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# Syngas Biomethanation by Mixed Microbial Consortia in Trickle Bed Reactors

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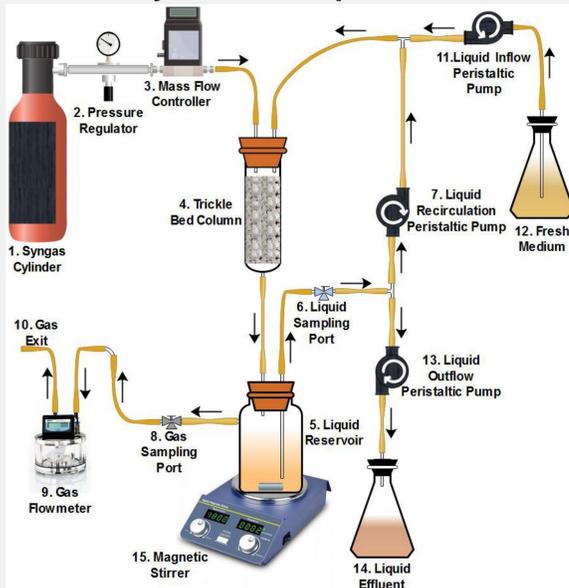
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## Background and Motivation

Global energy needs are in a constant growing rate with a parallel increase in greenhouse gas emissions and waste production. These alarming topics render the use of renewable energy along with a transition to biobased economy necessary. Syngas (mainly composed of CO, CO<sub>2</sub> and H<sub>2</sub>) has been used for over 50 years as a raw material for the production of hydrocarbons through a catalytic chemical process called Fischer-Tropsch. Recently, great interest has emerged for an alternative exploitation of this gas based in the inherent ability of microbial species to convert it to biofuels [1].

The anaerobic fermentation of syngas presents noteworthy advantages compared to the conventional catalytic path including a flexibility to the H<sub>2</sub>/CO ratio, a higher tolerance to undesired impurities in the substrate and increased product specificity. The basic bottleneck of this bioprocess is the low solubility of CO and H<sub>2</sub> to water-based media and therefore alternative methodologies for the increase of mass transfer should be applied [2]. The work following has a target to analyze challenges of syngas fermentation from enriched anaerobic sludge in a trickling bed reactor and it is part of SYNFERON project.

## Laboratory Scale Setup



The composition of syngas used was 45% H<sub>2</sub>, 25% CO<sub>2</sub>, 20% CO and 10% N<sub>2</sub> and represented the effluent of a fluidized bed gasifier fed with wood pellets. The main components of the bioreactor configuration (Fig. 1) involved the syngas cylinder, the trickle bed column where the gas was converted to methane by the developed biofilm and the liquid reservoir used as a sump for the collection and the mixing of the recirculating liquid.

## Mesophilic vs Thermophilic Syngas Biomethanation

The trickle bed reactor was operated in mesophilic (37 °C) and thermophilic conditions (60 °C) for the conversion of syngas to biomethane. The bioreactor was inoculated with enriched mixed microbial consortia and experimental data regarding the conversion efficiency of the substrate and the volumetric methane productivity were collected under steady state conditions.

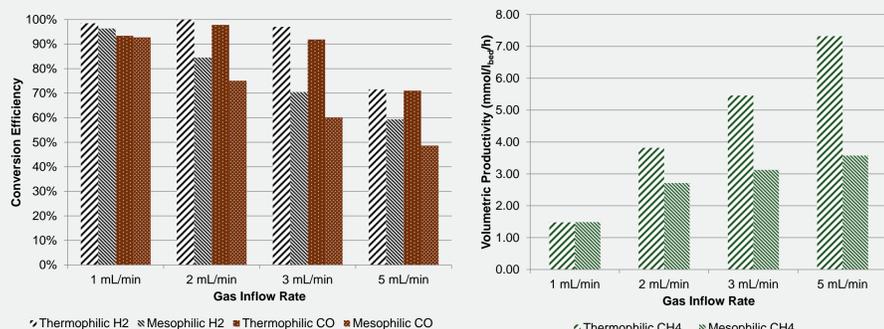


Figure 2. Conversion efficiency of CO and H<sub>2</sub> and volumetric productivity of CH<sub>4</sub> at mesophilic and thermophilic conditions

Improved uptake rate of the substrate and higher volumetric productivity of CH<sub>4</sub> was observed under thermophilic conditions (Fig. 2). Sequencing on samples collected have demonstrated significant differences of the microbial populations in the two temperature regimes.

## External H<sub>2</sub> Supply for Natural Gas Grade CH<sub>4</sub> Production

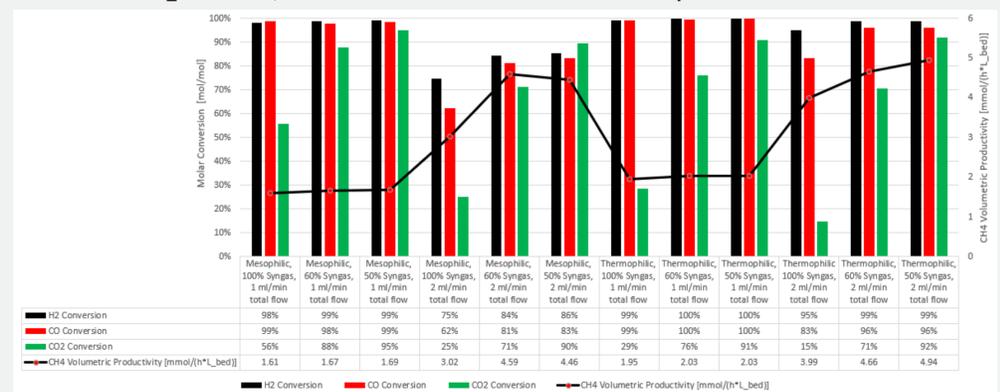
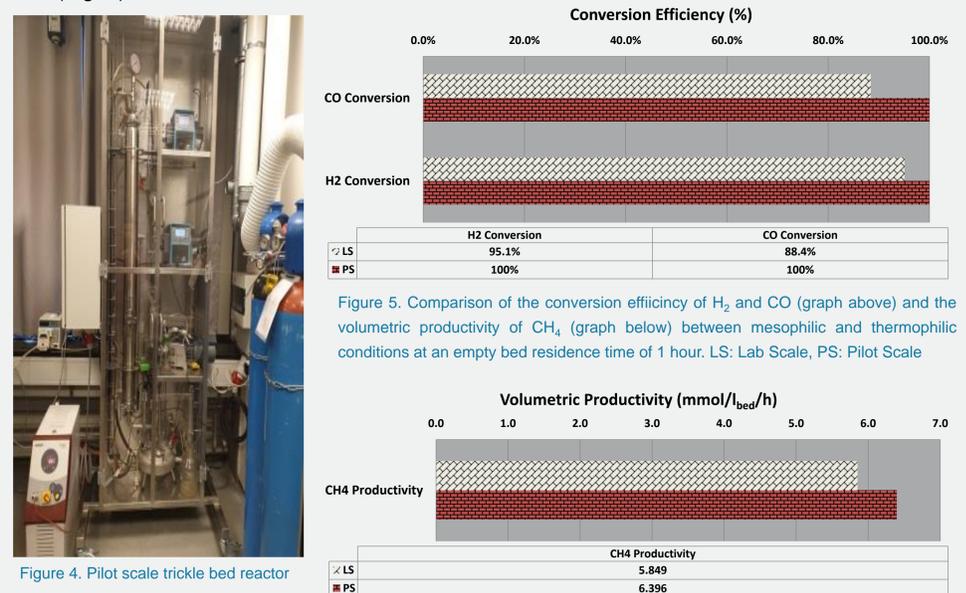


Figure 3. Conversion Efficiency and Volumetric Productivity of CH<sub>4</sub> at mesophilic and thermophilic conditions at flow rates of 1 ml/min and 2 ml/min and syngas/H<sub>2</sub> fractions of 100%, 60% and 50%.

CO<sub>2</sub> was in a high stoichiometric excess compared to the available energy from H<sub>2</sub> and CO for its fixation to CH<sub>4</sub>. As a result, additional supply of the electron donor H<sub>2</sub> was supplied so as to identify the ideal ratio of syngas/pure H<sub>2</sub>. While the inflow rate of pure H<sub>2</sub> and syngas was equal the conversion efficiency of CO<sub>2</sub> reached a value of 92% with full conversion of H<sub>2</sub> and CO (Fig. 3) and the composition of CH<sub>4</sub> at the exit of the reactor was higher than 95%.

## 28x Scale-up of the Trickle Bed Reactor

The obtained results from the lab scale experiments without additional H<sub>2</sub> supply at thermophilic conditions were checked in a pilot scale trickle bed reactor under the respective operational conditions. The pilot scale unit (Fig. 4) presented an improved performance compared to the lab scale one (Fig. 5).



## Conclusions

The use of trickle bed reactors for the biomethanation of syngas proved to be an effective technology with important potential. Thermophilic conditions enhanced the volumetric productivity of CH<sub>4</sub> while external H<sub>2</sub> supply led to the production of a gas able to be introduced in the natural gas grid of Denmark. Finally, a pilot scale unit was operated under the same operational conditions with the lab scale one and presented higher conversion efficiency of the substrate and better productivity.

## References

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