PhD proposal

CO₂ Storage and Utilization through biologically induced calcium carbonate precipitation in phototrophic sulfur cycle

Research project description

Microbial processes and environmental biotechnology can play a major role to face the key challenges of global warming mitigation and reduction of ecosystems disturbance by human waste or wastewater. Not only microbial reactions can be used for wastewater and nutrients capture and recovery, but they can also promote CO₂ sequestration by concomitant biomass production and biologically induced carbonate precipitation. Our ambition is to develop biotechnology aiming to recover CO₂ gas (from industry or from biogas) and simultaneously remove or valorize nutrients from waste or wastewater.

As algae, phototrophic bacteria as cyanobacteria and purple bacteria are naturally able to promote such CO₂ sequestration through calcium carbonate precipitation. Basically all microbes which can induce alkalinisation (local pH increase) have a potential which is reinforced by calcium linked exopolymers produced by their metabolism. The microbial species involved in sulfur cycle show good potential. For instance some purple bacteria are able to oxidize H₂S into sulfate and be selectively grown under phototrophic condition. Coupled with sulfate reducing bacteria, the achievement of the sulfur cycle could be an innovative way for CO₂ sequestration and waste or wastewater treatment.

In this context, the objective of the PhD is (1) to investigate the selection and control of dedicated microbial consortia growing in specific bioreactors (biofilm and/or granular reactors), (2) to scrutinize the synergies between biokinetics and physical-chemical reactions inducing precipitation, (3) to develop a modelling approach for optimizing and extrapolating the system. This work will be based on lab-scale experiments, specifically designed bioreactor set-up for batch and continuous experiments, chemical and biochemical analytical methods for following the nutrients consumed, the bioproducts, the microbial community and the minerals produced.

The PhD candidate will be in charge of designing of the experiments and planning and realizing analytical program, developing mathematical models to optimize the process and propose design criteria. The work will be supported by TBI technical and analytical platforms and a technical staff.
How to apply?

The applicants are required to have completed Master level studies in high-quality educational organization in a discipline supporting the research theme and methods (Process engineering or biological engineering or chemistry, modelling skills desirable). Good language skills in English are required and a good command of French is desirable.

The applicants are kindly asked to apply for the position by sending before the 20th of April 2021, their CV, study records from the Master studies and a motivation letter to the research supervisors:
Prof. Mathieu Sperandio (sperandio@insa-toulouse.fr)
Dr. Claire Dumas (cl_dumas@insa-toulouse.fr)
Dr. Matthieu PeyreLavigne (mpeyrela@insa-toulouse.fr).

Laboratory

Toulouse Biotechnology Institute (TBI) is a mixed research unit hosted by INSA of Toulouse, and linked to INRAE (UMR 792), CNRS (UMR 5504). INSA-Toulouse is an academic engineering school of Toulouse University, with 8 engineering departments. Toulouse Biotechnology Institute (TBI) is a multidisciplinary research institute with 350 employees in multiple disciplines: microbiology, biocatalysis, bioprocesses, separation techniques, environmental assessment. Internationally recognized, TBI holds an innovative position at the interface between life sciences and process sciences. (http://www.toulouse-biotechnology-institute.fr).
This PhD project, related to Process and Environmental Engineering doctoral school, will be hosted by the team named SYMBIOSE, “microbial ecosystems and bioprocessing purification and recovery team”. With 12 permanent staffs and 15 PhD candidates, Symbiose team promotes interactive and multidisciplinary research for environmental biotechnology. The group has developed research on systems for industrial and municipal waste and wastewater management for the last 40 years, and focused in the last decade on resource recovery, based on combined biological and physico-chemical technologies.