ID34- SPIRAL INERTIAL MICROFLUIDICS FOR SIZE BASED MICROALGAE SEPARATION

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Abstract
The identification of toxic microalgae is essential for the sustainable management of activities, such as aquaculture, being also relevant for environmental monitoring and marine research purposes [1]. For these reasons, there is an increasing demand for in situ, reliable, portable, autonomous, low-cost and of easy operation technologies and devices able to detect early signs of potential toxic algal populations within the context of long term monitoring programmes. To this aim, a multisensory platform for in-situ phytoplankton quantification and taxonomic identification designed for underwater deployment and based on lab-on-chip (LoC) technology has been developed. It combines flow cytometry with optical and electrical measurements. The separation of microalgae based on cell size prior to analysis is key to reduce the complexity and heterogeneous nature of seawater samples while also offering a degree of distinction between taxonomic groups. This work investigates and develops a simple inertial microfluidic device based on a spiral microchannel that achieves size-based separation of microparticles/cells. The theoretical principle of their separation was analysed trough numerical simulations and experimental tests were also performed. Using a 5-loop spiral (300 µm width and 100 µm height), 20 µm and 40 µm polystyrene (PS) microparticles were successfully separated for a flow rate of 2000 µl/min, showing its potential for microalgae size-based separation. Furthermore, the simple structure and high throughout makes this technique suitable for integration in LoC devices [2, 3].

Keywords
Spiral Inertial Microfluidics, Microalgae Sorting.

NUMERICAL SIMULATIONS
Microparticles separation in a spiral microchannel were simulated in COMSOL Multiphysics to examine the influence of inertial microfluidics on microparticles trajectories. The simulated spiral has five turns with channel dimensions of 300 µm width and 100 µm height with a fully developed flow rate of 1000 µl/min. Figure 1 shows the results obtained in the simulations, where a separation between 20, 30 and 40 µm particles can be observed.

EXPERIMENTAL RESULTS
In experimental tests, a 5-loop spiral 300 µm width and 100 µm height of and four outlets was fabricated in PDMS (figure 2). 20 µm and 40 µm PS microparticles were chosen to test the separation capabilities of the designed spiral. A good separation between the selected particles was achieved for 2000 µl/min, with particles of different sizes exiting through different outlets.

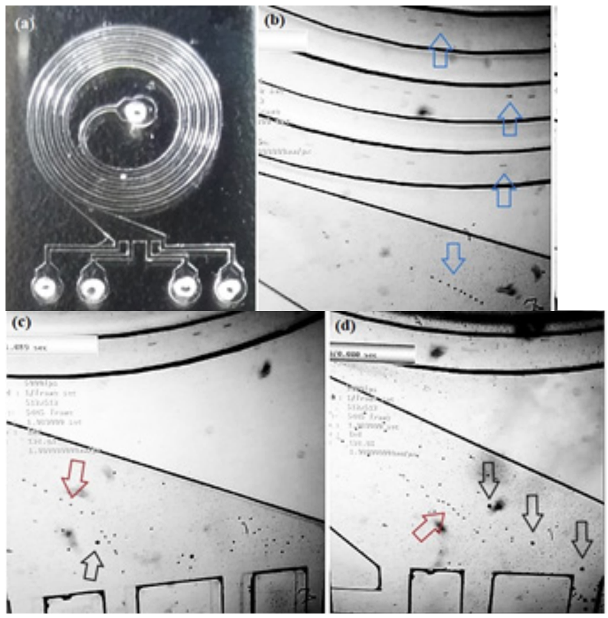

Fig 2. Experimental results: (a) PDMS spiral with four outlets; (b) Microparticles (blue arrows) being transported and focused at the microchannels for a flow rate of 1000 µl/min; (c) 20 µm (red arrow) and 40 µm particles (black arrow) both exiting through the same outlet for a flow rate of 1000 µl/min; (d) 20 µm (red arrow) and 40 µm particles (black arrow) with separated trajectories exiting through different outlet for a flow rate of 2000 µl/min.

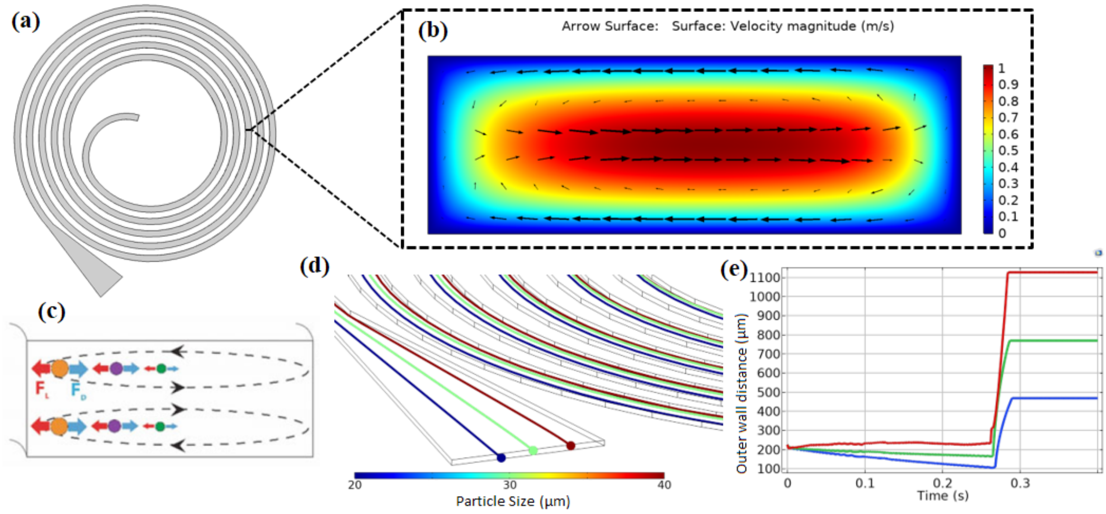

Fig 1. Numerical simulation results: (a) spiral geometry used in the simulations; (b) Dean vortices formed at the microchannel cross-section;
(c) schematic representation of the equilibrium position of particles resulting of the interaction between the net lift force (FL) and the Dean drag force (FD) adapted from [2]; (d) particles (20, 30 and 40 µm) trajectories and final positions at the outlet and (e) plot of the particles distance to the outer wall of the microchannel (y-axes) as they travel from the inlet to the outlet.

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