INTERNSHIP OFFER - MASTER 2

Study of the reactive transfer of a bio-based acid in milli/microfluidics

CONTEXT:

3-hydroxypropionic acid (3-HP) is a molecule used in the synthesis of numerous chemicals (acids and polymers). It is a key intermediate in the production of acrylic acid and its polymer derivatives. Currently produced from petroleum, the search for a bio-based alternative is now a major challenge: according to the Department of Energy (DoE), 3-HP is one of the 10 platform molecules that urgently need to be produced from biomass.

Research efforts, particularly at the SayFood joint research unit, are therefore being conducted to produce this molecule in a bioreactor and recover it using a separation process[1]. The current separation process used to recover 3-HP is a membrane contactor. The objective of this internship is to lay the scientific foundations for an alternative to this technology: an intensified continuous process at milli/microfluidic scale. A proof of concept has already been carried out on lactic acid (a positional isomer of 3-HP acid) by a Colombian research team[2,3,4] (Figure 1).

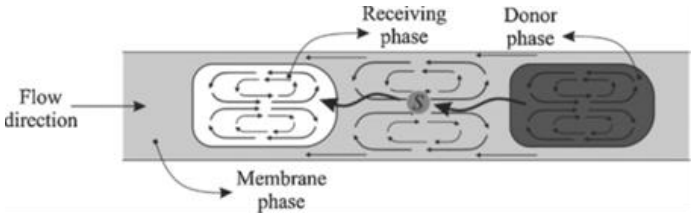

Figure 1: Lactic acid millifluidic extraction

The donor phase contains the acid to be extracted. This phase is dispersed in a continuous organic phase (membrane phase), which includes an extraction agent (amine). The extracted molecule is then recovered by a receiving phase. Taylor vortices (specific hydrodynamic structures typically found in confined fluid/fluid flow) ensure the transfer of the complexed acid from the donor phase to the receiving phase, as well as the renewal of matter inside the droplets.

INTERNSHIP GOALS:

The objectives of the internship are as follows:

- To study, using a rigorous experimental approach, and quantify by HPLC, the kinetics of 3-HP acid extraction in a two-phase medium (acid/liquid membrane) for different milli-microfluidic capillary geometries;
- To use image processing (MATLAB/Python) and a high-speed camera to observe the shape of the droplets and quantify their geometric properties as a function of operating conditions (particularly in terms of interfacial area);
- To propose a reactive extraction model (eventually dimensionless) that takes into account the quantified phenomena.

Depending on the progress of the internship and the skills that the intern wishes to develop, other aspects may be explored, such as:

- The use of a CFD software (COMSOL, OpenFOAM) to model two-phase flow;
- Experimental tests combining extraction and back-extraction, and phenomena quantification;
- The development of custom parts/prototypes using the Ecole Polytechnique's FabLab.

In order to carry out these tasks, the successful candidate will be able to count on the support of a multidisciplinary scientific team, spread across the MoDiC and ProBioSSep teams at the SayFood joint research unit, as well as the technical expertise of the site's technology center. Depending on the progress of the internship, written or oral communications may be considered, in French or English, for example as part of the Paris Saclay University/ENS Junior Congress. **This internship is part of the launch of an ANR JCJC project**. A PhD student is expected to be recruited on this topic during the internship, to start in the last quarter of 2026.

REQUIRED PROFILE:

We are looking for a Chemical Engineering/Process Engineering or Fluid Mechanics student, at Master's level or equivalent (five years of higher education). The successful candidate must be independent and scientifically curious, and able to read and write fluently in English. Basic scientific programming skills in MATLAB or Python, as well as experimental planning skills, would be highly appreciated.

GENERAL INFORMATION:

- Entity: SayFood joint research unit, AgroParisTech, Palaiseau ;
- Duration: 6 months starting in March 2026 (subject to adjustment depending on the candidate);
- Remuneration: In accordance with current legislation (approximately €650/month depending on the number of days worked);
- Accomodation: Possibility of renting student accomodation on site ;
- Secularism: The person recruited will be subject to the charter of secularism in public services (law 2021-1109 of August 24, 2021). In particular, no religious symbols may be worn in the workplace.

APPLICATIONS:

Applications and requests for further information should be sent to the persons listed below. The application file should include the following documents: CV, cover letter, and M1/M2 reports. Applications will be processed in order of arrival, with a **deadline of November 21, 2025**.

- Kevin LACHIN (kevin.lachin@agroparistech.fr) ;
- Murielle HAYERT (murielle.hayert@agroparistech.fr) ;
- Ana-Karen SANCHEZ (ana-karen.sanchez-castaneda@inrae.fr).

BIBLIOGRAPHY:

[1]Arana Agudelo et al., *Reactive liquid–liquid extraction of bio-based 3-hydroxypropionic acid using a biocompatible organic phase containing a tertiary amine: A model-based approach to elucidate dominant mechanisms*, Separation and Purification Technology, 294 (2022), 1-13

[2] Pérez et al., *Integration of a liquid membrane in Taylor flow regime with a fermentation by Lactobacillus casei ATCC 393 for in-situ lactic acid removal*, Chem. Eng. Process.: Process Intensification, 140 (2019), 85-90

[3] Pérez et al., *Modeling of a liquid membrane in Taylor flow integrated with lactic acid fermentation*, Chem. Eng. Process. : Process Intensification, *144 (2019), 1-9*

[4] Pérez et al., *A new concept of liquid membranes in Taylor flow: Performance for lactic acid removal*, Chem. Eng. Process. : Process Intensification, 139 (2019), 95-102