Toulouse Biotechnology Institute
Bio & Chemical Engineering

Université de Toulouse

OFFER OF PHD THESIS

ODYSSEUS: Optimization of carbon Dioxide and oxYgen maSS transfer in biorEactors: a mUltiscale Study

Laboratory

Laboratory: **Toulouse Biotechnology Institute (TBI) INSA UMR CNRS 5504 UMR INRA 792**
Web: https://www.toulouse-biotechnology-institute.fr/
Research Group: **TIM - Transfer Interface Mixing**
Web: https://www.toulouse-biotechnology-institute.fr/poles/equipe-tim/

Thesis's project description

The performance of fermentation bioreactors is strongly related to the oxygen transfer from air bubbles to microorganisms to improve microbial yields. The action of the bubbles helps to mix the reactor and also strips out waste gases (carbon dioxide). However, accurately characterizing the gas-liquid mass transfer in such processes is still a challenging issue, mainly because of the liquid phase complexity. The aim of the work thesis is to develop specific techniques and rigorous models to better estimate the various mechanisms that govern the mass transfer process locally. This PhD is a part of the ANR project ODYSSEUS ("Optimization of carbon Dioxide and oxYgen maSS transfer in biorEactors: a mUltiscale Study "), which objective is to predict the CO_2 and O_2 mass transfers in bioreactors, considering the physicochemical properties of the culture media at different scales (from molecular thermodynamics, cell and bubble scale to reactor scale) and the local hydrodynamics. This project presents theoretical developments to increase the knowledge of transfer phenomena in complex systems. It also presents important practical and engineering aspects, with potential industrial impact on bioreactor efficiency.

Firstly, a new technique for visualizing gas-liquid matter transfer will be implemented. Using a microfluidic visualization bench, oxygen and carbon dioxide molecules responsible will be visualized as close as possible to the interface. This new method will enable us to monitor the dual mass transfer in different gas-liquid systems. In a second phase, we will focus on implementing mass transfer experiments in a reduced-size bubble column, in order to reproduce in the laboratory, the gas-liquid contactors used in the fermentation industry. These experiments, coupled with new knowledge of the microscopic scale, will enable us to propose and validate new models for predicting matter transfer for industry. These experimental and modelling studies will also use numerical modelling tools (COMSOL, FLUENT) and will build on work already carried out by previous PhD and master's students.

This work, funded by the French National Research Agency (ANR-23-CE51-0002), is also part of a collaborative research project with laboratories belonging to the FERMaT research federation (FR 3089). The work will be published in international peer-reviewed journals and presented at several conferences, including the "International Conference on Gas-Liquid and Gas-Liquid-Solid Reactor Engineering" in Goa (India) in 2026. Other conferences in France and Europe will also be considered (Société Française de Génie des Procédés, European Congress of Chemical Engineering, etc.).

The PhD student will also have the opportunity to teach in the GP3E department of INSA Toulouse as a part-time lecturer (within the limit set by the thesis contract of 96 hours per year ~ 2 k€/year).

Applicant

Candidates should have a Master's degree or Engineering diploma in Process Engineering, Chemical Engineering, Physical Chemistry or Environment, with a strong interest in experimentation.
Salary: €1,900 net per month for 36 months.

Expected start: October 2024.

Supervision: Nicolas Dietrich, Gilles Hébrard and Sandrine Alfenore

Send CV and cover letter including the professional project envisaged to: dietrich@insa-toulouse.fr