IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:

Microfluidics for electrospinning: Behavior of an electrified polymer jet in the presence of an external coflowing liquid

Project Number	**IMURA0382**	
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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

Microfluidics is recently emerging as a robust tool to generate polymer-based materials such as micro and nano particles and micro fibers. However, generation of fibers in the nano scale on a steady basis is a challenging task because of the complexities involved in the implementation of electrospinning process inside a microfluidic device. Use of an external liquid co-flowing with the electrospun liquid can help avoid some of these complexities. For example, the external liquid can flush away the built up charge within the microfluidic device, preventing any disruption to the steady generation of fibers. For the successful use of this technique to generate nano fibers, a broad understanding on the behaviour of an electrified polymer jet in the presence of an externally coflowing liquid is needed. This project will involve conducting experiments to study the various behavioural regimes of such coflowing electrified liquid jets. Operating diagrams that map the transition from cone-jet mode (which results in generating drops) to whipping mode (the mechanism that leads to fiber formation) will be generated. Theoretical component of the project

will involve, modeling the evolution of coflowing electrified liquid jets and use of stability analysis to obtain theoretical operating diagrams to corroborate experimental findings.

Project aims

The specific aims of the project include:

1) Experimental investigations on the behaviour of an electrified liquid jet in the presence of an external coflowing liquid;
2) Generation of operating diagrams that map the transition from cone-jet mode to whipping mode;
3) Investigations on the critical role played by the external liquid on the jet diameter;
4) Developing a model that captures the evolution of coflowing electrified liquid jets inside a microfluidic device;
5) Using stability analysis to obtain theoretical operating diagrams for comparison with experiments.

Expected outcomes

1) The project will result in a thorough understanding on the evolution of an electrified polymer jet coflowing with an external liquid. In turn, this will lead to identifying the key system parameters needed to operate in whipping mode, the basic mechanism that leads to fiber formation.
2) In addition to facilitating the implementation of electrospinning inside a microfluidic device, the employed external liquid will help gain additional control over jet diameter, deposition of fiber, etc.
3) The proposed research will also address the characterization of whipping instability, which hitherto is little understood due to its chaotic nature in traditional electrospinning. The chaotic oscillations are dramatically reduced in the presence of an external liquid.

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

The project fits into the “Nanotechnology” theme of the IITB-Monash Research Academy. It will lay a platform to develop a novel microfluidics-based method to generate nanofibers that will provide additional control over fiber diameter, length, etc. The project will enhance our understanding on the mechanisms that govern the steady generation of polymer-based nanomaterials such as nano particles and nanofibers.

Capabilities and Degrees Required

The student should have good experimental skills and also keen interest on theoretical modeling. Interest in developing/exploring novel designs of devices for application-based microfluidics is desired.