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On the influence of gasification tars on biological methanation

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Purpose

Biological methanation is a promising technology in the field of Power-to-Gas, using archaea to convert H_2 and CO_2 or CO, respectively, to methane.

The price-driving factor of biological methanation is the H_2 from the electrolysis. It is up to 80 % of the costs. An expansion of the substrate spectrum to lignin-containing residues, such as forest residues or roadside greenery, is relevant from the perspective of economy, but also for climate policy. This will help to replace H_2 out of the electrolysis using renewable resources.

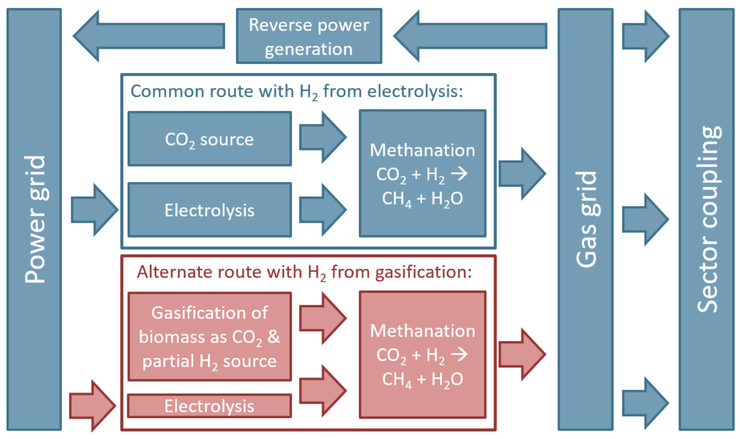

Fig. 1: Concept of Power-to-methane with electrolysis as single and alternatively additional H2-source besides biomass gasification

Therefore a conversion of the residues by gasification and subsequent biological methanation is proposed, as can be seen in Figure 1. As gasification tars are unavoidable in this process, their influence on the methanation is investigated.

Approach and methodology

A 6.8 l stirred tank reactor has been developed at the Chair of Energy Process Engineering, FAU Erlangen-Nürnberg. It is fully automated and operated with a mixed culture consisting of a high-performance pure culture and supplementary post-digestion sludge from a biogas plant. The off-gas is permanently measured with a gas analyzer. The CSTR body is pointed in Figure 2.

The microorganisms are fed with H_2 and CO_2 in stoichiometric proportion in general, skipping firstly to real synthesis gas from an allothermal steam gasifier.

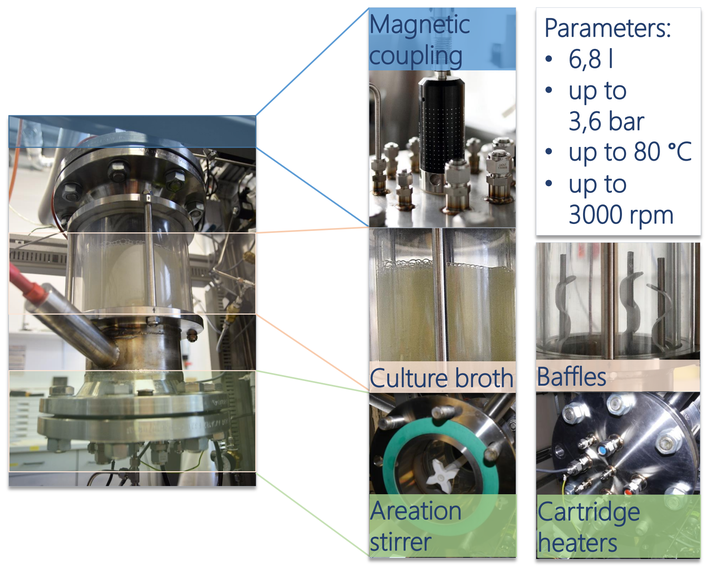

Fig. 2: Photography of the CSTR body and its crucial components and parameters

CO, high temperatures and ashes are excluded as the cause for the observed performance decrease by further experiments. Further, real tars or cocktails/single components of a representative synthetic tar mixture are added to the digester. The tar cocktails are separated by their molecular size into mono-, di- and tri-aromatic or higher hydrocarbons.

Results

With an MPR_R of 1.5 l/(l·h) at a methane content of 42.67 %, or a maximum methane purity of 95.91 % at an MPR_R of 0.17 l/(l·h), the maximum performance limits are mainly consistent with the literature.

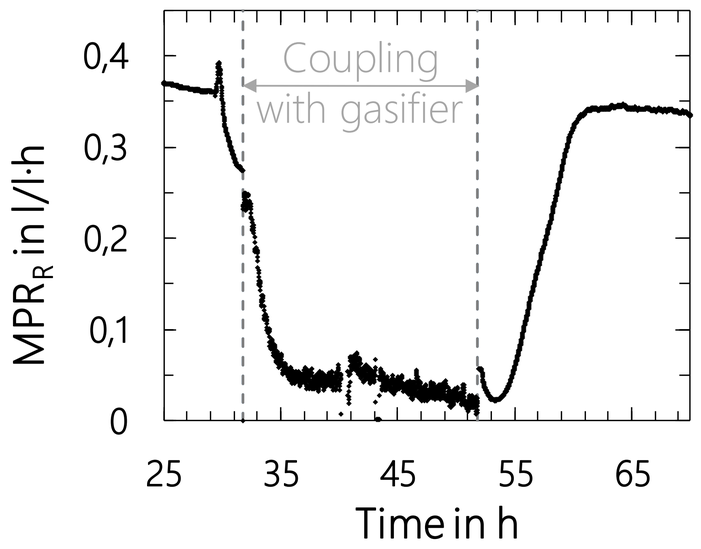

Fig. 3: Figure 3: Methane production rate over the experimentation time for the coupling of allothermal steam-gasification in a fluidized bed with biological methanation

During digester feeding with unpurified synthesis gas directly from a gasifier into the biological methanation process, the MPR_R is reversibly decreasing, as shown in Figure 3. This is caused by the tars, as further experiments on other possible factors and dosing of separated tars from the gasifier show. This can be verified with a synthetic tar mixture which is representative for the used gasifier. Thereby the maximum load of synthetic tars added to the stirred tank reactor lies in a range of 0.33 to 0.48 g/l.

However, this effect is not equally attributable to different groups of tar constituents. While monoaromatic hydrocarbons show no effect at all, the maximum tar load for the group of two-ringed tars is 0.17 g/l and for three- and four-ringed aromatics it is 0.06 g/l, as shown in figure 4. Individual components show no effect due to their low solubility. Solubilities of the tar mixtures are of interest, as they are higher than the sum of the single components and only solute tars do harm the microorganisms.

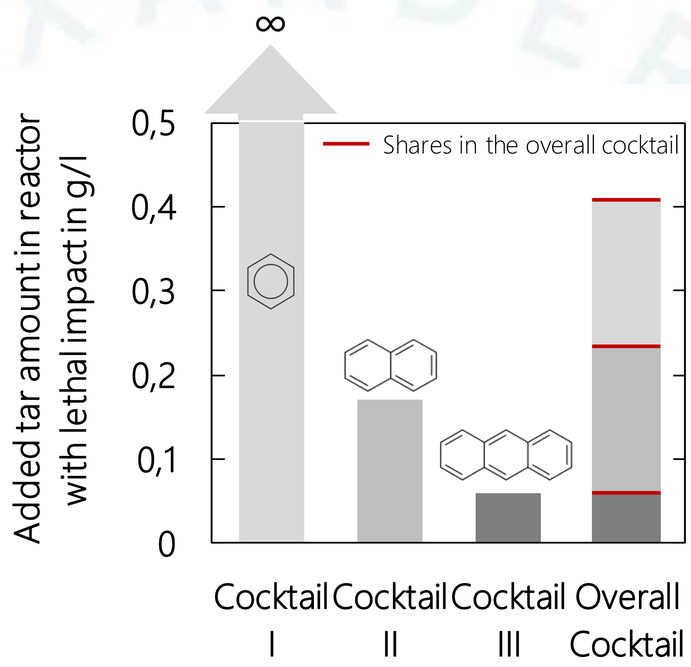

Figure 4: Lethal tar concentration of mono (Cocktail I), di- (II) and tri-aromatic and higher (III) hydrocarbons and a represantative tar combination (Overall) for the allothermal steam-gasification in the biological methanation

Accordingly, it can be concluded that utilisation of lignin-containing residues by gasification in biological methanation is possible if low-tar gasifiers with a focus on light tar components are used.

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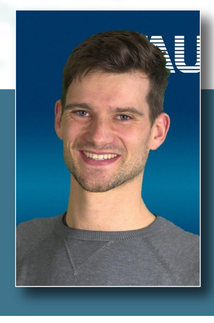

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