Development of microfluidic Tissue-on-Chip platforms

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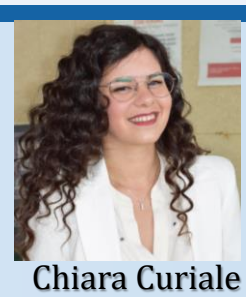

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Organ-on-Chip technology

Concept

In recent years, there has been a paradigm shift in the field of biomedical research, with a growing inclination towards in-vitro models that replicate the physiological processes of living organisms. One remarkable innovation is the development of organ-on-a-chip (OoC) technology, which offers a platform for emulating complex in-vivo environments in a controlled laboratory setting. In fact, OoC platforms can allow for more efficient, cost-effective, and ethically sound research methodologies. These bioengineered platforms can integrate living cells, biomaterial scaffolds such as hydrogels or synthetic polymers, and microfluidic channels to recreate the physiological microenvironment and dynamic interactions found within the body. Organ-on-a-chip technology has also been used to model various diseases, including cancer, neurodegenerative disorders, and infectious diseases, so a more accurate understanding of disease mechanisms can be attained, while also enabling the assessment of potential therapeutics within a context that closely mimics physiological conditions.

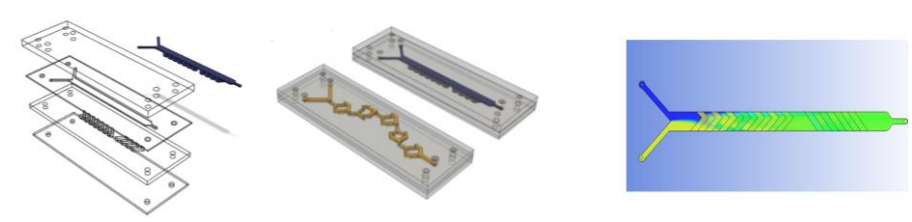
Scientific approach

This research project focuses on developing in vitro models based on Organ-on-Chip (OoC) microfluidic platforms by integrating advanced microfluidic systems, computational fluid dynamics modeling, rapid prototyping, and dynamic cell cultures.
The approach to achieving the study's objectives involves several phases: (i) design of microfluidic systems, (ii) optimization and 3D printing or laser cutter assembly, (iii) chip perfusion, and (iv) cell culture. The research theme aligns with industrial engineering topics, with a focus on cutting-edge biomedical engineering research.
Upon the design's completion, computational fluid dynamics (CFD) simulations are employed to evaluate the fluid flow patterns within the proposed microfluidic chip. COMSOL Multiphysics and Ansys Fluent, powerful software tools for simulating physics-based phenomena, are used to predict fluid behaviour.
The chip, composed of polymethylmethacrylate, utilizes a multi-layered structure bonded through heat press at 70 °C, ensuring robustness and reliability combined with rapid prototyping fabrication routes.
By incorporating scaffolds into the chip, such as membranes or hydrogels, the culture of the desired cells is then initiated.

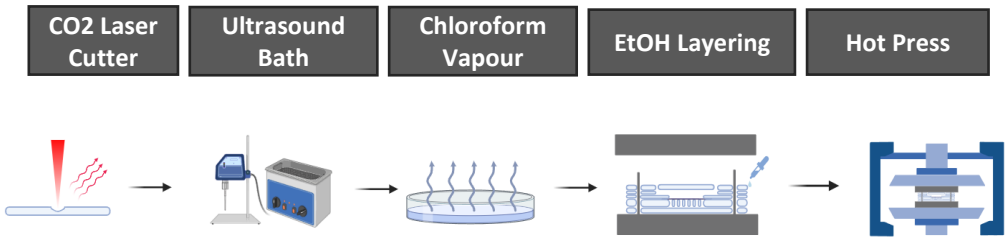
Research objectives

The aim of this PhD project is to bridge the gap between traditional cellular models and animal models, necessitating innovative research methodologies. Specifically, the project focus on the fabrication of microfluidic systems, integration with scaffolds and their optimization. Biological test is also carried out in a dynamic culture through the perfusion with a pump.
Overall, this organ-on-chip system, using advanced microfluidic technology, has promising applications in drug delivery, personalized medicine, and food science, benefiting healthcare and nutrition research.

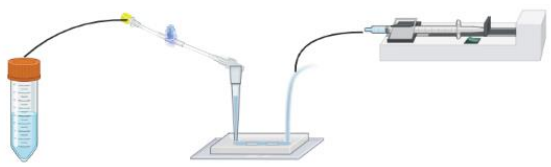
Design of microfluidic systems



Fabrication



Chip perfusion



Dynamic cell culture

The objective of this study is to evaluate the effect of dynamic cell culture compared to static cell culture, using scaffolds integrated into a microfluidic device.