# Proposed List of MELiSSA PhD Topics

**Topic Title:** MEC design optimization, characterization, and modelling

**Keywords:** MELiSSA loop, MEC, modelling, electrochemistry

**Abstract**

MELiSSA stands for "Micro-Ecological Life Support System Alternative". MELiSSA is the European project for circular life support systems and is characterized by a biological and chemical/physical approach based on first principles modelling and implementation of a suitable deterministic engineering approach. Within the MELiSSA loop, the effluent of MELiSSA Waste Compartment (C1), rich in Volatile Fatty Acids (VFAs) needs to be converted to $CO_2$. This $CO_2$ can thereafter undergo two different pathways: 1) oxygen ($O_2$) recovery or; 2) biomass production (i.e., proteins, biofilm, etc.).
Previous studies to maximize VFA to $CO_2$ transformation did not yield to successful results as high levels of carbon (C) were being diverted to biomass production rather than $CO_2$ formation. Considering these results, alternative technologies were explored focusing on improving the yield of VFA oxidation to $CO_2$, as well as replacing the known undesired natural end-product of VFA oxidation, methane ($CH_4$), by $CO_2$. Technology exploration identified bio-electrochemical based Microbial Electrolysis Cell (MEC) as a feasible tool to achieve the above-mentioned objectives.

MEC technology is currently used in wastewater treatment plants as a renewable way of producing bio-hydrogen from VFA-rich filtrate by means of an unknown exoelectrogen microbial consortium. MEC units are electrochemical cells composed of an anode and cathode, separated (or not) by an anion selective membrane which enables (anions to pass between the anodic and cathodic compartments. The anode compartment is colonized by exoelectrogen and anaerobic microorganisms that conduct oxidation using organic compounds as electron donor and the anode as electron acceptor. In the cathode compartment, water reduction takes place because of the required power input applied to fix the potential of the anode, producing hydroxyl ions ($OH^-$) and hydrogen protons ($H^+$).

The proposed PhD will study and optimize the design of the current MEC unit and conduct the characterization of the microbial communities and effluents (liquid and gas), including the development of a mechanistic mathematical model approach. Attention will be given to modelling a continuously fed MEC unit and modelling for the membrane mass transfer. Focus should be placed to the development of a MEC Unit coupled to the MELiSSA C1 compartment and overall integration into the complete MELiSSA loop.

These results will be useful to assess the impact of the MEC unit inclusion in the MELiSSA loop for C2. The specific ALiSSE (Advanced Life Support System Evaluator) criteria will be the evaluation reference. They provide a decision-making tool to support ECLSS (Environmental Controlled Life Support Systems) trade-off between mass, technology, safety, lifecycle cost and strategic considerations for a given Space Mission

**Impact on MELiSSA Project:**
Definition of technologies and modelling strategies for the microbial electrolysis cell process in the MELiSSA loop

**Potential MELiSSA Partners:**
Universidad Autonoma de Barcelona (S), University of Gent (B), VITO (B), University Clermont-Auvergne (F)

**References:**

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ESA Technical Note 137.4 Appendix. Applicable document for using Oscar Methodology System Engineering applied to the MELiSSA data management system: requirements

**Candidate's background requirements:**
Candidates preferably possess a degree in biology, chemistry, biotechnology or bioengineering. They must be familiar with metabolic pathways analysis, process engineering and simulation tools.