Curriculum Vitae

Personal details

Name: Bharat Kumar
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Education

- PhD. in Physical Sciences (2004-2010), Raman Research Institute, Bangalore, India (affiliated to Jawaharlal Nehru University, New Delhi, India).
- Master of Science (Physics) [specialization in Materials Science] (2004), Gulbarga University, Kalaburagi, India (**4**th rank, First Class).
- Bachelor of Science [Physics, Chemistry & Mathematics] (2002), Laxmi Venkatesh Desai College, Raichur, affiliated to Gulbarga University, India (First Class and 1st rank in college).
- Higher Secondary (XII) Pre-university College Board (1999), Laxmi Venkatesh Desai College, Raichur, India (First Class).

Research Experience

From January 2014: Assistant Professor, School of Physical Sciences, Central University of Karnataka.

August 2013 - January 2014: DST-INSPIRE Faculty, Department of Chemical Engineering, Indian Institute of Technology Kanpur.

August 2010 – July 2013: Post-doctoral Research Associate, Department of Physics and Astronomy, University of South Carolina, Columbia, SC, USA.

August 2006 – July 2010: Senior Research Fellow, Soft Condensed Matter Group, Raman Research Institute.

July 2004 - July 2006: Junior Research Fellow, Soft Condensed Matter Group, Raman Research Institute.

Teaching Experience

January 2014 to till date: Assistant professor at School of Physical Sciences, Central University of Karnataka (CUK).

Under Graduate level courses:
1. Engineering Physics – I
2. Engineering Physics – II

Post Graduate level courses:
1. Classical Mechanics
2. Thermodynamics & Statistical Physics
3. Soft Matter Physics
4. Solid State Physics
5. Nanoscience and Nanotechnology

Courses developed: At Central University of Karnataka I am a part of the Board of Studies which developed the courses for the Integrated (B.Sc. – M.Sc.) programme, Engineering Physics courses, M.Sc. (Physics), and PhD (Physics) programmes. In addition to regular core courses, I have also developed two new elective courses on Soft Matter Physics and Nanoscience and Nanotechnology for post graduate and PhD programmes. I was also involved in developing laboratory curriculum for the Physics Department at Central University of Karnataka.

Academic Administration Experience:

1. Coordinator of Department of Physics, Central University of Karnataka, since January 2015
2. Member and convener of Board of Studies for the Department of Physics, Central University of Karnataka
3. Member of Academic Planning Committee, Central University of Karnataka. The seven member committee was formed by Central University of Karnataka to build the 5 year roadmap for the University.
4. Member of various administrative committees like purchase committee, annual report committee, committee to write a proposal to MHRD under Rashtriya Avishkar Yojana scheme, special officer in the examination section, Coordinator for the CUK Convocation – 2015, committee for implementing Choice Based Credit System at CUK, committee for developing ICT facilities at CUK, etc.

Sponsored Projects

Period	Sponsoring Organization	Title of Project	Grant
Five years	Department of Science and Technology, Govt. of India	Electrical interactions between antimicrobial peptides and supported lipid bilayers	Rs. 35 Lakh
Three Years	Department of Science and Technology, Govt. of India	Electrical properties of amyloid peptides and their interaction with biomembranes	> Rs. 38 Lakh

Computer Skills:

I have extensively used a variety of software packages and languages including **Mathematica**, *C++*, and Labview for my research work. I have also used "**COMSOL Multiphysics**". I can operate in Windows and Linux operating systems.

Awards and Recognitions:

1. (In 2012) I was awarded DST-INSPIRE faculty fellowship by department of science and technology (DST, Govt. of India) to carry out research on electrical interactions between antimicrobial peptides and supported lipid bilayer membranes.
2. (In 2010) Post-doctoral fellowship awarded by University of South Carolina, Columbia SC, USA. The project is funded by Army Research Office, USA.
3. (In 2006) Best oral presentation award in international conference on Liquid crystals organized by University of Mumbai at Mumbai.
4. Qualified Joint Entrance Screening Test (JEST-2004) and GATE-2004.
5. (In 2003) I was awarded summer research fellowship by ***Jawaharlal Nehru Center for Advanced Scientific research***. The fellowship was renewed again in summer 2004.
6. (In 2002) University scholarship awarded by Gulbarga University, Gulbarga for securing highest marks in B.Sc Physics.
7. (In 2002) First Rank in college in B.Sc. Programme.

List of publications

Refereed International Journals:

1. "Novel mesogenic azobenzene dimer at air-water and air-solid interfaces"
   Bharat Kumar, A K Prajapati, M C Varia and K A Suresh; *Langmuir* **25**, 839 (2009).

2. "Kinetics of *trans – cis* isomerization in the azobenzene dimers at air-water interface"
   Bharat Kumar and K. A. Suresh; *Phys. Rev. E* **80**, 021601 (2009).

3. "Stress-strain relation in the collapse of Langmuir monolayer of a dimer of disc shaped moiety"
   Bharat Kumar, K A Suresh, S. K. Gupta and Sandeep Kumar; *J. Chem. Phys.* **133**, 044701 (2010).

4. "Dielectric constants by multifrequency non-contact atomic force microscopy"
   Bharat Kumar, Joseph C. Bonvallet and Scott R. Crittenden; *Nanotechnology* **23**, 025707 (2012).

5. "Spreading and retraction dynamics of a dye doped smectic liquid crystal domain at the air–water interface"
   Viswanath P., Suresh K. A. and **Bharat Kumar**; *Soft Matter* **8**, 11180 (2012).

6. "Stern potential and Debye length measurements in dilute ionic solutions with electrostatic force microscopy"
   Bharat Kumar and Scott R. Crittenden; *Nanotechnology* **24**, 435701 (2013).

7. "Synthesis and Characterization of Novel Azobenzene-based Mesogens and their organization at Air-Water and Air-solid Interfaces"
   Santanu Kumar Pal, Monika Gupta, Nishtha Agarwal, Ashima Arora, Sandeep Kumar, **Bharat Kumar,** and Goutam Sheet; *RSC Advances* **4**, 41371 (2014)

8. "Nanoscale dielectric measurements from electrostatic force microscopy"
   Bharat Kumar and Scott R. Crittenden; *Mod. Phys. Lett. B*, **28**, 1430011 (2014).

9. "Charge transport in liquid crystalline triphenylene polymer monolayer at air-solid interface"
   H. N. Gayathri, **Bharat Kumar**, K. A. Suresh, H. K. Bisoyi and Sandeep Kumar; *Phys. Chem. Chem. Phys.*, **18,** 12101-12107 (2016)

Papers presented in conferences and talks given:

1. "Electrical properties of polymeric liquid crystalline monolayer at air-water interface" at International Conference on Macromolecules (ICM – 2016) organized by Mahatma Gandhi University, Kottayam at Kottayam during 13 – 15th May 2016 (***Invited talk***).
2. "Stern potential measurements in liquids using electrostatic force microscopy" at "International Conference on Nanoscience and Technology" (ICONSAT-14) organized by Institute of Nanoscience and Technology (Mohali) at Chandigarh during 2-5 March 2014.
3. "Debye screening length of electrolytic solutions from capacitive force measurements using atomic force microscopy" at American Physical Society March Meeting 2013, Baltimore, MD, **USA**.
4. "Multi-frequency amplitude modulated non-contact atomic force microscopy for nano-scale dielectric measurements" at American Physical Society March Meeting 2012, Boston, MA, **USA**.
5. "Star shaped mesogens at interfaces" at Conference on disorder, complexity and biology II, Banaras Hindu University, Varanasi, **India**; January 2009.
6. "Stress-Strain relation in the collapsed Langmuir monolayer" In-house meeting, Raman Research Institute; November 2008.
7. "Amphiphilic dimers of disk shaped molecules at interfaces" (Poster presentation) in 15th National Conference on Liquid Crystals, Indian Institute of Science, Bangalore, **India**; October 2008.
8. "Dimers of Disc shaped molecules at air-water and solid-air interfaces" at Interface of Life-School on Biophysics, Indian Institute of Technology Madras, Chennai, **India**; January 2008.
9. "Kinetics of photoisomerization of mesogenic azomolecules at air-water and air-solid interfaces" in XVII Liquid crystal conference at Augustow, **Poland**; September 2007.
10. "Azobenzene molecules at air-water and air-solid interfaces" In-house meeting, Raman Research Institute; May 2007.
11. "Studies on Langmuir monolayers and LB films of novel H-shaped mesogenic molecule" in International conference on liquid crystals, University of Mumbai, **India** December 2006. (**Secured best oral presentation award**).
12. "AFM studies on mesogenic discotic molecules" at Saha Institute of Nuclear Physics, Kolkata, **India** January 2006.

References:

1) **Prof. K. A. Suresh**
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Statement of Research Interests

Organic molecules became very popular as novel electrical materials with applications varying from thin-film devices to molecular electronics and nanotechnology because of low cost synthesis and properties like self-assembly. The studies on electrical and mechanical properties of thin films of organic molecules also find its importance in understanding various biological phenomena. The properties of thin films of organic molecules are predominantly controlled by the molecular structure, intrinsic molecular dipole moment, charge distribution at the interface, and intermolecular forces (van der Waals forces). My research so far has focused on the mechanical and electrical properties of thin films of organic molecules including liquid crystal films formed by self-assembly of molecules at air-water and air-solid interfaces.

During my doctoral research, we carried out studies on the effect of molecular structure on the self-assembly behavior and electrical properties of ultra-thin films at air-water and air-solid interfaces. The molecules studied exhibited liquid crystalline phases in bulk. The details of the research work done are given below.

Experimental techniques:

To study the ultra-thin films at air-water interface, we have used surface manometry, Brewster angle microscopy, epifluorescence microscopy and reflection microscopy and thin films at air-solid interface (Langmuir-Blodgett films) were studied using Fourier transform infrared (FTIR) spectroscopy, UV-vis spectroscopy and scanning probe microscopy. We have used atomic force microscope (AFM) extensively to understand the electrical and mechanical properties of the LB films.

Thin films of azobenzene molecules at interfaces:

Thin films of azobenzene molecules find applications in microelectronics, optical devices and biochip technology. We have studied the stability and phase transitions of Langmuir monolayer of a novel H-shaped mesogenic azobenzene dimer (12D1H) at air-water interface. The wetting behavior of the 12D1H LB film transferred onto hydrophilic and hydrophobic substrates was studied using AFM. Our analysis of the AFM topography images shows spinodal dewetting of the 12D1H bilayer on the hydrophobic substrate. [Bharat Kumar *et al. Langmuir* 25, 839-844 (2009)]

Effect of *in-situ* modification of molecular structure on the monolayer properties was also studied. We find that the photo-isomerization of 12D1H monolayer at air-water interface results in the change of surface pressure at constant area per molecule. The kinetics of photo-isomerization of the trans-isomers of the 12D1H was studied from the surface pressure measurements as a function of time. Unusual second order kinetics was observed. A model similar to Lindemann-Hinshelwood mechanism was proposed to explain the observed kinetics. [Bharat Kumar *et al. Phys. Rev. E* 80(2), 021601 (2009)]

Discotic liquid-crystals are known as new generation materials for organic electronics as they exhibit unique molecular electronic properties due to delocalization of electrons along the columnar structures. This makes them potential candidates for technological applications like field-effect transistors, photovoltaic solar cells, light-emitting diodes and sensor devices. In addition, there are some biologically

important disk-shaped molecules like vitamins, hemoglobin and chlorophyll. Therefore, studying supramolecular assemblies of derivatives of the disk-shaped molecules are important from the point of view of technology as well as biology.

Mechanical properties of Langmuir monolayer:

Mechanical properties and phase transitions of Langmuir monolayer of discotic liquid crystals were investigated at the A-W interface employing surface manometry and Brewster angle microscopy techniques. The material used was a dimer of triphenylene moiety (tp-dimer) and it exhibited a uniform phase that can be transferred onto solid substrates at different surface pressures by LB technique. AFM studies showed that the triphenylene moieties in the LB film were in the edge-on configuration. The mechanical properties of the Lanmguir monolayer were studied using surface manometry and we found that the monolayer collapse pressure is related to compression rate by a power law relation. Our studies also showed that the strain rate has Arrhenius temperature dependence. [Bharat Kumar *et al.; J. Chem. Phys.* 133, 044701 (2010)]

Nanoscale Electrical Conductivity:

Nanoscale electrical conductivity of thin films of novel discotic oligomers were studied using current sensing AFM (CSAFM). The materials studied were oligomers of electron deficient anthraquinone moities (AQP) and electron rich triphenylene moieties (TrP) and a hybrid oligomer containing both anthraquinone and triphenylene moities (AQD6). LB film of these materials on the gold substrate form a metal-insulator-metal junction when a conducting AFM tip is in contact with the film. Our analysis of the current-voltage data for AQD6 monolayer between the AFM tip and gold substrate shows that when a bias voltage is applied to the substrate, charge transfer occurs through the film by *electron tunneling*. In addition, a transition in the tunneling mechanism from direct tunneling at low applied bias voltages to the injection or Fowler-Nordheim tunneling at high applied bias voltages is observed. From the analysis of the Fowler-Nordheim regime we calculated the barrier height of the film. The transition in the tunneling mechanism is attributed to the optimum barrier height imposed by the AQD6 monolayer film for the charge transfer. [Manuscript under preparation]

On the other hand current-voltage characteristics of monolayer films of AQP and TrP did not show any such transitions in the tunneling mechanisms and only exhibited direct tunneling.

During post-doctoral research we have carried out the following projects:

Electrical characterization of soft ultra-thin films using AFM: This project intended to develop AFM based techniques to study the capacitive forces between AFM cantilever tip and sample for electrical characterization of soft materials. The ultimate goal of this project was to develop a reliable technique which can be used to obtain dielectric constant of soft materials like biological matter in air and liquid media. Previous known AFM techniques use high applied bias voltages (typically greater than 1 V) to obtain the capacitive forces between the AFM tip and sample. Application of high bias potential between the AFM tip and sample can damage the soft materials. We have successfully developed and demonstrated a new multi-frequency AFM method which can be used to obtain dielectric constant of soft materials with high accuracy

but by applying bias voltages as low as 100 mV between the tip and sample in air (Bharat Kumar et al, *Nanotechnology* **23**, 025707 (2012)).

We have also extended capacitance force microscopy for the electrical characterization of soft materials in ionic solutions. We demonstrated the ability to measure the surface potential and Debye length in dilute ionic solution with atomic force microscopy. We have developed an analytic expression for the capacitive gradient between and AFM tip and conducting sample in electrolyte solution from the linearized Poisson-Boltzmann equation. The analytic expression fits well with our experimental data and further the fit parameters can be used to obtain the surface potential of any sample in an ionic solution. (Bharat Kumar et al, *Nanotechnology* **24**, 435701 (2013)).

Charge transport in nanowires produced by electrogenic bacteria: The project aimed to understand the mechanism of charge transport through the nanowires (known as pili) produced by electrogenic bacteria commonly used in microbial fuel cells. The electrical characterization of the nanowires was carried out using atomic force microscopy (AFM) based techniques like Kelvin probe microscopy, current sensing AFM and multi-frequency AFM.

Current research activities:

Currently our research activities are focused to understand the electrical interactions between polyelectrolytes and charged soft surfaces. In particular, we are investigating the electrical interactions between charged proteins/peptides/amino acids and lipid membranes. These investigations will help in understanding biological phenomena like (a) the role of electrical interactions during the process of killing of microbes by the anti-microbial peptides, (b) formation of amyloid plaques on the healthy cells leading to diseases like type-II diabetes, Alzheimer's disease etc.