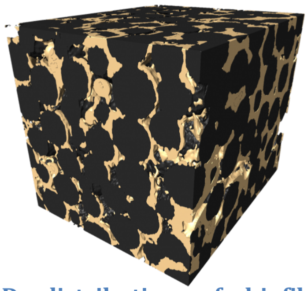
PhD position

Controlling bacterial clogging in porous micro-bioreactors

Lab	Institute of Fluid Mechanics, Allée Camille Soula, 31400 Toulouse, France.
Funding /Project	European Research Council. ERC Starting Grant. Project BEBOP.
Main supervisors	Yohan Davit, yohan.davit@imft.fr & Pascal Swider
Dates & Salary	September 2021. Flexible. Salary is bout 2135 euros gross monthly.
Example publication	Investigating the influence of flow rate on biofilm growth in three dimensions using microimaging. S Ostvar, G Iltis, Y. Davit, S Schluter, L Andersson, BD Wood and D Wildenschild. Advances in Water Resources (2018).
Background	Biophysics, or biotechnology, or engineering, or microbiology.
Other	For more info about research activities @ IMFT, http://yohan-davit.com

Candidate background. The relevant background includes chemical engineering, process engineering, experimental fluid mechanics, microfluidics, biophysics, bioengineering, microbiology or microbial ecology. To some extent, the exact focus of the work and tools can be tailored to the interest and background of the candidate. The primary criterion will be somebody who is extremely motivated and who will be fully involved in a multidisciplinary project involving 3 PhDs, 2 postdocs and several collaborations.



3D distribution of biofilm (gold) in a packing of beads (black). Image obtained using X-ray microtomography.

Localization and duration. The successful candidate will be working at the Institute of Fluid Mechanics in Toulouse. Most of the work will be conducted at the BioPorousLab, an experimental laboratory at the University Hospital (CHU Purpan).

Scientific project. When bacteria develop onto a solid surface, they produce a matrix of extracellular polymeric substances and form a biofilm. Biofilm growth in porous media can clog pores and induce an important increase in pressure drop. In this work, we ask whether we can control this bioclogging and the permeability of porous structures? Developing new strategies to manage bacterial growth and a control theory for biofilms in porous media would have numerous applications in engineering, including in soil bioremediation or for creating novel classes of self-repairing materials. From a fundamental viewpoint, this implies that we understand the fundamental mechanisms of growth and development of bacteria in porous media.

To tackle this problem, we have developed an approach based on X-ray tomography to image the 3D distribution of biofilms in porous structures. We have also developed a micro-bioreactor technology based on 3D printing that can be used to study both bacterial growth in porous media and the system response in permeability. We want to characterize the pressure drop and control it, by using modifications of hydrodynamic, nutrient and temperature conditions; by introducing bacterial predators; and by altering communications between bacteria. The goal of this PhD work is to develop a demonstration micro-bioreactor for which we can control precisely and in a reversible manner the permeability. We will use our existing technology (collaboration with Laurent Malaquin from LAAS-CNRS), that we will adapt to allow for control engineering.

We are looking for an extremely motivated student who will be fully involved in a multidisciplinary project at the interface between physics, fluid mechanics and microbiology.

Research context. This position is part of a large project (BEBOP, 2019-2024) funded by the European Research Council. The goal of BEBOP is to figure out how we can use bacteria to control the properties of porous structures (e.g. porosity, permeability). We envision that this will unlock a new generation of biotechnologies, such as self-repairing construction materials or self-cleaning bioreactors. The main scientific obstacle to this technology is the lack of understanding of the biophysical mechanisms associated with the development of bacterial populations within complex porous structures. Therefore, the first scientific objective of BEBOP is to gain insight into how fluid flow, transport phenomena and bacterial communities (biofilms) interact within connected heterogeneous structures. To this end, we will combine microfluidic and 3D printed micro-bioreactor experiments; fluorescence and X-ray imaging; high performance computing bringing together CFD, individual-based models and pore network approaches. The second scientific objective of BEBOP is to create the primary building blocks toward a control theory of bacteria in porous media and to construct a demonstrator bioreactor for permeability control.

The research lab in Toulouse is the institute of fluid mechanics (Allee Camille Soula, 31400 Toulouse, France.), which is associated with both the University of Toulouse and the CNRS. This is one of the largest labs in fluid mechanics in France, with about 65 academics, 35 technicians and engineers, 80 PhD students and 20 postdocs. Research covers a wide range of topics in fluid mechanics (biomechanics, turbulence, multiphase systems, heat transfer, multiscale reactive transfers). IMFT is considered one of the best laboratories in its area in France.

How to apply? Apply directly on the CNRS website emploi.cnrs.fr at the following address: https://bit.ly/2Zn0ofh