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Microbial methanation of hydrogen and carbon dioxide in anaerobic trickle bed reactors

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Introduction

In Germany, the amount of power generated from renewable resources is constantly increasing and strongly influenced by a fluctuating availability of the resources, such as sun, wind and water. Thus, covering the energy demand from industry and private households continuously, will become more and more challenging and the need for advanced and efficient energy conversion and storage technologies is clearly growing. Currently, various available technologies (e.g. batteries, pump storage hydro power systems) are only applicable as short- or midterm storage due to limited capacity. In contrast, the German gas grid has one of the largest long term storage capacities available for up to 24 billion m^3 (~250 billion kWh), equivalent to 25 % of Germanys yearly gas consumption [1].

Research objectives

In this context, this thesis aims to further study and develop the microbial generation of methane as a storable gas directly from hydrogen and carbon dioxide (Fig. 1), which is a promising alternative to the chemical-catalytic Sabatier reaction. The required hydrogen can be generated in times of excess power via electrolysis, the carbon dioxide streams could be used directly at their origin (e.g. industries, biogas plants). As a result of limited mass transfer processes, limitations originating from the introduced gases to the microbial community have been observed in several studies [2, 3]. Through establishing this process within an anaerobic trickle bed reactor, an improved hydrogen mass transfer would be expected and the system can be operated without pressurized gas

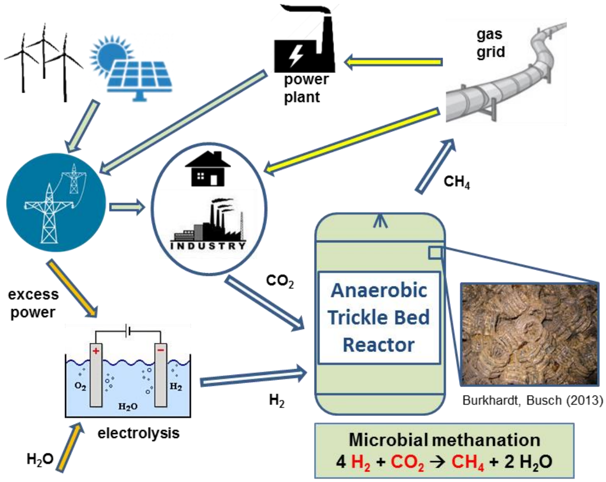

Fig. 1: Microbial methanation reactors as a link between energy and gas grid, transferring excess power into storable methane.

supply, possibly increasing the energy efficiency compared to bubble column, membrane or chemostat systems [4–6]. With regard to process efficiency and applicability, the influence of different inocula, process temperatures as well as CO_2-sources will be investigated. To be applied as a future energy conversion and storage technology, this research also focuses on flexible (on demand) operation, studying the impact of periods without gas supply on microbial community and methane generation.

Experimental Setup

The experimental studies will be performed in gas-tight and explosion proof anaerobic trickle bed reactors with a volume of 60 l, equipped with online measurement devices for pressure, temperature and pH. Gas supply for the reactors can be varied in H_2/CO_2 composition. CH_4, H_2 and CO_2 in the effluent gas will be continuously monitored. The microbial composition will be investigated with focus on enriching dominant species of hydrogenotrophic methanogenic archaea during long-term operation as well as on micro and macro nutrient requirements. Molecular biology techniques (i.e. (RT)qPCR, cDNA/DNA ratio, biomarker) will be used to identify composition of the microbial species with regard to quantity and quality.

Expected outcomes

The results will identify the potential of microbial methanation in anaerobic trickle bed reactors to act as an efficient and reliable link between energy and gas grid by transferring excess power into storable methane.

References

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