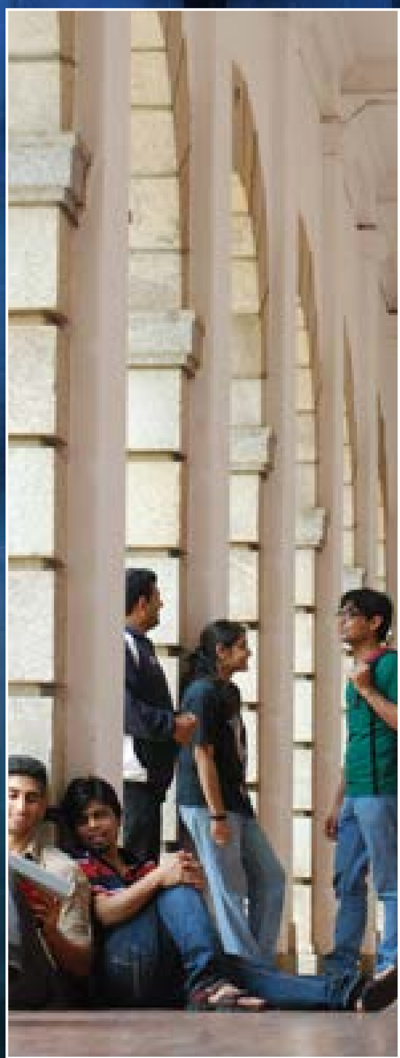
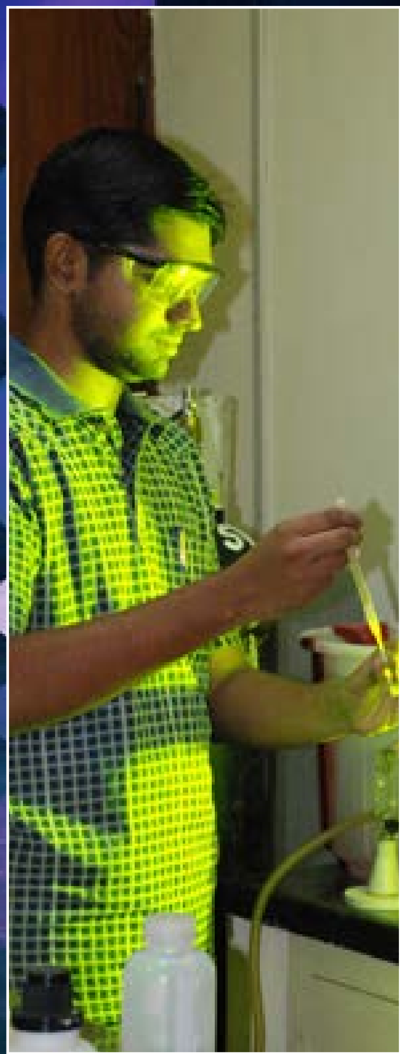
Department of

Chemical Engineering





Indian Institute of Science, Bangalore

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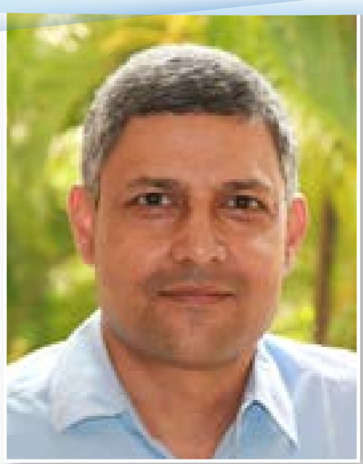


Message from the Chairman

On behalf of all members of the department of chemical engineering, I extend my warm greetings. Situated in a century-old renowned institution, this department is itself over 50 years old. Through the years, it has built high quality teaching and training programmes, and engaged in research on problems of technological importance to India, and humankind in general. We are proud to have trained students who have gone on to work in a diverse range of industries and institutions, thereby contributing to the industrial growth of India. We are equally proud that we continue to contribute to current areas of technology and engineering science.

We offer a PhD and two masters programmes, which build on a strong base of advanced and diverse graduate courses and encourage students to undertake research that is challenging and intellectually stimulating. Chemical engineering has been a bridge discipline from its inception, melding concepts from chemistry, physics and engineering to understand realistic industrial processes, and building a strong mathematical foundation for their description.
The research conducted in the department today is truly multi-disciplinary, bringing in concepts from frontier areas in biology, nanotechnology and other sciences as is evident from the diverse profiles of the members of our faculty who are at the forefront in their specializations.

We also remain engaged more directly with the society at large. Through the Outreach programme, we conduct internship programmes for college students and deliver lectures in colleges. We participate at various levels in the administration of science and technology programmes in the country. Our alumni are well placed in academic institutes and in several of the leading national and multinational industrial organizations.

The coming years pose many challenges, and also offer opportunities. Our department aims to remain one of the premier departments of chemical engineering in the country, and strives to achieve a place among the best in the world.

GANAPATHY K AYAPPA

Origins and Evolution of the Department

The Department of Chemical Engineering was started in 1943 as a wing of the Division of Pure and Applied Chemistry at the Indian Institute of Science (IISc). The Chemical Engineering wing earned the full status of a department in 1947. In 1961, it was affiliated to the Engineering Faculty and renamed the Department of Chemical Engineering (ChemE).

Our department began as a center of excellence in research and higher education in chemical engineering to address the needs of a phenomenally growing chemical industry in post-independence India. It has evolved significantly over the last six decades, reflecting changes in the Indian chemical industry and the chemical engineering profession worldwide. Research in the fifties and sixties was focussed on thermodynamics, reaction kinetics, catalysis, and unit operations, and was followed in the seventies by chemical reactor theory and transport processes. Scores of catalysts were developed for homogeneous and heterogeneous reactions central to our industry, and a variety of chemical reactors were designed and analyzed. Gradually, the focus shifted to more basic research in multiphase systems. In subsequent years, our department went on to make major theoretical contributions in multiphase systems and won considerable national and international acclaim.

Newer areas like colloid and interfacial science, biochemical engineering, complex fluids, and polymer science appeared on the chemical engineering arena in the eighties. The department has emerged today as a center of excellence in modelling complex fluids and advanced materials. Endeavors in biochemical engineering initiated during the eighties have culminated today in the establishment of several novel bioreactors across the country.

The turn of the century is witnessing the fusion of traditional chemical engineering areas with modern fields like information science, communication technology, nanoscience, and biology. In keeping with this transition, our department today has acquired a significantly interdisciplinary character. Our current activities extend to such diverse areas as biochemical and metabolic engineering, colloid and interfacial science, polymer engineering and science, complex fluids, environmental engineering, granular flows, molecular modelling and simulation, nanotechnology, theoretical biology, transfer processes, and process systems engineering. At the same time, we retain our traditional strengths as work on reactor analysis and multiphase systems, continues.

Our department has had a longstanding tradition of providing its students with chemical engineering education of the highest international standards.

We currently offer programs leading to the Master of Engineering, ME, Master of Science, MSc (Engg), and Doctor of Philosophy, PhD degrees. The high faculty-to-students ratio facilitates close interaction and a cherished informal atmosphere. Since 1961, more than 500 degrees have been awarded in the ME, MSc (Engg), and PhD programs. Our alumni today include industrialists and academicians in India and abroad.

Chairpersons

N Govindarao	1947-49
SK Nandi	1949-51
SS Ghosh	1951-54
E Weingartner	1954-58
NR Kuloor	1960-70
DS Viswanath	1970-75
R Kumar	1976-80
G Narasimhan	1981-83
PK Deshpande	1983-89
M Ravindram	1989-91
MS Murthy	1991-94
KS Gandhi	1994-97
KK Rao	1998-02
JM Modak	2002-08
PR Nott	2008-14

Facts at a Glance

Student body

The department is home to about 40 PhD, 5 M Sc (Engg) and 30 ME students. The students join IISc ChemE department from all parts of country after graduation from NITs, IITs and other reputed institutions. The average span of time spent by a PhD, MSc and ME candidate is 5, 2.5 and 2 years, respectively.

Faculty

Eleven full-time professors, two senior scientific staff and visiting professor(s) form the core of the academic staff at the department. All the teaching faculty hold PhDs from reputed institutions in India or abroad. The faculty are well-known authorities in their fields and many are fellows of the major science and engineering academies of the country. Two of our professors are also recipients of the prestigious Shanti Swaroop Bhatnagar award. Apart from this, several of the retired and emeritus professors still maintain a strong connection with the department.

Measures of excellence

Apart from IISc being ranked in the top 100 schools in the world (Shanghai rankings, 2013), ChemE department is consistently ranked in the top 100 chemical engineering programs in the world (QS Top university rankings, 2013). It is considered one of the top chemical engineering departments in the country for graduate studies.

Tuition fees & Financial aid

The annual tuition fee for PhD and Master students is Rs. 9000 and Rs. 6000, respectively. The PhD students receive monthly scholarships of Rs. 16000/18000 (with BE/ B Tech/M Sc) and Rs. 18000/20000 (with ME/M Tech). The Masters students receive Rs. 8000 per month. Several other awards from IISc and government agencies like Council of Scientific and Industrial Research (CSIR) and Department of Biotechnology (DBT) as well as Bristol-Myers Squibb are available on a competitive basis.

Teaching and Research

The chemical engineering department strives for the highest international standards of teaching and research. Apart from seven core courses that cover engineering, mathematics and basic chemical engineering principles, as many as eleven elective courses spanning environmental engineering to theoretical biology are offered. Research in the department is a critical part of the teaching process and each of the degree programs require thesis work ranging from one (ME) to approximately five (PhD) years of dedicated research and training.

Publications

Our department has many prolific researchers and the average number of publications is greater than 50 per year. Several of the professors have also authored well-known graduate texts and research monographs.

Funding

The department is funded well from various government agencies such as Department of Science and Technology (DST), Department of Biotechnology (DBT), Council of Scientific and Industrial Research (CSIR) and international organizations like NIH and Wellcome Trust. The department operates several major grants like IRPHA, FIST and one center of excellence. We also have funding from industrial colloborations (Samsung, Procter & Gamble, BPCL, etc.) which support our research activities.

Alumni

High standards of imparted training and education combined with the excellcent quality of students produces ChemE graduates from IISc who go on to lead illustratous careers. Our alums can be found in all levels of the industrial sector and occupy strategically important positions in various corporations such as Dr. Reddy's Labs, ITC and SABIC. Many of the ChemE graduates also go on to undertake successful careers in academia and can be found in top chemical engineering departments of the country.

Interesting Tidbits

Here are some interesting facts and figures about our department.

- Prof R Kumar set up a fluidized bed reactor with the largest diameter of that time for roasting pyrites ore.
- Prof KS Gandhi's book on "Heat & Mass Transfer: A Transport Phenomena Approach" is highly popular among graduate students that helps them to solve transport process problems from a physical and mathematical perspective.
- Prof V Kumaran was the first to study the stability of fluid flows past soft materials at low flow speeds, an area which is becoming increasingly relevant in microfluidics and biological fluid dynamics.
- Prof G Madras has the highest number of publications and citations between 2000-2012 among all engineering faculty in India.
- Prof SK Gupta developed a new framework for discretization of population balance equations (PBEs) along with co-investigator, Dr. D Ramkrishna at Purdue which has over 500 citations.
- Prof. Manas Chanda's book on "Introduction to Polymer Science and Chemistry: A Problem Solving Approach" is followed by many Universities in India, Sweden, U.S and Canada.
- With growing environmental concerns and need for green technologies, Prof K Kesava Rao was among the few early proponents of waste water recycling from hostels and other places in the institute.
- Prof Jayant Modak was instrumental in setting up plants for the treatment of effluent water from coffee plantations and the extraction of gold from ore tailings.

Academic Programmes

Degree Programmes

Chemical engineering at the Indian Institute of Science offers several degree programs tailored to gain various levels of training in course and research experience.

Master of Engineering, ME

The ME programme is a two-year course based program designed to prepare students to address complex industrial and technological problems through an advanced knowledge of various chemical engineering subjects. A bachelor's degree in chemical engineering or a related field is necessary to enter the programme. Selection is based on the score obtained in the GATE Chemical Engineering Paper. The programme consists of 32 credits of course work and 32 credits of project work. Of the course credits, 21 credits are from compulsory core courses and the remaining from electives.

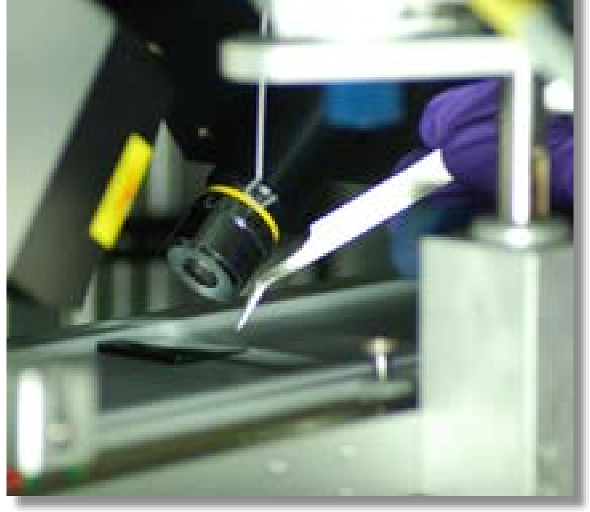
Master of Science, MSc (Engg)

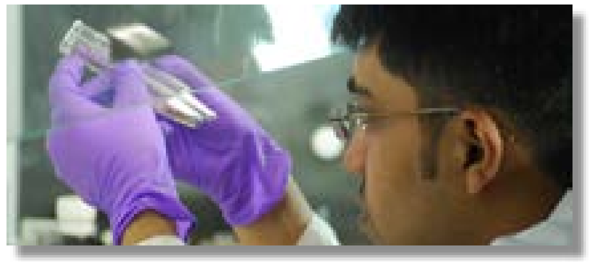
The MSc (Engg) programme is research based and designed to prepare students for advanced chemical engineering practice through research, development, production and process design. A bachelor's degree in engineering or a master's degree in sciences with mathematics as a subject at the bachelors level (at least) is required to enter the programme. Selection is based on the score obtained in the GATE exam and an interview.

Each student selects a research advisor and plans a programme of course work and thesis research. A minimum of 12 credit hours of graduate course work, of which at least 6 credits are from core courses, in addition to a 3 credit mathematics course are required for the MSc (Engg) degree. Independent research work is assessed through a general test midway into the programme and a final defense of the thesis.

Doctor of Philosophy, PhD

The PhD programme is designed to prepare each student to participate in technology development, problem solving and innovation in chemical engineering, be it in industry, research institutions and universities. Students can enter the PhD programme either with a master's or a bachelor's degree in engineering. Selection is based on the score obtained in the GATE exam and an interview.





PhD applicants with a master's degree in engineering

In the PhD programme, each student selects a research advisor and plans a program of course work and thesis research. Six credit hours of graduate course work must be completed before research may begin. Independent research work is assessed by a comprehensive examination midway in the program and annual assessments thereafter culminating in a defense of the thesis at the end.

PhD applicants with a bachelor's degree in engineering

Each student selects a research advisor and plans a program of course work and thesis research. A minimum of 18 credit hours of graduate course work are required for the bachelor entrants to the PhD program. Independent research work is assessed through a comprehensive examination midway in the program annual assessments thereafter culminating in a final defense of the thesis.

Admissions

Admission to the ME program is in the August semester only. The applications are generally received in March every year. The admission procedure is advertised in all national daily newspapers in January/February every year including details of GATE, which is conducted in February.

Admission to the MSc(Engg) and the PhD programmes is for the August semester (applications submission in March). Candidates are called for an interview on the basis of their scores in GATE or Joint CSIR-UGC National Entrance Test for JRF or UGC-NET for JRF. A GATE score is not necessary for students who have a masters degree. The final selection is based on the performance in the interview. Interviews are held in June.

External Registration and Quality Improvement Programmes (ERP & QIP)

These programmes enable mid-career professionals to acquire a higher academic degree. The ERP candidates are typically sponsored by reputed industries and research organizations. The QIP is meant for faculty members from engineering colleges to gain a higher academic degrees. In both, selection is by an interview.

Financial Aid

Fellowships are provided to all selected students who join the degree programs in Chemical engineering. Fellowship amounts per month for various programs are as follows; Rs. 8000 (ME and MSc Engg) and Rs. 16000-20000 (PhD). Apart for this, the ChemE department also awards the Bristol-Myers Squibb fellowship that includes a stipend (Rs. 25000 for PhD candidates and Rs. 12000 for MSc Engg) as well as Rs. 75000 per year of contingency (for travel, conferences registration, etc.). Apart from the above, IISc provides an allowance of Rs. 50000 to assist in travel to international conferences.

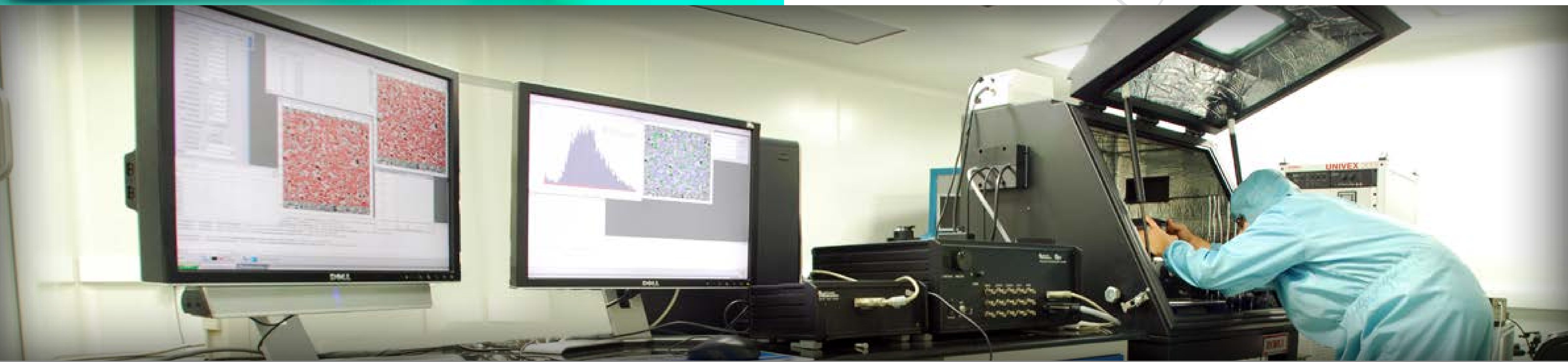
Areas of Research

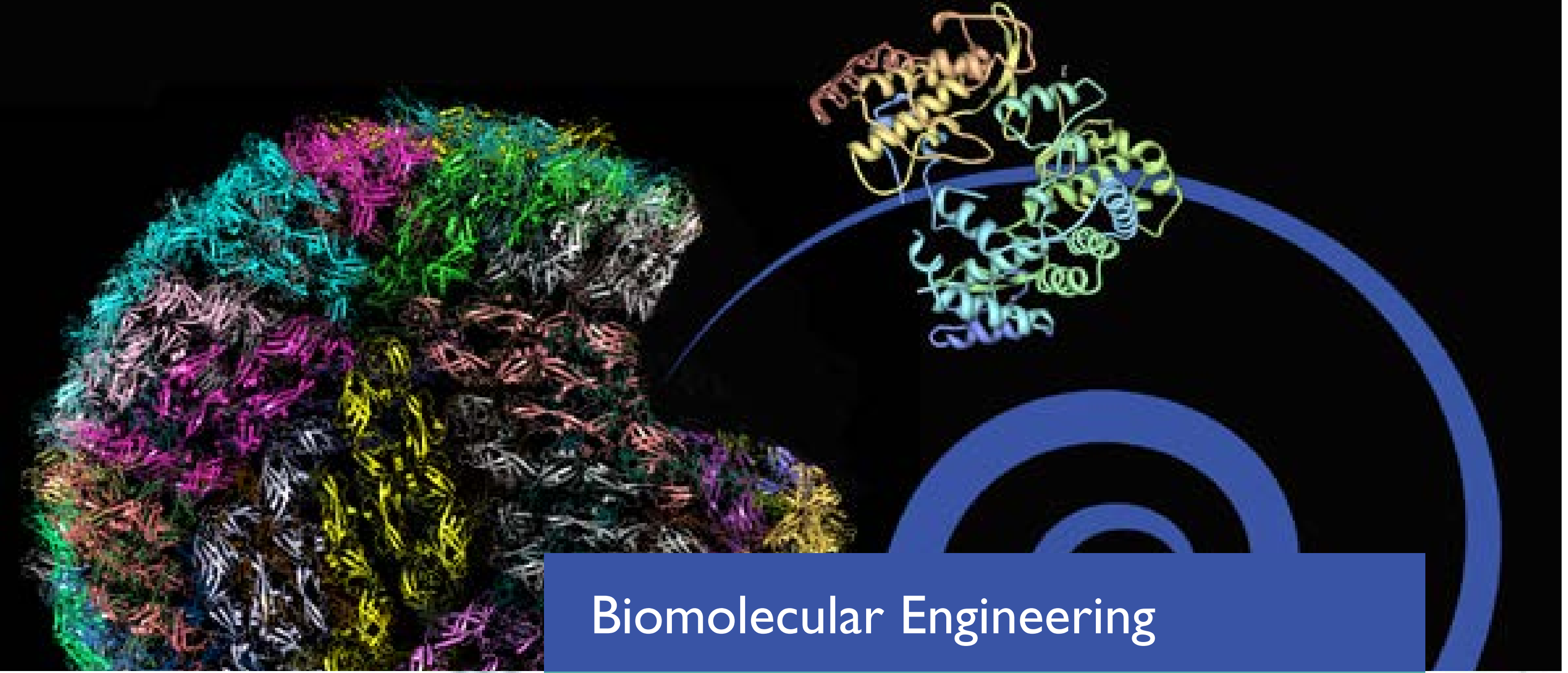
Our research areas include not only the classical topics in Chemical Engineering but also, diverse multidisciplinary areas where most recent and challenging problems are being addressed. Many unsolved problems in various disciplines require substantial knowledge of chemical engineering. Combined with our rigourous course work students are motivated to learn many new topics and thereby enhance their problem solving skills from a scientific and engineering perspective.

Our research areas include:

- Biomolecular Engineering
- Catalysis and Reaction Kinetics
- Colloids and Interfacial Science
- Complex Fluids
- Energy Engineering
- Environmental Engineering
- Nanotechnology
- Thermodynamics, Statistical Mechanics and Molecular Simulations

Faculty	Thermodynamics, Statistical Mechanics and Molecular Computations	Nanotechnology	Environmental Engineering	Energy Engineering	Complex Fluids and Transport Processes	Colloids and Interface Science	Catalysis and Reaction Engineering	Biomolecular Engineering
KG Ayappa	●					●		●
NM Dixit	●						●	●
SK Gupta		●		●		●		
V Kumaran	●				●			
G Madras		●	●	●		●	●	●
JM Modak							●	●
JR Mudakavi			●					
PR Nott					●	●		●
KK Rao			●					
R Roy		●						●
P Sudeep	●	●		●		●		
S Venugopal		●		●		●		





Biomolecular Engineering

Engineering of biological processes from the molecular to the organismal scale is central to addressing key problems in medicine and healthcare as well as energy and environmental sustainability. Our department employs a unique blend of theory, simulations, and experimental techniques for biomolecular engineering. Fully atomistic and coarse grained molecular simulations are being developed to derive fundamental insights into protein interactions underlying disease states, which help identify novel drug and vaccine targets. Sophisticated single molecule spectroscopic experiments have been set up to probe rare molecular interactions within living cells, allowing first-hand observations of events that cause development and disease. Viral infections that are important globally and nationally, such as HIV, hepatitis C, and dengue, are an important focus of our efforts. Modelling and simulations of viral dynamics and evolution coupled with single molecule experiments and data from patients, obtained in collaboration with clinicians, are being employed to unravel the origins of the failure of current treatments and to design more potent and economical therapeutic protocols. Reaction network theory and experiments on quorum-sensing are being used to understand cellular signalling events and emergent systems-level properties that viruses and bacteria manipulate to overcome our immune response, presenting new avenues for vaccine design. Metabolic engineering of bacteria coupled with optimization and control techniques for bioreactors is being exploited to produce biofuels and degrade environmentally harmful effluents and waste. Our efforts thus synergize a broad spectrum of engineering and design techniques to achieve precise manipulation of biological phenomena for improved healthcare and sustainable development.

Catalysis and Reaction Engineering

Developing new catalysts, methods, and processes that deliver efficient and economical ways to carry out chemical transformations encompasses this field. Using knowledge from catalytic chemistry, reaction mechanisms, reaction kinetics, and transport processes, researchers in the department are trying to improve on reactions that span from polymer degradation to biomass conversion in reactors. Significant progress has been made in understanding of polymer polymerization and degradation under various conditions using experimental and kinetic modelling. Other interesting avenues of pursuit are in the development of catalysts for organics degradation and enzymatic catalysis in supercritical carbon dioxide. Similarly, designing and engineering improved steps for nanoparticle synthesis are allowing us to develop new reactors/contactors to control nanoparticle mean size and polydispersity. Efforts are also ongoing to unravel systems level properties of complex cell signalling and transcription networks applying ideas from reaction network theory, with the goal of identifying novel drug targets and outcomes of intervention. Another key theme has been to understand the mineral-microbe interactions that can be utilized for bioprocessing of various industrial materials. Using detailed mathematical models for coupling multiphase transport phenomena and biochemical reaction kinetics in bioreactors, problems in bioleaching of minerals and ores, biological adsorption of toxic metals and biomethanation of biomass are being addressed.

Colloids and Interface Science

A reduction in the length scale of reactors and attempts to create microstructured systems with novel and desired properties have brought in the interplay of colloidal and interfacial interactions to prominence over a broad range of length scales. Our department has earlier contributed richly to the understanding of bubble and drop formation at orifices, foam bed contactors/ reactors, and agitated dispersions.

Researchers are currently engaged in investigating colloidal interfacial behaviour at nano and sub-nano length scales. Synthesis of nanoparticles, nanowires, and nanorods, and formation of arrays and superlattices of nanoparticles for a variety of applications are controlled by manipulation of colloidal interactions and nucleation of a new phase. The formation of monolayers and bilayers and modulation of their properties for lubrication and oral care applications through sub-nanoscale chemical substitutions is another focus area in the department. Current research efforts in the department to store electrical energy efficiently in classical and novel batteries and super-capacitors draw heavily from new materials and interaction entities such as ions, charged surfaces, charged cavities, and charged micro-porous solids. These new storage systems are required to harness power from solar and other renewable resources.

Complex Fluids and Transport Processes

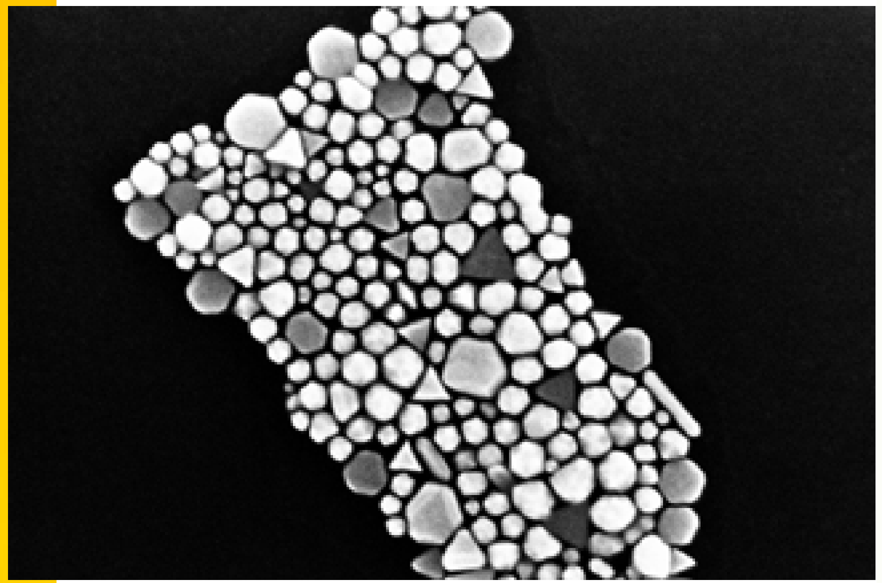
From food grains and processed foods, through industrial products such as paints and mineral slurries, to hygeine and cosmetic products such as toothpaste and lotions, complex fluids are an intimate part of our lives. They range from multi-phase mixtures (e.g., ice-cream, a dispersion of fat globules, ice crystals and air bubbles in an aqueous liquid) to simply a collection of discrete particles (e.g. dry food grains). They are interesting subjects for study because their response to applied forces is more complex than that of "normal" fluids such as water and air. Though diverse in their constitution, there are similarities in important aspects of their behaviour, and also in the tools used for their study. Faculty in our department engaged in studying complex fluids employ a variety of tools: experimentation at macroscopic and microscopic scales, continuum mechanical modelling and computation, and particle-dynamics simulations. We have groups engaged in the study of granular flows, fluidized beds, solid-liquid and liquid-liquid dispersions, and liquid-crystalline mesophases, to name a few. Our tools of experimentation include rheometry, high-speed imaging, confocal microscopy, and the use of soft microchannels for synthesis and mixing of fluids. Our computational tools span length and time scales from study of phenomena at the molecular scale, through mesoscale dynamics and population balances, to continuum mechanical simulations. Through our studies, we hope to achieve two objectives. On one hand, we want to develop materials and design processes required for today's technology and on another, we hope to understand the fundamental physical and chemical processes that underly the dynamics of complex fluids, which in turn will help in the design of newer and novel products and processes of the future.

Nanotechnology

Buoyed by the ever-advancing ability to characterize, control and fabricate materials at the nanoscale, the interdisciplinary field of nanotechnology is becoming pervasive in every aspect of our lives. The potential application areas of nanotechnology range from semiconductor electronics, smart materials, energy solutions to biological diagnostics. Nanotechnology research in our department similarly ranges in its diversity and extends from simulations to understand phenomenon at the nanoscale to the engineering processes for generating nanomaterials and nanoarchitecture.

Researchers are applying molecular dynamics and Monte Carlo simulations to understand structure and dynamics of fluids confined to the nanoscale that are important for developing novel gas storage applications and enhancing our molecular view of wear at the nanoscale. Similarly, population balances approaches are being employed to investigate the role of various mechanisms, such as nucleation, growth, coagulation, capping, and ripening of nanoparticles in influencing particle size distribution to develop better and efficient nanoparticle synthesis methods. Aggregation and 3D nanoparticle array formation is being modeled with thermodynamic and statistical mechanics approaches.

Novel technologies are being pioneered for high throughput synthesis of metal nanoparticles and semiconductor nanowires in large scales. Extending these for generation of functional nanoscale architectures with guided self-assembly to form 2D and 3D superlattices is a key theme of the current work in the department. Researchers in our department are also interested in biological processes at the molecular level to understand underlying mechanisms. Design and characterization of polymers at the nanoscale has led to the development of new materials with unique structure, properties, and functions.



Energy Science and Engineering

The standard of living across the nations is strongly correlated with per capita energy production. Given the limited and finite nature of fossil fuels and the problems associated with the traditional renewable resource such as hydel power, it is imperative to develop technologies to harness and store energy from renewable sources such as solar energy, wind energy, tidal energy, etc. Renewable energy also has an additional advantage of being by and large environment friendly.

In this department, pioneering research is being carried out towards the development of new materials and processes for energy capture and storage. Fundamental work on methane and natural gas storage using novel adsorbents such as metal organic frameworks (MOFs) and covalent organic frameworks (COFs) is currently pursueds using computational tools such as ab-initio electronic structure calculations and classical Monte Carlo simulations. Continuum and molecular modelling studies pursued in the department are helping us in improving the design and performance of rechargeable batteries and super-capacitors. Fundamental work on nanoparticle self-assembly carried out in the department is helping towards development of novel devices that greatly enhance the collection efficiency of solar power.

Environmental Engineering

Research work in our department addresses problems of land, water, and air pollution. Consider the problem of plastic waste that is plaguing many of our cities and towns. We are trying to degrade the polymers in solution, using a variety of techniques. Even though the projects have not covered the last mile between lab and the land, we hope to do so within the next few years.

Several promising photocatalysts have been developed that appear to be good at degrading pollutants in waste water from industries. Similarly, supercritical solvents have been developed for enzymatic reactions to produce compounds that are used in the pharmaceutical and food industries. Efforts has also been focused to develop activated carbon fabric and modified granular activated carbon for the removal of gases such as CO_2, NOx, CO and also Cr and As. Work is in progress to reduce or eliminate foul smell from the sites (landfills) that have been identified by the Corporation of Bangalore. Methods have been developed to determine sub-microgram levels of Mo and Fe in industrial effluents.

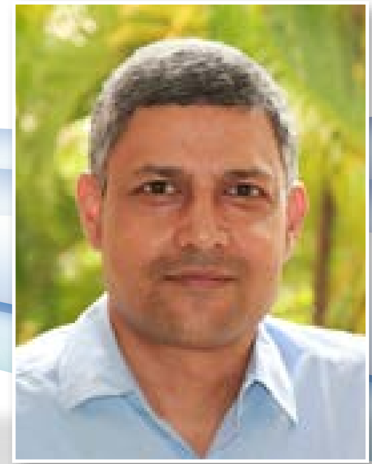
Our major research interests concern engineering and designing of processes and tools for treatment of water from various sources to make them compatible for human consumption or environmental release. One main theme has been defluoridation of drinking water where we have shown how column design and choice of adsorbents are critical to the output water quality. Similarly, we have demonstrated the use a solar still for the treatment of drinking water, rainwater harvesting and efficient disposal of spent analytical reagent can be achieved at the laboratory scale. Similar efforts are being pursued for reuse of greywater and development of inexpensive 'biosand' filters for the rural population.

Thermodynamics, Statistical Mechanics and Molecular Simulations

Understanding phenomenan at the molecular scale allows one to tailor products using a bottom-up approach. We study a wide variety of phenomenon using classical molecular dynamics and Monte Carlo simulations and statistical thermodyamics, which require a knowledge of the forces between the various molecules. This approach provides a molecular understanding of adsorption and separations processes, catalysis, energy storage for transportation, novel drug synthesis protocols, nanoparticle engineering, biomembrane function and transport in complex fluids. Using a variety of molecular simulation techniques, we study transport and phase equilibria of fluids confined to the nanoscale, fluids adsorbed in microporous materials such as zeolites and metal organic frameworks, gas hydrates, structure, dynamics and flows of complex oil-water-surfactant systems and protein biomembrane interactions. With enhanced computing power, molecular simulations are increasingly providing a powerful in silico method to predict properties of a wide variety of engineering systems without resorting to detailed experimentation. Multiscale modelling strategies which bridge molecular level information with continuum transport models that are of direct engineering relevance are also being pursued.

K GANAPATHY AYAPPA

Professor
PhD, University of Minnesota



Research:

Interfaces play an important role in science and technology occurring in solid-liquid, solid-gas as well as more complex systems encountered in surfactant mesophases and biomolecular systems. Research in our group is focused on primarily understanding molecular and physicochemical properties of these interfaces. We use modeling techniques ranging from ab initio methods to study interactions at the electronic scale, molecular modeling to study the atomistic and mesoscale, as well as continuum models to study heat and mass transport. When a fluid is confined to nanometer dimensions or restricted due to the presence of a surface, the structure and dynamics of the fluid are considerably altered. We are interested in understanding the heterogeneous state of this interfacial fluid; solid, liquid or glass. This has implications while developing nanofluidic devices for transport as well as in unraveling forces between surfaces, with implications in understanding friction and lubrication. Fluids confined in microporous materials are important in the area of hydrogen or methane gas storage for transportation and carbon-dioxide capture. Here we use Monte Carlo simulations to assess a wide variety of materials such as zeolites, metal organic frameworks (MOFs) and porous carbons to study their potential as storage materials.

Biological membranes which are a critical component of all living systems is yet another example of a dynamic soft interface. Using a combination of theoretical, simulation and experimental methods, research in this area is focused on understanding the interactions of pore forming toxins and nanoparticles on supported bilayer membrane platforms and living cells. The precise mechanism for pore formation and ensuing effects on the membrane mechanical properties or mechanical stability of cells that undergo lysis is poorly understood. The interactions of proteins and nanoparticles with bilayer membranes have implications in developing novel drug and gene therapies. In collaboration with faculty in biology and physics we study the effects of protein mutagenesis and dynamics of membrane-protein interactions on supported bilayer platforms using high resolution optical microscopy techniques.

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Awards:

Fellow of Indian National Academy of Engineering , 2013

Courses:

CH 201 Chemical Engineering Mathematics
CH 236 Statistical Thermodynamics
CH 247 Introduction to Molecular Stimulations
BE 202 Thermodynamics and Transport in Biological Systems

Publications:

1. A Debnath, P Maiti, KG Ayappa, Simulation of Influence of Bilayer Melting on Dynamics and Thermodynamics of Water, Physical Review Letters, 110, 018303 (2013).
2. V Kandagal, AD Pathak, KG Ayappa, Sudeep Punnathanam, Adsorption on Edge Functionalized Bilayer Graphene Nanoribbons: Assessing the role of Functional Groups on Methane Uptake, Journal of Physical Chemistry C, 116, 23394-23403 (2012).
3. SH Krishnan and KG Ayappa, Glassy Dynamics Under Confinement, Physical Review E, 86, 011504 (2012).
4. A Malani, KG Ayappa, Relaxation and Jump Dynamics of Water at the Mica Interface, Journal of Chemical Physics 136, 194701 (2012).
5. FM Thakkar and KG Ayappa, Melting and Mechanical Properties of Polymer Grafted Lipid Bilayer Membranes, Journal of Chemical Physics, 135, 104901 (2011).

Narendra M Dixit

Associate Professor
PhD, University of Illinois, Urbana-Champaign

Awards:

Young Scientist Medal, Indian National Science Academy, 2010

Associate, Indian Academy of Sciences, 2008-2011

Courses:

CH 242 Special Topics in Theoretical Biology

BE 202 Thermodynamics and Transport in Biological Systems

Publications:

1. P Padmanabhan, U Garaigorta, NM Dixit, Emergent properties of the interferon signaling network may underlie the success of hepatitis C treatment. Nature Communications 5: 3872 (2014).
2. PU Thangavelu, V Gupta, NM Dixit, Estimating the fraction of progeny virions that must incorporate APOBEC3G for suppression of productive HIV-1 infection. Virology 449: 224-248 (2014).
3. K Tripathi, R Balagam, NK Vishnoi, NM Dixit, Stochastic simulations suggest that HIV-1 survives close to its error threshold. PLoS Computational Biology 8: e1002684 (2012).
4. SM Krishnan, NM Dixit, Ribavirin-induced anemia in hepatitis C virus patients undergoing combination therapy. PLoS Computational Biology 7: e1001072 (2011).
5. S Gadhamsetty, NM Dixit, Estimating frequencies of minority nevirapine-resistant strains of HIV-1-infected individuals naïve to nevirapine by using stochastic simulations and a mathematical model. Journal of Virology 84: 10230-10240 (2010).

Research:

Our research focuses on the development of mathematical and computational models of biological phenomena with the goal of improving our ability to combat infectious diseases. Our current focus is on HIV and hepatitis C. These viral infections affect hundreds of millions worldwide. Current treatments often fail and no vaccines exist. The goal of our research is to identify ways of improving the outcomes of current therapies and to devise strategies for the design of new, more potent therapies and vaccines.

The remarkable evolvability of these viruses makes the design of robust drugs and vaccines a challenge. Our recent efforts have been to develop quantitative descriptions of viral evolution using mathematical models and sophisticated computer simulations in order to identify the nature of drugs and vaccines that might exhibit lasting antiviral activity. In collaboration with colleagues in the science departments on campus, we are in the process of optimizing the design of such molecules. A second limitation of current therapies is their severe side effects. Using tools from pharmacokinetics and viral dynamics, we are developing dosing strategies that strike a balance between the antiviral and toxic effects of drugs, potentially enabling personalized medicine and minimizing costs and treatment duration.

At a more fundamental level, our research is focused on understanding how viruses evade our immune system. Our immune responses are orchestrated at multiple levels of hierarchy. Following pathogen recognition, a large series of signaling events suppresses viral replication within infected cells. Subsequently, other arms of our immune system are recruited to eliminate infected cells and viral particles. The immune response also evolves in response to viral evolution. Yet, viruses, using a handful of genes, overcome this remarkable immune machinery. We employ ideas from reaction network theory to understand these virus-host interactions and identify ways to tilt the balance in favor of the host. The resulting insights would lead to guidelines for vaccine design.

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Sanjeev Kumar Gupta

Associate Professor
PhD, Indian Institute of Science

Research:

Our interests span diverse fields in colloidal science and interfacial engineering, ranging from nanoparticle synthesis, microfluidics, turbulent dispersions, foams, process intensification, and energy storage systems. We combine experiments, process modelling, CFD, and the framework of population balances to address problems in these areas. Discrete simulations of small systems and solution technique for population balance equations are other allied interests.

In nanoparticle synthesis, the effort in our group is focussed on developing engineering scale processes for synthesis of metal and inorganic nanoparticles. The route taken is to explore the interplay of nucleation, growth, coagulation, capping, and ripening of nanoparticles in influencing particle size distribution, and ways to externally modulate them to exercise the desired control on mean size and polydispersity. We have unravelled new pathways for nanoparticle synthesis and developed new contactors/reactors outside microfluidics framework for higher throughputs.

Our group has contributed significantly to the understanding of turbulent liquid-liquid dispersion processes, and continues to invest effort in understanding an interesting phenomenon, named phase inversion. At a critical value of dispersed phase fraction, the dispersed phase becomes the continuous phase and vice-versa. We find that the turbulent energy which controls breakup and coalescenec of drops individually has no influence on the critical value and the inversion process goes through an interesting dynamic structure close to the inversion point.

We have a strong interest in energy storage especially in batteries and ultra-capacitors. Our group has recently initiated detailed modelling and experimental efforts to understand and quantify processes at micro level, with the aim to harness the potential of flow batteries and super-capacitors. We use full scale simulations using high performance computing (224 cores XEON E5-2670 cluster) to assist us in our efforts.

We seek to join hands with others to address challenging problems around us: design of small residential buildings for extreme summer and cold in northern parts of India, energy efficient ways to recycle plastic waste in our cities, and hand operated emulsification device.

Awards:

Indian National Science Academy Young Scientist Medal, 1998

Associate, Indian Academy of Science, Bangalore, 1997

P S Narayana Medal, Best Thesis in Mechanical Sciences, IISc, 1993

N R Kuloor Medal, IISc, 1989, 1993

Courses:

CH 233 Interfacial and Colloidal Phenomena

CH 235 Modelling in Chemical Engineering

CH 245 Computational Transport Phenomena

Publications:

1. Siva Rama Krishana Perala and Sanjeev Kumar, On the Mechanism of Metal Nanoparticle Synthesis in the Brust--Schiffrin Method, Langmuir, 45, 203--211 (2013).
2. Kara Zabetakis, William E Ghann, S Kumar, and Marie-Christine Daniel, Effect of high gold salt concentrations on the size and polydispersity of gold nanoparticles prepared by an extended Turkevich–Frens method. Gold Bull. 45, 203-211 (2012).
3 M Girish, S Lakshmanan, KN Sravan, S Venugopal and S Kumar, Effect of Reagent Addition Rate and Temperature on Synthesis of Gold Nanoparticles in Microemulsion Route. Ind. Eng. Chem. Res. 50, 8786-8791 (2011).
4. SS Chauhan, J Chakraborty, and S Kumar, On the solution and applicability of bivariate population balance equations for mixing in particle phase. Chem. Eng. Sci. 65, 3914-3927 (2010).
5. R Reddy, and S Kumar, Dispersal of sticky particles. Europhys. Lett. 80, 56001 (2007).

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V Kumaran

Professor

PhD, Cornell University

Research:

In the broad areas of complex fluids and complex flows, our research interests range from molecular studies (below figure) to macroscopic applications such as microfluidic devices and fuel cells. We employ rigorous theoretical analysis (theorems in non-equilibrium statistical mechanics, kinetic theory, and hydrodynamic stability), complex simulations (rarefied gas flows, lamellar mesophase simulations from molecular to continuum scales, and large scale turbulent particle-gas simulations) and sophisticated experiments (microfluidics, and nano-engineering of catalyst layers) to uncover fundamental phenomena and to demonstrate their potential impact on applications in microreactors, hypersonic transport and energy conversion systems.

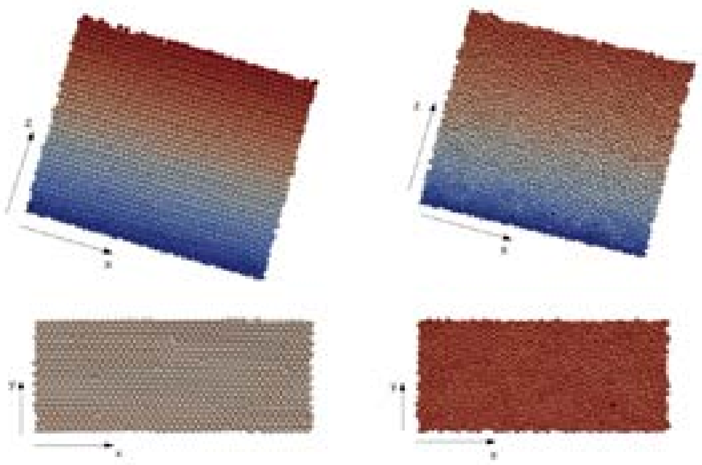

Figure shows a simulation of how granular flow behaviour changes on an inclined plane with respect to particle size ratios. Side view (top) and to view (bottom) of the flow for a ratio of base particle/ flowing particle size 0.61 (a) and 0.62 (b) at an angle of inclination = 21° is shown.

Awards:

Prof. Rustum Choksi award for excellence in research for engineering, 2012

JC Bose National Fellowship, 2007

Fellow, Indian National Academy of Engineering, 2006

Swarnajayanti Fellowship, Government of India, 2002

Fellow, Indian National Science Academy, 2001

Bhatnagar Award, Government of India, 2000

Amar Dye-Chem Award, Indian Institute of Chemical Engineers, 1999

Fellow, Indian Academy of Sciences, 1998

Indian National Academy of Engineering Young Engineer Award, 1997

Indian National Science Academy Young Scientist Medal, 1996

Courses:

CH 203 Transport Processes

CH 232 Physics of Fluids

Publications:

1. V Kumaran and S Bharathraj, The effect of base roughness on the development of a dense granular flow down an inclined plane, Phys. Fluids, 25, 070604 (2013).
2. MKS Verma and V Kumaran, A multi-fold decrease in the transi- tion Reynolds number, and ultra-fast mixing, in a micro-channel due to a dynamical instability induced by a soft wall, J. Fluid Mech., 727, 407-455, (2013).
3. V Kumaran and S Maheshwari, Transition due to base roughness in the dense granular flow down an inclined plane, Phys. Fluids, 24, 053302, (2012).
4. PS Goswami and V Kumaran, Particle dynamics in the channel flow of a turbulent particle-gas suspension at high Stokes number. Parts 1 & 2 J. Fluid Mech., 687, 1-71, (2011).
5. V Kumaran, Fluctuation-dissipation relation for non-linear Langevin equations, Phys. Rev. E, 83, 041126, (2011).

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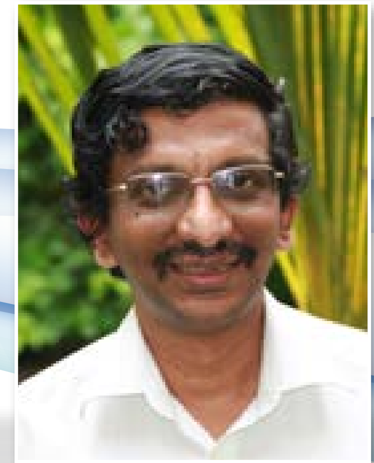
Giridhar Madras

Professor

PhD, Texas A&M University



Research:

Our research group focuses on reaction kinetics, as applied to various systems and processes in the environmental and energy sector. Some of the major focus areas are as follows:

Reaction with Macromolecules

Degradation of plastics in solution is a new process and we are studying the kinetics and degradation rate of various polymers in solution. We have developed continuous distribution kinetic models to determine the rate parameters and the activation energies for polymer degradation from the time evolution of the molecular weight distributions. We have investigated the use of ultrasound, acids, microwaves and UV light as a means for polymerization and degradation. The kinetics of the reactions have been investigated and radical mechanisms are proposed to satisfactorily explain the experimental data. We have also developed new polymers as hydrogels and for use in tissue engineering.

Catalytic Reactions

Our approach is to develop several new materials that are used as catalysts for known reactions. We also propose new reaction pathways/mechanisms providing us with a method to develop new materials with superior properties. In this regard, we have synthesized new materials that work as photocatalysts for the degradation of a wide variety of dyes and organics that are common pollutants in waste water. We have also developed new catalysts for the three way catalysis and CO and hydrocarbon oxidation and proposed new mechanisms governing these reactions. All the catalytic reactions investigated in our studies have applications in the energy and environmental industries.

Reactions and Separations in Supercritical Fluids

Supercritical fluids have proven useful for the processing of biological materials and may provide an attractive alternative solvent for enzymatic catalysis. We are studying the use of lipases for transesterfication, esterification and hydrolysis reactions, which result in products that are used in the pharmaceutical and food industries. We have shown that cheap enzymes may be effectively used to achieve much higher conversions in supercritical carbon dioxide than that obtained in non-aqueous organic media like hexane. We also investigate the solubility and adsorption equilibria of organics in this media and develop new models for correlating the experimental results.

Awards:

Fellow, Indian National Science Academy, 2014

Fellow, Indian National Academy of Engineering, 2014

Fellow, Indian Academy of Sciences, 2014

Among top 1% scientists for more than 5000 citations, Web of Science

Shanti Swarup Bhatnagar award, CSIR, India, 2009

Presidential Swarnajayanthi Fellowship, DST, India, 2006

Scopus Young Scientist, Elsevier, 2006

Courses:

CH 202 Numerical Methods

CH 207 Applied Statistics and Design of Experiments

CH 237 Polymer Science and Engineering

Publications:

1. D Jagadeesan, Y Sundarayya, Giridhar Madras and CNR Rao Direct conversion of calcium carbonate to C1-C3 hydrocarbons RSC Advances, 3, 7224-7229 (2013).
2. VM Shinde, G Madras Synthesis of nanosized Ce(0.85)M(0.1)Ru(0.05)O(2-δ) (M=Si, Fe) solid solution exhibiting high CO oxidation and water gas shift activity. Applied Catalysis B: Environmental, 138-139:51-61 (2013).
3. S Gupta, S Seethamraju, PC Ramamurthy, G Madras Polyvinylbutyral based hybrid organic/inorganic films as a moisture barrier material. Industrial and Engineering Chemistry Research, 52(12):4383-94 (2013).
4. SA Singh, G Madras Photocatalytic degradation with combustion synthesized WO_3 and WO_3-TiO_2 mixed oxides under UV and visible light. Separation and Purification Technology, 105:79-89 (2013).
5. SN Reddy, G Madras Measurement and correlation of quaternary solubilities of dihydroxybenzene isomers in supercritical carbon dioxide. Journal of Supercritical Fluids, 73:63-9 (2013).

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Jayant M Modak

Professor
PhD, Purdue University

Awards:

Fellow, Indian National Academy of Engineering, 2004

Sir C. V. Raman Young Scientist Award, Government of Karnataka, 2004

Biotechnology Process Development Award, Department of Biotechnology, Government of India, 2003

Alexander von Humboldt Research Fellowship, Alexander von Humboldt Foundation, Germany, 1999-2000

Amar Dye Chem award for Excellence in Research, Indian Institute of Chemical Engineers, 1996

P. C. Ray Award, Indian Institute of Chemical Engineers, 1983

G. P. Kane Gold Medal, University of Bombay, 1983

Courses:

CH 246 Advanced Process Control

UG 302 Design Principles for Environmental Engineering

Publications:

1. S Sontakke, C Mohan, JM Modak, G Madras, Visible light photocatalytic inactivation of Escherichia coli with combustion synthesized TiO_2, Chemical Engineering Journal, 189, 101-107 (2012).
2. S Samira, P Akash Raja, C Mohan, JM Modak, Photocatalytic Degradation of Crystal Violet (CI Basic Violet 3) on Nano TiO_2 Containing Anatase and Rutile Phases (3:1), Journal of Thermodynamics & Catalysis, 3: 117 (2012).
3. AR Mandli and JM Modak, Evolutionary Algorithm for the Determination of Optimal Mode of Bioreactor Operation, Industrial & Engineering Chemistry Research 51 (4), 1796-1808 (2011).
4. DN Priya, JM Modak, P Trebše, R Žabar, AM Raichur, Photocatalytic degradation of dimethoate using LbL fabricated TiO_2/polymer hybrid films, Journal of hazardous materials 195, 214-222 (2011).
5. S Sontakke, J Modak, G Madras, Effect of inorganic ions, H_2O_2 and pH on the photocatalytic inactivation of Escherichia coli with silver impregnated combustion synthesized TiO_2 catalyst, Applied Catalysis B: Environmental 106 (3), 453-459 (2011).

Research:

Modelling, Optimization and Control of Bioreactors

Genomic revolution in recent decade has resulted in availability of molecular level information about functioning of the cell. Our research focuses on utilization of such data for quantitative analysis of growth and metabolite production by microbial systems. In recent years, our work is focused on methylotrophic yeast, *Pichia Pastoris*, an industrially important recombinant protein expression system. We have investigated the secretion of number of growth hormones and developed a modelling framework suitable for engineering analysis of such systems. Microorganisms are often thought of as ultimate optimal machines and our research attempts to understand the growth behavior of microorganisms using the principles and tools of control theory.

Optimal design and control of fermentation processes is a challenging and dynamic control problem. Our research in this area focuses on developing computationally efficient algorithms, which combine the rigor of optimal control theory and advanced search techniques such as genetic algorithms. Our interest is to address optimal control problems, which are characterized by their multiple performance measures, such as, yield and productivity of the bioreactor. These measures are often non-commensurable and competing with each other.

Computation Fluid Dynamics has emerged as an important tool for understanding of mass-energy-momentum interactions in multiphase reactors. One of the research area of interest to us is extending the application of CFD to enhancing the understanding of biotic-abiotic interactions in bioreactors. We are investigating several systems such as anaerobic wastewater treatment processes and photo-bioreactors for algal growth.

Advanced Waste Water Treatment

Photocatalysis is an advanced oxidation process, which has shown to possess an enhanced capability to remove a wide range of contaminants from aqueous effluents. We are interested in using novel photocatalysts for inactivation of microorganisms as well as exploring the potential of photocatalysis in reduction reactions.

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Faculty - Academic

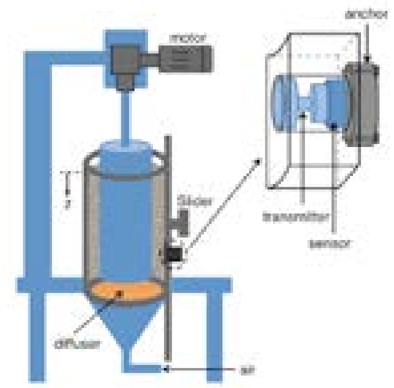
Prabhu R Nott

Professor and Chairman
PhD, Princeton University

Research:

I am interested in the mechanics of complex fluids, such as dry granular materials (food grains, pharmaceutical powders, etc.) and particle-fluid suspensions (slurries, paints, etc.). Understanding their flow and dynamics is of tremendous practical benefit, as they occur in many industrial processes and natural phenomena. Moreover, they pose interesting scientific challenges. We try to build reliable continuum mechanical descriptions, and test them by conducting simple yet probing experiments and particle dynamics simulations. We try to achieve an understanding of the macroscopic behaviour by relating them to phenomena at the microscopic scale.

Another interest I have is on the collective dynamics of swimming microorganisms. This started as a fluid mechanical problem of the collective behaviour of Stokesian swimmers that interact purely by hydrodynamic (physical) interactions, but very soon I realized that even the most primitive microorganisms communicate by an elaborate (biological) signalling apparatus. We are now studying the interplay between signalling and motility, and to the collective phenotypic changes that occur over longer time-scales. In collaboration with Dr. Deepak Saini, I aim to develop a quantitative understanding of how signalling affects motility, how the two are related to the phenomenon of quorum sensing, and lead ultimately to the formation of biofilms. Such an understanding has significant technological value, as microbial biofilms are thought to be responsible for many infections, and resist the action of antibiotics by building a thick polysaccharide coat.



Schematic of our cylindrical Couette rheometer for granular materials. The novelty of the apparatus is the three-axis force sensor that is mounted on a vertical slider, enabling the measurement of all components of the traction on outer cylinder as a function of the depth.

Courses:

CH 206 Seminar Course

CH 243 Mechanics of Particle Suspensions

CH 234 Mechanics of Granular Materials

Publications:

1. KJ Gutam, V Mehandia, B Venkatesh, & PR Nott, The stress in sheared granular columns: anomalous profile due an anisotropic microstructure, Phys. Fluids, 25 (5), (2013).
2. V Mehandia, KJ Gutam & PR Nott, Anomalous stress profile in a sheared granular column, Phys. Rev. Lett. 109, 128002, (2012).
3. G Subramanian & PR Nott, The fluid dynamics of swimming microorganisms and cells, J. Indian Inst. Sci. 91 (3), 383–414 (2011).
4. PR Nott, Boundary conditions at a rigid wall for rough granular gases, J. Fluid Mech. 678, 179–202, (2011).
5. PR Nott, E Guazzelli, and O Pouliquen, The suspension balance model revisited, Phys. Fluids, 23, 043304, (2011).

Books:

1. Rao, KK and Nott, PR An introduction to granular flow, Cambridge University Press (2008).

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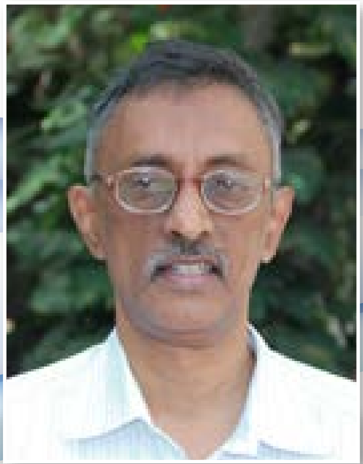
K Kesava Rao

Professor
PhD, University of Houston



Awards:

Fellow, Indian Academy of Sciences, 1992

Courses:

CH 205 Chemical Reaction Engineering

CH 244 Treatment of Drinking Water

Publications:

1. L Anjaneyulu, EA Kumar, R Sankannavar, and KK Rao, Use of a solar still for defluoridation of drinking water and rainwater harvesting, Ind. Eng. Chem. Res. 51, 8040-8048, (2012).
2. R Balakrishnan, R Sankannavar, and KK Rao, A mechanism for the occurrence of ions in distilled water, Ind. Eng. Chem. Res. 50, 13202-13209, (2011).
3. Rohit, L Kanwar, and KK Rao, A low-cost portable colorimeter for the estimation of fluoride in drinking water, Sensors and Actuators B, 149, 245-251, (2010).
4. ML Dhoriyani, KK Jonnalagadda, RK Kandikatla, and KK Rao, Silo music: sound emission during the flow of granular materialsthrough tubes, Powder Techol. 167 55-71, (2006)

Books:

1. Rao, KK, and Nott, PR, An Introduction to Granular Flow, Cambridge University Press (2008).

Research:

Our major research interests concern engineering and design of processes and tools for treatment of water from various sources to make them compatible for human consumption or environmental release. One main theme has been defluoridation of drinking water where we have shown how column design and choice of adsorbents are critical to the output water quality. Our studies showed that the surface of the activated alumina pellets undergoes changes upon pre-soaking with deionzied water, possibly caused by a phase transition from boehmite to gibbstie. We demonstrated a strong effect of pre-soaking and column diameter on the volume of treated water obtained from column experiments.

On another front, we have demonstrated the use a solar still for the treatment of drinking water, rainwater harvesting, and efficient disposal of spent analytical reagent at the laboratory scale. Water samples distilled in an inclined-basin solar still displayed successful reduction of total dissolved solids, total hardness, calcium hardness as well as fluoride levels to within the desirable limits for drinking water. Rainwater harvested from the upper surface of the still had water quality parameters comparable to those of bottled water, but the amount of total dissolved solids was much lower. Concerns with the water odour were successfully addressed by replacing sand layer with activated carbon. We are also interested in the reuse of greywater discharged from washing machines for flushing toilets.

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Rahul Roy

Assistant Professor
PhD, University of Illinois, Urbana-Champaign

Research:

How do events taking place at the molecular level translate to biologically significant phenomena?
We develop single molecule and nanoscopic optical imaging techniques to understand this basic question. Using highly sensitive detection of single biological macromolecules like proteins or nucleic acids by both optical and non-optical methods, we determine the molecular behaviour at the single molecule level as well as its distribution at the population level. Our research interest spans from self-assembly of viral particles to the dynamics of RNA dependent RNA Polymerase.

Viral Self Assembly

Virus particle generation is a classical example of self-assembly which is amenable to targeting by drugs. However, in absence of quantitive assays that probe kinetics of the assembly process and its dependence on the role of parameters like pH, salt concentration and protein-nucleic acid allostery, we have seen limited progress made for anti-virals against the viral structural proteins. Our goals here are

a) to develop techniques that allow characterization of structural dynamics of macromolecular assemblies at the nanometer scale with sub-second time resolution.
b) to probe the Dengue virus capsid assembly at the single virus level in real-time and probe the role of protein-nucleic acid allostery.

Single Molecule RNA Polymerase Dynamics in Living Cells

Mechanistic understanding of the viral replication process by RNA dependent RNA Polymerases (RdRPs) inside the cells is complicated as it is inherently stochastic. It initiates from a small number of single stranded (ss)RNA molecules (sometimes just one) during its initial phase (i.e. during negative strand synthesis). Complexity further increases as RdRP compartmentalizes in membrane-bound heterogeneous structures for positive strand synthesis from double stranded RNA. Furthermore, RdRP regulation arises from phosphorylation, structural changes or transient interactions with other viral/host proteins that generates a heterogeneous population of replication complexes. It is unclear how such diverse phases of replication are regulated to ensure efficient replication during the infection cycle. To address these issues, we are developing spectroscopic and imaging tools to study inter-molecular and intra-molecular dynamics in living cells with single molecule sensitivity.

Awards:

Wellcome Trust - DBT India Alliance Intermediate Fellowship, 2013

Innovative Young Biotechnologist Award, Department of Biotechnology, India, 2013

Jane Coffin Childs Memorial Post Doctoral Fellowship, 2008-2011

Courses:

CH 205 Chemical Reaction Engineering

CH 248 Molecular Systems Biology

Publications:

1. ZW Zhao, R Roy, JCM Gebhardt, DM Suter, AR Chapman and S Xie, "Spatial organization of RNA polymerase II inside a mammalian cell nucleus revealed by reflected light-sheet super-resolution microscopy" PNAS (USA), 111(2):681-6 (2014).
2. JCM Gebhardt, DM Suter, R Roy, ZW Zhao, AR Chapman, S Basu, T Maniatis and S Xie, Single-molecule imaging of transcription factor binding to DNA in live mammalian cells. Nature Methods, 10(5):421-6 (2013).
3. R Zhou, A Kozlov, R Roy, J Zhang, S Korolev, T Lohman and T Ha, SSB Functions as a Sliding Platform that Migrates on DNA via Reptation. Cell, 146(2): 222-32 (2011).
4. G Tang, R Roy, T Ha and S Patel, Kinetics of Transition to Elongation Phase by T7 RNA Polymerase. PNAS (USA), 106(52): 22175-80 (2009).
5. R Roy, A Kozlov, T Lohman and T Ha, Rolling Migration of SSB Stimulates RecA Filament Formation. Nature, 461(7267): 1092-7 (2009).

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rahulroy@chemeng.iisc.ernet.in

SUDEEP N PUNNATHANAM

Assistant Professor
PhD, Purdue University

Courses:

CH 206 Seminar Course
CH 204 Thermodynamics
CH 247 Introduction to Molecular Simulations

Publications:

1. SR Ganagalla and SN Punnathanam, Free Energy Barriers for Homogeneous Crystal Nucleation in a Eutectic System of Binary Hard Spheres, J. Chem. Phys., 138, 174503, (2013)
2. G Pavaskar and SN Punnathanam, Determination of Favorable Inter-Particle Interactions for Formation of Substitutionally Ordered Solid Phases from a Binary Mixture of Oppositely Charged Colloidal Suspensions, J. Chem. Phys., 138, 174504, (2013)
3. G Pavaskar, S Sharma and SN Punnathanam, Effect of Charge Asymmetry and Charge Screening on Structure of Superlattices Formed by Oppositely Charged Colloidal Particles, J. Chem. Phys., 136, 134506, (2012)
4. S Ravipati and SN Punnathanam, Analysis of Parameter Values in the van der Waals and Platteuw Theory for Methane Hydrates Using Monte Carlo Molecular Simulations, Ind. Eng. Chem. Res., 51, 9419, (2012).
5. VS Kandagal, A Pathak, KG Ayappa and SN Punnathanam, Adsorption on Edge-Functionalized Bilayer Graphene Nanoribbons: Assessing the Role of Functional Groups in Methane Uptake, J. Phys. Chem. C, 116, 23394, (2012)

Research:

The research in our group is directed towards understanding the relationship between macroscopic thermodynamic behavior and microscopic interactions using the principles of statistical mechanics. The physical insights gained from such studies can help us in developing molecular theories to determine thermodynamic properties. They also aid in the development of molecular models to predict bulk behavior using molecular simulations. Our current focus is on understanding solid-fluid equilibrium in nanoparticle suspensions, thermodynamic behavior of gas-hydrate systems, thermodynamics of adsorption in microporous materials such as zeolites and metal-organic frameworks (MOFs), and molecular modelling of electric double layer super capacitors. The primary tools used in our research include molecular simulations (both Monte Carlo and molecular dynamics) and density functional theories.

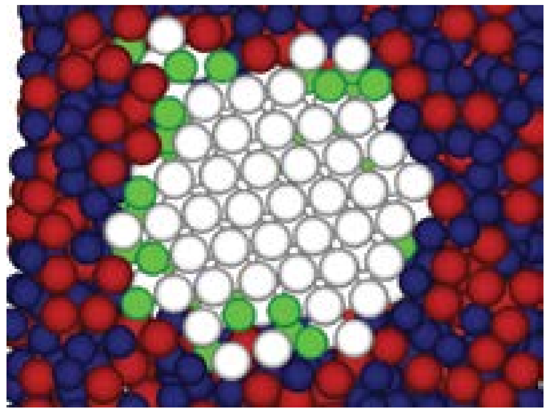

Figure shows a plane cut through the critical nucleus of a eutectic system of binary hard spheres. The hexagonal ordering of a 111 crystal plane, particle A (white) and particle B(green) is evident in the cluster.

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FACULTY - ACADEMIC

S VENUGOPAL

Assistant Professor
PhD, Purdue University

Research:

An underlying theme of research activities in our group is the development of a process engineering toolkit that will enable the use of metal nanoparticles as building blocks for applications in the fields of sensing, energy conversion, and nanoelectronics. We have developed a scalable process for the formation of robust arrays of metal nanoparticles on any desired substrate. This has aided in the fabrication of several devices such as floating gate memory devices, flexible SERS (Surface Enhanced Raman Scattering) substrates and PEMFC (Proton Exchange Membrane Fuel Cell) catalyst layers. Currently, we are working on fabricating chemiresistive sensors and nanowire array based photoelectrodes for DSSCs. Furthermore, a room-temperature process for the synthesis of monodisperse metal nanoparticles in colloidal form was developed and patented. Based on the insights gained, we are now working on novel reactor designs for high-throughput, continuous flow synthesis of monodisperse metal nanoparticles. We have also discovered a simple process for fabricating conductive electrodes on paper using an office inkjet printer. Presently, we are working on utilising such conductive films to develop low-cost products for water filtration, medical diagnostics and ubiquitous sensing.

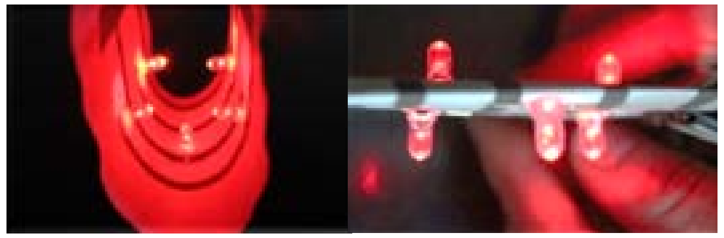

Figure shows five LEDs "stapled" onto a conductive electrode circuit printed on paper. A 700 nm thick layer of silver nanowires was deposited using a commercial office inkjet printer.

Awards:

Humboldt Research Fellowship for Experienced Researchers, 2013-14

Associate, Indian National Academy of Sciences, 2009

Publications:

1. SK Sivaraman, and V Santhanam, " Realization of thermally durable close-packed 2D gold nanoparticle arrays using self-assembly and plasma etching", Nanotechnol. 23, 255603 (2012).
2. G Muralidharan, Navakanta Bhat, and V Santhanam, " Scalable processes for fabricating non-volatile memory devices using self-assembled 2D arrays of gold nanoparticles as charge storage nodes", Nanoscale, 3 (11), 4575-4579 (2011).
3. SK Sivaraman, Sanjeev Kumar, and V Santhanam, " Monodisperse sub-10 nm gold nanoparticles by reversing the order of addition in Turkevich method - The role of chloroauric acid", J. Colloid Interf. Sci. 361 (2), 543-547 (2011).
4. G Muralidharan, SK Sivaraman, and V Santhanam, " Effect of substrate on particle arrangement in arrays formed by self-assembly of polymer grafted nanoparticles", Nanoscale, 3 (5), 2138-2141 (2011).

Patent:

1. V Santhanam, SK Sivaraman, "Methods for preparing metal and metal oxide nanoparticles", US 8361188

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J R Mudakavi
Principal Scientific Officer
PhD, IIT Madras

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Research:

My major interests lie in environmental pollution control and determination of trace and ultra trace metal ions and organics in environmental samples. We have developed activated carbon fabric (ACF) and modified granular activated carbon materials (MOGAC) for the respiratory masks that are widely applicable for many gases. The technology has been transferred to HEG Limited, Bhopal and is now in commercial production. MOGAC are also useful in removing toxic heavy metals like chromium, arsenic, lead and anions such as fluoride and nitrates. Using MOGAC a continuous adsorption process has been developed for the removal of chromium. We are also exploring the use of activated alumina for the removal of fluoride from the RO rejects.
Our other research areas include effluent characterization of the effluent and generation of energy from the desiccated coconut industry. We have demonstarted for the first time that coconut wash water and coconut water can be successfully combined for anaerobic digestion that generates enough methane with good calorific value. Another active research front is the reduction of foul smell from the landfill sites that have been identified by the Bangalore Metropolis. We are also developing green analytical methods for the determination of sub-microgram levels of Mo and Fe in industrial effluents.

Awards:
Best engineering material award for the development of activated carbon fabric
Rashtriya Gourava prashasti for achievements in Research and Education

Courses:
CH 239 Modern Instrumental Methods of Analysis

Publications:
1. JR Mudakavi, BV Narayana, and R Kiran, Characterization and utilization of iron rich dry ash from an electric arc furnace. Curr. Sci. 76, 473-475, (1999).
2. JR Mudakavi and BV Narayana, Toxic heavy metal contamination of the soil and biota: part 2: Environmental considerations, Ind. J. of Environ. Protect. 18, 101-108, (1998).
3. B Welz, G Schlemmer, and JR Mudakavi, Palladium nitrate - magnesium nitrate modifier for electrothermal furnace atomic absorption spectrometry. Part 5: Performance for the determination of 21 elements, J. of Anal. Atomic Spectrometry 7, 1257-1271, (1992).
4. B Welz, G Schlemmer, and JR Mudakavi, Palladium nitrate - magnesium nitrate modifier for electrothermal furnace atomic absorption spectrometry. Part 3: Determination of mercury in environmental standard reference materials, J. of Anal. Atomic Spectrometry 7, 499-503 (1992).
5. JR Mudakavi, Spectroscopic determination of traces of mercury with 1,10-phenanthroline and eosine, Analyst 11 (1983).

Books:
1. JR Mudakavi, Principles and practices of Air pollution control and analysis, I.K.International Publishing House Pvt. Ltd., New Delhi (2010).
2. JR Mudakavi, G V Gore, Hazardous waste management, ISTE Publication, Bangalore (2006).

P T Raghuram
Senior Scientific Officer
MSc (Engg), IISc

Ph: +91 80 2293 2319
ptr@chemeng.iisc.ernet.in

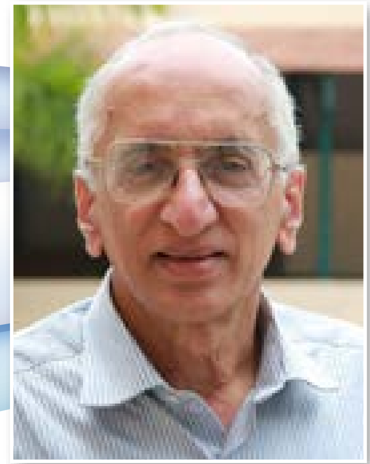
Research:

I have major interests in gas liquid reactions in Ejector systems. Using experiments and modelling, we have designed and analysed ejector systems for bubble size, holdup and interfacial area. Criticality of bubble size is investigated in detail using high speed photography and image analysis.

Another of my interests lie in demonstration of experiments to students. Simple experiments are set up to enable students to understand the fundamentals and develop an interest in research. Some of these include silo music, flow of sand and water from bottles, putt-putt boat, bands in a rotating cylinder of sand containing particles of two sizes.

Awards:
Best Paper Award in Chemcon, Trivandrum, India, 1989

Publications:
1. PT Raghuram and TB Suneetha, Bubble size measurement and error analysis in a gas liquid ejector. Indian Journal of Chemical Technology, 19,442-446, (2012).
2. PT Raghuram, Interfacial area measurement in a gas-liquid ejector for a sodicum chloride - air system. Indian Journal of Chemical Technology, 16, 278-282 (2009).
3. PT Raghuram and TR Das, Holdup measurement in a gas-liquid ejector for a sodium chloride-air system. Indian Journal of Chemical Technology 13, 144-148, (2006).
4. PT Raghuram and TR Das, Bubble size measurement in a gas-liquid ejector for a Sodium chloride-Air system. J. Chem. Engg. of Japan. 35, 389-392 (2002).
5. PT Raghuram and KK Rao, Serendipity in the development of demonstration experiments Phys. Edu., U K 31, 313-320, (1996).



M S Ananth
Visiting Professor
PhD, University of Florida

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Research:

Mathematical modelling and Molecular Thermodynamics

Self-consistent theory of liquids: An exact theory for the radial distribution should lead to the same equation of state from both the 'pressure' and 'compessibility' equations. However all theories for g(r) are approximate and fail to do so. Our current research attempts to develop a systematic approach to correct this anamoly.

The Gibbs-Tolman theory derives a way of predicting surface tension of liquids from equation of state information. Our current research (jointly with Dr. Kesava Rao) extends this approach to liquid mixtures and attempts to derive universal correlations.

Awards:
Herdillia award for excellence in basic research in chemical engineering, IIChE, 1994
Fellow, Indian Institute of Chemical Engineers, 1994
Fellow, Indian National Academy of Engineering, 1999

Courses:
CH 236 Statistical Thermodynamics

Publications:
1. MS Ananth, THE NATIONAL PROGRAMME ON TECHNOLOGY ENHANCED LEARNING, International Engineering Education Proceedings, 71-77, (2009).
2. MS Ananth, 'Indian Science and Technology Parks' in 'Understanding Research, Science and Technology Parks: Global Best Practices', Report of a Symposium, The National Academic Press, Washington DC, 61-66 (2009).
3. KV Narayanan and MS Ananth, A modified SCLC model for the thermodynamic properties of single & mixed electrolytes, Fluid Phase Equilibria, 114, 89-121 (1996).

Professor - Retired

K S Gandhi
Professor (Retired)
PhD, University of California, Berkeley

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Research:

Modelling of electrochemical power sources, specially lead-acid batteries, lithium ion batteries and fuel cells, is the focus my research. Performance of fuel cells and batteries depends upon a balance of electrocatalytic properties of electrodes, ionic and electronic resistance of electrodes and electrolyte, and diffusion of active ingredients participating in the electrochemical conversion reactions that generate power. Apart from this, management of thermal effects and electrolyte distribution are some other important factors that determine performance. Batteries have a finite life since electrodes, which are porous, degrade. Degradation could be due to several causes. Some of them are: mechanical failure caused by fatigue, alteration of the porous structure which prevents access to reactive materials and regeneration of reactive materials during charging cycles outside electrodes. I use mathematical modelling to address these issues as it can be a powerful tool for design, and diagnostics of performance as well as degradation.

Awards:
Dr B P Godrej Life Time Achievement Award, 2011
Fellow, Indian National Academy of Engineering, 2003
Fellow, Indian Academy of Science, 1990

Courses:
CH 245 Computational Transport Phenomena

Publications:
1. KS Gandhi, Use of Fick's Law and Maxwell--Stefan Equations in Computation of Multicomponent Diffusion A.I.Ch.E. Journal 58(11), 3601-05, (2012).
2. KS Gandhi, Storage of electrical energy. Indian Chemical Engineer, 52(1), 51-75, (Text of Prof HL Roy memorial lecture delivered in CHEMCON 2009, Visakhapatnam) (2010).
3. KS Gandhi, Modelling of freezing phenomena induced by chemical reactions Ind. Engg Chem. & Res 48(21), 9755-9762, (2009).
4. KS Gandhi, AK Shukla, SK Martha, and SA Gaffoor, Simplified mathematical model for effects of freezing on the low-temperature performance of the lead-acid battery. J. Electrochem. Soc. 156(3), A238-A245, (2009).
5. Sanjeev Kumar, KS Gandhi, and R Kumar, Modelling of formation of gold nanoparticles by Citrate Method. Ind. Engg Chem. & Res 46, 3128-3136 (2007).

Books:
1. KS Gandhi, Heat & Mass Transfer: A Transport Phenomena Approach, 1st Ed., New Age Publishers, Delhi (2011)

M CHANDA

Emeritus Professor
PhD, Indian Institute of Science

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Research:
Polymer science and technology
Ion-exchange technology
Waste water treatment
Solar desalination

Awards:

I.E.L. Award for Excellence in Process Development from the Indian Institute of Chemical Engineers, 1988

International Scientific Exchange Award from National Sciences and Engineering Research Council of Canada, 1980, 1982, 1983, 1985,1988, 1990, 1992

Fellow, Indian National Academy of Engineering, 1992

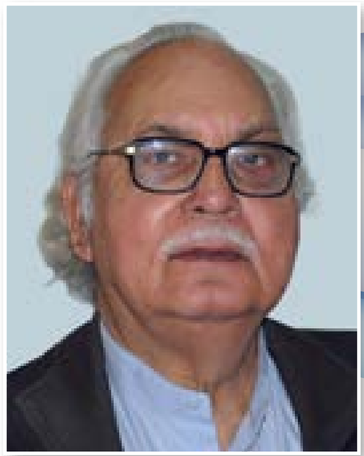
Biographical sketch in Marquis Who's Who in the World, Millennium Edition, 2000, American Biographical Society

Publications:

1. M Chanda, A Sarkar and JM Modak, Ethoxylated polyethylenimine gel-coated on textile-grade acrylic fiber: a thermally regenerable superfast sorbent for water desalination. J. Appl. Polym. Sci. 93, 883-893, (2004)
2. M Chanda and G L Rempel, A superfast sorbent based on textile-grade polyacrylonitrile fiber/fabric: rapid removal of uranium from mildly acidic aqueous solutions of low concentration. Ind. Eng. Chem. Res. 42, 5647-5655, (2003).
3. M Chanda and G L Rempel, A new method of gel-coating polyethylenimine (PEI) on organic resin beads: high capacity and fast kinetics of PEI gel-coated on polystyrene. Ind. Eng. Chem. Res. 40, 1624-1632, (2001).
4. M Chanda and G L Rempel, A gel-coated ion-exchange resin: a new kinetic model. Chem. Eng. Sci. 54, 3723-3733, (1999)
5. S Naskar, SA Pillai, and M Chanda, Photocatalytic degradation of organic dyes in aqueous solution with TiO2 nanoparticles immobilized on foamed polyethylene sheet. J. Photochem. Photobiol. A 113, 257-264, (1998).

Books:

1. M Chanda Introduction to Polymer Science and Chemistry: A Problem-Solving Approach, 2nd Ed. CRC Press Taylor & Francis Group (2013)
2. M Chanda and SK Roy, Plastics Technology Handbook, 4th Ed., CRC Press Taylor and Francis Group (2007)



RAJINDER KUMAR

Honorary Professor
PhD, Punjab University

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Research:
Multiphase phenomena
Dispersion of fluids in liquids from submerged nozzles
Engineering analysis of foam beds
Analysis of turbulent stirred dispersions
Bio-leaching of copper from lean ores
Multicomponent Precipitation involving small systems
Analysis of sonochemical reactors

Awards:

Padma Bhushan awarded by President of India, 2003
Prof NR Das memorial lecture, NASc, 1997
Shanti Swarup Bhatnagar Award, INSA, 1997
Jawaharlal Nehru Birth Centenary Visiting Fellowship, INS, 1995
FICCI Award for Physical Sciences, 1994
Alumni Award for excellence in Research in Engineering, Indian Institute of Science, 1991
Shri Om Prakash Bhasin Award for Engineering, 1991
Syed Hussain Zaheer Medal for Engineering and Technology by INSA, 1989
Dr. KG Naik Gold Medal given by M.S.University of Baroda, 1988
Vasvik Award, 1986
Herdilia Award for `Excellence in Basic Research', given by IIChE, 1985
Bhatnagar Prize for Engineering Sciences, given by CSIR, 1976
Fellow, Indian National Academy of Engineering, Indian Academy of Sciences, Indian National Science Academy

Publications:

1. R Bandyopadhyaya, R Kumar and KS Gandhi, Modelling of CaCO3 nanoparticle formation during overbasing of lubricating oil additives. Langmuir 17, 1015-1029 (2001).
2. R Bandyopadhyaya, R Kumar and KS Gandhi, Simulation of precipitation reactions in reverse micelles. Langmuir 16, 7139-7149 (2001).
3. D Niyogi, R Kumar and KS Gandhi, Water blown free rise polyurethane foams. Polym. Engg. Sci. 39, 199-209 (1999).
4. S Kumar, V Ganvir, C Satyanand, R Kumar and KS Gandhi, Alternative mechanisms of drop breakup in stirred vessels. Chem. Eng. Sci. 53, 3269-3280 (1998).
5. R Rajan, R Kumar and KS Gandhi, Modelling of sonochemical oxidation of CCl4 in aqueous solutions Environ. Sci. Tech. 32, 1128-1133 (1998).

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Junior Scientific Assistant
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NARAYANAPPA
Upper Division Clerk
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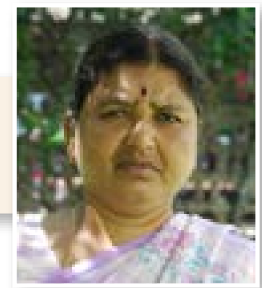
MAHADAVAPPA S
Mechanic

DODDARANGAIAH M
Mechanic

MAHADEVA RAO
Helper

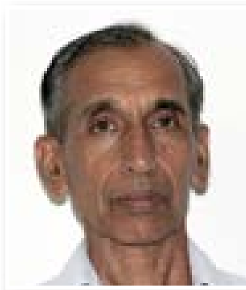


MUNI LAKHSMAMMA
Housekeeping

OTHER STAFF

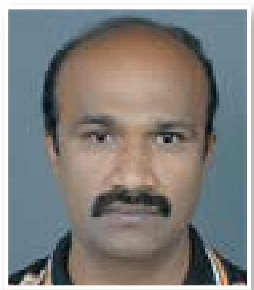
KALA

ASHWINI



PUTTANNA

DEEPAK



VENKATA

Courses

CORE COURSES

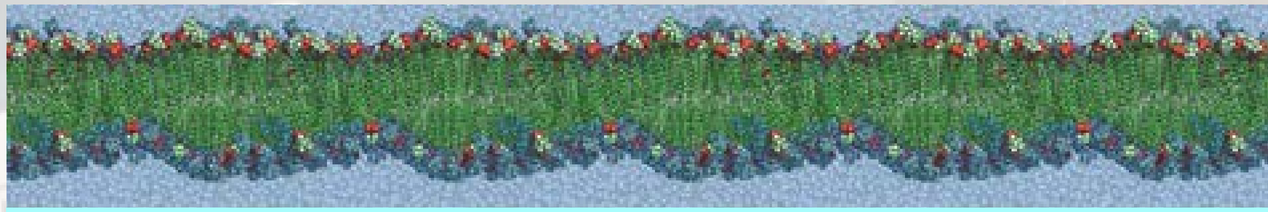
CH 201	3.0	Chemical Engineering Mathematics
CH 202	3.0	Numerical Methods
CH 203	3.0	Transport Processes
CH 204	3.0	Thermodynamics
CH 205	3.0	Chemical Reaction Engineering
CH 206	1.0	Seminar Course
CH 207	1.0	Applied Statistics & Design of Experiments
CH 299	32.0	Dissertation Project

ELECTIVES

CH 232	3.0	Physics of Fluids
CH 233		Interfacial and Colloidal Phenomena
CH 234	3.0	Mechanics of Granular Materials
CH 235	3.0	Modelling in Chemical Engineering
CH 236	3.0	Statistical Thermodynamics
CH 237	3.0	Polymer Science and Engineering
CH 239	3.0	Modern Instrumental Methods of Analysis
CH 242	3.0	Special Topics in Theoretical Biology
CH 243	3.0	Mechanics of Particle Suspensions
CH 244	3.0	Treatment of Drinking Water
CH 245	3.0	Computational Transport Phenomena
CH 248	3.0	Molecular Systems Biology

Conferences and Workshops

The Department of Chemical Engineering and ChemE professors frequently organize international/national conferences and workshops in coordination with other units. The diversity and breadth of the meetings and its participants reflects the diverse interests of the department researchers. They provide a platform for leading national and international researchers to come together and also germinate successful international collaborations.



INDO-US Symposium On Structure, Dynamics & Mechanics of Biological Membranes

at Indian Institute of Science, Bangalore, December 29-31, 2012

http://chemeng.iisc.ernet.in/biomem/index.html

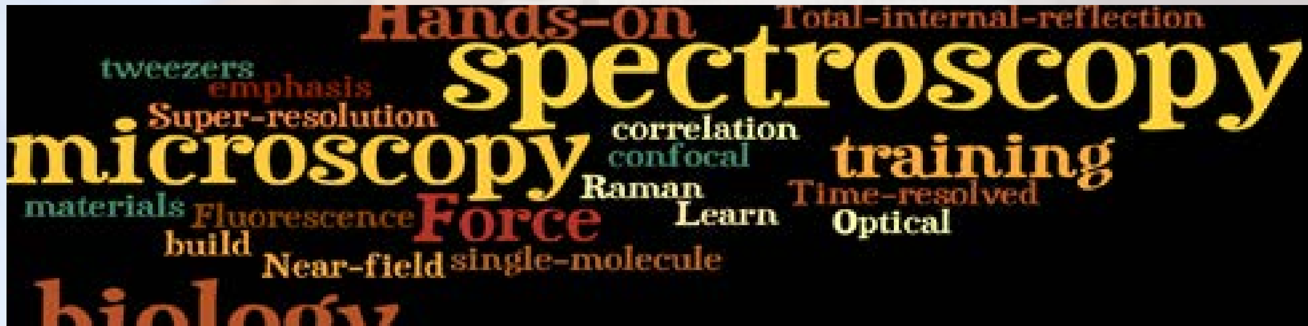
The underlying relationships between the structure, dynamics, and mechanics of biological membranes were discussed by scientists from U.S.A. and India engaged in cutting-edge research in the fundamental and applied aspects of bio-membrane research.

International Conference on Population Balance Modelling PBM 2013

at Indian Institute of Science, Bangalore, September 11-13, 2013

http://chemeng.iisc.ernet.in/pbm2013/

Researchers interested in using population balance modelling and its application to disease progression, understanding of biological systems, mining, control of wastewater treatment, nanoparticle synthesis processes, and chemical processing industry came together. More complex systems, solution and simulation strategies, mono and multivariate size distribution dependent model based control actions were discussed over three days.



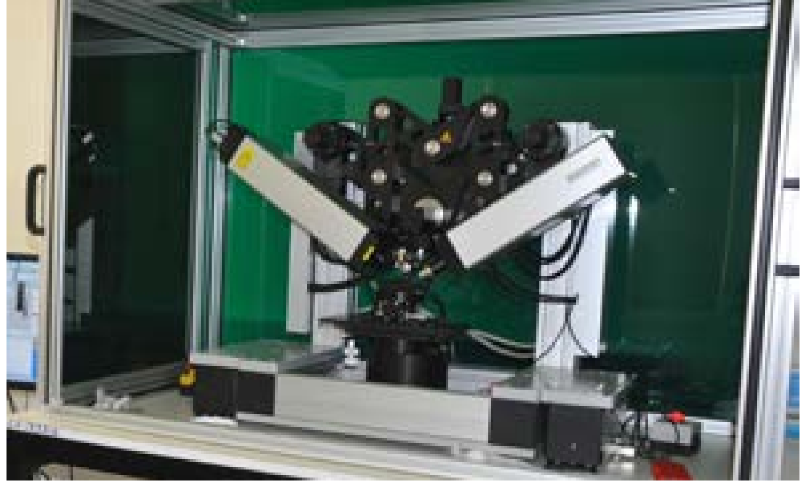
National Fluorescence Workshop FCS 2013

at Indian Institute of Science and Jawaharlal Nehru Centre for Adanced Scientific Research, Bangalore
November 24-28, 2013

http://fcsworkshop.in/

FCS-2013 is intended to focus on in-depth theoretical training and hands-on exploration of emerging techniques in fluorescence and Raman spectroscopy for biology and material science. Apart from research and didactic talks, satellite sessions will provide hands-on training on construction of confocal and total-internal-reflection microscope from generic parts.

Facilities



Building

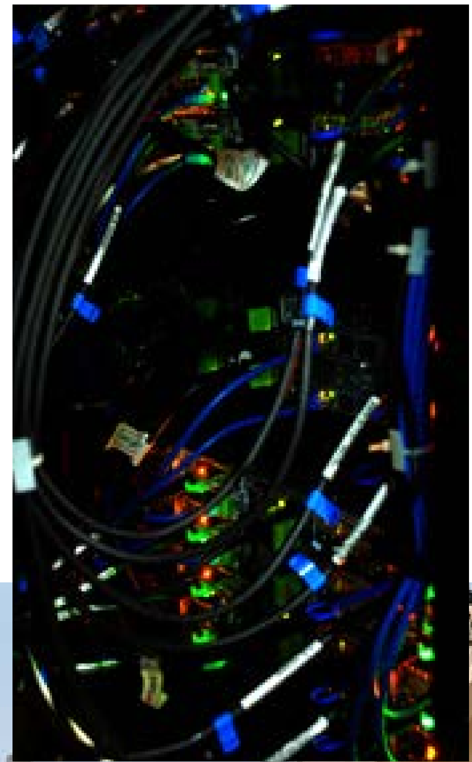
The Department of Chemical Engineering is located in the heart of the IISc campus. Originally constructed in the 1960s, the building has been significantly renovated in recent times. Spanning about 15000 square feet of experimental laboratory space and 5000 square feet of office space, class room and conference rooms, the department houses twelve experimental and computational laboratories. Two cleanrooms (400 square feet, Class 10000; 225 square feet, Class 100000) are available in the department for nanomaterial synthesis/analysis and single molecule imaging. The department has its own library-cum-lounge as well as computer lab for student study and discussion.

Experimental facilities

With several experimental groups sharing the resources in the department, the experimental facilities have grown and evolved over the years and the department now houses advanced spectroscopy, chromatography, imaging and material property measurement instruments from a variety of sources. It also houses a large collection of chemical and biochemical reactors which are regularly used for experimental investigations.

Computing facilities

The department has excellent computational facilities that cater to the research needs of the faculty and the students. The department computer laboratory houses state-of-the-art computers equipped with the latest software packages that can support specialized applications including CFD modelling as well as plant and reactor design.
Advanced computational facilities in individual research groups including six highly customized in-house computer clusters devoted to research are available.



"The rigorous course work and research training that I obtained in IISc are the best I could have hoped for. They prepared me well for my post-doctoral research at Minnesota, as well as for my current position at IIT Kanpur.

My best non-academic experience was the very-friendly student crowd (at least in my times), where one could call upon anyone for a cup of coffee at any time of the day (or night!) and discuss research and other struggles in the life of a graduate student."

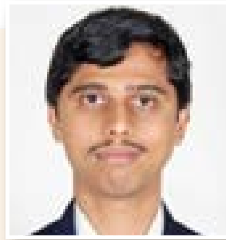
vshankar@iitk.ac.in

V. Shankar
Professor, IIT Kanpur

"I have been conducting fundamental research (towards PhD, postdoc and research at IITB). The emphasis on fundamental research laid out via various courses and research training during MSc (Engg) at IISc has been of tremendous help in all the post IISc pursuits so far. I enjoyed Prof. Gandhi's modelling course and Prof. Kesava Rao's heat and mass transfer course. These courses gave a good flavor of how to come up with a hypothesis for a given problem."

Ganesh A Viswanathan
Assistant Professor, IIT Bombay

ganeshav@iitb.ac.in



"I give full credit to ChemE, IISc for shaping up my career in R&D. I have worked with Dow Chemicals previously and with Shell for last 7 years and I still feel that the education I got from ChemE dept is very useful in my job. I had a short industrial experience before joining IISc however after completing masters from IISc my career has scaled to different height. The research oriented syllabus, excellent coaching & guidance, high standards in exams etc. were quite useful. The passion for technical stuff acquired in ChemE IISc, helped me in surviving in the R&D field."

saurabh.kaujalgikar@gmail.com

Saurabh Kaujalgikar
Process Technologist, Shell Bangalore

"Its a wonderful place with lots of freedom and great atmosphere to do research. As many feel, the importance of IISc will be felt only after we leave the place. During my academic period, I used to wonder when i am going to submit my thesis. But now, i keep remembering those wonderful nights at IISc, which is totally absent in corporate world."

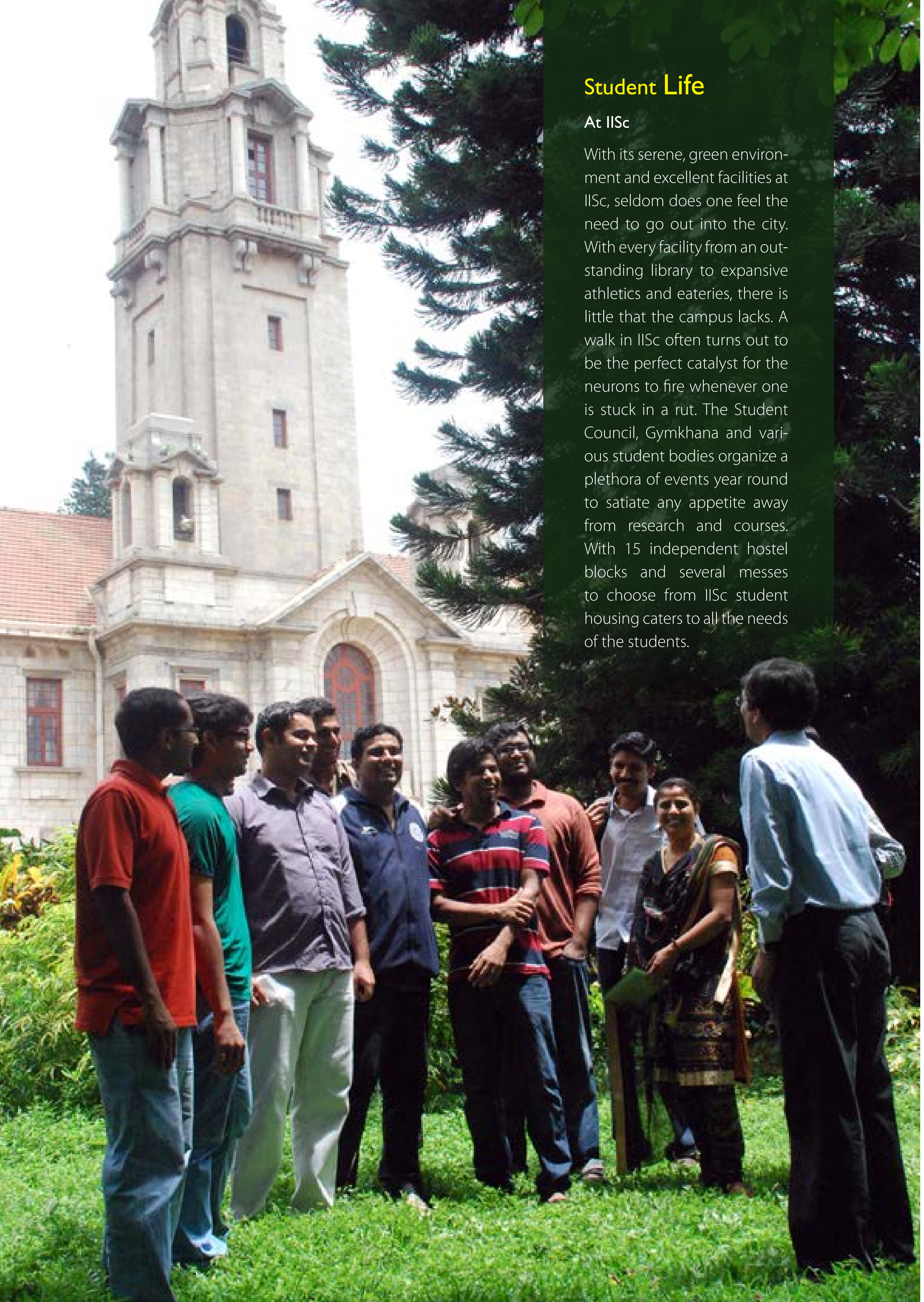
girish1984@gmail.com

Girish M
Research Scientist, Unilever R&D Bangalore

"I completed both masters and PhD from the chemical engineering department at the IISc. The interest each faculty member shows in training a student towards conducting research is phenomenal. The very fundamental questions raised in day to day life by my colleagues and the faculty at the department made me think in the right direction of solving important research problems. With the training I was provided with, now I am very much excited to contribute my part to science and hence to the society, as a post doctoral fellow at the MIT, Boston."

siva.perala@gmail.com

Siva Rama K Perala
Post Doctoral Fellow, MIT Cambridge



Student Life

At IISc

With its serene, green environment and excellent facilities at IISc, seldom does one feel the need to go out into the city. With every facility from an outstanding library to expansive athletics and eateries, there is little that the campus lacks. A walk in IISc often turns out to be the perfect catalyst for the neurons to fire whenever one is stuck in a rut. The Student Council, Gymkhana and various student bodies organize a plethora of events year round to satiate any appetite away from research and courses. With 15 independent hostel blocks and several messes to choose from IISc student housing caters to all the needs of the students.

Chemical Engineering Association

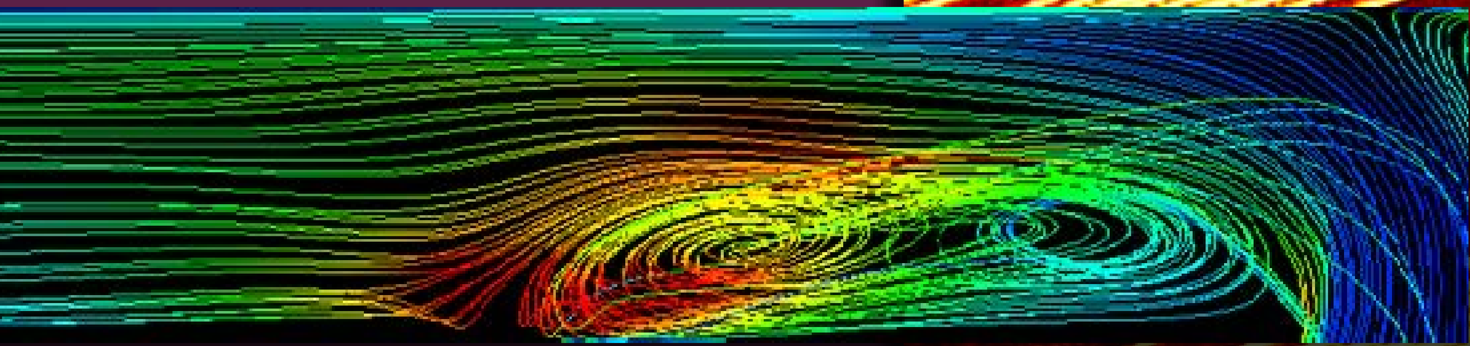
CEA serves as a common platform for ChemE students alums and faculty to get together. CEA organizes lectures, field trips, outreach programs, sporting events, a cultural night and annual symposia generating a vibrant and enriching environment for all. CEA also serves the additional role of liaison between the current students and the alumni of the Chemical Engineering department. The best part about CEA is that it is an organization of the ChemE students run almost independently by the students and hence providing extensive opportunities for honing leadership qualities and promoting professional growth while having fun with your friends and colleagues.

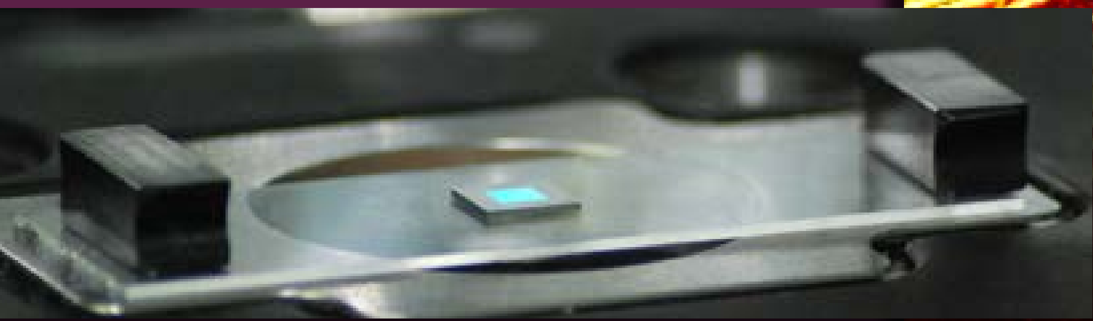
In the department

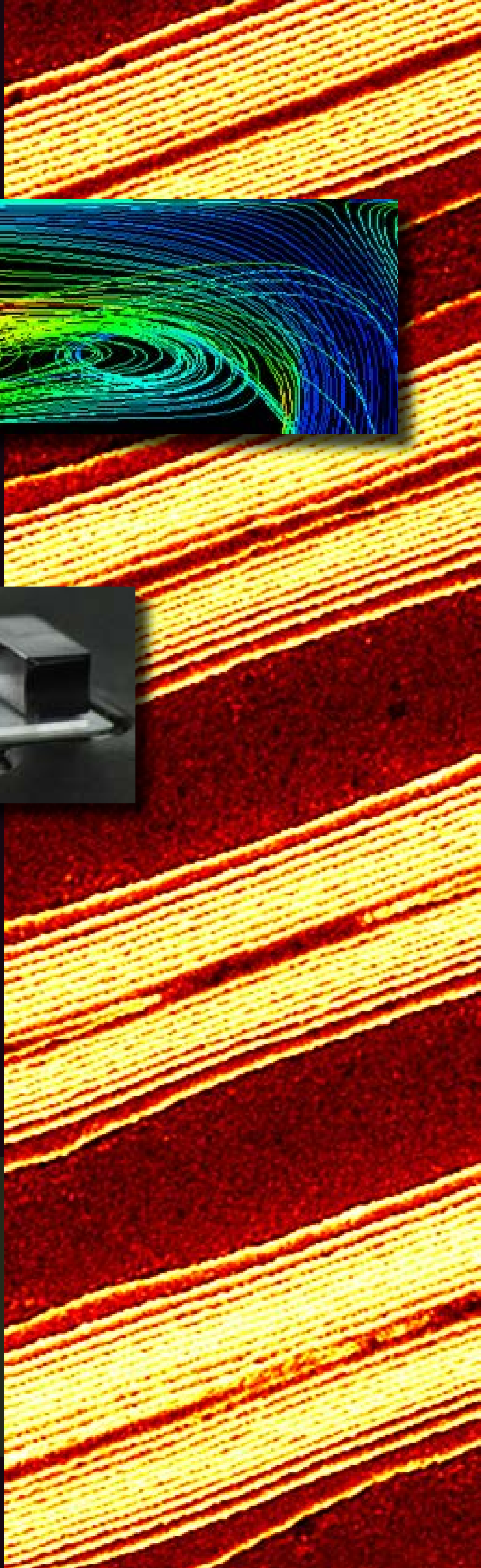
Students find the ChemE faculty to be friendly and genuine in their intentions. While the course work and research is rigourous and demanding, ChemE professors are easily accessible for conceptual doubts or suggestions related to research. The small size of the ChemE department means a very familiar and pleasant environment for all where one is able share thoughts (and not just pertaining to research or science) over a cup of coffee in the library cum lounge. The academic freedom in framing their own research problems and then addressing with various techniques makes it an extremely rewarding journey. The existing camaraderie among the students effectively makes the department their second home.

Bangalore and beyond

Bangalore is an exciting cosmopolitan city with many major industrial, commercial and educational centers. Nicknamed as 'Silicon Valley of India' on one hand to signify its global IT-industry and 'Garden City' on the other, it resembles the struggles of a new city that is trying to maintain its historical integrity under perpetual growth. The beautiful and equitable climate, beautiful gardens, parks and natural lakes, provide ample opportunities for sight-seeing. Bangalore is also famous for its shopping malls, bustling plazas, bars and restaurants that are favorites among the students. Apart from the nearby city of Mysore, the Shivanasamudra Falls, Ranganathittu Bird Sanctuary, Nagarhole and Baneeerghtta National Parks are some of the attractions for the wild-at-heart.







Learn more about our programmes, faculty, students, courses, facilities and alumni by visiting our website at

http://chemeng.iisc.ernet.in

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Designed by:
Naina (Sai Maa) • Vadhana V • Rajat Desikan • Ayush Agrawal • Rahul Roy