Magneto-responsive microfluidic mixing in ionic liquid media

Proposers

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Introduction

Fluid control is fundamental for microfluidic lab-on-a-chip performance. Development of integrated multi-function microfluidics (e.g. micro-chemical reactors, biomedical platforms or environmental monitoring) depends upon strategies to tackle mixing, pumping, concentration, etc. which are critical elements for automated processing at the microscale. Integrated systems combining magnetism and magnetic nanoparticles (MNP) with microfluidics are a growing but not well explored route for non-contact fluid control and bioanalysis. This combination may enable bidirectional pumping with no mechanical moving parts in contact with the flow. Additionally, it can operate at low voltages or low power requirements, which allow for operation in low-resource environments. Moreover, MNP, suitable for magnetic actuation, can provide a functional substrate for molecule binding, making them extremely versatile to provide solutions for major microfluidic challenges in biomedicine-related applications. However, effective system integration strategies such as magnetically driven mixing in microchannels are still not fully understood and its implementation is far from trivial.

Project outline/goal

Well-defined fabrication/operation protocols for MNP manipulation in Ionic Liquid based microfluidic devices (magnetic mixers), is still lacking for commercial technological applications. The work program encompasses research and development of new MNP micromixing technologies. It aims at designing and fabricating a high-performance microscale magnetic micromixer (to be developed at INESC-MN) externally actuated by permanent magnets occupying well defined positions in a custom-made automated rotational platform (to be developed at INESC-ID) without the need of manufacturing costly micron-sized mechanical components. At this scale the balance between hydrodynamic and magnetophoretic forces as well as fluid-particle dynamics remain unclear particularly in the presence of strong external fields as rotation-based. As such, numerical simulations combined with experimental work, thorough characterization of the flow, fluid and magnetic properties of external actuators will also be considered. This innovative approach intends to tackle rapid and precise fluid flow control at the microscale with increased efficiency and reduced energy consumption, making way to a new generation of magneto-responsive microfluidic mixers for biochemical analysis.

Partner 1 – INESC-MN

The microfabrication will make use of state-of-the-art techniques available at Cleanrooms Class ISO 4 and ISO 5 and laboratorial facilities at INESC-MN. Literature review and flow dynamics and magnetism simulations carried with a commercial software will support the CAD design of the device. System variables such as temperature, flow velocity and flow pressure, flow geometry, compliance, porosity, etc. as well as relevant magnetic properties will be considered in simulations. Optical, mechanical and structural characterization of the micromixer

Partner 2 – INESC-ID

The magneto-responsive microfluidic mixer modes of operation will be set by externally actuating MNP in flow by a set of permanent magnets micrometrically positioned onto a custom-made rotating platform. The control and automation of the rotating platform will be devised at INESC-ID. The rotating platform is expected to enable the study of the influence of variables such as applied magnetic field, magnetic uniformity, residual magnetism, PM size or PM position as well as rotating speed on the mixing efficiency of the device.

System Integration – INESC-MN and INESC-ID

The automated system will be integrated with the magneto-responsive microfluidic mixer to demonstrate the mixing efficiency of the device when subjected to process variables. As such, a broad range of flow rates, rotating speeds of the rotating platform and magnetic fields will be addressed, and optical investigation of fluid patterns will be compared to the results obtained by numerical simulation. The establishment of facile and reproducible microfabrication and operation protocols and tools to project MNP manipulation in IL based microfluidic mixers is expected. As a major result, the mixing module will be a key module to be integrated in state-of-the-art lab-on-a-chip devices for biomedical applications.

Student profile

The candidate must be organized, sociable, responsible, good team worker and motivated. The candidate must have a solid background in Biological Engineering, Engineering Physics or related areas and experience in automation, data acquisition/treatment and cleanroom microfabrication techniques.