Continuous nitrification of artificial urine with a bacterial co-culture in a packed-bed bioreactor

Justyna Barys[1,2,3], Christel Paille[1], Carolina Arnau[2], Frances Godia[2], Nico Boon[3], Siegfried Vlaeminck[3,4], Peter Clauwaert[3]

[1]Life & Physical Sciences and Life Support Laboratory, European Space Research and Technology Centre, European Space Agency, The Netherlands, [2]MELiSSA Pilot Plant – Laboratory Claude Chipaux, Universitat Autònoma de Barcelona, Spain, [3]Center of Microbial Ecology and Technology, Faculty of Bioscience Engineering, Universiteit Gent, Belgium, [4]Research Group of Sustainable Energy, Air and Water Technology, Department of Bioscience Engineering, Faculty of Science, University of Antwerp, Belgium

Introduction

MELiSSA aims at producing food via vegetable crops and edible phototrophic bacteria. To produce phototrophic biomass conversion of urine into a nitrate substrate should be achieved.

Urea hydrolysis Heterotrophs — *Ammonium oxidation AOB* — *Nitrite oxidation NOB*

urea → NH_4^+ → NO_2^- → NO_3^-

COD removal Heterotrophs

COD → CO_2

For converting urea into nitrate, it will be necessary to use a bacterial consortium composed of strains allowing urea hydrolysis, ammonium and nitrite oxidation. Additionaly selected bacterial consortium shall oxidzize COD content.

Cell immobilization on a solid support is particularly interesting for nitrification purposes, as nitrifiers are slow growing microorganisms.

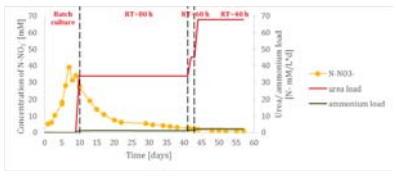
Advantages of biofilm growth in the bioreactor:

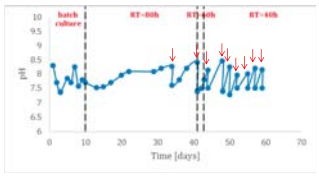
- Cell retention in the bioreactor
- Easy continous operation
- Attached growth more compatible with Space conditions

The main goal of the conducted research is to develop a defined microbial consortium to nitrify synthetic urine in the continuous system based on immobilized cells in a packed-bed bioreactor.

Results

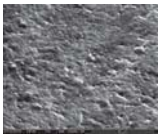
Continous culture of *N. europaea*, *N. winogradskyi* and *C. pinatubonensis* (heterotroph) with PVA gel bioreactor beads;
used media – AOB/NOB medium with urea instead of ammonium sulphate

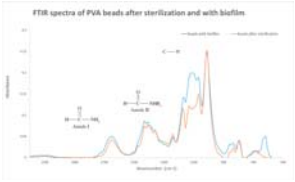


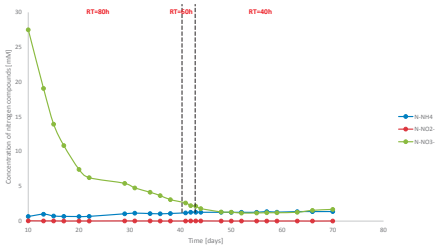


Batch culture of *N. europaea* and *N. winogradskyi* with PVA gel bioreactor beads

E-SEM photo – PVA beads with bacterial biofilm







Conclusions:

- Nitryfying bacteria can form biofilm on PVA gel bioreactor beads
- PVA gel bioreactor beads are good material for nitryfying biofilm formation, but cannot be sterilized in 121°C in dry conditions
- Increase of pH during bacterial cultivation can indicate urea hydrolysis, but also CO_2 stripping
- Stabilisation of nitrate contentration can indicate that *N. europaea* and *N. winogradskyi* were active in the culture
- Need to estabilish new bacterial consortium and new composition of synthetic urine medium to improve urea to nitrate transformation efficiency

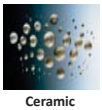
Future tests

Taking as a basis these preliminary results, a more systematic work was planned in order with the final target to test it in the MELiSSA Pilot Plant:

a) Selection of the optimal defined microbial consortium
b) Definition of synthetic urine medium composition
c) Selection of an autoclavable, non-compressible biofilm carrier supporting good biofilm development
d) Preliminary tests in the bench scale packed-bed bioreactors


Polypropylene


PTFE


Ceramic


Porous glass


Denstone DeltaP