

Smart magnetic soft materials to develop artificial muscles and therapeutic robots

May 6 2021



Interaction forces between magnetic particles translate into macroscopic transformations of the smart polymers. Credit: 4D-BIOMAP

Developing a new generation of artificial muscles and soft nanorobots for drug delivery are some of the long-term goals of 4D-BIOMAP, an ERC research project being undertaken by the Universidad Carlos III de Madrid (UC3M). This project develops cross-cutting bio-magneto-mechanical methodologies to stimulate and control biological processes

such as cell migration and proliferation, the organism's electrophysiological response, and the origin and development of soft tissue pathologies.

"The overarching idea of this research project is to influence different [biological processes](#) at the [cellular level](#) (i.e., wound healing, brain synapses or nervous system responses) by developing timely engineering applications," explains 4D-BIOMAP's lead researcher, Daniel García González from the UC3M's Department of Continuum Mechanics and Structural Analysis.

The so-called magneto-active polymers are revolutionizing the fields of solid mechanics and materials science. These composites consist of a polymeric matrix (i.e., an elastomer) that contains magnetic particles (i.e., iron) that react mechanically by changing their shape and volume. "The idea is that the application of an external magnetic field leads to internal forces in the material. These forces result in alterations of its mechanical properties, such as stiffness or even shape and volume changes which may interact with the cellular systems", explains Daniel García González. The researcher recently published a scientific article in *Composites Part B: Engineering* about this topic with his colleagues from the UC3M's Department of Structural Analysis and the Department of Bioengineering and Aerospace Engineering. In this cross-cutting collaboration, motivated on original experiments, they propose a model that provides theoretical guidance to design magneto-active structural systems that could be applied in epithelial wound healing stimulation.

The magneto-mechanical response is determined by the material properties of the polymeric matrix and magnetic particles. If these processes are controlled, other engineering applications could be developed, such as soft robots that can interact with the body or a new generation of artificial muscles, notes the researcher, who explains the potential of this technology with a comparison: "Let's imagine someone

who is on the beach and wants to step forward quickly. However, the sand (the mechanical environment) makes it a little more difficult for them to move forward than if they were stood on tarmac or an athletic track. Similarly, in our case, if a cell is on a substrate that is too soft, it will make it more difficult to move. So, if we are able to alter these substrates instead and create this athletic track for cells, we will make all of these processes develop more efficiently."

4D-BIOMAP (Biomechanical Stimulation based on 4D Printed Magneto-Active Polymer) is a five-year project funded with 1.5 million Euros by the European Research Council through an ERC Starting Grant within the Framework Program for Research and Innovation, Horizon 2020 (GA 947723). This research project is being approached from a multidisciplinary perspective, involving knowledge from disciplines such as solid mechanics, magnetism, and bioengineering. In addition to this, computational, experimental, and theoretical methodologies will be combined.

More information: D. Garcia-Gonzalez et al. Influence of elastomeric matrix and particle volume fraction on the mechanical response of magneto-active polymers, *Composites Part B: Engineering* (2021). [DOI: 10.1016/j.compositesb.2021.108796](https://doi.org/10.1016/j.compositesb.2021.108796)

Provided by Carlos III University of Madrid

Citation: Smart magnetic soft materials to develop artificial muscles and therapeutic robots (2021, May 6) retrieved 25 April 2024 from <https://phys.org/news/2021-05-smart-magnetic-soft-materials-artificial.html>

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