**Syngas Mass Transfer in a Membrane Bioreactor.**

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**Highlights**

* Syngas fermentation is a promising route for bio-based production of commodity chemicals
* Syngas fermentation mass transfer limitations can be overcome in a membrane bioreactor
* Mathematical models can describe mass transfer and conversions in a membrane bioreactor

**1. Introduction**

Syngas can be obtained from sustainable and renewable processes such as biomass and municipal waste streams gasification, water and carbon dioxide electrolysis or directly from gaseous waste streams of heavy industry (e.g. steel industry) [1]. Syngas fermentation to commodity and fine chemicals is an emergent technology in biobased economy and it is foreseen to have an important contribution against climate change, by the reduction of greenhouse gas emissions and simultaneous valorization of waste streams. Syngas fermentation for ethanol production is a process currently being established at commercial scale. Novel microbial processes are developed to drive syngas biotechnological applications towards the production of more valuable multi-carbon compounds.

At the process side, the mass transfer limitation is the major resistance for gaseous substrate diffusion, due to the low aqueous solubilities of the gaseous substrates and reduced mass transfer coefficients. This is one of the urgent challenges to be tackled in syngas fermentation to building blocks, so that sufficient productivity and product titers can be achieved [2].

Membrane bioreactors are a promising configuration for overcoming gas to liquid mass transfer limitations in syngas fermentation [3]. High gas-liquid interfacial areas can be achieved in hollow fiber membrane modules given their geometry and higher driving force can be obtained by increased transmembrane pressure. However, so far the potential of membrane bioreactors has not been systematically explored for syngas fermentation.

**2. Methods**

Syngas fermentation in suitable membrane bioreactors is mathematically modeled using Comsol Multiphysics, using chemostat data and literature data. This allows computational fluid dynamics calculations. Model-based optimization incorporates syngas feed rate and composition, nitrogen source feed rate, pressure, cell concentration, product concentration, and liquid flow rate. Additionally, the model optimization results will be used for design of experiments of the membrane bioreactor at lab scale and further validation of the model.

**3. Results and Discussion**

The syngas substrates are fed in hollow fiber lumens and the microorganisms are maintained on the shell surface, that is, on the liquid contacting side of the membrane fibers. At many conditions, the microorganisms can form biofilms. The gaseous substrates permeate across the hollow fiber wall toward a biofilm, where the microorganisms convert the gaseous substrates into the product, which then diffuses to the liquid phase.

**4. Conclusions**

At sufficiently high membrane area, mass transfer kinetics does not remain limiting. Therefore, other relevant phenomena need to be taken into account as well, such as fluid dynamics, fermentation stoichiometry and kinetics, and biofilm formation kinetics.

**References**

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