Research projects 2023-2024, 6 months

Title

Organs-on-chips based on textile microfluidics: new materials for new applications

Supervisor:

Name: Jean-Louis Viovy, Dr Emeritus CNRS, UMR 168, CNRS/Institut Curie/IPGG
Phone: 06 07 67 59 62
E-mail: jean-louis.viovy@curie.fr
Co-supervisor: Vivian Aubert, UMR 168, CNRS/Institut Curie/IPGG
Phone: 06 84 07 16 02
E-mail: vivian.aubert@curie.fr

Host Laboratory:

Affiliation: Institut Curie, CNRS, PSL
Lab Name: UMR168, Institut Pierre Gilles de Gennes pour la Microfluidique (IPGG)
Address: IPGG, 6 Rue Jean Calvin, 75005 Paris

Partners or collaborations :

Name: Prof. F. Boussu
Phone: +33 320256476
E-mail: fboussu@gmail.com
Affliliation: ENSAIT (Ecole Nationale Supérieure des Arts et Industries Textiles)
Lab Name: GEMTEX (Génie et Matériaux Textiles)
Address: 2 allée Louise et Victor Champier BP 30329 59056 ROUBAIX CEDEX 1 FRANCE

Project description :

Microfluidics and microfabrication have recently undergone an explosive development in biology. They allow to position, address and study cells with an unprecedented accuracy and resolution. A particular promising application is the development of “organs-on-chip” (OOC), reproducing the structure, physiology and functions of tissues and organs[1]. They constitute an ideal partner to stem cell technologies, adding to this field or research the possibility to pre-position cells, and to stimulate them with physical or biochemical cues with a high spatial and temporal resolution. This has enormous potential for research and for drug and toxicity testing, as an intermediate between conventional in vitro culture and animal models, but also as a way to avoid problems in translation from animals to humans in drug development, thanks to the use of OOC based on human primary cells or IPSCs. Last but not least, these

[1] Verhulsel, M., Vignes, M., Descroix, S., Malaquin, L., Vignjevic, D. M., & Viovy, J. L.. A review of microfabrication and hydrogel engineering for micro-organs on chips. *Biomaterials*. doi: 10.1016/j.*biomaterials*.2013.11.021

systems will also allow for the preparation of implants for regenerative medicine. Currently, however, OOC are based on microelectronics clean-room technologies, they are complex and expensive to fabricate, and the transposition of these technologies to biomaterials is not straightforward. Among others, it faces the following dilemma: it is easy to prepare artificial materials (e.g. silicone PDMS) with suitable resolution and mechanical properties for easy manipulation in microfluidics, but they lack essential biological properties, and notably the possibility to be penetrated and/or remodeled by cells. Conversely, biological or bio-hybrid hydrogels exist, with the latter properties, but when used as microfluidic devices, they are extremely difficult to fabricate and manipulate, and often too fragile.
We have developed in our team a new technology, "textile microfluidics", which allows to overcome the above dilemma. In short, it amounts to combine textile and microfluidic technologies to prepare microfluidic systems involving a textile-based support, which brings to the system its architecture, mechanical stability and resistance while preserving the flexibility required by many organs. This textile is embedded in a hydrogel, which can be adapted to the searched biological application: since the textile brings mechanical strength, relatively fragile hydrogels can be used more easily. Finally, the hydrogel comprises a network of microchannels, which are prepared thanks to a unique technology of sacrificial textile fibers. These microchannels can be used as models of ducts or vessels, permeated by cells, nutriments solutions, gases or biofluids, to mimick the 3D architecture of various organs. Also, the "composite" nature of the chip and the presence of the textile armature will strongly increase mechanical resistance, and allow the introduction of mechanical active functions. We have previously shown that cells can be grown in these kind of chips. In this project, we shall focus on the improvement of "materials" aspects. In particular, the first generation systems raised problems of visualization, due to the non-transparency of the fibers. We made last year a proof of concept of the use of transparent fibers, to solve this problem. The present project will build onto this, to prepare chips with high optical properties. We shall also develop structural aspects, going towards 3D architectures to better mimick "thick" tissues.

This interdisciplinary project will be developed in the team "Macromolecules and Microsystems in Biology and Medicine", a multidisciplinary team of about 20 persons working at the interface between physics, chemistry and biology[2]. The team is located in IPGG the first French Institute entirely dedicated to microfluidics. The project will benefit from the whole technological platform and support of the engineers of IPGG (clean room, microfabrication facility, culture rooms, microscopy), and if needed of the technological platforms and engineers of Curie Institute. It will benefit from the expertise of A. Salles, a former BioMat Student who worked in the project and is continuing as a PhD in collaboration with the lab, and A. Kaddouche a Textile Engineer.
The project will also be developed in collaboration with ENSAIT in Roubaix, the National Superior Engineering school and research center of Textile technologies, fully dedicated to the development and teaching of textile technologies at the highest level. Ensait will provide textile expertise and woven textile structures. The project, mostly experimental, will require knowledge in biomaterials and cell culture, curiosity for new fields and ability to work in team.

[2] https://science.curie.fr/recherche/physique-chimie-biologie-multi-echelle-et-cancer/physico-chimie/equipe-descroix/

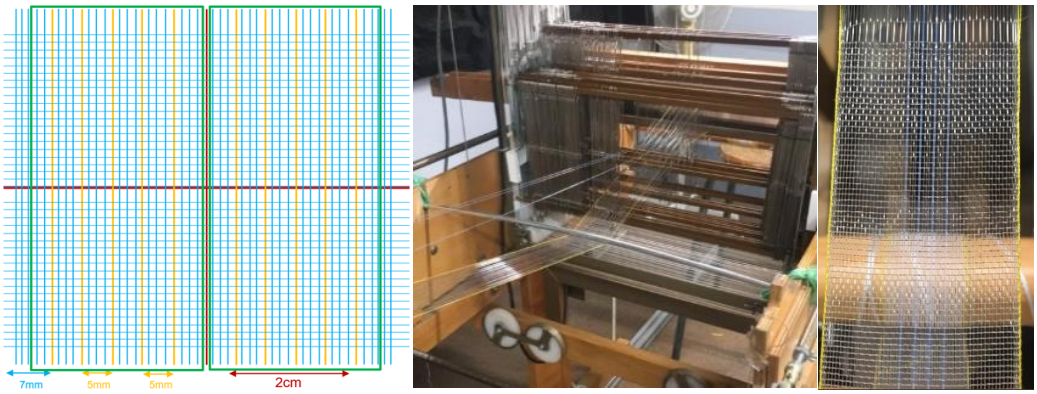

Figure 1. Example of textile patterns with microchannels, weaving machine, and textile structure used to make textile organ-on-chips. .

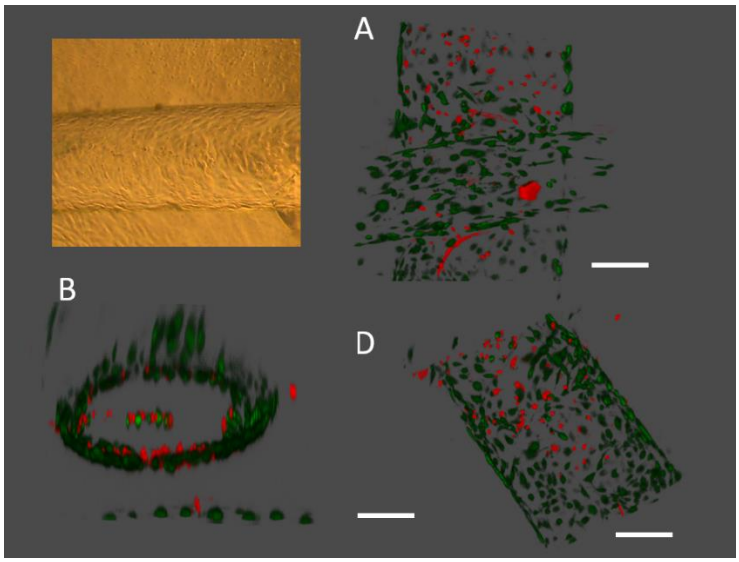

Figure 2. Images of human endothelial cells cultured in textile organs on chip, with "live (green)-dead(red)" confocal imaging, from top (A,D) and side (B) of a channel, and by transmission imaging (top left)