



Editorial Hans Reith, Project Coordinator

The Fourth Newsletter marks the end of the first half of the project. Once more, significant progress has been achieved in recent months in all Work Packages in the areas of CO₂ concentration from air, cultivation, product monitoring, harvesting and recycling of water and nutrients as well as in biorefinery of algae biomass into valuable fractions for product applications. Good progress has also been made in WP2, aimed at bioprospecting and selection of robust, highly productive algal strains. An important achievement is the installation of three identical outdoor pilot scale cultivation systems at partner locations in Norway, Spain and Chile. These systems will be used to evaluate and directly compare the performance and commercial potential of algae strains grown under 3 different climatic conditions.

In the area of product development (WP4), further tests have been conducted showing the feasibility of incorporating algae in resins for plywood panels by project partner CHIMAR. An evaluation of the panels in accordance with European Standards shows that they are suitable for both interior and exterior applications. Promising results have also been obtained with regard to the potential use of bioactive fractions with valuable functionalities to stimulate plant growth. Several new product concepts have been identified. Partner SPAROS has successfully applied microalgae as an added-value ingredient in aquafeed.

In order to generate business cases as well as a business plan, a focus table has been developed (WP4). Business cases will be selected according to their competitive performance and market attractiveness. Preparation of the demonstration work (WP5) is ongoing. Work on scaled-up production of algae oils and functional proteins is already well underway. In WP6, significant progress has been achieved in the area of process designs and lifecycle assessment, including scenario analysis of microalgae cultivation.

A particular highlight was the second Annual Progress Meeting held in Las Palmas de Gran Canaria (ES) on 17-19 November 2015, where the progress achieved in the first 24 months was reviewed and plans were made for the coming period. The meeting included a visit to the Spanish Bank of Algae operated by partner *Fundación Canaria parque científico tecnológico de la Universidad de las Palmas de Gran Canaria*. Here, partners visited the culture collection and laboratory facilities. Furthermore, partners visited the nearby Ecoaqua culture pilot scale testing installations (<http://ecoaqua.ulpgc.es/>). Ecoaqua's main objective is to foster research excellence in sustainable aquaculture under an ecosystem approach. This visit was very valuable because there is a close link between microalgae cultivation and the fast-growing aquaculture sector due to the unique properties and increasing importance of microalgae as a healthy, sustainable feed ingredient for aquaculture of fish, shellfish and shrimps. Indeed, this



is a major application area addressed in MIRACLES through participation of partners EWOS and SPAROS.

A dissemination highlight was the participation of the MIRACLES consortium in the *Bioeconomy Investment Summit*, held in Brussels (BE) on 9-10 November 2015. Participation comprised a stand organised by partners IDC, WU and Fitoplancton Marino and a 10 minute presentation of the project by the coordinator. The aim was to promote the MIRACLES project, including the technologies and products under development and the products developed by partner Fitoplancton. This participation yielded various valuable leads and contacts for project development and exploitation of results.

Overall, the project shows excellent progress. In the coming year, the development of concrete products and demonstration actions will form an important and exciting focus. I am really looking forward to it!

Hans Reith, Project Coordinator.

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Great progress in algae cultivation

During this period, partner Fitoplancton Marino has investigated the influence of different light spectra on RNA expression in the microalgae *Nannochloropsis gaditana* and has found some genes involved in fatty acid and lipid metabolism with an expression profile that is clearly associated with a specific light condition. The project will focus on a cost-effective design for the concentration of CO₂, and Twente University has obtained promising results on a small scale for the concentration of CO₂ from air.

[Readmore](#)



Wageningen University and the University of Huelva have made progress with the foam-bed reactor, and have identified surfactants that are compatible with different microalgae and the foam-bed photo-bioreactor. The system can now operate continuously for more than a week at a time. Vito and Thomas More have set up a medium recycling test at pilot scale, comparing different technologies for water recycling. The test results show good growth of *Nannochloropsis gaditana* on the membrane filtration permeates. The results will be validated in tests on the submerged membrane system using IPC® membranes.

“Green” separation processes

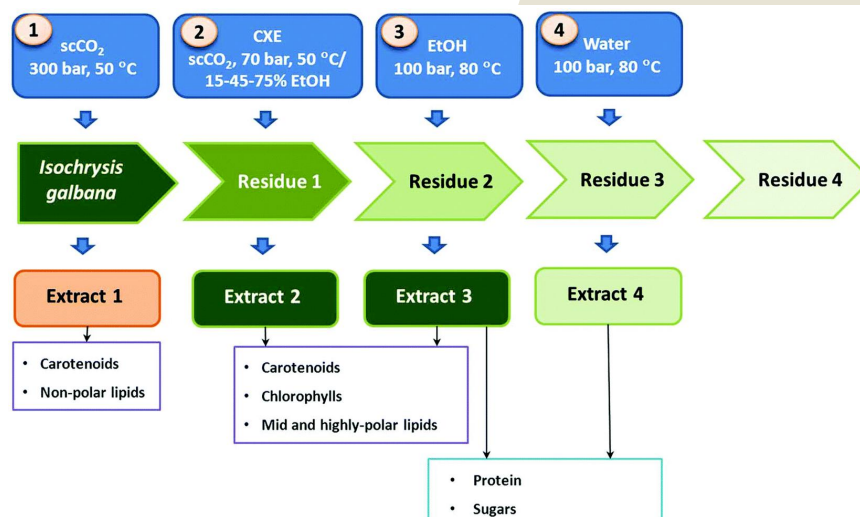


Separation of interesting components.

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Wageningen UR “Food & Biobased Research” made good progress in separating interesting components. Ultrafiltration is an essential unit operation for a microalgal biorefinery, and can be incorporated in the process to obtain a protein-enriched fraction after cell disruption. Hence, significant progress has been achieved in terms of separation efficiency and protein yield obtained during ultrafiltration. Nevertheless, the process requires optimisation in order to improve filtration efficiency and the protein yield obtained in the filtrate.

CSIC has evaluated green sequential pressurised processes for algae biorefinery, and has successfully achieved downstream processing of freeze-dried *Isochrysis galbana*¹, starting from non-polar solvents and ending with polar ones.



Green sequential pressurised processes for algae biorefinery

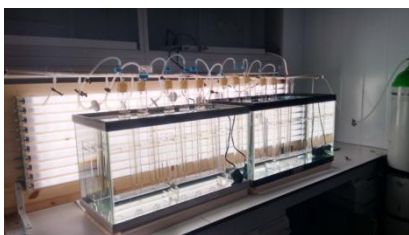
Currently, CSIC is developing a green platform in the reverse order of polarity. This reverse process offers several advantages regarding energy savings and cost reduction, as the freeze-drying step can be avoided and algae biomass can be directly used after harvesting.

Promising bioprospecting results and establishing outdoor production systems under extremely different climatic conditions

The MIRACLES project has defined a need to identify more robust, highly productive strains in order to unlock the full industrial potential of microalgae. One of the main focuses of MIRACLES is on bioprospecting these new, robust and productive algal isolates to evaluate their industrial potential.

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¹[Green Chemistry, 2015, 17, 4599-4609]



Screening Arctic microalgae isolates for high levels of polyunsaturated fatty acid at the University of Bergen.

The WP2 bioprospecting campaign, which has involved continuous sampling in Norway, Spain and Chile, has so far resulted in 350 established clonal isolates. All these novel isolates are subject to cultivation experiments and systematic evaluation of their industrial potential. So far, screening has identified 14 isolates as being commercially promising based on various properties requested by MIRACLES industry partners. The selected isolates are being characterised in more detail by WP2 bioprospecting partners, but samples will also be distributed to WP3 and WP4 partners for further biochemical analysis and functional evaluation by the industry partners themselves.

Outdoor cultivation of selected algal strains that are adapted to extreme climatological conditions is now being evaluated. In 2015, both the MIRACLES partners in Bergen and Las Palmas acquired, installed and set up identical GWP-III reactor systems for this purpose. Implementation of a similar system at the location of the Chilean partner is underway. These cultivation systems will be used to compare and monitor how different climates and varying environmental conditions affect the growth, biochemical profiles and commercial potential of standard microalgae strains. This will contribute to an assessment of cultivation in areas with a limited potential for agriculture, and will help broaden the resource base and product portfolio of the algae industry.

Algae-derived panels

MIRACLES partner CHIMAR has been working on the development of algae-derived adhesives suitable for the production of wood-based panels.



Synthesis of PF-algae resin: Plywood panels produced with reference PF & PF-algae resins (samples F & E).



Plywood panels produced with reference PF & PF-algae resins (samples F & E)

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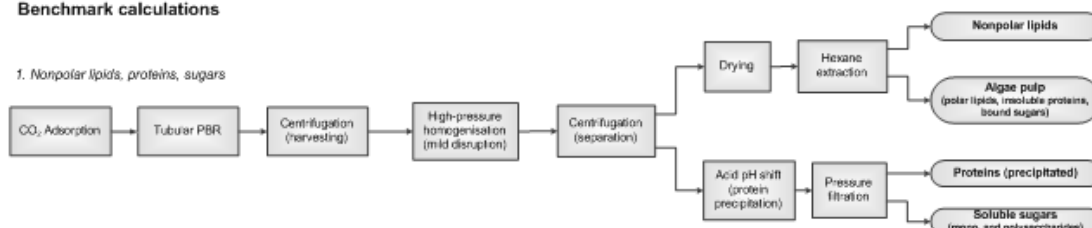
CHIMAR has tested various algae species during development of phenol-formaldehyde (PF) resins modified by the use of algae. Some of these resins have been successfully applied as binders in the production of three-layer plywood panels at laboratory scale. The panels have been tested and evaluated in accordance with current European standards, and they have been found to be suitable for either interior or exterior applications.

Evaluation of selected integrated value chains and life cycle assessment of microalgae cultivation

This action is aimed at the implementation of a techno-economic and sustainability assessment of a multi-product integrated biorefinery for microalgae.

Benchmark calculations

1. Nonpolar lipids, proteins, sugars



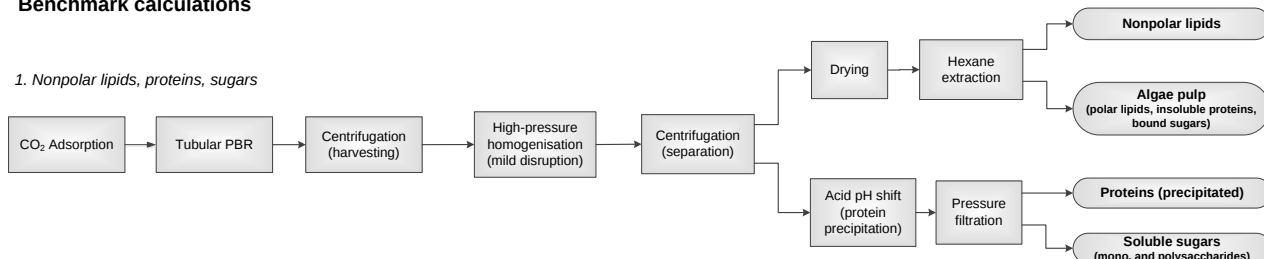
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Initial evaluation of benchmark value chains

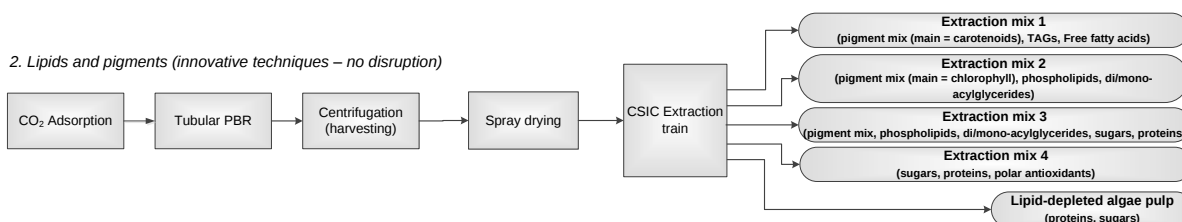
In recent months, mass and energy balances have been calculated for selected benchmark value chains (see Figure below). Lab-scale results from the project have been transferred to a large scale using engineering rules. Standard techniques have been used for non-polar lipids, proteins and sugars, while the extraction train developed by CSIC is aimed at lipid- and pigment-rich fractions.

Benchmark calculations

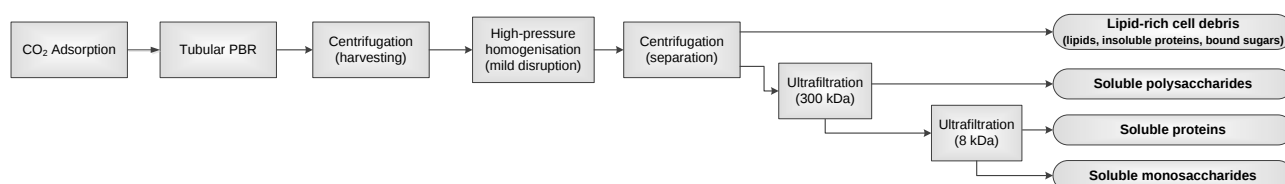
1. Nonpolar lipids, proteins, sugars



2. Lipids and pigments (innovative techniques – no disruption)



3. Proteins and sugars (innovative techniques)



Benchmark value chains including innovative techniques developed in the MIRACLES project



Key findings are:

- Heat consumption is especially high for the CO₂ adsorption, drying and extraction train, while most electricity is consumed by the circulation system in the tubular PBR.
- Material demand seems to be especially high for the extraction train in comparison with the other process units and chains.
- There is high potential to recycle water. We suggest quantifying the economic and environmental impacts to evaluate the overall chain performance.

Life cycle assessment – scenario analysis of microalgae cultivation

LCA results have been calculated based on the production system of Spanish partner Fitoplancton Marino, including all steps from pre-cultivation to freeze drying. Different scenarios have been investigated and compared to the base scenario: a shift from the standard Spanish energy mix to wind energy, a newer circulation system, and yield variations. An environmental hotspot is the current circulation system and related energy consumption. Development options are: to lower electricity consumption (already implemented), to use a flow-emission electricity supply and to increase yield and stabilised at a high level.

Business plan – new conceptual developments

In order to generate business cases as well as the business plan, a focus table has been developed. Business cases will be selected according to their competitive performance and market attractiveness. The stakeholder message will be evaluated at different levels per stakeholder group. Product properties, user demand, the level to which these two aspects coincide, benefits and estimated market size will be described in the near future for specific business cases.



2nd Annual Progress Meeting held in Las Palmas de Gran Canaria (Spain) on November 17th, 18th and 19th, 2015.

The Project's 2nd Annual Progress Meeting took place in Las Palmas de Gran Canaria, Spain, bringing together all consortium partners for three days on the 17th, 18th and 19th of November 2015. The meeting started with a review of progress achieved in the activities undertaken over the past six months. R&D results were presented and discussed between partners. A highlight of this meeting was consideration of the industrial approach for the coming months.

On the 19th of November, the meeting concluded at the location of project partner Fundación Canaria parque científico tecnológico de la Universidad de las Palmas de Gran Canaria, where partners visited the pilot scale algae cultivation and laboratory facilities. More information can be seen on our [Facebook page](#).

