2018 Helmholtz – OCPC – Program
for the involvement of postdocs in bilateral collaboration projects

PART A

Title of the project: Pulsed microwave radiation as a cell disruption method for efficient microalgae downstream processing.

Helmholtz Centre and institute: Karlsruhe Institute of Technology, Institute for Pulsed Power and Microwave Technology (IHM)

Project leader: Dr. Wolfgang Frey

Web-address: https://www.ihm.kit.edu/english/index.php
Description of the project (max. 1 page)**:**

In the past years microalgae gained a lot of attention because they are considered to be a promising, renewable feedstock for food, feed, fine chemicals and biofuel production. However, up to now they are mainly used for the production of high-value low-volume products and not for commodities like biofuels. Microalgae are capable of producing high amounts of intracellular lipids that are very well suited for the transformation into biofuels like aviation petrol. Since algae cells have strong cell walls, disintegration and extraction are rather difficult and energy intensive, and so far, no efficient technology for the extraction of microalgae oils has been developed.
Therefore, the search for efficient, appropriate cell disintegration and extraction methods is vital to increase competitiveness of algae for the production of high volume, low cost substances like lipids for biofuels. Our Institute is currently world leader in down processing of fresh microalgae with pulsed electric field. Additionally, we have started to investigate pulsed microwave as a disruption techniques which we believe is very promising especially for sea water microalgae species which are difficult to process with pulsed electric field due to high salt content.

Some previous studies suggest that microwave processing can be an efficient pre-treatment method that considerably improves the yield of lipid extraction. However, no study until now has enabled to quantify precisely what energy input is necessary to achieve efficient cell disruption with microwave processing, since most of the work has been carried out with conventional kitchen microwave devices. Moreover, the mechanisms inducing cell disruption by microwave radiation, in particular high frequency electric field interaction with lipids, are not well understood.

Our institute has recently developed an applicator specifically designed to expose microalgae suspensions to microwave radiation providing defined electric field and energy conditions. Moreover, the applicator enables to apply microwave radiation not only in a continuous mode

but also in a pulsed mode, which substantially reduces treatment energy. This experimental setup is currently worldwide unique.

The post-doc will investigate the effect of the microwave radiation on microalgae. Experiments will be performed on fresh microalgae cultivated at our institute. Focus will be initially on the fresh water species *Auxenochlorella protothecoides* and on the sea water species *Nannochloropsis sp.* which are both high lipid producing species. Other species might be used if required.

The first step will consists in investigating how microwave can induce the disruption of microalgae. A crucial point from a basic research point of view is to assess the respective contribution of thermal effects and of direct electric field interaction. This requires decoupling of both effects and can be investigated by comparing effect of pulsed and continuous microwave with identical energies. Additionally the primary target of the microwave radiation should be determined. This will require evaluation of the modification of the properties of cells membrane, of cell-wall and of intracellular organelles like lipid bodies, using diagnostics such as fluorescent microscopy and electron microscopy. During this phase of the project, the exposure to continuous, low-intensity microwave radiation will be compared to intense pulsed radiation for identical energy input.

In a second step, the efficiency of the microwave pre-treatment on the extraction of lipids will be evaluated using solvent extraction. Gas chromatography and spectroscopy techniques will be used to obtain the fatty acid composition of the extracted oil and to quantify other oil components, especially the high value added products such as carotenoids, monounsaturated fatty acids and polyunsaturated fatty acids. Based on these data, the quality of the extracted oil and the suitability for biofuel production and for other applications in the food industry will be assessed. Finally, the post-doc should investigate the possibility of integration of the microwave pre-treatment in a biorefinery concept by evaluating the properties of the residual fraction with regards to component valorisation.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

In order to implement our microwave assisted down processing methods on large scale, we are looking for an institute specialised in production and valorisation of microalgae biomass. In order to make a large scale demonstration, it is however required to have access to a biomass which is adapted to the pursued application.

The Microalgae Biotechnology Group of professor Liu of the Qingdao Institute of Bioenergy and Bioprocess Technology (Chinese Academy of Sciences) has a long lasting experience in screening of microalgae species, mass cultivation technologies and in construction of industrial systems for biofuels and valuable chemicals from microalgae. Due to the common research interest in the field of microalgae valorisation using partly different technological approaches in the downstream processing at the Qingdao Institute and KIT, we do believe that a bilateral collaboration in the proposed research field would be of great benefit to both institutions.

Required qualification of the post-doc:

- PhD in biology, biochemical engineering or chemical engineering
- Experience with microalgae and/or macroalgae would be a strong benefit. However, a candidate with solid background in down-processing and extraction techniques of other plants is also suitable for the project. No specific knowledge regarding microwave is required for the project but a candidate with some affinity or interest for physics will be preferred. In all cases, the high level of qualification in biology and biological engineering remains the dominant criteria.
- Additional skills in lipid extraction techniques, High performance liquid chromatography (HPLC), Gas-chromatography (GC) are additional benefits for the project. The candidate will also have to use fluorescence microscope and eventually electron microscope. Some knowledge of those imaging technics would be beneficial.

PART B

Documents to be provided by the post-doc, necessary for an application to OCPC via a postdoc-station in China, which is affiliated to a research institution like a university:

- Detailed description of the interest in joining the project (motivation letter)
- Curriculum vitae, copies of degrees
- List of publications
- 2 letters of recommendation
- Proof of command of English language

PART C

Additional requirements to be fulfilled by the post-doc:

- Max. age of 35 years
- PhD degree not older than 5 years
- Very good command of the English language
- Strong ability to work independently and in a team