Further development of the synthesis gas fermentation process.

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1. Introduction

In the face of global warming, the storage and utilization of CO_2 produced by industrial processes has become increasingly important [1]. One novel idea to deal with this problem is the utilization of CO_2 and H_2 via a fermentation process. Synthesis gas fermentation uses microorganisms to convert, gas mixtures of H_2, CO_2 and CO into alcohols and organic acids [2]. Compared to classic thermocatalytic processes, the microbial conversion of synthesis gas has a high potential for increasing efficiency and simplifying handling [3]. This is due to milder reaction conditions, like lower process pressures and temperatures, as well as the reduction of process steps, which are made possible by the ability of microorganisms to synthesize complex molecules in one process step. The synthesis gas fermentation process is especially challenged by the gas-liquid mass transfer as a limiting factor [4], the effect of the H_2: CO: CO_2 ratio in synthesis gas on product yield and growth rate, as well as low product yield and high cost in general [5].

2. State of the art and future prospects

Many studies have been conducted to improve the conditions of syngas fermentation [5, 6] as well as to describe models [7, 8] representing product and biomass formation under batch and continuous fermentation conditions. At the Institute of Catalysis Research and Technology (IKFT) a continuous laboratory reactor (synthesis gas fermentation plant for high pressures for the production of alcohols and acetates "SANDRA", Figure 1.) has been developed [9–11]. Various experiments have already been carried out at IKFT with this reactor system to determine the influence of various parameters on fermentation.

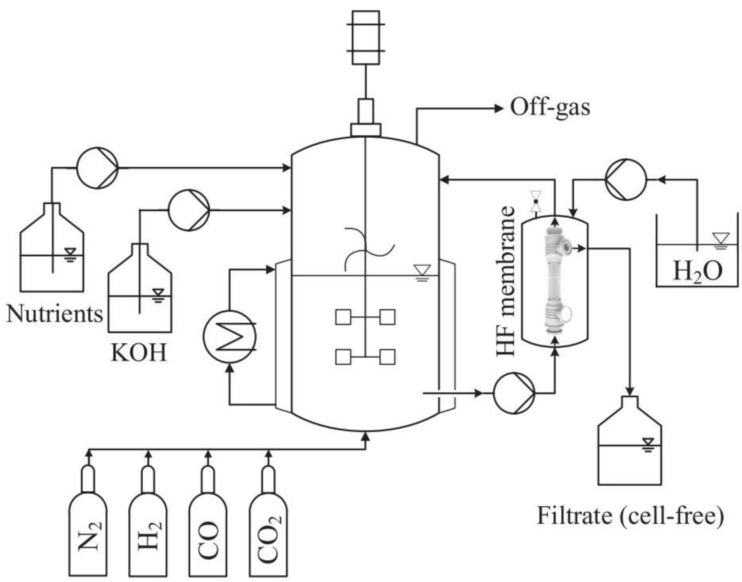

Figure 1. Setup of reactor system with cell retention (HF) [10].

For example, Stoll et al. [9] and Perret et al. [10] were able to determine the influence of pressure, pH value and various synthesis gas mixtures on product formation and biomass growth of *Clostridium ljungdhali*. Perret et al. [11] were also able to improve space time yield of produced C2 species by 46 % by using cell retention.

A major goal of future work is to increase the overall process efficiency of the synthesis gas fermentation. Establishment of a stationary state in this biological system is slow due to the long residence time of the liquid phase and possible adaptation processes of the microorganisms. Therefore, the purely empirical optimization of reactor operation is extremely time-consuming. Due to this slow reactor behavior, it is also not possible to adjust parameters of formal kinetic rate equations to the results of concentration measurements, as it is common in heterogeneous catalysis. Continuous control of reactor operation, using appropriate estimator or soft sensor concepts to achieve the optimum operating condition, with respect to targets such as total carbon fixation, would help to drastically reduce reactor operating times. At the same time, this could provide information about the system that is needed for a future knowledge-based scale-up of the technology.

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