

Project title; Additive manufacturing of stimuli responsive scaffolds for biomedical applications

Description

Biomaterial based scaffolds have emerged as a potential intervention for personalized drug delivery, wound healing and skin tissue regeneration. These are intricate three-dimensional structures, serving as carriers for cells and medications, facilitating their integration and delivery into the body.

This research project in collaboration with Queen Victoria Hospital is about improving the design and fabrication of 3D printed scaffolds for applications in drug delivery and regenerative medicine. We will investigate the use of additive manufacturing (AM) technologies combined with advanced materials that have the ability to change their shape, properties and functions over time in response to external stimuli such as magnetic fields and light sources. It also explores the adoption of novel robotic based volumetric imaging and its integration with AI tools for the development of personalised 3D printed scaffolds models for tissue regeneration.

Keywords:

Additive manufacturing, robotics, drug delivery, stimuli responsive scaffolds, biomedical applications.

Method

This research will investigate novel 3D printing methodologies for the manufacturing of stimuli responsive scaffold, including:

- The use of magnetic and/or light-stimuli micro particles and polymers to create devices that can be actuated to either sense/deliver drugs to specific sites in the body using external illumination/magnetic fields or to create biomaterials-based scaffolds for tissue regeneration.
- Multi-physical simulation will be used to design complex structures and geometries based on application specific needs.
- Conducting experimental testing to assess the mechanical and structural properties of the scaffolds as well as the interaction with magnetic fields and light.

Skills / experience required

Mechanical, Electrical, Computing, Biomedical, Chemical Engineering, Physics or Computer Science Background.

Key readings

[1] Yan, Chaolu; Aviles-Espinosa, Rodrigo; Wang, Shouguang; Rendon-Morales, Elizabeth (2025). 3D printed magnetic scaffolds for precise and tunable on-demand drug delivery. AIP advances. Journal contribution. <https://hdl.handle.net/10779/uos.30555398.v1>

[2] C. Yan, R. Aviles-Espinosa, S. Wang and E. Rendon-Morales, Design and Fabrication of 3D-Printed Magnetically Triggered Soft-Porous Scaffolds for Drug Delivery, 2024 International Conference on Networking, Sensing and Control (ICNSC), Hangzhou, China, 2024, pp. 1-5, doi: 10.1109/ICNSC62968.2024.10759996.

[3] C. Yan, R. Aviles-Espinosa, and E. Rendon-Morales, Towards the development of personalized drug delivery systems using 3D printed magnetically triggerable elastomers, 11th International Electronic Conference on Sensors and Applications, Engineering Proceedings, 82 (1) MDPI 2024

[4] Rendon-Morales E, Shi K, Woodbine L, Maniruzzaman M, Nokhodchi A, Aviles-Espinosa RA; Characterization of magnetically triggerable millirobots for on demand drug delivery using a brightfield microscopy metrology system. European Focus on Microscopy Conference 2022.

[5] Shi K, Aviles-Espinosa RA, Rendon-Morales E, Woodbine L, Salvage JP, Maniruzzaman M, Nokhodchi A, Magnetic field triggerable macroporous PDMS sponge loaded with an anticancer drug, 5-fluorouracil, ACS Biomaterials Science and Engineering7(1):180-195 American Chemical Society, 2021.

[6] Shi K, Aviles-Espinosa R, Rendon-Morales E, Woodbine L, Maniruzzaman M, Nokhodchi A, Novel 3D printed device with integrated macroscale magnetic field triggerable anti-cancer drug delivery system, Colloids and Surfaces B: Biointerfaces192 Elsevier 2020.

Learning Outcomes

Upon completion, students will be able to:

- Apply a research methodology to improve the design of complex structures and geometries of 3D printed scaffolds.
- Develop skills to formulate an independent literature review of the proposed research area
- Interpret data from multi-physical simulations to guide fabrication processes.
- Apply experimental techniques to understand the interaction of the magnetic field and light with the material properties including stiffness, shape and its relationship to drug release kinetics.
- Evaluate and understand the suitability of 3D printed technologies for tissue equivalents in clinical settings and precision drug delivery.

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