amU
Aix Marseille Université

Ecole Doctorale des Sciences Chimiques ED250

Contrats Doctoraux **2026**

Intitulé du Sujet de Thèse : …In-cell monitoring by NMR spectroscopy of lipid metabolism in microalgae

Laboratoire : ………BIP, UMR 7281…………..

Equipe : ……Enzymology in complex medium (BIP02)………..

Directeur de thèse HDR (100%) : …Frédéric Carrière……

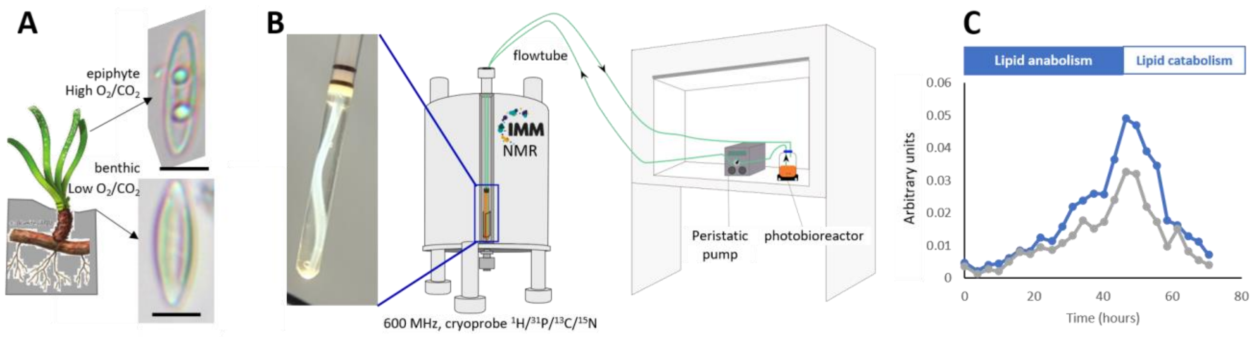
Co-encadrant HDR ou non HDR (0%) : Hélène Launay

email : carriere@imm.cnrs.fr, hlaunay@imm.cnrs.fr

Descriptif du projet

Aquatic photosynthetic microorganisms, such as cyanobacteria or diatoms, are the primary producers of marine ecosystems, i.e. they synthesize organic compounds from dissolved carbon dioxide (CO_2). They produce for instance polyunsaturated fatty acids (PUFAs) and derived lipids that are a transiently stored in lipid droplets and membranes before they are mobilized by the ensemble of the food chain [1, 2]. They represent a source of both energy and essential precursors for various cellular functions. From another perspective, the various applications of lipids in nutrition, oleochemistry and biofuels are major drivers of current research efforts for harnessing photosynthesis in microalgae and plants. A better understanding of photosynthesis and carbon metabolism in microalgae is however required to unlock these developments. Our group at the BIP laboratory combines physiological studies on microalgae with the characterization and valorization of lipids [3]. We have a peculiar interest for the model diatom *Phaeodactylum tricornutum*n [4, 5], ubiquitus to shallow waters, that can adapt to various environments differing in the availability of dissolved inorganic carbon (CO_2 or bicarbonate), level of O_2, light and temperature. These diatoms can be found either in the sediments (reefs, sands or mudflats; benthic microalgae) or bound as biofilms on macroalgae and seagrasses (epiphytes) or free in the water column (planktonic). Benthic diatoms in mudflat can experience very high CO_2/O_2 ratios, while epiphytes diatoms experience very low CO_2/O_2 ratios because of the photosynthetic activity of their support. The lipids metabolism of diatoms from these environments is thus expected to be highly versatile depending on the environments ([6, 7], Fig A). The project aims at developing the biochemical and biophysical tools to describe the transitions in lipid metabolism induced by change of culture conditions such as dark/light transition or epiphytes/benthic- lifestyles.

We will benefit from the newly installed on-flow NMR apparatus that couples a photobioreactor to an NMR spectrometer ([8] Fig B). The BIP2 group has demonstrated that intracellular lipids can be monitored and quantified during cell culture upon change of the conditions (ie. nitrogen deprivation and resupply, Fig C [4]). During the project, the PhD student will adapt these culture conditions already mastered by the group to the on-flow NMR apparatus, using designed microfluidic devices. The lipids composition and amounts will be monitored using standard double correlation experiment on ^{1}H, ^{31}P and ^{13}C nuclei thanks the newly installed ^{1}H-$^{19}F/^{31}P/^{13}C/^{15}N$ cryoprobe purchased by the IMM NMR platform. The supramolecular organisation of the lipids (lipid droplets, membranes, micelles) will be monitored using Diffusion Ordered Spectroscopy [9]. In cell data will be confronted to flow cytometry after lipid staining and analysis after lipid extraction (TLC-densitometry, GC-FID, FTIR) routinely performed at IMM and BIP2. Running cost and NMR time will be supported by the PEPR projects AlgAdvances (B-BEST) and CO_2_CMϕ (FairCarboN).



M2 candidates with knowledge in analytical chemistry, spectroscopy (NMR), microalgal and/or lipid metabolism are encouraged to apply.

References Bibliographiques

1. Sidi Boune MV, […], Launay H, Carrière F (2024) The yellow mullet fish oil from the Banc d'Arguin Imrâguens in Mauritania: an example of polyunsaturated fatty acids transfer from diatoms to the fish within the alimentary chain. OCL 31:23. DOI: 10.1051/ocl/2024023
2. Feiner ZS, et al (2018) Species identity matters when interpreting trophic markers in aquatic food webs. PLoS One DOI: 10.1371/journal.pone.0204767
3. Fachini BR, […], Launay H, Carrière F (2025) Digestion and bioconversion of microalgal galactolipids by direct action of lipolytic enzymes on *Chlamydomonas reinhardtii* biomass. Algal Research DOI: 10.1016/j.algal.2025.104121
4. Prioretti L, Avilan L, Carrière F, et al (2017) The inhibition of TOR in the model diatom *P. tricornutum* promotes a get-fat growth regime. Algal Research DOI: 10.1016/j.algal.2017.08.009
5. Chaumier T, et al (2024) Genome-wide assessment of genetic diversity and transcript variations in 17 accessions of the model diatom *P. tricornutum*. ISME Commun DOI: 10.1093/ismeco/ycad008
6. Sérès Y, et al (2025) Decoupling of plastid and endomembrane homeoviscous response to low temperature and darkness in *P. tricornutum*. BMC Plant Biol DOI: 10.1186/s12870-025-07406-9
7. Castaldi A, et al (2025) Multiblock metabolomics responses of the diatom *P. tricornutum* under benthic and planktonic culture conditions. Marine Drugs DOI: 10.3390/md23080314
8. Cerofolini L, et al (2019) Real-time insights into biological events: in-cell processes and protein-ligand interactions. Biophys J DOI: 10.1016/j.bpj.2018.11.3132
9. Sahaka M, […], Carrière F, Launay H (2024) Monitoring galactolipid digestion and simultaneous changes in lipid-bile salt micellar organization by real-time NMR spectroscopy. Chem Phys Lipids DOI: 10.1016/j.chemphyslip.2023.105361