IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Smart nanoparticles: does shape matter?**
Project Number	**IMURA0260**

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Research Academy 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. Advanced computational engineering, simulation and manufacture
2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

Interactions between nanoparticles and human cells have been subject of intense scrutiny in recent years due to their implications in various biomedical applications such as imaging, vaccine adjuvant, drug delivery, and targeted cancer treatment. The size and surface properties of nanoparticles are undoubtedly important, while a recent study on their interactions with macrophages (Sharma et al., J. Controlled Release, 147, 2010, 408-412) suggests that shape is another significant factor influencing cell attachment and internalization independently of size. However the uptake mechanisms and pathways in relation to nanoparticle properties are still inconclusive and require more fundamental studies to enable the design of 'smart' nanoparticles. In addition, particles with unique behaviour observed only at the nanoscale including superparamagnetism or surface activity will have other inherent properties affecting their cellular interactions, as well as their functionalitiy (for example, magnetic nanoparticles for MRI). Hence, the thrust area of biomedical application motivates us to carry out a systematic study of magnetic oxide nanoparticles of various sizes and shapes, and investigate their magnetic resonance properties with various surface functionalities and cell lines.

Project aims

We have the capability to engineer biocompatible and biodegradable nanoparticles with precise morphology, size, and surface properties to provide a library of nanoparticles for mechanistic studies on their interactions with different cell types for targeted applications including drug delivery and imaging. The specific aims of this project are:

- Designing a range of biodegradable and/or biocompatible nanoparticles (e.g. iron oxide, zinc oxide) of uniform size in the range between 10 nm and 100 nm,
- Investigate the effect of various shapes (for example, needle, spherical, rod-like) on cell uptake, interaction and magnetic properties. The particles will be functionalised for stability and to enable targeting to specific cell receptors.
- Characterisation of surface properties, toxicity, uptake and interactions with different cell types

in vitro. The understanding will aid in the formulation and design of nanoparticles for a specific application.

- Proof of concept for a specific biomedical application (targeted drug delivery and/or imaging)

Expected outcomes

The expected outcomes of the project are:

- Developing better fundamental understanding of the effects of nanoparticle properties (particularly shape) on cellular interactions and uptake, as well as adjuvant and toxicity effects.
- Designing better functional nanoparticle systems for a targeted biomedical application.
- Closer working collaboration between the researchers at IITB and Monash University through the joint project utilising the expertise and facilities from both groups.

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

The project addresses the Nanotechnology theme of the Monash-IITB Reseach Academy by developing suitable nanoparticle systems through fundamental understanding of their properties and how they interact with living cells. The project will combine the expertise from Prof. Aslam's group (IITB) in synthesising particles with defined morphology and size, and Dr. Selomulya's group (Monash University) in characterising the properties and utilising these particles for a specific biomedical application.

The Department of Chemical Engineering at Monash University has state of the art laboratories with excellent research performances in advanced particle engineering, biotechnology, pharmaceutical science, and nano-structured materials, and is well equipped to support this research for functional nanoparticles. Monash University has excellent research infrastructure and personnel (Monash Centre for Electron Microscopy, Australian Regenerative Medicine Institute) and has consistently performed at the top of the rankings in nanotechnology and engineering research. It is also a major partner in the Melbourne Centre for Nanofabrication, the Australian Synchrotron, and the South East Melbourne Innovation Precinct, with new initiatives such as New Horizons collaboration with CSIRO and the Green Chemical Futures facility currently in development. The proposed project fits well with the university's strategic research plan to focus on innovative research with potential benefits for Australia and the world.

Capabilities and Degrees Required

- Candidates with excellent academic performance and MTech in Physics/Materials Science (desired to work towards bio-related applications of magnetic nanoparticles)