Flexible Magnetic 3D Printed Robots for Cell and Drug Delivery

Guillem Lopez[1], Arnau Llobera[1], Judith Fuentes[1], Dalia Mahdy[2], Islam S.M. Khalil[3], Maria Guix[1], Samuel Sanchez[1,4] Veronika Magdanz[1*]

[1]Institute for Bioengineering of Catalonia (IBEC), The Barcelona Institute of Science and Technology (BIST). Barcelona, Spain
[2]German University in Cairo, New Cairo City, Egypt
[3]Department of Biomechanical Engineering, University of Twente, Enschede, The Netherlands
[4]Institució Catalana de Recerca i Estudis Avancats (ICREA), Barcelona, Spain

The actuation of microrobots by using external magnetic fields allows the untethered control of such microdevices and have the potential to make medical operations less invasive and more precise. They are promising for many applications, such as targeted therapy or minimally invasive surgeries. Current challenges in the field of magnetic microrobotics include efficient propulsion, biocompatibility and highly precise functionality for advanced manipulation purposes.

Our work addresses at first the optimization of the flexibility of a soft magnetic swimmers fabricated from PDMS by tuning its material properties. Second, the influence of the location of its magnetic segments on the forward propulsion by magnetic actuation is studied (Fig.1A). Also, its biocompatibility and potential as cell delivery machines is investigated (Fig.1B).

Further, we explore other materials with advanced properties such as stimuli-response to temperature, allowing on-demand adaptability of their shape and triggered cargo release. Poly-N-isopropylacrylamide is presented as one optional material to obtain shape-changing structures by 3D printing this stimuli-responsive hydrogel and applying reversible temperature triggers (Fig.1C). These adaptive microrobots can be explored for cargo loading and release purposes. The addition of gold nanorods allow the laser-triggered thermoresponse by photothermal mechanism and thereby release of cargo (Fig.1D).

These preliminary investigations aim to pave the way to develop flexible magnetic and highly functional magnetic robots for cell and tissue delivery and on-demand cargo delivery within the framework of the La Caixa Junior Leader program. This project welcomes interactions with experts from microfabrication of biomaterials and regenerative medicine.

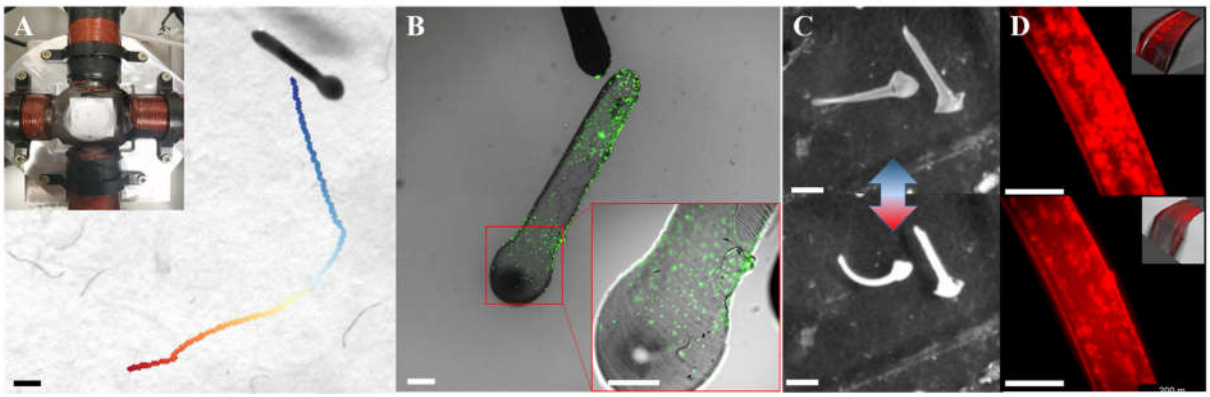

Figure 1: Flexible magnetic robots for cell and cargo delivery. A) Swimming path of elastomeric PDMS filament actuated by oscillating magnetic fields generated by electromagnetic coil setup (inset). Scale bar 2mm. B) Skeletal muscle cells grown on PDMS showing its biocompatibility and cell cargo ability. Scale bar 500µm. C) Shape change of 3D printed PNIPAM structures when changing temperature from 30°C (top) to 38 °C (bottom). Scale bar: 2mm D) Release of fluorescently labelled microparticles (red) from PNIPAM filaments when 747nm light is applied for 8 minutes. Top image: Before light exposure, bottom: after light exposure. Inset shows cross-section of z-stack. Scale bars 200µm.