Interdisciplinary PhD Programme – July 2023

Sl. No.	01
Dept.	Biosciences and Bioengineering
Project Code	ID_BT_AK_CJ
Joint Supervisors	Dr. Ajaikumar B. Kunnumakkara (BSBE) Dr. Chandan K Jana (CH)
Title of the Project	Computer Aided Development of Synthetic Drugs that target TNF-α-induced Protein 8 Family 3 for the Treatment of Lung Cancer
Project Summary	Background: Lung cancer is the most common cancer in the world kills approximately 1.8 million people annually. Even though a number of drugs have been developed for the treatment of this cancer, most of them fail in the clinic due to drug resistance and severe adverse side effects. Therefore, development of novel therapeutic targets and safe and efficacious therapeutic agents is necessary for the better management of this disease. Recently, we have shown that TNF-α-induced Protein 8 Family 2 also known as TIPE2 has a major role in the development and different processes in lung cancer (Bordoloi et al., 2019). Our results showed that TIPE2 is highly over expressed in lung cancer compared to normal lung tissues and the inactivation of this protein inhibits the survival, proliferation, invasion and migration of lung cancer cells. Moreover, knockdown of this protein inhibited the expression of COX-2, surviving, XIAP, Cyclin D1, CXCR-4, MMP-9 and upregulated the expression of p53 and p21 that are involved in different processes of development of lung cancer. In addition, we have shown that inactivation of this protein inhibited NF-□B pathway in lung cancer cells. Further, we have shown that tobacco components such as nicotine, NNK, NNN, Benzopyrene etc induce this protein in lung cancer cells. These results shed light to the fact that TIPE2 can be used as a therapeutic target in lung cancer. Computer Aided drug development has gained significant attention nowadays. With the help of different insilico tools it is possible to find out different molecules that binds to different proteins and also to model molecules that target these proteins. Therefore, in the present study we aim to model different molecules that target TIPE2 protein, and synthesise these molecules and then determine their anticancer activity by different preclinical models. Objectives: 1. To design molecules that target TIPE2 by insilico methods 2. To synthesise the molecules that target TIPE2 by chemical methods 3. To determine the anticancer property of these molecules by preclinical studies. Interdisciplinary components This project is an amalgamation of three different areas of research. First, the computer aided modelling of molecules that target TIPE2. Second, the synthesis of these molecules obtained from insilico studies and Third, the anti-lung cancer activities of these molecules by preclinical studies. This project has high translational significance as it directly benefits a large number of cancer patients. Reference: Bordoloi D, Banik K, Padmavathi G, Vikkurthi R, Harsha C, Roy NK, Singh AK, Monisha J, Wang H, Kumar AP, Kunnumakkara AB. TIPE2 Induced the Proliferation, Survival, and Migration of Lung Cancer Cells Through Modulation of Akt/mTOR/NF-κB Signaling Cascade. Biomolecules. 2019 Dec 6;9(12):836. doi: 10.3390/biom9120836. PMID: 31817720; PMCID: PMC6995575.
Sl. No.	02
Dept.	Biosciences and Bioengineering
Project Code	ID_BT_SN_CP

Joint Supervisors	Dr. Selvaraju Narayanasamy (BSBE) Dr. Chandan Pal (MA)
Title of the Project	Deterministic and Stochastic Modelling of Biosorption of Endocrine Disruptors and its Toxicological Evaluation via Machine Learning based Artificial Neural Network
Project Summary	Significance of the topic and the time relevance: Water pollution is the one of the major threats to the environment, about 4 billion people around the world are affected by water scarcity. The demand for freshwater rises beyond its supply, thus creating the need for the efficient reuse of the water. In India the major rivers are polluted with the harmful contaminants making the lives of millions of people difficult. Especially in Northeast India the Brahmaputra river is been reported to contain the trace number of endocrine disruptors. Endocrine disruptors (EDs) are the major class of organic pollutants which compromises the homeostasis of human and animal hormonal system. Due to this there urges a need for the removal of this hazardous pollutant from the wastewater. One of the most promising method to effectively treat the wastewater is the biosorption process. The bio derived adsorbents offer cost effective and efficient removal of the pollutants. The interactions between the adsorbent and adsorbate can be determined using mathematical equation pertaining to isotherms, mass transfer and kinetics. Thriving these equations offer detailed understanding of the adsorption process that helps to design the effective adsorption process. To deal with the multitude data and to extract meaningful information from the data, Machine Learning (ML) can be used. The machine learning based models can be of great use to determine the behaviour of the pollutants in the wastewater treatment process. The proposed study includes, • Detection and quantification of EDs in contaminated surface water from various parts of North Eastern India. • Development of bio-based adsorbents and optimization of process parameters using Artificial Neural Network (ANN) for maximum removal of EDs from wastewater. • ML based evaluation of biosorption with real time samples of North Eastern India containing EDs. • Ecotoxicological assessment using plants, microorganisms and fish before and after removing EDs.
Sl. No.	03
Dept.	Biosciences and Bioengineering
Project Code	ID_BT_SS_SS
Joint Supervisors	Dr. Senthilkumar Sivaprakasam (BSBE) Dr.Sreedeep Sekharan (CE)
Title of the Project	Biosynthesis of bacterial cellulose from agro-industrial wastes and its applications in improving the water retention of soil
Project Summary	With climate change impact in place, the whole world is witnessing unprecedented droughts in the past few decades. This has an undesirable impact on agriculture and food security due to excessive water shortage and temperature. It is obvious that engineering interventions are necessary to tackle the situation of water stress and water loss. It is also important to minimize the amount of irrigation water. Water absorbing polymers is a reliable soil additive for managing water stress condition in soils. It can absorb significant amount of water during irrigation and/ or rainfall and act like a mini reservoir. The stored water gets released into the soil during drought period, which can be used by plants/ crops for its survival. This interdisciplinary Ph.D. proposal aims to utilize agro-industrial waste for the synthesis of bacterial cellulose by elite wild/metabolically engineered strain. Enhanced production of bacterial cellulose with desirable material and functional properties could be achieved by bioprocess optimization. Bacterial cellulose synthesized via bioprocess would be in its purest form and have abundant hydroxyl group, which makes it an ideal candidate material for graft polymerization and converting it into a three-dimensional polymer structure. Such a structure is capable of storing water without getting dissolved. This project also aims to further optimize graft polymerization for achieving maximum water absorbency. The water absorbing polymer will be further studied for its interaction in different type of soils. Efforts will be made to minimize its salt-sensitivity and for sustaining water absorbency. The impact of particle size of cellulose on water absorbency in soil will be characterized.

Sl. No.	04
Dept.	Chemical Engineering
Project Code	ID_CL_NP_PK
Joint Supervisors	Dr. Nageswara Rao Peela (CL) Dr.Pavan Kumar Kancharla (CH)
Title of the Project	Conversion of Levulinic Acid to Value-Added Chemicals using Flow Chemistry.
Project Summary	Most of the materials such as polymers and fine chemicals are being produced from fossil-based resources such as petroleum. However, these processes polluting the environment, causing the severe global warming and increase the import bill. There is a huge scope to produce these materials from lignocellulosic biomass in a sustainable and pollution-free manner with nearly zero carbon footprint. Even though the amount of biomass available is very high, the materials produced from this feedstock worldwide is restricted to only 5% approximately. This gap can be filled by adopting novel technologies to produce platform chemicals from the biomass. In India, the surplus lignocellulosic biomass available is more than 500 million tons per year. If we use this feedstock to produce materials and fuels, then we can reduce the import bill to great extent.
Sl. No.	05
Dept.	Chemical Engineering
Project Code	ID_CL_SS_SS
Joint Supervisors	Dr. Senthilmurugan Subbiah (CL) Dr.Senthilkumar Sivaprakasam (BSBE)
Title of the Project	Application of advanced process analytics for bioprocess development through real-time monitoring, control and optimization
Project Summary	Nascent stages of process development require various analytical tools to assess the information about biochemical reaction systems. Reaction calorimeters (fermentation calorimeters) elucidate the reaction mechanism, heat energies, and other thermodynamic driving forces. Real-time interpretation of metabolic shifts through microbial heat generation and applying thermodynamic laws permit testing whether the reaction is in accordance with the metabolic pathways. However, the development of thermodynamic analysis in biotechnology is severely impeded due to the complexity of bioprocess, heterogeneity of phases, and a multitude of irreversible reactions. The lack of primary data is one of the several reasons why a biotechnological process is not thoroughly optimized compared to a chemical process. This project aims to develop methods to quantify the biological heat flux (UA) that emanates during a biochemical reaction. Variations in the UA attributed to changes in the heat transfer area (fed-batch and continuous fermentation) and rheological modifications of the fermentation broth due to the cell growth will be evaluated through the incorporation of various calibration methods (Partial Least Squares, ANN), constrained based modelling and state estimators (Kalman observer, Luenberger observer). Apart from the temperature control of the reaction content, other critical process parameters that vary dynamically during the biochemical reaction need to be maintained at the desired levels. This control problem will be circumvented by coupling advanced control strategies (adaptive control, model predictive control) with online optimization techniques for a robust control of process variables. The project also aims to uptake Quality by Design principles to impart continuous process improvement by enabling seamless process control and automation. Soft sensors from other process analyzers (Dielectric spectroscopy, Exhaust gas analyzer, Optical density probe) will be deployed to develop an integrated process control and optimization platform for laboratory-scale fermentation. The developed framework will be tested on various microbial systems leading to high value-added therapeutics.
Sl. No.	06
Dept.	Chemical Engineering

Project Code	ID_CL_KM_RT
Joint Supervisors	Dr. K. Mohanty (CL), Dr. Ranjith Thangavel (SESE)
Title of the Project	Bio-mass derived electrode materials for next-generation batteries and hybrid capacitors
Project Summary	The global push for dependency on renewable energy sources has fuelled the research and development on high energy density energy storage devices. Electrochemical energy storage devices, viz, batteries and capacitors are the key essential components for storing the renewable energy generated, and helping to integrate the renewable energy with electric grid. Moreover, batteries and capacitors have a potential application in emission free electric-vehicles. Carbon materials have been playing a significant role in the development of next-generation energy storage devices. Research on carbon-based materials plays an important role in improving the energy density of electrochemical energy storage devices. Biomass-derived carbon materials are an inexpensive, eco-friendly, and alternative sustainable energy material for realizing high energy storage applications. Carbon derived bio-mass can show the highest performance in energy storage devices due to their ultra-high surface area, tailored architecture with large pore volume, micro-meso-macro porous morphology, and tuned surface characteristics. This proposal aims to utilize the bio-mass derived carbon for several energy storage applications like lithium sulfur batteries, sodium-ion batteries, and sodium hybrid capacitors. Amorphous, and crystalline carbon type carbon will be made from several biomass precursors, and studied as electrode materials for batteries and capacitors. Sufficient advancement on engineering the porous architecture of the biomass carbon to achieve high surface area (>2600 m2 g-1) for better ion storage capability will be studied. Defect engineering and surface functionalization of carbon materials with several chemical functionalities will also be undertaken for increasing the charage storage capability of bio-mass carbon. Bio-mass derived carbon has very low particle density, reducing the volumetric performance of the energy storage device. Studies to improve volumetric performance of the bio-mass carbon by increasing the particle density (>1 g cc) will be extensively made. Furthermore, the material/electrode packing density is also very crucial to achieve high volumetric energy output. Thick carbon electrodes will reduce the ion movement at high rates due to traffic jam issue at innermost pores. Research will be directed towards preparation of porous carbon electrode with industrial standard mass loadings (>20 mg cm-2) for energy storage devices. The research proposal will bring new insights towards commercialization of bio-mass derived carbon materials for energy storage applications.
Sl. No.	07
Dept.	Chemistry
Project Code	ID_CH_AD_SK
Joint Supervisors	Dr. Animesh Das (CH) Dr.Sachin Kumar (BSBE)
Title of the Project	Exploring the Synthesis and Therapeutic Potential of N-enriched Cationic and Neutral Polycyclic Aromatic Hydrocarbons
Project Summary	Polycyclic aromatic hydrocarbons (PAHs) represent a privileged class of molecules, vastly important in organic electronics.1 Interestingly, PAHs decorated with heteroatoms such as boron (B) and nitrogen (N) exhibit modulated optoelectronic properties due to modified molecular energy levels and intermolecular interactions.2 Particularly, the N-containing PAHs (N-PAHs) have drawn a considerable recent attention by covering a wide range of applications in diverse fields including materials science (semiconductors, light emitting diodes, NLOs), and biology (imaging agents).2 Therefore, considerable efforts have been made for the synthesis of N-PAH architectures with adaptable number, position and valence state of the substituting N atoms thus allowing a systematic structure–property understanding for judicious development of application suitable molecules. Further, cationic N-PAHs can show tuneability of optoelectronic and supramolecular properties due to the partially delocalized charge within the π-conjugated ring framework. To fulfil the increasing demand of rapid synthesis of a variety of such neutral and cationic PAHs including N-PAHs, annulative π-extension (APEX) of (hetero)aromatic molecules via transition metal-catalyzed C–H activation reactions has emerged as a powerful protocol.3 The features such as step-economy, high efficiency and selectivity, operational convenience etc. bring large benefits to the APEX protocol compared to traditional multistep methods. In this context, beyond double C–H activation, there is a special focus toward developing one-pot multiple C–H activation–annulation approach to fuse multiple π-conjugated rings surrounding the parent polyaromatic backbone via

	sequential and extremely selective π-extension steps, thereby toting more value to this novel chemistry. Nevertheless, such kind of challenging multi-annulation strategy has been extremely limited to only a few reports.4 Next, these newly synthesized cationic N-PAH and a neutral N-PAH will be examined in cellular imaging studies as specific mitochondria and lysosome-targeted biomarkers. Further different biological activities such as antibacterial, antiviral, antioxidant, and antifungal activities will also be examined by using these compounds.
Sl. No.	08
Dept.	Chemistry
Project Code	ID_CH_CJ_MK
Joint Supervisors	Dr. Chandan K. Jana (CH) Dr. Manish Kumar (BSBE)
Title of the Project	Synthesis and biological evaluation of functionalized aliphatic N-heterocycles for the development of a potential antibacterial agent against Leptospira interrogans.
Project Summary	Leptospira interrogans is the causative agent of leptospirosis, a globally important zoonotic disease. The transmission of the pathogenic Leptospira between animals, humans, and the environment is essential for maintaining its enzootic cycle. Over a million cases of leptospirosis are reported every year, with approximately 60000 deaths in humans. Leptospirosis being a zoonotic disease, disables livestock production in developing tropical and sub-tropical countries where animal rearing is a primary source of livelihood. Various antibiotics such as cephalosporins, cefotaxime, ceftriaxone, penicillins and cephems have become widely used for the therapy of leptospirosis. However, one or more bacterial strain was found to be resistant to these classes of antibiotics. In addition, many of the known potential antibacterial agents are structurally complex and thus, these are difficult to obtain in adequate quantity. Hence, the identification of a new class of safe, highly effective and easily accessible chemotherapeutic agents acting on novel pathways to curtail such persistent bacteria becomes inevitable. Functionalized aliphatic N-heterocycles belong to a promising class of molecules because of their important pharmacological profile. In addition, they are found as key moieties of many bioactive molecules and medicinal drugs. Synthesis of a library of structurally diverse functionalized aliphatic N-heterocycles and studies on the structure activity relation (SAR) would help to identify a new class of potential antibacterial agents against Leptospira interrogans. Therefore, the project aims to synthesize structurally diverse functionalized N-heterocycles starting from readily available alicyclic amines. These synthetic molecules will be subjected to biological evaluation to identify the most potent candidate.
Sl. No.	09
Dept.	Chemistry
Project Code	ID_CH_CM_AG
Joint Supervisors	Dr. Chandan Mukherjee (CH) Dr. Animes K. Golder (CL)
Title of the Project	Metal-Organic Complexes and their Applications in CO2 and N2 Reduced Products Including Ammonia
Project Summary	Conversion of CO2 molecules to the value-added products, e.g., carbon monoxide, methanol, formic acid, methane, acetaldehyde, ethanol, etc., is one of the pertinent strategies for utilizing CO2 and reducing its concentration in the environment (valorization of waste). Electrochemical reduction of CO2 molecules is one of the processes where renewable energy sources, e.g., water, air, solar, could be utilized. Hence, a more biofriendly method could be adapted for the conversion. In the process, the main difficulty lies with the initial activation step of linear robust CO2 molecules. The transformation of CO2 to bent CO2•- requires high energy (ECO2/CO2•- = -1.90 V vs. SHE) as structural rearrangement is needed. In this context, the proton-assisted reduction of CO2 via multiple-electron transfer processes in the presence of metal-complexes or metal oxides as catalysts has gained significant interest as the reduction occurs at a relatively low potential due to the formation of thermodynamically stable metal ion-bound CO2 molecules/species. Initially, CO2 molecule binds to the metal

	centre, which lowers the activation energy to CO2 anion radical formation, followed by further electron transfer to CO2•– and proton (H+)-coupling various reduced products are generated. Thus, various metal catalysts (small molecule metal complexes, metal-organic frameworks, and metal oxides) will be tested to facilitate the electrochemical reduction process. The formation of urea is accompanied by NH3 gas. The gas generation is energetically unfavourable and economically not benign (Haber-Bosch process). To pursue in situ urea production, catalysts can be designed where both N2 and CO2 gas reductions followed by coupling occur. Metal ions have a different affinity towards CO2 and N2 molecules. Thus, polynuclear metal complexes with varying ions of metal, mixed metal oxides, and metal-organic frameworks comprising of various diverse metal ions will be tested for the electrochemical generation of urea.
Sl. No.	10
Dept.	Chemistry
Project Code	ID_CH_AK_BM
Joint Supervisors	Dr. Akshai Kumar A S (CH) Dr. Biman B Mandal (BSBE)
Title of the Project	Synthesis and evaluation of pincer-metal complexes as anti-viral agents
Project Summary	Metal complexes have enjoyed tremendous success in mediating and/or catalyzing organic transformations.1 This can be attributed to the fact that metals have a wide range of coordination numbers, geometries, thermodynamic and kinetic preferences for ligand substitution, easily accessible redox states and structural diversity.2 This sort of bodes well with the numerous variations that one can achieve with the ligands themselves and hence offers a plethora of metal-ligand combinations. These properties of metal complexes also serves as a great recipe for the design of novel metal-based therapeutic agents.3 Metal complexes with specific medicinal properties could be designed through a good understanding of the influence of the above factors on biological activity. Rosenberg's discovery of cisplatin4 as an anticancer drug paved the way for subsequent attempts to use other metal complexes in therapeutics. This in addition, to the subsequent discovery of vitamin B12 a natural biomolecule with a metal carbon bond has led to the development of bioorganometallic chemistry. Over the years several new types of metal complexes such as metallocenes, metal carbonyls and metal carbenes that contain M-C bonds have been employed not only for the treatment of cardio-vascular and gastro-intestinal disorders but also as psychotropics, anticancer, antifungal, antiarthritic, antimicrobial, antiparasitic, antidiabetes and antiviral drugs.3,5 In the context of the recent outbreak of the pandemic COVID-19, researchers from diverse backgrounds are racing against time for design of efficient antiviral therapeutic agents. Though there are currently no metallodrugs that are approved for the treatment of virus diseases. It is noteworthy that Bis(2-methylimidazole)[(bis(acetylacetone)(ethylenediimine)]- cobalt(III), CTC-96 has completed phase II clinical trials for the treatment of Herpes simplex labialis and phase I clinical trials for the treatment of two viral eye infections.6,7 The mode of action is via preventing the entry of the virus into cells through inhibition of membrane fusion events. It has been shown that (acacen)cobalt(II) complexes bind covalently to histidine residues of zinc finger domains thereby preventing the binding of the protein to its recognition oligonucleotide.7 Similarly, a variety of transition metal compounds are known to inhibit different families of enzymes leading to decreased activities of HIV, severe acute respiratory syndrome coronavirus, influenza virus, herpes simplex virus, and hepatitis B virus in vivo.8,9 In this context, we propose the investigation of pincer-metal complexes as potential antiviral agents. We propose to design pincer-metal complexes10 that would bind and/or interact (via metal and/or heterocyclic based anchillary ligands) with relevant enzymes/residues leading to inhibition of membrane fusion events. We believe that a rational design of such complexes holds promise for the discovery of novel antiviral drugs with new mechanisms of action. On a long run, the emphasis would be to explore several other properties such as anti-cancer, antifungal, antiarthritic, antimicrobial, antiparasitic and antidiabetes. References: 1 Hartwig, J. F., University Science Books; Sausalito, CA: 2010. 2 Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K.; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006. 3 Mjos, K. D.; Orvig, G.; Chem. Rev. 2014, 114, 4540−4563

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Sl. No.	11
Dept.	Chemistry
Project Code	ID_CH_UM_SS
Joint Supervisors	Dr. Uttam Manna (CH) Dr. Sreedeep Sekharan (CE)
Title of the Project	Functional Nanomaterial in Agriculture for Fertilizer and Water Management
Project Summary	The focus of current agriculture is towards higher productivity through optimized use of resources. The use of agricultural waste for improving the productivity is the new norms for achieving the ultimate goal of circular economy and sustainability in agricultural sector. Two important factors determining the overall productivity and agricultural economy is fertilizer use and water consumption. An optimized use of both these resources would result in decreasing the cost of farming and at the same time improve the efficiency of its usage. From the past literature, it is clear that there is a wide scope for improving the fertilizer usage efficiency. Most of the nutrients that are applied in the form of fertilizer leach out to deeper layers of soil or ends up in water bodies due to excessive use. This is not a conducive condition for soil as well as water bodies. It also aggravates the use of chemicals in the fertilizer industry due to the high application rate. A best management practice for fertilizer application would comprise of using minimum amount with maximum residence time. One of the objectives of this study would be to utilize the concept of nanotechnology for proposing slow release macro/ micro nutrients into the soil and how to retain within the root zone with minimal loss. Similar to fertilizer, it is always desirable to save irrigation water to the best possible in today's world of extreme weather and frequent occurrence of drought. Another objective of this study is to explore the possibility of transforming agri-waste to water storing materials through nanotechnology intervention. Its performance in soil and how it translates to plant growth will be explored. In both the above objectives, the concept of hydrophobicity may be relevant for optimizing the process and enhancing its performance. Therefore, the third objective of this study will be to explore the possibility of nanotechnology for inducing hydrophobicity for functionalizing fertilizer and water release with additional properties. The developed products will be subjected to a detailed characterization and interaction with soil for evolving suitable guidelines.
Sl. No.	12
Dept.	Chemistry
Project Code	ID_CH_KR_PK
Joint Supervisors	Dr. Kalyan Raidongia (CH) Dr.Prasenjit Khanikar (ME)
Title of the Project	Development of mechanically stable proton conducting membranes for PEM water electrolysis and hydrogen fuel cell
Project Summary	As hydrogen is the most efficient and clean energy carrier, the economic future of the country relies on eco-friendly production of high purity H2 from different sources and application of the same in areas like in mobility/transport, industry and energy. However, several issues related to production, storage, distribution and end use are yet to be solved. The student selected here will work on certain vital issues of PEM water electrolysis and fuel cell devices which is hindering its

	practical utility and cost effectiveness. In terms of sustainability and environmental impact, PEM water electrolysis (or fuel cell) is considered to be the most promising techniques for efficient hydrogen production (or utilization), but most of the devices are still dependent only a few selective proton conductive membranes (i.e. Nafion, and fumapem). Development of proton conducting membrane with great chemical, mechanical and thermal stability that can be operated at high current densities is one of the top priorities for practical utility of both PEM water electrolysis and H2 fuel cell. Another practical issue with current generation of PEM water electrolysis and H2 fuel cell is the loading (or coating) of catalyst on the commercial PEMs, which are very fragile at higher temperature. Typically, catalyst coating on membranes require hot pressing and mechanical instability at higher temperatures drastically limits the options of coating. We propose to develop processes where catalyst will be coated during the fabrication of the membranes to avoid complications related to fabrication of membrane electrode assemblies. Re-stacking of 2D nanomaterials into freestanding proton conducting membranes is a highly active area of research with great potentials of applications in multiple areas. However, low mechanical stability of these membranes is a major hindrance towards its practical applications. The student selected here would apply different chemical crosslinking methods to improve the mechanical stability of the fabricated proton conducting membranes. Processes and techniques to be used/learnt during the PhD duration: 1) Fabrication of PEM water electrolysis and hydrogen fuel cell 2) Synthesis of different 2D nanomaterials like graphene oxide, V2O5, Mxene etc. 3) Evaluation of the mechanical properties of the fabricated membranes 4) Characterization of materials through various spectroscopic and microscopic techniques Methodology: 1) Synthesis of different 2D nanomaterials. 2) Fabrication of proton conducting membranes and optimization of its mechanical properties. 3) Fabrication of PEM water electrolysis and hydrogen fuel cell and testing efficiency.
Sl. No.	13
Dept.	Chemistry
Project Code	ID_CH_KB_RT
Joint Supervisors	Dr. Krishna Pada Bhabak (CH) Dr.Rajkumar P. Thummer (BSBE)
Title of the Project	Stimuli-responsive Fluorogenic Prodrugs for the Co-delivery of Anti-Cancer Drugs and Specific Enzyme Inhibitors for the Treatment of Cancer
Project Summary	Background/Origin of the Proposal: Cancer cells generally require high energy resources for the cellular division, metastasis and for the cellular biogenesis. Modification of biosynthetic pathways and energy production have been recognized as avid hallmarks of cancer. The level of reactive oxygen species (ROS) in cancer cells is generally higher than normal cells and the overproduction of ROS in cancer cells is caused primarily due to the dysregulation of multiple metabolic enzymes. For example, the expression levels of thymidylate synthase (TS), aldose reductase (AR), cyclooxygenase-2 (COX-2) and glutathione-S-transferase pi (GSTP1) are reported to be up-regulated in many organ-specific cancer cells.1 Moreover, these four target proteins are found to be interconnected with the dysregulation of ROS level in malignant cells. For example, thymidine catabolism involves ROS production and promotes cellular survival and metastasis. The enzyme thymidylate synthase catalyzes the transformation of deoxyuridine monophosphate (dUMP) to deoxythymidine monophosphate (dTMP) and maintains DNA replication and repair. Similarly, aldose reductase catalyzes the reduction of ROS-induced lipid peroxidation-derived aldehydes and the related glutathione-conjugates to the corresponding alcohols, which is responsible for the induction of inflammatory signals. Furthermore, it is well-established that cyclooxygenases (COX-1 and COX-2) induce and elevate the inflammatory signals with the generation of prostaglandin leading to the overproduction of ROS. Another major concern of the chemotherapeutic drug effectiveness is associated with the chemoresistance, which is triggered by the over-expression of GSTP1. It has been shown that the higher level of glutathione (GSH) in tumor cells is reported to be risky in certain cancer

	types such as head and neck carcinoma as it helps in many chemotherapeutic drug inactivation catalyzed by GSTP1. The overproduction of GSTP1 at the tumor micro-environment is quite common and the resistance of chemotherapeutic drug activity is mainly induced by GSTP1 via GSH conjugation. Therefore, selective and effective inhibition of one or more of these overexpressed enzymes is reported to be important for controlling the abnormal cellular proliferation of cancer cells.1b, 2 However, the existing strategies of such inhibition processes have drawbacks/limitations such as (a) direct administration of enzyme inhibitors can be non-selective towards cancer cells over non-malignant normal cells; (b) direct administration of the inhibitors to the cells invites more side-effects by sudden increase in the drug concentration in the plasma level; (c) most of the inhibitors targeting these enzymes or receptors are not fluorogenic in nature, rendering the real-time monitoring difficult. In the present research plan, we plan to design and synthesize turn-on fluorogenic prodrugs for the targeted and selective inhibition of the above overexpressed enzymes using the specific stimuli-triggered sustained release strategy. The development of turn-on fluorogenic prodrugs would involve several step organic synthesis. Additionally, an adjuvant delivery of an anti-cancer drug and an enzyme inhibitor will also be considered to minimize the drug-resistance and the drug-induced side-effects. After the synthesis, the prodrugs, the drug release profiles will be investigated initially using the spectroscopic methods and finally in the cellular medium. With our strategy, we expect to resolve the above limitations with effective treatment strategies for cancer with minimized side-effects.
Sl. No.	14
Dept.	Civil Engineering
Project Code	ID_CE_HS_VK
Joint Supervisors	Dr. Hrishikesh Sharma (CE) Dr. Vinayak Kulkarni (ME)
Title of the Project	Rehabilitation of Blast Injury Victims Via Indian Treatment Methods
Project Summary	In a blast epicenter (kill zone), most people are dead or mortally injured. In the secondary perimeter (critical casualty zone), there are more survivors, but many of them likely have multiple injuries. In the blast periphery (walking-wounded zone), most casualties have non–life-threatening injuries and psychologic trauma. An explosion creates a blast wave. An intense blast wave can tear tissue. A less intense blast can damage the eardrums, lungs, and abdomen. Blast waves also throw debris at very high speed that can injure any part of the body. This teasers h aims to study and propose treatment methods to the Blast injury by several Indian treatment methods.
Sl. No.	15
Dept.	Computer Science and Engineering
Project Code	ID_CS_CK_PG
Joint Supervisors	Dr. Chandan Karfa (CSE) Dr. Pritwijit Guha (EEE)
Title of the Project	Machine Learning Guided Hardware Security Analysis: Learning and Predicting Keys
Project Summary	Many semiconductor companies use offshore third-party foundries to manufacture their chips. While cost-effective, this fabless model introduces security concerns. Since the foundry has access to the chip layout, it can reverse engineer the chip's functionality and steal the designer's intellectual property (IP). IP theft of this nature is a serious concern. One approach to preventing IP piracy is logic obfuscation in which the circuit functionality is locked using an additional key input. The IC only functions correctly for a secret key value, known only to the designer. The correct key is not revealed to the foundry. When fabricated chips are received from the foundry, the designer activates the chip by loading the correct key in a tamper-proof memory.

	There are plenty of works on logic obfuscation – both on attack and defence sides, both at gate level and RTL designs. Since the oracle (activated chip) is available, correct and corresponding incorrect pairs of outputs can be generated from oracle and locked circuits. A combination of Heuristic Search Strategies and Machine Learning approaches can predict (almost) correct keys by learning from input-error association patterns. Thus, this work aims at exploring Machine Learning approaches to attack a logic-locked circuit for key prediction.
Sl. No.	16
Dept.	Electronics and Electrical Engineering
Project Code	ID_EE_CK_SN
Joint Supervisors	Dr. Chandan Kumar (EEE) Dr. Sukumar Nandi (CSE)
Title of the Project	Cyber security for grid-connected power electronic converters
Project Summary	Grid-connected power electronic converters are key enabling technologies for interfacing renewable energy sources, energy storage, electric vehicles, microgrids, and high-voltage dc transmission lines with the electrical power grid. As the number of power converters in modern grids continually increases, their monitoring and coordinated control in a proper way to support the grid is necessary. With remote control of these converters, it also exposes them vulnerable to cyber-attacks. In this project, machine learning based tools will be developed for cyber security of such grid-connected power electronic converters.
Sl. No.	17
Dept.	Electronics and Electrical Engineering
Project Code	ID_EE_SN_MK
Joint Supervisors	Dr. Shabari Nath (EEE) Dr. Manas Khatua (CSE)
Title of the Project	Control of SIMO DC-DC power electronic converters using AI (artificial intelligence)
Project Summary	Various applications of power electronics like portable electronics, electric vehicles, IoT, and renewable energy sources require different regulated DC voltages and most of them are moving towards miniaturization. The power management unit of these applications operating from single voltage source demand better efficiency, compactness, longer battery life, and multiple regulated voltages. To achieve these requirements, single-input multiple-output (SIMO) DC-DC converters are a promising solution. The SIMO converters can generate multiple different DC voltage levels from only one available DC voltage level with reduced component count, reduced losses, reduced physical size and increased efficiency. Although SIMO converters offer many advantages, their control is more complex than simple DC-DC converters. In simple DC-DC converters, there are two modes – continuous conduction mode (CCM) and discontinuous conduction mode (DCM). Most of the simple DC-DC converters can be controlled using simple compensators. However, analysis of SIMO converters shows that these converters have various sub-modes in both CCM and DCM. Further, they have problems of cross-regulation and cross-coupling. Cross-regulation is the problem of disturbance in different outputs when any one load is changed. Cross-coupling is the problem of disturbance in different outputs when any one output voltage is changed. Due to the above problems, advanced controllers are required for control of SIMO converters. Artificial intelligence (AI) is a promising solution for control of complex problems like SIMO converters. AI can be used conveniently for highly non-linear systems without rigorous mathematical modeling of the power electronic converter. There are various AI methods. For power electronics applications, usually artificial neural networks (ANN) are used. ANN is one of the AI methods. For control of SIMO DC-DC converters, first ANN needs to be trained by collecting huge amounts of data offline. After that, the trained ANN is used for control of the converter in real-time.

	In the offline mode of AI, different data sensed for voltages, currents, and temperatures of the SIMO power electronic converter are sent by IoT transmitter to a cloud server. The cloud server collects thousands of data and trains the ANN model. The trained ANN model is then implemented in a microcontroller/DSP/FPGA control platform. The ANN model generates the gate pulses for the gate drivers and controls the switches of the converter in real-time. While applying for PhD on this topic, candidate requires to have basic knowledge of power electronics and circuit theory. During the course of PhD, student will need to acquire the knowledge of AI, if not known at the time of application.
Sl. No.	18
Dept.	Electronics and Electrical Engineering
Project Code	ID_EE_HN_TM
Joint Supervisors	Dr. Harshal B. Nemade (EEE) Dr. Tapas K. Mandal (CL)
Title of the Project	Point-of-care-testing devices for non-invasive detection of heavy metals and pathogens in biological samples.
Project Summary	In the recent era, non-invasive detection of biomarkers using point-of-care-testing (POCT) devices is getting colossal considerations in healthcare applications. The technique is simple, user friendly, cost effective, highly sensitive, and is beneficial in monitoring the maladies including chronic diseases. Various health organizations like National Cancer Institute (NCI) USA, World Health Organization (WHO), etc. have been recommending the estimation of biological molecules present in excreted fluids as a diagnostic tool of different diseases. Recognition of biomarkers from the volatile organic compounds (VOCs) present in exhaled breath condensate is a well-accepted technique for various diseases like asthma, diabetes, airway inflammation, anorexia, and alcoholic liver disease. Apart from the VOCs, most of the heavy metals together with arsenic are also health hazards and may be carcinogenic. Early detection of such compounds in biological samples should help us to take precautionary steps against various acute diseases. All these metals are mainly entering into body through the food chain and are either deposited in nails/hairs/mucus or excreted through urine/sweat. Therefore, it is proposed to detect heavy metals in these sources and develop POCT sensors for rapid detection of heavy metals acting as environmental pollutants and similarly develop devices in field of healthcare diagnosis. The concept can be extended for early stage detection of parasites/pathogenic bacteria/viruses causing diseases including urinary and pulmonary tract infections. A non-invasive, quick and point-of-care detection of glucose level can help adopting precautionary steps and monitoring the disease. Sensing acetone gas/vapour present in exhaled breath at room temperature is correlated with blood sugar level present in human body as acetone is derived from Glycogenolysis process that regulates the glucose level in the blood. The human body excretes acetone produced due to metabolism through either exhaled breath or urine. A POCT device will be developed for instant measurement of blood sugar present in human body. The prototypes will be fabricated from metal oxide sensors using a copper based nano-composite as sensing materials. The sensing materials will be characterized for chemical properties by standard techniques like FTIR analysis and Raman spectroscopy analysis, and for electrical characteristics using I-V analysis and transient current response. Metal oxide sensors have advantages like chemical and thermal stability, cold-chain-free operation over the enzymatic sensors. However, enzymatic sensor is an alternative route which will be explored in future if required."
Sl. No.	19
Dept.	Electronics and Electrical Engineering
Project Code	ID_EE_RJ_AK
Joint Supervisors	Dr. Ravindra Kumar Jha (EEE) Dr. Abhishek Kumar (CE)
Title of the Project	Simulation and Fabrication of a MEMS Accelerometer-Based Seismic Sensor

Project Summary	Occurrence of earthquake (EQ) or its induced effects in terms of damages, liquefaction etc. can be witnessed in almost every terrain type across the Indian subcontinent. In order to understand the building response, quantification of induced effects, development of fragility curves etc. larger sets of regional ground motions is a prerequisite. Keeping in mind the damages witnessed during 2015 Nepal EQ, 2022 Dekhiajuli EQ, 2023 Turkey EQ and many more, which were directly the amplified ground motion due to local soil effect, accurate assessment of local soil characteristics at the recording station is also a must. In addition, regional ground motion records are also needed for understanding of tectonic setting of the region, dominating fault mechanism and temporal variation in ground shaking. Thus, for all the purposes mentioned above, regional ground motion records by means of installing ground motion sensors/ geophones in EQ prone region is mandatory. Typically, the signal amplitude of a geophone is linearly proportional to velocity above its resonance frequency, with a roll-off of –40dB/decade below resonance. Microelectromechanical (MEMS) accelerometers, on the other hand, have been demonstrated to provide a relatively flat amplitude and phase frequency response over bandwidths ranging from a few Hz up to 100 Hz. Recent work on the optimisation of various MEMS accelerometers have also resulted in devices that offer an acceptable resolution, making them potentially attractive for seismic applications. However, these high-resolution MEMS accelerometers are still limited by their inability to operate over a large dynamic range. MEMS accelerometer for earthquake has to be designed for low frequency and it should have low noise floor <1$\mu g/\sqrt{Hz}$. The pink noise in these devices are prominent and hinders the low-frequency measurement due to the inherent relationship between sensitivity and natural frequency in these devices. Once the device is fabricated, the testing and data analysis of these devices will be very cruicial. We intend to perform at least three sets of experiments i.e. static acceleration measurements, dynamic acceleration testing, and noise floor estimation.
Sl. No.	20
Dept.	Mechanical Engineering
Project Code	ID_ME_AD_SG
Joint Supervisors	Dr. Amaresh Dalal (ME) Dr. Siddhartha Sankar Ghosh (BSBE)
Title of the Project	Design and development of a microfluidic device for sustained drug release in cancer theranostics
Project Summary	It has been estimated that cancer-related deaths could reach 13 million deaths year by 2030. Metastases cause most deaths, but other factors add to cancer-related mortality. These factors include a lack of immediate diagnosis and other health complications from ineffective drug treatment. Chemotherapy is one of the most prevalent cancer treatments, but the treatment is not solely confined to the cancer site. Without the targeted nature of chemotherapeutics, the treatment also kills other healthy cells like hair cells and white blood cells. Numerous researchers are now gaining interest in targeted drug delivery by nano-carriers. The nano-carriers are nanoparticles designed to carry the anti-cancer drug to the concerned site, just like a targeted missile. But in addition to the targeted delivery, it is also essential to achieve control and sustained drug release at the site. Targeted therapy by nano-carriers can only serve half a purpose in a controlled release. A considerable effort is required to develop techniques for controlled drug delivery to the targeted site. Drug delivery microchip that can be implantable is gaining a great deal of interest in the context of sustained and controlled drug release. Our research group conducted several microfluidic-based cancer research studies in recent years. Nath et al. [1] investigated the migration and viability of HeLa cells passing through a 7 μm channel. The HeLa cells deformed substantially in the entry region, moved and extended maximum in the transit region, and regained their original shape in the exit region. They also observed the cell viability that showed approximately 50 % of the HeLa cells survived and were able to retain properties after passing through the constricted channel. Prasad et al. [2] studied the shear thinning, self-healing nature of hydrogel drug carriers migrating through the constricted microchannel. The hydrogel drug carriers showed remarkable elastic recovery after undergoing high shear flow. They also studied drug loading and drug release by the hydrogel carriers. Prasad et al. [3] also reported the aggregation tendency of the commercial anti-cancer drug Paclicad at increased flow rates inside micron-sized constricted microchannels. The aggregation tendency was reported to be shear-induced. In the present project, we will propose a diffusion-controlled drug release device to achieve zero-order drug release. In the diffusion-controlled drug delivery microchip, a well serves as a reservoir for the drug particles. A microchannel filled with biocompatible polymer acts as a diffusion barrier between the drug

	particles and body fluid. The body fluid will be allowed to infiltrate through the biocompatible polymer-filled channel and reach through the reservoir well filled with the drug. The drug particles dissolve with body fluid, and the solution flows back through the same channel and gets released into the human body. To optimize the size of the microchip, a drug-loading device will also be fabricated as a part of the drug delivery system. The drug-loading device will be designed to create a chaotic motion that can create a stirring effect for the desired drug loading. References [1] B. Nath, A. Raza, V. Sethi, A. Dalal, S. S. Ghosh, and G. Biswas, "Understanding flow dynamics, viability and metastatic potency of cervical cancer (HeLa) cells through the constricted microchannel," Sci. Rep., vol. 8, no. 1, pp. 1–10, 2018. [2] N. K. Prasad, R. Shome, G. Biswas, S. S. Ghosh, and A. Dalal, "Discerning the self-healing, shear-thinning characteristics and therapeutic efficacy of hydrogel drug carriers migrating through constricted microchannel resembling blood microcapillary," Colloids Surfaces A Physicochem. Eng. Asp., p. 127070, 2021. [3] N.K. Prasad, R. Shome, G. Biswas, S.S. Ghosh, A. Dalal, Transport Behavior of Commercial Anticancer Drug Protein-Bound Paclitaxel (Paclicad) in a Micron-Sized Channel, Langmuir. 38 (2022) 2014–2025.
Sl. No.	21
Dept.	School of Energy Science and Engineering
Project Code	ID_EN_FK_SS
Joint Supervisors	Dr. Farrukh Khalid (SESE), Dr. Senthilmurugan Subbiah (CL)
Title of the Project	Performance evaluation of the H2 generation system and end-use applications
Project Summary	Using energy analysis as a tool for understanding and improving the efficiencies of energy systems may be ambiguous and perplexing. The exergy analysis can be used to assess and improve the efficiencies energy systems, and can help better understand the losses in energy systems by providing more useful and meaningful information than energy provides. Exergy is the maximum work (or electricity) producible from a system or a flow of matter or energy relative to a reference environment. Exergy is a measure of the potential of the usefulness or value of a system or flow. The exergy method is useful for improving the efficiency of energy-resource use, for it quantifies the locations, types and magnitudes of wastes and losses. In general, more meaningful efficiencies are evaluated with exergy rather than energy analysis, since exergy efficiencies are always a measure of the approach to the ideal. Therefore, exergy analysis identifies the margin available to design more efficient energy systems by reducing inefficiencies. Researchers are showing much interest in the suitability of existing natural gas pipelines for hydrogen transportation (gaseous form). Recently, Oil India Limited (OIL) and H2e power has set up a renewable energy (solar energy) based electrolyzer plant at PS3, Jorhat, Assam. The main purpose of the project is to produce green hydrogen so that it can be blended to the existing Natural gas network. The existing hydrogen consumes 100 kW of electric power produced by the solar PV plant. In conjunction with H2e power IITG will help the OIL by providing comprehensive report on the blending of hydrogen (on-site production) with the natural gas for the existing Assam Gas Network. The specific objectives that would be consider in the present study are as follows: • To design an experimental set up for the blending of hydrogen in the NG. • To do the onsite testing for various compositions of hydrogen in the NG. • To carry out the corrosion study to see the effect of hydrogen blending on the NG pipeline. • To propose and suggest a strategy for smooth and cost-effective way of blend gas. • To do the comprehensive study on the performance of the existing hydrogen plant along with technologies like PEM, SOEC via energy and exergy efficiencies