IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Bioinspired assembly in model nanoparticle-membrane systems for investigating nanoscale interaction**	
Project Number	**IMURA1047**	
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Monash Department:	Department of Material Science & Engineering	
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IITB Department:	Physics,	

Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*

1	***Material Science/Engineering (including Nano, Metallurgy)***
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*
6	***Bio, Stem Cells, Bio Chem, Pharma, Food***
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*
8	*HSS, Design, Management*

Research Themes:

Highlight which of the Academy's Theme(s) this project will address?
(Feel free to nominate more than one. For more information, see www.iitbmonash.org)

1	*Artificial Intelligence and Advanced Computational Modelling*
2	*Circular Economy*
3	*Clean Energy*
4	*Health Sciences*
5	***Smart Materials***
6	*Sustainable Societies*
7	*Infrastructure*

The research problem

Define the problem

Semi-rigid polyelectrolyte DNA chains form complexes with oppositely charged macroions such as colloidal particles, amphiphilic molecules and charge phospholipid membrane via gain in entropy of the released counterions from complexation of the DNA and macroions. The cationic lipid-DNA complexes have been studied experimentally and theoretically for structural tunability and diversity of the complexes due to their potential applications for materials and medicine. Further advances in biophysics, involves integration of functional nanoscale structures with biomolecules for exploring nanomaterial's functionality at nano-bio interface. Many bio-applications are limited due to complexity of nanoparticle's interactions with biological environment leading to structure deformations and formation of holes and pores in membrane. Studying nanoparticle-cell membrane interactions requires the use of model system which are simple to understand under laboratory settings yet good enough to mimic the complex cell membrane systems. The lipid membranes are responsible for performing several biological applications. We aim at exploring a self-assembly behaviour of the nanoparticle-lipid complexes in-situ and at the air-water interface to understand the physics of nanoscale interaction of inorganic nanomaterials with charged biomolecules. Our studies will unravel the role of dominant forces for particle assembly and design rules for wide variety of the crystal assembly as a function of lipid composition and lipid/DNA ratio, aimed at exploring the interactions determining their structure and stability. Broadly, we will investigate the relationship between assembly mechanism, order-disorder transition and symmetries of formed lattices.

Project aims

Define the aims of the project

We aim at exploring the self-assembly behaviour of the nanoparticle-lipid complexes at varying nanoparticle size, morphology and surface properties and study their interfacial transport properties in bulk/solution as well as in 2D geometry. Using small angle x-ray scattering (SAXS), fluorescence imaging and Cryo microscopy methods, we will probe the structures of DNA-coated nanoparticles and cationic liposomes formed via electrostatic interaction between negatively charged DNA chains and positively charged liposomes. One of the major challenges in the use of complexes at nano-bio interface for the biomedical applications is the limited understanding of its structural stability. Our studies will focus to unravel the nanoscale interaction and its effect on the formation of complexes in the presence of salt solutions and at different pH conditions and provide quantitative understating of the self-assembly mechanism.

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the students stay at IITB and at Monash

Student at IITB is expected to learn the nanoparticle synthesis, assembly and characterization. Training on handling biological samples such as DNA and lipids will be provided. The student will learn Langmuir Blodgett method based advance techniques for membrane assembly and interfacial rheology measurements. Student while at Monash will get exposure to the advance x-ray scattering measurement techniques such as small angle x-ray scattering and grazing small angle x-ray scattering. Student will be trained on optical and bio applications of the structures at the nano-bio interface.

Expected outcomes

Highlight the expected outcomes of the project

Scientific training of the student in data collection, analysis. Publications, patents and demonstration of the

proof of concept.

How will the project address the Goals of the above Themes?

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Theme: Nanotechnology

This proposal aims to manufacture biomimetic nanostructures and investigate its application in the optical and bio area, which comes under the nanotechnology and biomaterial theme.

Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project

To be provided once the selection of the student is complete.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

MSc in Physics, Material Science, Nanotechnology, M.Tech in Nanotechnology.

Necessary Courses

Name three tentative courses relevant to the project that the student should complete during his/her coursework at IITB (the student will require to secure 8 point in these courses)

Analytical Techniques in experimental Physics

Physics of nanomaterials

Biological Soft Matter

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

To be provided once the selection of the student is complete.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Novel Functional Materials
Biosciences, Bio Medical Engineering
Nanotechnology, nanoscience
Smart Manufacturing