Power to Methane

WP2/3: A promising new method for hydrogen delivery to methanogens results in more methane from biomass

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Excess of renewable electricity from wind turbines or solar panels is used for electrolysis of water. To store this renewable energy as methane, the hydrogen is fed to an anaerobic digester to stimulate biological methanation by hydrogenotrophic methanogens. These work packages focus on the best ways for hydrogen delivery and the community changes in a biomethanation reactor as a result of hydrogen supply.

Introduction

Biological Power to Methane is based on the ability of microorganisms to make methane from (renewable) hydrogen and carbon dioxide. The effect of hydrogen on methane formation was studied at mesophilic conditions (42°C) at atmospheric pressure in two 10 L bioreactors (Infors) in an *ex situ* setup (Figure 1), with different ways of hydrogen supply and appropriate controls.

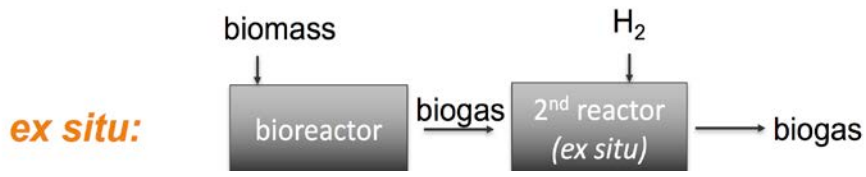

Figure 1. Reactor set-up used for biological methanation

Methane Evolution Rate (MER)

In the above setup, the Methane Evolution Rate (MER), which expressed the amount of biomethane (in mmol) formed from H_2 and CO_2 per litre reactor- volume per day, appears to be about 0.3 mmol CH_4 / litre / day. In order to be able to play a significant role, the MER must be increased by at least a factor of 100. To achieve this, there are two challenges: 1.) how do we ensure that the H_2 addition is not the limiting factor, and 2.) how we get the cell density so high that the MER can increase by a factor of 100. From previous experiments (data not shown), the H_2 addition is not a limiting factor, but the cell density of the methanogenotrophic Archaea is very low. Therefore, we now developing a reactor in which the methanogens are immobilized on different carriers in order to increase the cell density within the bioreactor. The diagram below shows a schematic layout that can be examined 5 different carriers**.**

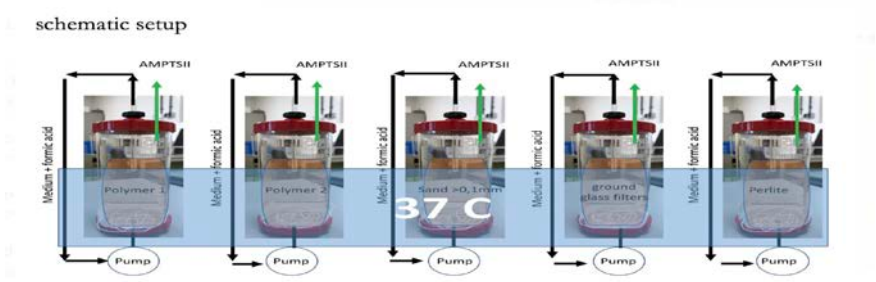

Figure 2: different carriers (polymer 1 and 2, sand, ground glass filters and perlite) are tested in a small batch reactor. In each reactor, MTA medium is pumped around with formic acid (2 grams / liter). Hydrogenotrophic methanogens convert formic acid to CO_2 and CH_4. Both the CO_2, the CH_4 and the formic acid concentration are measured.

Taqman

In WP3, the effect of exogenous addition of H_2 on an ex-situ biogas upgrading reactor on the microbial composition in the reactor is investigated. For this, we have developed primers and probes against hydrogenotrophic methanogens (MC; *Methanoculleus*, VIC labelled) and acetoclastic methanogens (MSL; *Methanosarcinales*, FAM labelled). In Figure 3, it can be seen that there is no difference in both reactions at the same time in two separate wells compared with both reactions at the same time in the same reaction vessel.

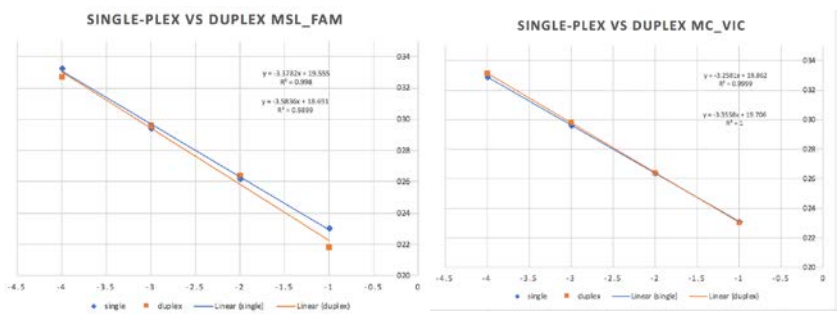

Figure 3: optimization of Taqman assay by making smart use of differently labeled probes. The MC gives a VIC signal and the MSL gives a FAM signal

Because the MC and MSL are not independent of each other (i.e. when one increases, the other automatically decreases and vice versa) a third target is needed in which all methanogens are measured.

Take Home Message

Biological methanation is a promising technology for the storage of electricity. The challenges are the exogenous addition of H_2 and subsequently the conversion of CO_2 to methane by microorganisms. In WP2 and WP3 we investigated the technological application of H_2 addition, and we look at increasing MER's. The first experiments to build a reactor with a (very) high MER have already started.

Future activities

- Building a 'new' type bioreactor with high (>50) MER's
- further develop a Taqman bioassay in which 3 targets (MC, MSL and a universal Archaea) can be measured simultaneously
- Next generation sequencing

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