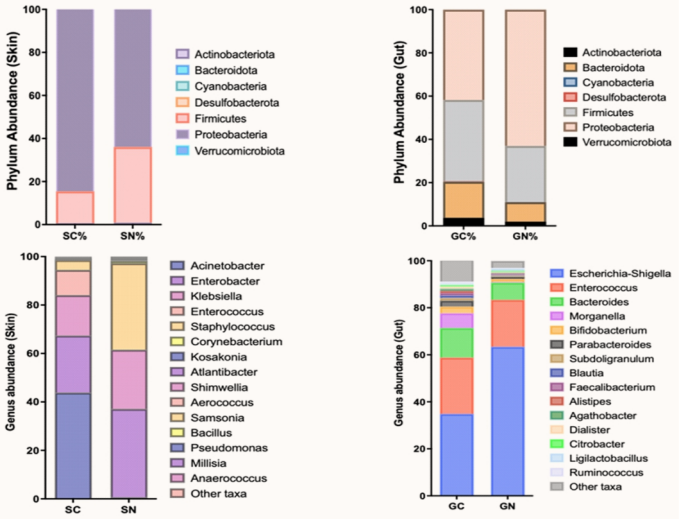


Figure 1: Phylum and Genus analysis.

Alpha-diversity analyses using Chao, Shannon, and Fisher indices also indicated variation in microbial richness and diversity among the experimental groups. These findings establish a basis for further

investigation of SeNP-associated microbiome modulation and its potential relevance to wound biology. The functional implications of these microbial changes require additional validation. In future studies, the best-performing nanoparticles will be utilized to coat gauze-based matrices for evaluating their antibacterial efficacy and potential applications in wound healing.

Innovation and Potential Impact

The distinctive feature of this research is the integration of nanotechnology, biomaterials, and microbiome research within a single wound-care strategy. Ongoing work includes further nanoparticle characterization, evaluation of bioactive matrix coatings, metabolomic profiling, and proteomic investigations to understand the molecular responses associated with SeNP exposure. Subsequent studies will assess the suitability of nanoparticle-coated matrices for wound-healing applications.

An important translational milestone is the filing of a patent titled *"Endophyte-Assisted Green Synthesis of Chalcogen-Based Nanoparticle-Coated Bioactive Bandage for Microbicidal Utility"* (Indian Patent Application No. 20251108846; filed on 18 September 2025). The technology has potential applications in advanced dressings for diabetic foot ulcers and chronic wounds, subject to further efficacy, biocompatibility, and safety evaluation.

Overall, this CEEMS-supported research establishes a promising foundation for developing bioactive, nanoparticle-functionalized wound dressings. By combining material engineering with microbial and molecular analyses, the project seeks to contribute to innovative wound-management technologies and future translational healthcare applications.

IN THEIR OWN WORDS



Dr. Harsh Sharma (Assistant Professor, Research)

My research journey has been centred on the development of advanced and sustainable composite materials, with a particular focus on vitrimer-based epoxy systems, self-healable and recyclable fiber-reinforced composites, graphene-based nanomaterials, and dynamic polymer networks. Over the course of my research career, I have progressively expanded my work from conventional polymer composites toward multifunctional and reprocessable materials that address the growing need for improved performance, durability, and sustainability.

My research has involved the development and experimental characterization of carbon- and glass-fiber-reinforced vitrimer composites, graphene oxide-based nanocomposites, and waste-derived carbon nanomaterials. Through this work, I have developed expertise in material synthesis, nanofiller functionalization and dispersion, interfacial engineering, and advanced characterization using techniques such as SEM, XRD, FTIR, TGA, DSC, and DMA, along with mechanical and thermal performance evaluation. My recent research has particularly focused on integrating recyclability, self-healing, reprocess ability, and sustainable material design into high-performance composite systems.

This research journey has also resulted in 20+ SCI-indexed publications, with my research work receiving 750+ citations, an H-index of 11, and an i10-index of 11. These achievements reflect the continuous research development and collaborative efforts throughout my academic career. My association with CEEMS has played an important role in supporting this journey. The availability of advanced characterization facilities, opportunities to work with sophisticated experimental techniques, and an encouraging research environment have significantly contributed to strengthening my research capabilities. CEEMS has also provided a platform for interdisciplinary research, scientific collaboration, and the translation of research ideas into meaningful experimental outcomes.



Dr. Shikha Bhogal (Assistant Professor, Research)

My affiliation with the Centre of Excellence in Emerging Materials (CEEMS), TIET has significantly contributed to my professional and academic development. My research focus on the development of diverse functional materials including but not limited to molecularly imprinted polymers, carbon dots, magnetic composites, mesoporous silica composites, and layered double hydroxides for the environmental applications. Alongside material development, I am involved in establishing detection and sensing methods for emerging contaminants, including the development of basic quality assurance approaches for their reliable analysis.

This work has enabled me to strengthen my expertise in materials synthesis, characterization, analytical method development, and application-oriented research while expanding into interdisciplinary areas. CEEMS has provided me an ideal research atmosphere through access to instrumentation, technical support, and opportunities for scientific collaborations. The Center has persistently motivated me to foster and generate my own research ideas and formulate research proposals, pursue publication possibilities, and investigate new applications of advanced functional materials. My technical expertise, research confidence, and scientific vision have been nurtured in the enriching atmosphere of CEEMS. I am immensely appreciative of the ongoing support and encouragement from CEEMS, which inspires me to pursue innovative and interdisciplinary research while enhancing my independent research profile.



Ms. Shikha

Project: ThermoXAI: Explainable Deep Learning for Breast Cancer Detection Using Thermal Imaging+

Supervisors: Dr. Simranjit Kaur, Dr. Sachin Kansal

I am currently working as a JRF in the Department of Computer Science and Engineering under the Center of Excellence in Emerging Materials (CEEMS) at Thapar Institute of Engineering & Technology. CEEMS, through its interdisciplinary research ecosystem and collaboration with Virginia Tech (USA), has provided me with an excellent platform to strengthen my research skills and contribute to meaningful advancements in healthcare using artificial intelligence.

My research focuses on the application of explainable deep learning for the early detection of breast cancer using infrared (IR) breast thermography. Breast thermography is a non-invasive, radiation-free, and patient-friendly imaging technique that analyzes temperature variations and heat distribution on the breast surface. Malignant tissues often exhibit abnormal thermal patterns due to increased blood flow and metabolic activity. However, conventional thermographic assessment largely depends on manual interpretation, making the diagnosis subjective and susceptible to variability. My work aims to develop intelligent and interpretable deep learning models that can automatically analyze thermal images, improve diagnostic accuracy, and provide transparent visual explanations to assist clinicians in making reliable decisions.

Being a part of CEEMS has greatly enhanced my research capabilities. The center has provided continuous financial support, access to advanced computational resources, opportunities for interdisciplinary collaboration, and an excellent academic environment that encourages innovation. CEEMS has also encouraged me to publish research in reputed international journals, participate in scientific discussions, and pursue collaborative research with clinical experts, thereby strengthening both my technical expertise and research outlook.



Dr. Rahul Gupta (Postdoctoral Fellow, CEEMS)

My association with the Centre of Excellence in Emerging Materials (CEEMS) has been an important phase in my research and professional journey. Coming from a background in materials science, with my doctoral research focused on aluminium matrix composites, tribology, and wear behaviour, my work at CEEMS has provided me with an opportunity to broaden my research perspective toward advanced polymer nanocomposites and functional materials.

At CEEMS, my research has focused on the development and characterization of advanced composite systems incorporating nanomaterials and shear-thickening fluids for applications involving impact resistance, energy absorption, and vibration damping. Working on these multidisciplinary problems has allowed me to develop expertise in material processing, rheological characterization, microstructural analysis, and interpretation of complex structure-property relationships. The research environment at CEEMS has also encouraged me to explore new experimental approaches and strengthen my ability to connect fundamental material behaviour with potential engineering applications.

One of the most valuable aspects of my experience at CEEMS has been access to advanced research facilities and characterization techniques. The availability of specialized equipment and the opportunity to interact with researchers working across different areas of materials science have significantly enhanced the quality and depth of my research. Discussions with faculty members, research scholars, and technical personnel have further helped me refine experimental methodologies, analyse results critically, and approach research problems from different perspectives.

CEEMS has also contributed significantly to my professional growth by providing an interdisciplinary and collaborative research environment. The exposure to emerging materials, advanced characterization methods, and application-oriented research has strengthened my technical skills and broadened my understanding of contemporary materials research. I am grateful to CEEMS for providing a platform that encourages scientific curiosity, collaboration, and continuous learning. The experience has strengthened my confidence as a researcher and motivated me to pursue innovative research aimed at addressing challenging engineering problems."



Ms. Anshu Tyagi

Project: Triglyceride/glycerol transformation into value added products employing graphene based heterogeneous catalysts

Supervisors: Dr. Amjad Ali (Department of Chemistry & Biochemistry) and Dr. B. N. Chudasama (Department of Physics & Material Sciences)

My research focuses on the design and development of Metal-Organic Frameworks (MOFs) and Graphene Oxide (GO)-based functional materials for environmental remediation and catalytic applications. Cu-based MOFs are particularly attractive because their accessible Cu active sites, tunable coordination environments, and redox properties can facilitate adsorption and catalytic electron-transfer processes, making them promising platforms for pollutant transformation. GO, with its high surface area, abundant oxygen-containing functional groups, and extended π-conjugated structure, provides effective adsorption sites and promotes interfacial interactions and charge transfer, which are beneficial for pollutant removal and photocatalytic processes.

Through this work, I investigate advanced materials for the efficient degradation and transformation of organic pollutants, including dyes, nitroaromatic compounds, and antibiotics. A key aspect of my research is to understand the structure-activity linking and synergistic effects of active sites, with the aim of developing efficient, reusable, and environmentally relevant heterogeneous catalysts.

This research has been supported by the TIET-Virginia Tech Centre of Excellence in Emerging Materials (CEEMS) through financial assistance and access to advanced research facilities. The support has provided a valuable platform for conducting interdisciplinary research and advancing my work in functional materials, heterogeneous catalysis, and sustainable environmental remediation.



Mr. Abhishek Chandel

Project: Utilization of non-biodegradable wastes for development of carbon and carbon supported nano/2D structures for sustainable energy

Supervisors: Dr. O. P. Pandey

I, Abhishek Chandel (Senior Research Scholar) working at the Centre of Excellence in Emerging Materials (CEEMS), Thapar Institute of Engineering and Technology (TIET). My research primarily focuses on the development of advanced two-dimensional (2D) materials for energy and environmental remediation applications.

My current research involves the synthesis and development of carbide and boride based MAX and MAB phases, which serves as precursor materials for the development of novel 2D materials, MXene and MBene. Through selective etching and surface engineering, these layered materials are being explored for applications in energy storage, electrocatalysis, photocatalysis, and environmental remediation. My work aims to establish structure-property relationships and develop sustainable, high-performance materials for emerging energy and environmental challenges.

The Centre of Excellence in Emerging Materials (CEEMS) has played an important role in supporting my research by providing access to advanced research infrastructure, characterization facilities, scientific expertise, and a collaborative research environment. The centre's academic collaboration and interdisciplinary research framework have enabled me to explore emerging materials and their potential applications beyond conventional material systems.

The fellowship support provided through CEEMS has significantly contributed to my research journey by enabling me to dedicate myself to scientific research, experimental investigations, publication activities, and professional development. In addition to supporting my research work, CEEMS has provided opportunities and support for participating in national and international conferences, workshops, seminars, and scientific training programmes, allowing me to interact with researchers, learn about emerging developments in materials science, and broaden my scientific perspective. The exposure to advanced materials research, state-of-the-art facilities, and collaborative research opportunities at CEEMS has significantly strengthened my capabilities in materials synthesis, characterization, and application-oriented research, while also enhancing my scientific communication and professional skills. This support has played an important role in helping my progress toward the development of innovative materials for sustainable energy and environmental technologies.



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