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UMTEC INSTITUTE OF ENVIRONMENTAL AND PROCESS ENGINEERING

UMTEC

The **Institute of Environmental and Process Engineering (UMTEC)** is divided into four departments: Raw Materials and Process Engineering, Waste and Resource Efficiency, Water and Wastewater Treatment, and Odor Management. Approximately 20 scientists and engineers from the fields of mechanical, process, environmental, and geoscience engineering conduct applied research and innovative projects.

In the **Department of Water and Wastewater Treatment** we develop applied solutions for wastewater treatment by means of processes analysis, testing procedures and material flow analysis. We look back on a longstanding experience working on projects for industrial partners, environmental institutions and authorities.

Our team currently consists of 7 engineers, a majority of whom have graduated from HSR (University of Applied Sciences Rapperswil) and ETH (Swiss Federal Institute of Technology Zurich). They are supported by interns and students.

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Dewatering of Microalgae

Background

The dewatering of algal biomass is an important process throughout various fields of application and research, for example, in the cosmetic, food and beverage industries. Valuable components such as carotenoids, vitamins and pigments are extracted. Dewatering also plays a central role in the energy use of algal biomass, in particular of microalgae.

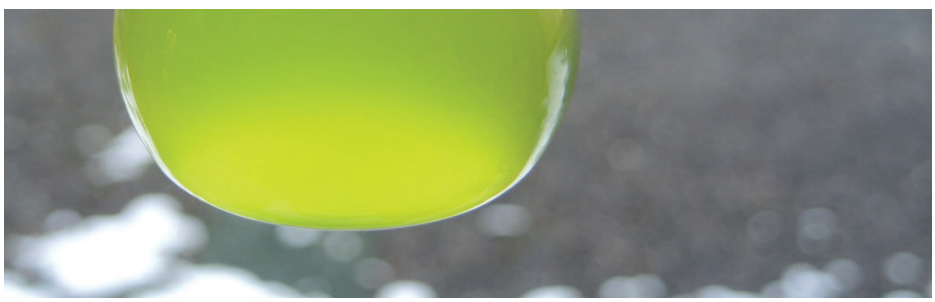
Algal biomass represents a future oriented energy source and an alternative to conventional bioenergy. Conventional biofuels of the 1st and 2nd generation typically consists of rape seed, soya, sugar cane or corn. The great advantage of algae is that it does not compete as a nutrient nor does it occupy farmland.[1]

The project SunCHem consists of the development of a new conversion process of algal biomass to methane.[2] The main focus lies on the cultivation and dewatering of the algae as well as the hydrothermal gasification of the biomass for energy generation purpose. Within the project, UMTEC is in charge of the technological evaluation of the dewatering of microalgae .

Challenges

Microalgae are simple organisms, in most cases monocellular autotrophic ("self-provider"), that range in size between one and several hundred micrometer. In order to grow they merely require carbon dioxide, light and the nutrients nitrogen and phosphorus. In natural surface waters they occur in low concentration. For commercial use they are cultivated in open ponds or closed photobioreactors that can reach an algae-concentration, under ideal circumstances, of up to 0.5% dry matter (DM).

For the SunCHem methanisation process and in order to achieve an ideal energy yield an algae concentration of 20% DM is necessary. For this reason microalgae from a low concentration suspension must be enriched up to 1000-times. In large industrialized applications this enrichment process consumes large amounts of energy and it is this aspect that will be key to the economic feasibility of the entire SunCHem process. Effectiveness of the dewatering process depends on the growth stage of the microalgae since size, form, mass density, cell surface charge as well as composition and concentration of the extracellular substances all have an influence.[3] For this reason, dewatering processes applied for mineral (non-organic) particles, such as wastewater or sewage, cannot be applied to microalgae directly.



Process Development

A dewatering process is under development targeting an algae-concentration of 20-30%DM, in order to assure optimal energy balance. For the technical clarification of the dewatering of microalgae, for example *Chorella sp* and *Pseudokirchneriella subcapitata*, various procedures are tested and the ideal operating parameters sought. Hereby, not only the dewatering step is considered, but also the antecedent harvesting step. In addition the algae are physicochemically characterized (size distribution, Zeta-Potential etc.). Based on the laboratory results an ideal process combination for a pilot run of the SunCHem process is defined.

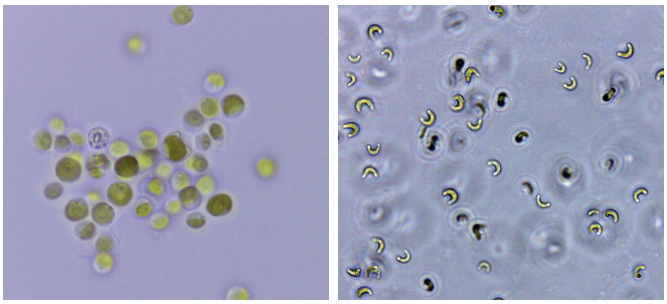


Fig.1: Microalgae Chorella sp (left, 1000 times enlarged) and Pseudokirchneriella subcapitata (right, 400 times enlarged)

Subsequent processes for enrichment and dewatering of algae biomass are being considered (fig.2.)

- Flocculation Evaluation of suitability of flocculants and supporting substances in dependence of the kind of microalgae, growth stage, pH-value, dose and cost. Given the charged surface of microalga, electrolytic processes as well as auto-flocculation are tested. Possible influences of iron or aluminum on the SunCHem methanisation process are considered.

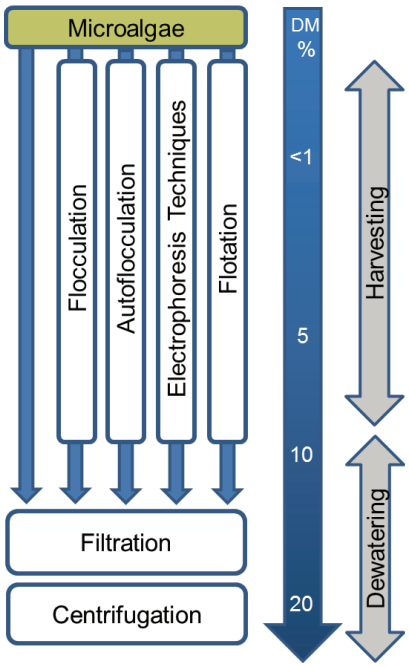


Fig.2: Potentially suitable processes for harvesting and dewatering of microalgae. Processes are tested and developed both individually and in combination.

- Flotation Microalgae are extracted from the original algae suspension via flotation with or without addition of flocculants and preferably via pressure-release floatation.
- Centrifugation Centrifugation can be tested both on unprocessed algae-suspension, as well as a subsequent process step to suspension that has undergone flocculation and/or floatation processing. Microalgae can be dewatered using disc-type centrifuge (Fig.3), however, given the high energy consumption, this step shall be reduced to a minimum.
- Filtration Given the „sticky“ characteristic of microalgae, surface filtration is a challenge from a process engineering point of view and not a suitable solution, especially for very small algae. In contrast to centrifugation however, filtration consumes very little energy. Various filtration processes are being evaluated (for example cross-flow filtration).

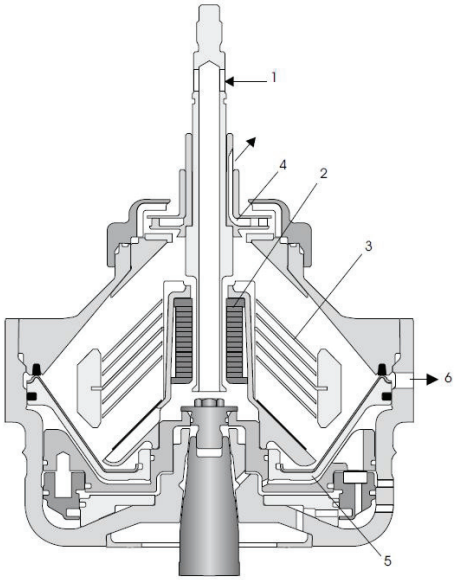


Fig.3: Disc-type centrifuge (Alfa Laval), can be employed continuously for dewatering of algae-biomass. (1) In-flow, (2) distributor, (3) Disc-seperators, (4) Drain watery phase, (5) Recipient floor, (6) Drainage algae-biomass

Project Partners and Sponsorship

In addition to UMTEC, following Swiss institutions participate in the SunCHem Project:

- Paul-Scherrer Institut (PSI)
- École Polytechnique Fédérale de Lausanne (EPFL)
- Swiss Federal Laboratories for Materials Science and Technology (EMPA)

The project is sponsored by the Competence Center for Energy and Mobility (CCEM) with participation of several companies (for example Swisselectric and Sulzer). Financing of UMTEC activities are covered by the University of Applied Sciences Rapperswil I (HSR)

[1] *Chisti, Y., 2007. Biodiesel from microalgae. Biotechnol. Adv. 25 (3), 294-306.*

[2] *Haiduc, A.G., et al., 2009. SunCHem: An integrated process for the hydrothermal production of methane from microalgae and CO_2 mitigation. J. Appl. Phycol. 21, 529–541.*

[3] *Henderson, R., et al. 2008. The impact of algal properties and pre-oxidation on solid liquid separation of algae. Wat. Res. 42, 1827-1845.*

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