trans algae INFOSHEET

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Pretreatment of Microalgae for Biogas

Microalgae have many possible applications, of which wastewater treatment combined with biogas production has been seen as one of the most feasible ones. However, some previous research as well as results in the TransAlgae project have shown that biogas yield from such microalgae can be low. Different pretreatment methods have been suggested as a possible solution.

PRETREATMENT METHODS FOR BIOGAS

The rate of biogas production as well as the methane yield is partly dependent on the availability of organic material for anaerobic digestion, performed by microorganisms. The first step of that biological process is hydrolysis, which is also often said to be what determines how fast the targeted biogas yield or biochemical methane potential (BMP) is reached. Generally, the purpose of pretreatment is to increase the availability and achieve a faster hydrolysis rate.

FOUR CATEGORIES AND SUB-PROCESSES

Pretreatment methods are commonly divided into four categories: Mechanical, thermal, chemical and biological. These categories are divided into different sub-processes and can also be combined for a better effect. But pretreatment methods are only done when it is beneficial, as they consume energy and require investments in machinery, which also needs to be operated. Simply put, the gain in energy in form of increased biogas production should outweigh the energy consumption and costs of pretreatment. Otherwise, pretreatment is not an option.

Anaerobic digestion is mainly a waste treatment method, with large variations in substrates and their properties. Pretreatment can be carried out to avoid process instabilities or inhibition. In these cases, it is a necessary step in a functional processes.

PRETREATMENT OF MICROALGAE

The idea of pretreatment of microalgae is not new. At an early stage it was recognized by some researchers as necessary for biogas production. It was planned from the beginning of TransAlgae to investigate this and evaluate if it pays off. In the case of microalgae, thermal and mechanical pretreatment have previously been identified as the most suitable.

In TransAlgae, thermal and ultrasound (which is a mechanical method) were chosen as pretreatment methods. Novia UAS found out early in the project that the BMP of the microalgae (figure 1) cultivated in real wastewater by the Swedish University of Agricultural Sciences (SLU) was somewhat low. This supported the planned pretreatment experiments.

The main reason that microalgae might need pretreatment for biogas production, is that the cell wall is difficult to degrade for the anaerobic microorganisms.

Figure 1. Centrifuged microalgae, cultivated by SLU in Umeå, Sweden, to be thermally pretreated at Novia UAS in Vasa, Finland.

THE CASE IN TRANSALGAE

To properly determine the pretreatment effect, influencing factors should be the same. This means that the samples from different conditions of pretreatment should preferably be done in the same assay. They then contain the same inoculum and can be properly compared. Novia UAS now has two units of AMPTS II (figure 2) that can be run in parallel. This may give a better picture, due to obtaining more results simultaneously.

Figure 2. Two AMPTS II-units by Bioprocess Control at Technobothnia in Vasa, Finland. They are used to find out the BMP of substrates and thus the pretreatment effect.

An additional challenge was the logistics – To determine the pretreatment effect, the sample should be as fresh as possible. Degradation and freezing may have same effect as pretreatment, which is partially breaking down the cell wall. The algae also needed to be sent by ferry across the border.

The samples were centrifuged before treatment. In both tests, one sample was not pretreated for comparison. For the thermal pretreatment, based on literature as well as energy balance, low temperatures were selected.

The thermal pretreatment times were 0.5, 5 and 10 hours. The temperature ranged from 70°C to 95°C, based on a design of experiments. The ultrasound pretreatment was carried out at SLU with a sonicator. 7 different settings and treatment times were applied. Ultrasound should however be repeated and higher specific energies tested.

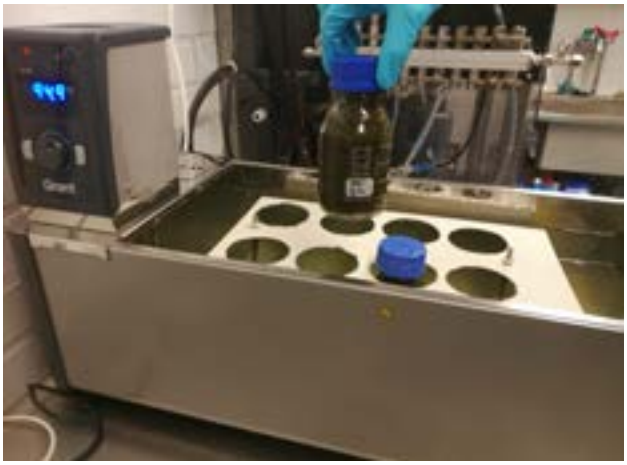

Figure 3. Samples from figure 1 that have been pretreated at 95°C at Novia UAS.

NEGATIVE EFFECT OF PRETREATMENT

Although ultrasound treatment could be investigated further, the BMP-assay show a decrease in biogas production. All thermal pretreatments that were tested also showed a negative effect on BMP. Only the harshest thermal treatment had a neutral impact. Pretreatment can also increase the rate of the reaction, which could improve economics, but no increase was found. In other words, based on these results, these microalgae should not be pretreated.

There are some previous examples in literature where pretreatment has had an undesirable impact. This may be caused by different factors, often specific to the substrate. Since microalgae cultivated in wastewater can have a complex and varying composition, the negative effect can be caused by several things, which should be investigated in detail.

Other options to improve biogas production should be considered instead. Co-digestion has previously improved BMP in TransAlgae. Also, if the algae has been subject to extraction of for example lipids, the harsh treatment could improve degradability. This is the next option to investigate in the project. Biogas would then be produced from the waste biomass from another process, according to the biorefinery principle.

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