Bioprocess development for wastewater recovering and bioenergy production: Interdisciplinary and multi-scale approach

Climate change and limitation of fossil fuel feedstock accelerate the research of new energy carrier. In this context, organic matter as a substrate to bioenergy production is very interesting and could be easily implemented. Indeed, in almost all wastewater treatment plants a bioreactor is implemented for organic matter removal. This bioreactor is generally inoculated with aerobic bacteria that need to be aerated. These bacteria could be replaced by an anaerobic bacterial ecosystem that could produce hydrogen from the oxidation of organic matter that are in wastewaters (dark fermentation process).

This concept would lead to the reduction of the energy cost of wastewater treatment and the production of a non carbonated carrier from wastes. The issue of this project is to decipher bacterial metabolisms involved in this transformation and inter-species interactions that take place in the ecosystem grown in the bioreactor. That is the reason why two laboratories are involved in this project: M2P2 (Mechanics, Modelling and Green Processes) lab for the chemical engineering approach and BIP (Bioenergetics and Proteins Engineering) for microbiology and biochemistry skills.

The aim of this thesis work is to study the behaviour of different bacterial consortia (synthetic or natural) inside a continuous biofilm reactor at different scales to decipher the biotic and abiotic parameters that are involved in the production of hydrogen by dark fermentation process.

As a first step a microfluidic setup would be designed and operated in order to understand the biological processes and the interactions promoted in the biofilm. The second step would consist in an experimental study at the bioreactor scale to optimise the processes of hydrogen production and consider the scale up of the process.

The dynamics of the bacterial consortium in time and space would be followed by different analytical techniques (microbiological, chemical and microscopic techniques) to determine metabolites profiles and cellular identification. In parallel to this, chemical engineering method would be employed to understand and optimise the behaviour of the bioreactor.

This multi-scale experimental study from the cell to the reactor would lead to the understanding of biological and chemical processes involved in mass transfers into the biofilm reactor.

This should result in the determination of the metabolic routes involved in these processes and the parameters that are able to influence these routes (molecular composition, cell-cell interactions, etc.).

At the end the experimental results should help to define process parameters to have simultaneously the best yields and the best conversion kinetics. These parameters would help to fit a scale up model to design a process that is able to optimize hydrogen production and wastewater treatment for discharge in the Environment.

Profile of the candidate: Master or Engineering Degree in Chemical Engineering or Biological Engineering. Skills in microfluidics or process simulation or microbiology would be appreciated. Good communication skills and an advanced level in English would be necessary.

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