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BIOLOGICAL FERMENTATION OF SYNGAS

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KEYWORDS

Syngas, carbon monoxide, anaerobic bioconversion.

ABSTRACT

Synthesis gas (or syngas) can be produced from a variety of materials including commonly-used fossil fuels, but also renewable organic compounds such as poorly degradable biomass sources and wastes, through gasification. Syngas is a mixture composed of mainly H_2, CO and CO_2 that can be used in a biological process for the production of fuels or usable chemicals.
The main goal of this work is to explore the potencial of biogas or other valuable compounds production from syngas.

INTRODUCTION

The interest in the biological conversion of syngas relies on the knowledge that some anaerobic microorganisms can effectively use CO and H_2 to produce added-value carbon compounds, such as ethanol, butanol, acetic acid, butyric acid, hydrogen and methane (Basu et al. 1993; Henstra et al. 2007; Worden et al. 1997). Microbiology of syngas bioconversion to biofuels has been recently reviewed (Henstra et al. 2007; Oelgeschlager and Rother 2008; Sokolova et al. 2009). Several mesophilic anaerobic microorganisms, e.g. *Clostridium carboxidivorans* and *Butyribacterium methylotrophicum*, were shown to produce short-chain fatty-acids and alcohols from CO and H_2. Mesophilic and thermophilic carboxydotrophic hydrogenogenic bacteria, e.g. *Rubrivivax gelatinosus*, *Rhodopseudomonas palustris*, *Rhodospirillum rubrum*, *Carboxydothermus hydrogenoformans*, *Carboxydocella thermoautotrophica*, *Desulfotomaculum carboxydivorans*, can convert CO and H_2O to H_2 and CO_2. Direct conversion of CO to CH_4 can be achieved by a few methanogenic archaea, namely *Methanosarcina barkeri*, *Methanosarcina acetivorans* and *Methanothermobacter thermoautotrophicus*. Production of CH_4 from the H_2 and CO_2 present in the syngas or via acetate is possible using hydrogenotrophic and acetoclastic archaea. Fatty-acids and alcohols can be converted to CH_4 by syntrophic mixed cultures (Schink and Stams 2006).

Syngas fermentation offers several advantages over catalytic conversion. The greater resistance to catalyst poisoning, and independence of a fixed H_2:CO ratio are generally mentioned (Henstra et al. 2007). Sulphur gas removal may not be required because the used microorganisms are fairly tolerant towards sulphur, being able to grow in the presence of up to 2% hydrogen sulphide. Particularly the milder processing conditions can reduce both capital and operating costs. Finally, biological catalysts are typically more specific than the inorganic reactions which may lead to lower purification costs (Heisnkanen et al. 2007). Syngas fermentation to methane is not yet studied and can present several interesting aspects.

In order to study the potential of different inocula for the synthesis of various interesting products from syngas, synthetic mixtures of CO, CO_2 and H_2 with different CO:CO_2:H_2 ratios and different operational conditions, namely temperature and pressure, were tested in bacth assays.

METHODS

Mesophilic experiments were performed at 37 °C starting with suspended sludge from a labscale anaerobic bioreactor. Simultaneously, thermophilic experiments were started at 55 °C using suspended slugde from an anaerobic digestor treating household solid wastes. For both experiments, pH was kept at 7.0, total pressure at 2.5 bar and it was used phosphate buffer 20mM. Synthetic syngas mixtures (60%CO:30%CO_2:10%H_2) were used as sole carbon and energy sources, diluted with H_2/CO_2 (80:20), in order to obtain the intended carbon monoxide concentration. During the all experiments, headspace composition was analysed by GC and fatty-acids and alcohols were analysed by HPLC. In order to study microbial dynamics of syngas-enriched cultures by using molecular techniques, samples for DNA isolation were collected and preserved.

RESULTS & CONCLUSIONS

Both assays started with 5% CO, reaching a maximum CO concentration of 20%. At mesophilic conditions, no CO was consumed after 41 days of incubation with 10% CO. At 55 °C, after four successive transfers using 10% CO, all carbon monoxide was consumed. However, no methane was formed and acetate was detected. Currently, a series of thermophilic experiments, using 20% CO, is ongoing.

The thermophilic suspended slugde used offers potential advantages over the use of mesophilic suspended slugde, related to the CO consumption. Therefore, successive transfers with syngas as a substrate, with different concentrations of CO, are being performed, aiming the isolation of novel syngas- or CO-utilizing microorganisms. After more than 5 successive transfers (that correspond to more than 100 days of incubation) and increasing the CO concentration from 5% to 60%, by using a phase contrast microscope, it was observed only two different morphological types of microorganisms. This fact indicates a specialization of the inocula in CO-consuming microorganisms.

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JOANA ALVES was born in Viana do Castelo and went to the University of Porto, where she studied Biology and obtained her degree in 2005. During 2005 she worked as a researcher in Laboratory of Microbiology, Wageningen University, The Netherlands. In the next four years she worked as a researcher project in University of Minho. Since 2009, she is doing her Ph.D. project in University of Minho.

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