Supported by:

Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

TECHNISCHE FAKULTÄT

6th International Conference on Renewable Energy Gas Technology (REGATEC)

Tars and Inhibition of Biological Methanation Using Synthesis Gas of an Allothermal Wood Gasifier

T. Trabold, T. Weidlich, J. Karl

Chair of Energy Process Engineering (EVT), Friedrich-Alexander-Universität Erlangen-Nürnberg, Fürther Str. 244f, D-90429 Nürnberg

Purpose

Some archaea are able to synthesize methane from H_2 and CO_2 or CO, respectively. This ability is used to substitute natural gas with the shown metabolic pathways and their combination:

$$CO + H_2O \rightarrow 2\ CO_2 + H_2$$

$$CO_2 + 4\ H_2 \rightarrow 2\ H_2O + CH_4$$

The usual H_2-source (electrolysis) can be changed to a new feedstock: ligneous biomass. Therefore, as shown in in figure 1, the biomass is gasified. This causes reduced dependency on cheap volatile electricity for the electrolysis.

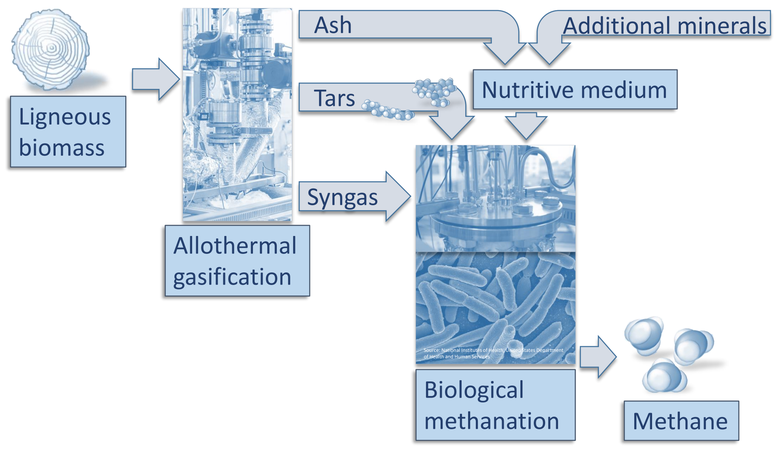


Figure 1: Concept of the biological methanation of ligneous biomass by coupling with allothermal gasification

The presented work is based on the BMWi-Project Ash-to-Gas and focusses on plant design of the CSTR, the done proof-of-concept and the durability of the used culture to syngas components, especially tars.

Approach and methodology

A continuously stirred tank reactor (CSTR) for anaerobe cultures has been built at the Chair of Energy Process Engineering, FAU Erlangen-Nürnberg.

The CSTR body is pointed in figure 2. Complementary to the shown parts and parameters, the CSTR is amongst others equipped with a pH probe and controlling unit and an O_2 purifier unit. The reactor can be operated in batch or continuously mode. The off-gas is permanently measured with a gas analyzer or a gas chromatograph.

The crucial factor to measure the performance of the culture is the methane production rate (MPR):

$$MPR = \frac{V_{n,\,produced\ CH_4}}{V_{digester} \cdot day}$$

Experimentation started, with dosage of synthetic and single components of syngas to the stoichiometric feed gas of CO_2 and H_2, leading to the final proof-of-concept with real syngas.

Afterwards the pure culture is augmented with a probe out of a biogas plant to decrease the concentration of by-products and their inhibition effects.

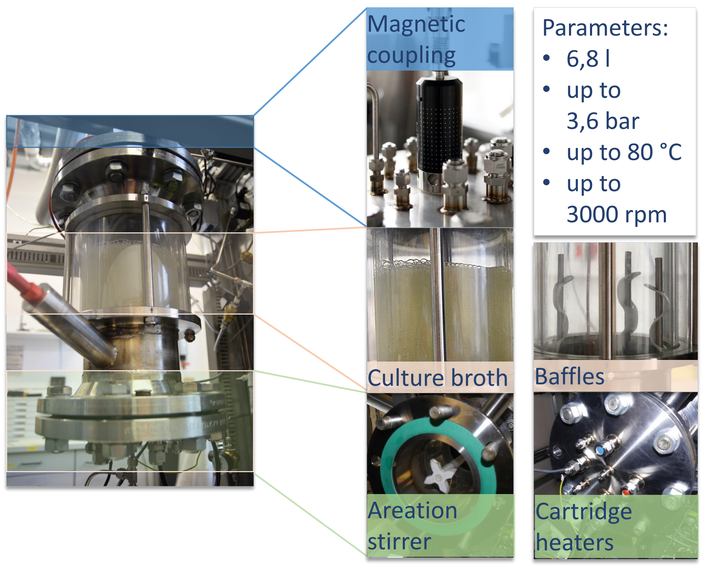


Figure 2: Photography of the CSTR body and its crucial components and parameters

Results

During all of the experimentation with pure culture, cell count and MPR do not get constant due to inhibition through by-products. This can be seen in figure 3, which shows results of addition of real gasification syngas to the digester.

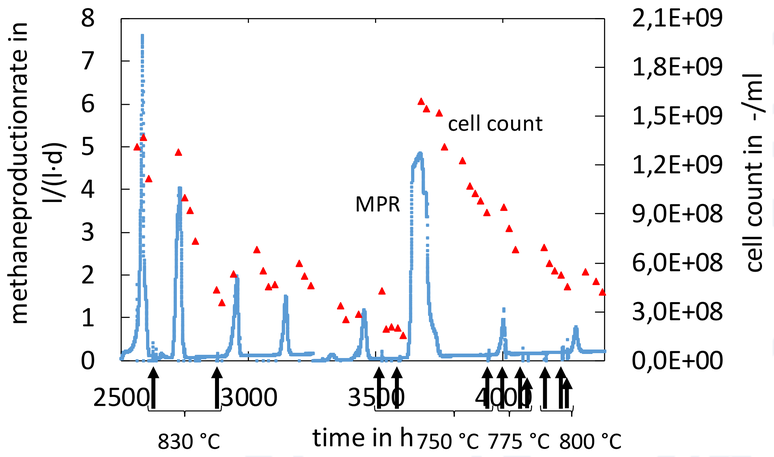
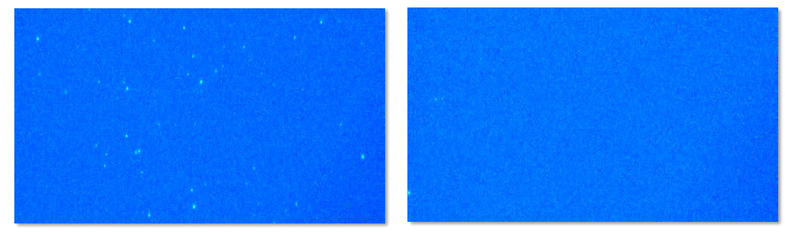


Figure 3: Depiction of the experiments on coupling the digester to the gasifier with ash filtration at different gasification temperatures

CO and gasification ash poses no challenge. Different behavior is shown with synthetic tar components. As acenaphtene decreases MPR instantly, toluene and methylnaphthalene do not.

After the first addition of real syngas, the cell count decreases and tar pearls are visible during microscopy, which are not vanishing. After an adaption phase the cell count recovers and the tar pearls vanish within three days after each further coupling, like shown in figure 4.



Fluorescent light @420nm; straight after coupling

Fluorescent light @420nm; 3 days after coupling

Figure 4: Shots in the transmitted light microscope, augmentation 100:1, show the fading of fluorescating tar pearls in the culture brooth

Figure 5 shows the evened out MPR of the augmented culture. Here a specie metabolizes the by-products of the used methane building archaeon.

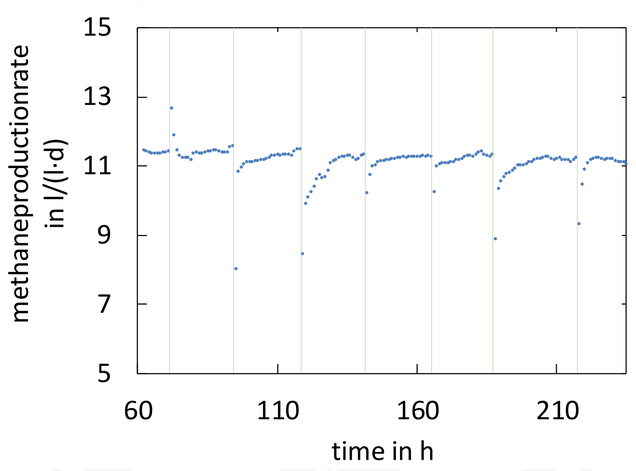


Figure 5: Depiction of the experiments augmentet mixed culture with marked feeding times

Conclusion and further research

Coupling biological methanation to biomass gasification is a promising technology. However, using pure culture is not the ideal way due to the gasification tars. Addition of microorganisms out of a biogas plant show higher and evener MPR due to the metabolism of by-products and therefore no product inhibition.

With this mixed culture, investigation of limiting concentration of tar components and possible by-products can be done.

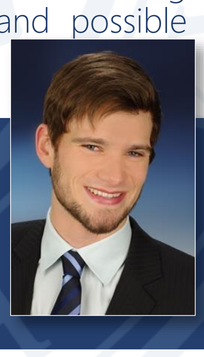
Lehrstuhl für Energieverfahrenstechnik

Prof. Dr.-Ing. Jürgen Karl

Thomas Trabold

+49 911 5302 9027

thomas.trabold@fau.de



Friedrich-Alexander Universität Erlangen-Nürnberg
Fürther Straße 244f, 90429 Nürnberg