

Subject proposal for Master 2 internship

Title:

“A new bio-sourced polymer for the fabrication of labs-on-a-chip”.

Supervisor/Contact:

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Laboratory and location:

The internship will take place at Institut des Nanotechnologies de Lyon (INL) located at Ecole Centrale de Lyon (Ecully) and UCBL campus (Villeurbanne), in the Device for Health and Environment group and at Institut des Matériaux Polymères (IMP) in the LIFE group, at UCBL campus (Villeurbanne)

Key word: *Lab-on-a-chip, biopolymer, eco-efficient processes, microstructuration*

Context: Labs-on-a-chip (LoCs) have promoted precise manipulation of extremely small volume of fluids and micro-objects, such as cells in a controlled environment. They address a wide range of applications, particularly in the biomedical field, and due to the growing demand for rapid, individualized tests at the point of care, the miniaturized medical diagnostics market is expected to reach \$75.5 billion by 2027 [1]. However, most of them are currently made from hydrocarbon-based polymers (mainly polydimethylsiloxane and thermoplastics), and the increase in single-use testing will have a negative impact on the environment, both in terms of their manufacture and destruction. In the wake of the growing environmental awareness, bio-sourced polymers have come forth as promising candidates for the production of LoCs. Despite their potentials, few researches have been published on the subject. The most widely used biopolymers are cellulosic materials. Fluids are transported through the device by capillary action, and the resulting LoCs are suitable for a wide range of diagnostic applications, but not for cell manipulation. Other biopolymers, such as (i) zien, a byproduct of ethanol production from corn, (ii) silk hydrogels, or (iii) poly(lactic acid) (PLA), have been reported, but none of them meets the LoC specifications in terms of transparency, microstructuration, impermeability, biocompatibility and biodegradability.

Chitosan is a non-toxic, biocompatible, biodegradable and antimicrobial polysaccharide composed of D-glucosamine and N-acetyl D-glucosamine units. Obtained from the deacetylation of chitin, the second most widespread natural polymer on Earth, it is industrially produced by valorizing wastes from the seafood industry (several million tons per year). Early research has enabled us to calibrate a chitosan filmification and neutralization protocol, as well as to microstructure the material and manufacture the first chitosan fluidic microsystems [2]. However, a number of technological challenges still need to be overcome.

Objectives: The initial results obtained for the manufacture of chitosan microfluidic systems are promising, and we now need to improve certain stages of the manufacturing process, study different microstructuring options to move towards multi-scale structuring of the material, and develop new bonding methods for the system assembly. During the internship, the student will explore different ways of cross-linking chitosan to make it impermeable. Currently, the film is neutralized, which limits its swelling to 50% and stabilizes it. Cross-linking could prevent any swelling. The challenge lies in developing a process compatible with an environmentally-friendly protocol. She/He will also test different deposition methods to improve the film planarity, which is crucial for multi-scale structuring. The aim is to deploy these techniques on thick chitosan films (few hundred μm). Structuration at the micro-scale will then be validated by nano-imprint. And finally, She/He will also work on the device bonding step, and on characterizing the performance of simple fluidic functions. The intern will benefit from the microfluidic facilities provided by INL (Nanolyon Platform) and gain training in various areas including: polymer formulation, micro-fabrication in cleanroom environment, microfluidic device manipulation, video-microscopy and data analysis.

Training period: 5 to 6 months, between February and September 2024

[1] <https://www.marketsandmarkets.com/Market-Reports/point-of-care-diagnostic-market-106829185.html>
[2] M. Zimmer, *et al.*, proceeding IEEE Biosensors conference, London, July 30-august 1, 2023

