IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Modeling jet breakup and drop impact of viscoelastic polymer solutions**	
Project Number	**IMURA0743**	
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Research Clusters:

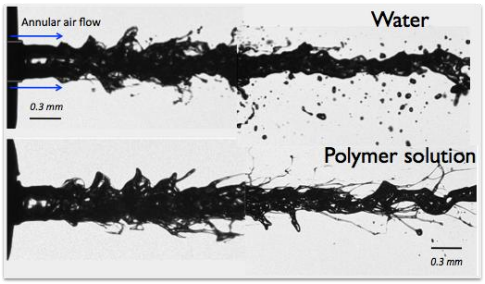
Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*
3	*Math, CFD, Modelling, Manufacturing*
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:

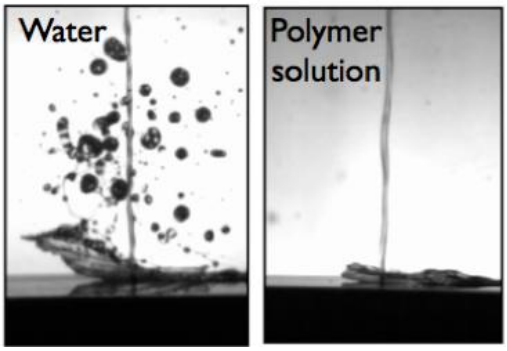
Highlight which of the Academy's Theme(s) this project will address? *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Advanced computational engineering, simulation and manufacture*
2	*Infrastructure Engineering*
3	*Clean Energy*
4	*Water*
5	*Nanotechnology*
6	*Biotechnology and Stem Cell Research*

The Research Problem:

Did you know that about *95% of all pesticides* is wasted, and ends up in ground, river and marine water? This is because of the formation of fine mist during spraying of agrochemicals, or because sprayed drops just bounce off the hydrophobic surfaces of leaves on impact. This is the primary source of the global problem of pesticide contamination of soils and water.



Small amounts of polymeric additives are known to dramatically change complex flows such as spraying and drop impact. These changes are also observed to suppress micro-droplet formation and prevent drops from scattering off surfaces after impact. However, choosing the best polymer for given conditions is currently done through expensive trial-and-error trials.



The pair of figures on the top demonstrates how very small amounts of dissolved polymers can eliminate formation of a fine mist in liquid jets; the bottom pair shows how polymer additives can suppress rebound and breakup of drops on impact with surfaces.

Aims:

Polymer molecules effectively act like tiny nanosprings, giving an additional elasticity to the viscous behavior of solvents such as water. Our goal is to mathematically model the fluid dynamics of spraying and drop-impact of polymer solutions.

We will use a new model of polymer solution viscoelasticity that has been developed at Monash. This model accurately relates the viscoelastic stresses in polymer solutions to deformation of polymeric nanosprings caused by the flow. It can thus predict the influence of parameters such as polymer structure, flexibility, molecular weight and concentration on viscoelastic effects.

Expected outcomes:

The model and simulations will relate the structure and concentrations of polymer molecules to the effect they have on the size distribution of drops in spraying, and their behavior after impact on surfaces. Simulations developed in this project can be therefore be used to find or design the best polymers for agrochemical, as well as other applications where drop formation and impact are critical, such as ink-jet printing, surface-coatings, fuel-injection, electrospinning, etc.

You will study advanced modeling of viscoelastic stresses in polymer solutions. More broadly, this will give you insight into how nano- and micro-scale dynamics with complex non-Newtonian fluids influences their macros-scale flow behavior. The equations describing the macroscopic flow will be integrated using advanced computational fluid dynamics (CFD) algorithms. We expect high-quality publications in top high-impact interdisciplinary journals; you will have the opportunity to travel and present at leading national and international conferences.

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

The Project involves mathematical modelling and aims to develop sophisticated simulation tools for predicting industrially relevant flows of polymeric fluids. It therefore satisfies the goals of the themes of “Advanced Computational Engineering, Simulation, and Manufacture”.

Capabilities and Degrees Required

To be selected on this Project, you will need to demonstrate a firm understanding of fluid mechanics, and standard numerical techniques for solving the ordinary and partial differential equations that arise in mechanics. This will include topics such as mass, momentum and energy conservation, the stress tensor, Newton's Law of Viscosity, the Navier-Stokes equations, the Reynolds number, similarity analysis, vector calculus in Cartesian, cylindrical-polar and spherical co-ordinate systems, surface and volume integrals in these co-ordinate systems, finite-difference methods, and the Crank-Nicholson method. Experience in programming in the context of mathematical modelling of physical phenomena is also essential. Students with an undergraduate or masters degree in physics, mechanical or chemical engineering are ideal. Applied mathematicians with a strong understanding of fluid and solid physics will also be considered.

Collaborators

The Project is a collaboration between and Profs. Shiva Gopalakrishnan and P. Sunthar at IIT Bombay and Profs. Murray Rudman and Prabhakar Ranganathan at Monash University.

Select up to **(4)** keywords from the Academy's approved keyword list **(available at www.iitbmonash.org)** relating to this project to make it easier for the students to apply.

CFD, simulation, microfluidics