PhD research proposal

« Microglace » - Development of a microfluidic device for sampling biological particles from ice cores

Location : Ecole Centrale de Lyon, Laboratoire AMPERE

Supervisors : Catherine Larose (HDR), Marie Frénéa-Robin (HDR), Julien Marchalot

Doctoral school : ED 160 EEA Lyon

Context

As climate change is a reality, we need to improve our knowledge of biotic systems in order to be able to predict the response of microorganisms to environmental forcing (1). Although ice and sediment cores have provided some physical and chemical data describing how our world has evolved over the last several hundred thousand years, they, unfortunately, do not explain the biotic response to climate forcing (2). Ice cores provide an untapped reservoir of biological information, as they constitute a window into past evolution and climate change events that are likely mirrored in microbial genomes (3). However, to date, no study has looked at the metabolic potential of these organisms in relation to their chemical environment.

Detailed subject description

The objective of this thesis is to participate in the development of a microfluidic device that will be able to isolate and characterize microbial communities immured in ice cores. Given that access to ice core samples for biological exploration is limited due to technical issues related to sample volume required in traditional approaches as well as contamination issues, there is a clear need to miniaturize and improve sampling and analysis tools. By miniaturizing the sample volumes, we will also increase the temporal resolution (in traditional methods, large sample volumes of ice are melted and incorporate different layers that represent different time scales).

The proposed device consists of modules that use different techniques to sequentially extract biomolecules based on their physical properties (size, compressibility and electric properties). A hybrid microfluidic device combining acoustophoresis (4-6) and dielectrophoresis will be designed to perform separation of large particles (i.e. debris, large cells) from smaller ones such as bacteria, viruses and free DNA. The isolated microbial communities will be lysed in the

device prior to DNA sequencing using equipment already available in the lab. The work will consist in designing the separation device with the help of simulation tools (Comsol Multiphysics), manufacturing the chips (use of fast prototyping tools & access to clean room facilities) and performing experiments on ice core samples generated in the lab.

The recruited student will join a multidisciplinary team composed of microbiologists and researchers specialized in the development of microsystems dedicated to cell biology. He/She will have access to experimental facilities including cell culture room, equipment dedicated to chip fabrication (soft-lithography equipment & access to INL NanoLyon platform) and testing (flow controllers, microscopes, high-speed camera, etc.).

Qualifications required:

Preferably, the applicant will hold a master degree in the field of microtechnology/microfluidics. Applicants with a background in physics or instrumentation will also be considered. The candidate should be strongly interested in experimental work and have good written and oral communication skills.

Funding:

This position is supported by a doctoral contract from Ecole Centrale de Lyon allocated by the French ministry of higher education and research (priority subject).
The gross monthly salary covers a total of € 1711,00. The doctoral student can undertake a supplementary teaching activity, granting an additional gross € 313,00.

Application

Applicants should send a CV and a cover letter before may, 15th to :
Catherine.larose@ec-lyon.fr, Marie.robin@univ-lyon1.fr and Julien.marchalot@insa-lyon.fr

References

1. Laybourn-Parry, J. Microbiology. No place too cold. Science (80). 324, 1521–2 (2009).
2. Knowlton C, Veerapaneni R, D'Elia T, Rogers SO. Microbial Analyses of Ancient Ice Core Sections from Greenland and Antarctica. Biology. 2013;2(1):206-232. doi:10.3390/biology2010206.
3. Maccario, L., Sanguino, L., Vogel, T. M. & Larose, C. Snow and ice ecosystems: Not so extreme. Res. Microbiol. 166, 782–795 (2015).
4. T. Laurell, F. Petersson, and A. Nilsson, "Chip integrated strategies for acoustic separation and manipulation of cells and particles," Chem. Soc. Rev., vol. 36, no. 3, pp. 492–506, 2007.
5. J. Shi, X. Mao, D. Ahmed, A. Colletti, and T. J. Huang, "Focusing microparticles in a microfluidic channel with standing surface acoustic waves (ssaw)," Lab Chip, vol. 8, no. 2, pp. 221–223, 2008.
6. S. Toru, F. Buret, and M. Frénéa-Robin. "Towards optimized conception of SSAW- based acoustic tweezers". IEEE NEMS conference, Hawaï, USA, Apr. 13-16, 2014.