IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Designing colloidal chains propelled by chemical reactions to be used as micromotors**	
Project Number	**IMURA0868**	
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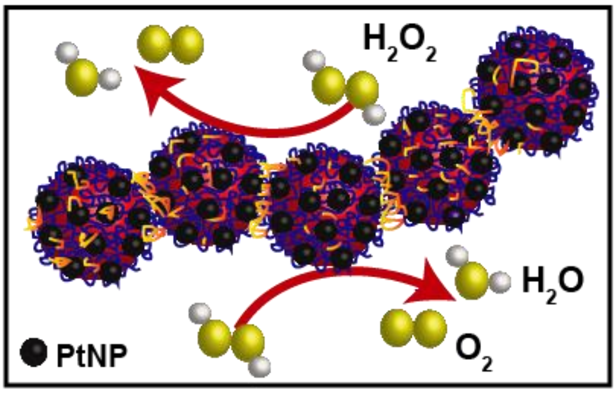
IITB Department:	Chemical Engineering	

Research Clusters: Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**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	***Material Science/Engineering (including Nano, Metallurgy)***	*1*	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)*	5	***Nanotechnology***
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design



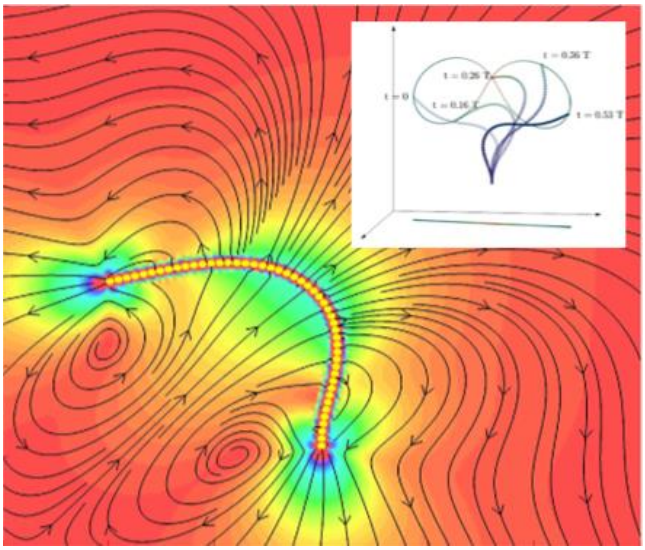
Schematic of a synthetic active colloidal chain coated with catalytic platinum nanoparticles (PtNP) that catalyze reactions at the chain surface (Image source: Biswas et. al. ACS Nano, 2017)

The problem: A few years ago, Prof. Guruswamy and his research group demonstrated a new technique for synthesising semiflexible chains of colloidal particles by trapping them in polymeric meshes. They followed this up by making these *active*: they coated them with nanoparticles that catalyze chemical reactions whose energy then propels these chains.

Our goal in this long-term research project is to exploit this chemical propulsion to design novel colloidopolymer micromotors that could achieve a range of functions in microfluidic devices. In this, we are inspired by biological systems that use micromotors for transporting particles from one end of a cell to another, for propelling whole cells, or for pumping and mixing fluids.

To do this, we need to understand how the physical characteristics of a colloidopolymer and the kinetics of the surface chemical reactions control the active motion achieved by the chain. Understanding this relationship would enable us to tune features such as chain length, flexibility, surface reactivity, *etc.* for different kinds of micromotor function. For instance, the characteristics required for single micromotor chains transporting payloads across microfluidic channels may be quite different from those required for chains to collectively pump fluid through a microchannel.

The approach: Dr. Ranganathan's group has developed modelling and simulation tools to extract mechanical forces and forces from experimental observations of semiflexible active filaments. In the first stage of this project, we aim to combine these tools with systematic experiments to calculate the forces and energies of the different contributions that lead to colloidopolymer activity, and further correlate them with physical and chemical parameters characterizing the chains. In the second stage, we aim to design and test these chains for use as micromotors firstly for transporting payloads within open channels and also past arrays of obstacles. We are also interested in studying how collective motion in systems of multiple active colloidopolymers can be exploited for mixing or pumping.



An active flexible microfilament can undergo wavy motions (inset) driving complex flows in the surrounding fluid. (Image source: Laskar et al., Sci. Rep., 2013)

The outcomes: The PhD project will provide you with in-depth training in cutting-edge chemical synthesis of novel colloidal systems, characterization techniques in soft-matter, advanced microscopy and image-analysis and micro/nanofluidic fabrication. You will also learn theoretical concepts underpinning active matter, colloidal systems and polymers. We aim to publish our results in high-impact journals and also, potentially, as patents. The Project can be the springboard for an exciting research career in microfluidics, soft matter, and nanosciences.

Expected outcomes

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

This project will develop novel active nanomaterials. Such systems might have implications for colloidal nanomachines that can, for example, provide targeted delivery of molecules loaded on the colloidal particles.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. 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.

Degree in Chemical or Mechanical Engineering or Physics.
Exposure to polymers or colloids would be useful.

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.

Monash - Prof. A. Neild (microfluidics), Prof. J. Soria (µPIV measurements)

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.

Nanotechnology, nanoscience