IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Ultrafast dynamics in assemblies of nanomaterials**	
Project Number	**IMURA0832**	
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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	*Advanced computational engineering, simulation and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*
7	*Humanities and social sciences*
8	Design

The research problem

Exciton dynamics in nanomaterials, their arrays and conjugates with dye molecules have generated a lot of interest in recent times. A myriad of phenomena are being studied in this system, ranging from shape dependence of nanoparticles on the ultrafast dynamics within them to the application of quantum dots (QDs) for light harvesting and charge separation in solar cells. Core shell quantum dots and quantum dot arrays, in particular, have emerged as rather interesting systems in this context. Exciton and charge transport

in carbon nanotubes and graphene are also being studied extensively. Another area of active research involves metallic nanoparticles, which have been used for centuries as exotic coloring materials for church windows, vases etc. The exquisite colours of metal colloids are due to the localised surface Plasmon resonance, which is coherent oscillation of conduction band electrons arising out of interaction with light. This is a rather interesting phenomenon, which has been exploited in the enhancement of fluorescence and Raman spectroscopic signals and has been projected to have immense potential in the field of light harvesting in dye sensitized solar cells and quantum dot solar cells. While the surface Plasmon resonance in nanoparticles is well studied, considerable interest has been generated in recent times in the field of the study of this phenomenon in nanoparticle assemblies. Such studies involve two parts: preparation of different kinds of assemblies of QDs as well as hybrid QD-noble metal nanoparticles and study of the ultrafast dynamics of electron relaxation in them. Both these aspects are to be addressed in the project.

Project aims

1. Preparation of assemblies of QD and QD-metal nanoparticles.
2. Scale-up of methods for the assembly of these
3. Ultrafast transient absorption studies of these nanoparticle assemblies to understand electron – phonon and phonon-phonon interactions in them.
4. Investigation of the role of the surrounding medium on such ultrafast dynamics.
5. Extension of such studies to single particle levels, using confocal microscopy, FCS and FLIM

Expected outcomes

1. Novel QD and QD-metal nanoparticle assemblies with high yield, stability and volume
2. A complete understanding of the mechanism of ultrafast phenomena in them
3. Newer nanoconjugates of gold and conducting polymer for light harvesting applications.
4. Detailed mechanism of light harvesting in such systems, with a view to development of improved materials

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

The project attempts to address an active area of research in nanotechnology. The collaborating groups have complimentary skills in this field. The group in Monash University are specialists in preparation of nanoparticle assemblies while the area of the group in IIT Bombay is in the study of ultrafast spectroscopy and dynamics, in femtosecond to nanosecond timescales. The collaboration is expected to generate understanding of the ultrafast dynamics within these nanoparticles, with the possibility of development of systems with potential application in light harvesting.

Capabilities and Degrees Required

M. Sc. In Chemistry with a strong background in Physical Chemistry and B. Sc. In Chemistry, Physics and Mathematics combination

Or

M. Sc. In Physics, with a good understanding of Chemistry

Or

A degree in Chemical / Electrical Engineering/ Materials Science, with a strong background of Chemistry and Physics

Potential Collaborators

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.

Optics, Photonics
Nanotechnology,nanoscience
Novel Functional Materials
Green Chemistry and Renewable Energy