Hydrogen and methane production from desugared molasses using a two-stage thermophilic anaerobic process

Hydrogen and methane production from desugared molasses by a two-stage thermophilic anaerobic process was investigated in a series of two up-flow anaerobic sludge blanket (UASB) reactors. The first reactor that was dominated with hydrogen-producing bacteria of *Thermoanaerobacterium thermosaccharolyticum* and *Thermoanaerobacterium aciditolerans* could generate a high hydrogen production rate of 5600 mL H₂/day/L, corresponding to a yield of 132 mL H₂/g volatile solid (VS). The effluent from the hydrogen reactor was further converted to methane in the second reactor with the optimal production rate of 3380 mL CH₄/day/L, corresponding to a yield of 239 mL CH₄/g VS. Aceticlastic *Methanosarcina mazei* was the dominant methanogen in the methanogenesis stage. This work demonstrates that biohydrogen production can be very efficiently coupled with a subsequent step of methane production using desugared molasses. Furthermore, the mixed gas with a volumetric content of 16.5% H₂, 38.7% CO₂, and 44.8% CH₄, containing approximately 15% energy by hydrogen is viable to be bio-hytane.

Biophotogeneration production from desugared molasses (DM) using thermophilic mixed cultures immobilized on heat treated anaerobic sludge granules

Hydrogen production from desugared molasses (DM) was investigated in both batch and continuous reactors using thermophilic mixed cultures enriched from digested manure by load shock (loading with DM concentration of 50.1 g-sugar/L) to suppress methanogens. H₂ gas, free of methane, was produced during batch cultivations, at different (DM) concentrations ranging from 1.5 g-sugars/L to 50.1 g-sugars/L. The highest yield of 237 ml-H₂/g-sugar was achieved during the DM batch fermentation at concentration of 2.1 g-sugars/L, whereafter the yield decreased with increasing DM concentration. The enriched hydrogen producing mixed culture achieved from the 16.7 g-sugars/L DM batch cultivation was immobilized on heat treated anaerobic sludge granules in an up-flow anaerobic sludge blanket (UASB) reactor. The UASB reactor, operated at a hydraulic retention time (HRT) of 24 h fed with 16.7 g-sugars/L DM showed good performance with a satisfactory hydrogen yield of 269.5 ml-H₂/g-sugar and rate of 4500 ml H₂/l·d. Fluorescent in situ hybridization (FISH) analysis of the microbial community of sludge from batch fermentation and the UASB-granules after 54 days of operation, was dominated by *Thermoanaerobacterium* spp., which are key players in fermentative hydrogen
production of DM under thermophilic conditions. Furthermore, the granules in the UASB reactor were also significantly containing Thermoanaerobacterium spp. and phylum Firmecutes (most Clostridium, Bacillus and Desulfobacterium) and Thermoanaerobacterium thermosaccharolyticum with a relative abundance of 36%, 27%, and 10% of total microorganisms, respectively. This study shows that hydrogen production could be efficiently facilitated by using anaerobic granules as a carrier, where microbes from mixed culture enriched in the DM batch cultivation were immobilized on, in an UASB reactor.

Performance and microbial community analysis of two-stage process with extreme thermophilic hydrogen and thermophilic methane production from hydrolysate in UASB reactors

The two-stage process for extreme thermophilic hydrogen and thermophilic methane production from wheat straw hydrolysate was investigated in up-flow anaerobic sludge bed (UASB) reactors. Specific hydrogen and methane yields of 89ml-H2/g-VS (190ml-H2/g-sugars) and 307ml-CH4/g-VS, respectively were achieved simultaneously with the overall VS removal efficiency of 81% by operating with total hydraulic retention time (HRT) of 4 days. The energy conversion efficiency was dramatically increased from only 7.5% in the hydrogen stage to 87.5% of the potential energy from hydrolysate, corresponding to total energy of 13.4kJ/g-VS. Dominant hydrogen-producing bacteria in the H2-UASB reactor were Thermoanaerobacter wiegelli, Caldanaerobacter suberaneus, and Caloramator fervidus. Meanwhile, the CH4-UASB reactor was dominated with methanogens of Methanosarcina mazei and Methanothermobacter defluvi. The results from this study suggest the two stage anaerobic process can be effectively used for energy recovery and for stabilization of hydrolysate at anaerobic conditions.
Submersible microbial fuel cell for electricity production from sewage sludge
A submersible microbial fuel cell (SMFC) was utilized to treat sewage sludge and simultaneously generate electricity. Stable power generation \((145\pm 5 \text{ mW/m}^2, 470 \Omega)\) was produced continuously from raw sewage sludge for 5.5 days. The maximum power density reached \(190\pm 5 \text{ mW/m}^2\). The corresponding total chemical oxygen demand (TCOD) removal efficiency was \(78.1\pm 0.2\%\) with initial TCOD of 49.7 g/L. The power generation of SMFC was depended on the sludge concentration, while dilution of the raw sludge resulted in higher power density. The maximum power density was saturated at sludge concentration of 17 g-TCOD/L, where 290 mW/m\(^2\) was achieved. When effluents from an anaerobic digester that was fed with raw sludge were used as substrate in the SMFC, a maximum power density of 318 mW/m\(^2\), and a final TCOD removal of 71.9\pm 0.2\% were achieved. These results have practical implications for development of an effective system to treat sewage sludge and simultaneously recover energy.
Biohydrogen production from wheat straw hydrolysate by dark fermentation using extreme thermophilic mixed culture

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Submersible microbial fuel cell for electricity production from sewage sludge
A submersible microbial fuel cell (SMFC) was utilized to treat sewage sludge and simultaneously generate electricity. Stable power generation (145±5 mW/m²) was produced continuously from raw sewage sludge for 5.5 days. The corresponding total chemical oxygen demand (TCOD) removal efficiency was 78.1±0.2% with initial TCOD of 49.7 g/L. The power generation of SMFC was depended on the sludge concentration. The maximum power density generated from raw sludge reached 190±5 mW/m². Dilution of the raw sludge resulted in higher power density. The power density was saturated at sludge concentration 17 g-TCOD/L, where maximum power density of 290 mW/m² was achieved. When effluents from an anaerobic digester were used as substrate in the SMFC a maximum power density of 318 mW/m², and a final TCOD removal of 71.9±0.2% was achieved. These results have practical implications for development of an effective system to treat sewage sludge and simultaneously recover energy.

Bioethanol, biohydrogen and biogas production from wheat straw in a biorefinery concept
The production of bioethanol, biohydrogen and biogas from wheat straw was investigated within a biorefinery framework. Initially, wheat straw was hydrothermally liberated to a cellulose rich fiber fraction and a hemicellulose rich liquid fraction (hydrolysate). Enzymatic hydrolysis and subsequent fermentation of cellulose yielded 0.41 g-ethanol/g-glucose, while dark fermentation of hydrolysate produced 178.0 ml-H₂/g-sugars. The effluents from both bioethanol and biohydrogen processes were further used to produce methane with the yields of 0.324 and 0.381 m³/kg volatile solids (VS)added, respectively. Additionally, evaluation of six different wheat straw-to-biofuel production scenarios showed that either use of wheat straw for biogas production or multi-fuel production were the energetically most efficient processes compared to production of mono-fuel such as bioethanol when fermenting C6 sugars alone. Thus, multiple biofuels production from wheat straw can increase the efficiency for material and energy and can presumably be more economical process for biomass utilization. (C) 2008 Elsevier Ltd. All rights reserved.
Biohydrogen production from xylose at extreme thermophilic temperatures (70 degrees C) by mixed culture fermentation

Biohydrogen production from xylose at extreme thermophilic temperatures (70 degrees C) was investigated in batch and continuous-mode operation. Biohydrogen was successfully produced from xylose by repeated batch cultivations with mixed culture received from a biohydrogen reactor treating household solid wastes at 70 degrees C. The highest hydrogen yield of 1.62 +/- 0.02 mol-H2/Mol-xylose(consumed) was obtained at initial xylose concentration of 0.5 g/L with synthetic medium amended with 1 g/L of yeast extract. Lower hydrogen yield was achieved at initial xylose concentration higher than 2 g/L. Addition of yeast extract in the cultivation medium resulted in significant improvement of hydrogen yield. The main metabolic products during xylose fermentation were acetate, ethanol, and lactate. The specific growth rates were able to fit the experimental points relatively well with Haldane equation assuming substrate inhibition, and the following kinetic parameters were obtained: the maximum specific growth rate (\( \mu_{\text{max}} \)) was 0.17h(-1), the half-saturation constant (\( K_s \)) was 0.75 g/L, and inhibition constant (\( K \)) was 3.72 g/L of xylose. Intermittent N2 sparging could enhance hydrogen production when high hydrogen partial pressure (>0.14 atm) was present in the headspace of the batch reactors. Biohydrogen could be successfully produced in continuously stirred reactor (CSTR) operated at 72-h hydraulic retention time (HRT) with 1 g/L of xylose as substrate at 70 degrees C. The hydrogen production yield achieved in the CSTR was 1.36 +/- 0.03 mol-H2/Mol-xylose(consumed), and the production rate was 62 +/- 2 ml/d.L-reactor. The hydrogen content in the methane-free mixed gas was approximately 31 +/- 1%, and the rest was carbon dioxide. The main intermediate by-products from the effluent were acetate, formate, and ethanol at 4.25 +/- 0.10, 3.01 +/- 0.11, and 2.59 +/- 0.16 mM, respectively.

Biofuel production: A new biorefinery for sustainable energy from crops: conversion of lignocellulose to bioethanol, biohydrogen and biomethane

Biofuel production: A new biorefinery for sustainable energy from crops: conversion of lignocellulose to bioethanol, biohydrogen and biomethane

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