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Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Combined Acetone-Butanol-Ethanol (ABE) and biogas production from macroalgae

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ABSTRACT

Butanol as a liquid biofuel can provide more benefits than ethanol, due to its gasoline-like properties. It can be produced from the same feedstocks as ethanol (starch and cellulosic sugars) but the butanol producing Clostridia sp. is able to ferment different kind of carbohydrates including C1 and C5 sugars. Macroalgae can grow on non-agricultural land, without increasing food prices, using fresh water, meanwhile consuming CO2 for growing. In addition, it has very high biomass yield with high carbohydrate content and represent a huge unexploited bioresource with potential for production of biofuel in the near future. The aim of our studies was to examine a combined biorefinery concept with butanol and biogas production. The effluent as a substrate was further studied in batch experiments by anaerobic digestion for biogas production.

RESULTS – ABE fermentation

Enzymatic hydrolysis (EH) experiments

EH was performed on hydrothermal pretreated (195°C, 10 min, without oxygen) U. lactuca and C. linum at 5% DM content to find the best enzyme mixtures:

1. Cellulases (Celluclast + Novozyme 188) at 25 FPU/g DM (Hydrolysis at 50°C pH4.8)
2. Cellulases (Celluclast + Novozyme 188) at 25 FPU/g DM and Spirizyme (Hydrolysis at 50°C pH4.8)
3. Liquozyme and cellulases (Celluclast + Novozyme 188) at 25 FPU/g DM and Spirizyme (Hydrolysis at 85°C for 1h at pH5.7 followed by additional cellulases and Spirizyme at 50°C, pH 4.8)

The highest final glucose content (13 and 7 g/l, respectively) was achieved when pretreated macroalgae were hydrolyzed by Liquozyme at 85°C for 1h at pH 5.7 followed by hydrolysis at 50°C, pH 4.8 applying Celluclast, Novozym 188 and Spirizyme.

Inhibitory studies

Liquid fractions of pretreated macroalgae were also tested to check any inhibitory effect. The liquid fraction was supplemented with additional glucose (30 g/l), salts and nutrients. Fermentations were performed on diluted (D, 50%) and undiluted (U) liquid fractions with C. beijerinckii under anaerobic conditions at 35°C.

According to our results compare to control synthetic medium (C), undiluted samples (U) showed some inhibitory effect on ABE fermentation, however detailed investigation was not performed to identify inhibitors.

Acknowledgement

The work was financially supported by the PSD Project (Energy Production from Marine Biomass: 2008-1-0050). Annette Eva Jensen, Ingelis Larsen and Tomas Fernqvist are thanked for technical assistance.

THE CONCEPT

Algae
( Pretreatment (hydrothermal/sterilization)
Solid
Enzymatic hydrolysis
ABE Fermentation
Biogas

SUBSTRATES

Chaetomorpha linum and Ulva lactuca (both harvested in Denmark) were used in our experiments.

CONCLUSIONS

- Macroalgae are certainly interesting substrates in a biorefinery concept due to their high carbohydrate content.

FUTURE PLANS

Future studies need to address:
- Finalize biogas experiments.
- Examination of saccharolytic activity of C. beijerinckii on macroalgae.
- Performing simultaneous hydrolysis and ABE fermentation.