Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes the PhD subject and supervisor proposed by the French Polytech network of 14 university engineering schools. Please contact the PhD supervisor by email or Skype for further information regarding your application.

Supervisor information	
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Polytech name	Clermont-Ferrand
University name	Université Clermont Auvergne
Country	France

PhD information	
Title	Microbial Electrochemical Cell for VFA removal
Main topics regards to CSC list (3 topics at maximum)	V-5 : Hydrogen production

Required skills in science and engineering	Chemical engineerring Bioprocess engineering and Micobiology Modelling and simulation (in chemical engineering)

Subject description (two pages maximum)

Context :

The team "Chemical Engineering, Applied Thermodynamics and Biosystems" (GEPEB) of Institut Pascal integrates chemical engineering approach for biological, chemical and physical phenomena involved in transformation and biotransformation processes. The GePEB team addresses areas of application such as the production of energy vectors, biomaterials, environmental engineering, food processes engineering and artificial closed ecosystems. The GEPB research team “Bioprocesses and Photo-reactive Systems” (BioSPhoR) focuses on the setup, understanding and optimization of reactors, photoprocesses and bioreactors and are part of the Engineering of (Bio)Processes and Energetics.

In several BioSphoR research projects involving the anaerobic digestion of organic waste products, a bottleneck concerning the removal and use of Volatile Fatty Acid by-products (VFA) has emerged. The main projects concerned are bioenergy / renewable energy vector projects (methanation, biohydrogen, biolipids) and the European Space Agency MELiSSA project (Life Support System for long term space missions). One possible technology for the removal and use of VFA is based on Microbial electrochemical systems (MESs).

MESs use microorganisms to covert the chemical energy stored in biodegradable materials to direct electric current and chemicals. Compared to traditional treatment-focused, energy-intensive environmental technologies, this emerging technology offers a new and transformative solution for integrated waste treatment and energy and resource recovery, because it offers a flexible platform for both oxidation and reduction reaction oriented processes. All MESs share one common principle in the anode chamber, in which biodegradable substrates, such as waste materials, are oxidized and generate electrical current. In contrast, a great variety of applications have been developed by utilizing this *in situ* current, such as direct power generation (microbial fuel cells, MFCs), chemical production (microbial electrolysis cells, MECs; microbial electrosynthesis, MES), or water desalination (microbial desalination cells, MDCs) (HemingWang and Zhiyong Jason Ren, 2013)

Objective

The objective of the PhD proposed is to develop a MEC bioreactor using the VFA produced after an anaerobic digestion step of organic matter for either:

- Production of H2 (or CH4) as an energy vector. In this application, the MEC reactor will be integrated as an additional step for in bioenergy production system or as a replacement of classical biological methanation process,
- Production of CO2. In the MELiSSA project the recovery of CO2 from organic waste is a challenging step as in the Carbon loop of the MELiSSA ecosystem CO2 is required for plant and algae growth (biomass + O2 producers). But CO2 must be recovered from organic waste without the use of oxygen which is reserved for crew.

Main tasks :

The main tasks during the PhD proposed will be :

- Study of the Microbial Electrolysis/Electrochemical Cells (MEC) using VFA :
  - Acquisition of knowhow and technology of MEC
  - Microbial community selection
- Lab scale MEC pilot development /design
- Application :
  - 1) enhanced H2 production from VFA ,
  - 2) enhanced CO2 production from VFA
  - 3) orienting microbial metabolism to high value final products from VFA fermentation

References / links :

Wang, Heming, et Zhiyong Jason Ren. « A comprehensive review of microbial electrochemical systems as a platform technology ». *Biotechnology Advances* 31, n° 8 (1 décembre 2013): 1796-1807. https://doi.org/10.1016/j.biotechadv.2013.10.001.

MELiSSA project : https://www.esa.int/Our_Activities/Space_Engineering_Technology/Melissa