Shape and Size Optimization of Swimming Microbots in Viscoelastic Biofluids

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The use of microbots in different areas of research have increased in the last years. Microbots are mechanical or electromechanical devices whose components are at or close to the scale of micrometers. Among the wide range of applications, the most promising ones lie in the field of biomedicine in the reparation of diseased cells, performing eye surgery, detecting cerebral aneurysms, delivering drugs in the right place without collateral damages or to remove blood clots[1]. Most of the potential microbots are bio-inspired swimming microdevices based on the propulsion mechanism of microorganisms like bacteria or spermatozoa, in fact, some recent works were focused in the study of the motion of these microbots according to the different natural techniques of these kind of microorganisms. Other works dealt with other robot capabilities, as the remote control or autonomy[2]. However, the body shape and size play a very important role in the study of their flow through the main conduits of the human body. The non-linear rheological behavior of the biofluids is crucial when the characteristic length scales are of the order of micrometers since the elastic effects are enhanced even at low Reynolds numbers. In this sense, *in vitro* experiments are fundamental for their relevance to *in vivo* applications of microbots in order to understand the flow field under different flow conditions. The aim of this work is to optimize the morphology of microbots in order to achieve a most effective motion when they swim through different conducts of the human body taking into account the viscoelastic properties of the biofluids.
This work is therefore, divided in different subobjectives which are describing in detail (Fig. 1):

- Selection and rheological characterization of solutions analogues to main human biofluids, i.e. blood. The selection of the blood analogues is done based on previous work[3] with a viscoelastic behavior close to real human blood and with a refractive index suitable for the *in vitro* models made of PDMS.
- The models with the characteristics geometries of the human body like veins or arteries are designed in AutoCAD. The microchannels are fabricated in polydimethylsiloxane (PDMS) from SU-8 photoresist molds using standard soft lithography techniques[4].
- The prototype of the microbot is developed according to some designs in literature which are bio-inspired microdevices.
- Flow visualizations, pressure drop measurements and micro-PIV are carried out with the biofluids analogues, and under different flow conditions: pulsatile and stationary. In order to visualize the flow streak-line photography technique is used. Pressure drop measurements is also important in order to study the impact on the flow dynamics due to the presence of the microbot and the possible repercussions on the channel walls. Moreover, the drag forces experienced by the microbot during the flow are measured simultaneous with birefringence tests to understand the non-Newtonian flow around the microdevice.

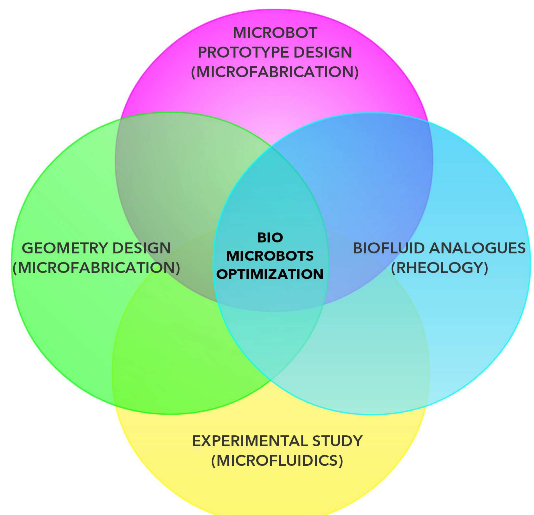

FIG. 1. Relationship between microfluidics, rheology and microfabrication in the optimization of swimming microbot's morphology.

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