DE LA RECHERCHE À L'INDUSTRIE

CHLORELLA VULGARIS, A PROMISING FEEDSTOCK FOR STARCH-BASED BIOPLASTICS

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ALGAEUROPE 2021

Online, 07-10/12/2021

Introduction

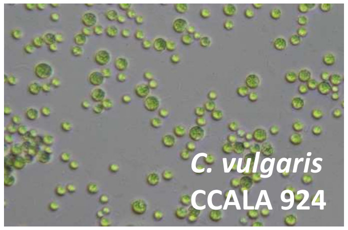
- **CEA** is involved in 2 European projects **SEALIVE**[1] and **Nenu2PHAr**[2] with a common objective: the development of new sustainable chains, aiming the creation of **greener** and **cost-effective plastics**.

- **Starch** is seen as a promising plastic **feedstock** since it can…

  … directly integrate **plastic blends**[3] → SEALIVE

  … be degraded into monomeric glucose to **feed PHA producing bacteria**[4] → nenu2PHAr

- **Microalgae** are **promising starch producers** since they **do not require arable lands** while having the advantage of **capturing atmospheric CO_2**.



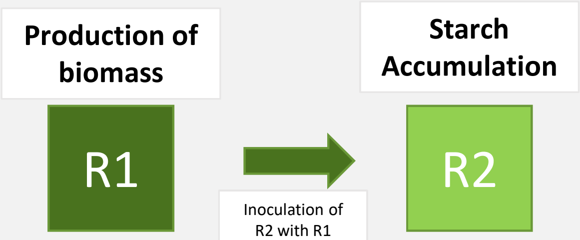
- ***Chlorella vulgaris** is known* to be an **excellent starch producer** (up to 60 %DW)[5] and a robust microalga, which can be cultivated at **industrial scale**.

Methodology

***Background:** C. vulgaris CCALA924 is known for producing starch under high light intensity and N-starvation*[5]

Objective: Development and validation of an optimized strategy for starch accumulation up to a pre-industrial scale

2-reactors-strategy (2R-S)



Production of biomass

R1

Inoculation of R2 with R1

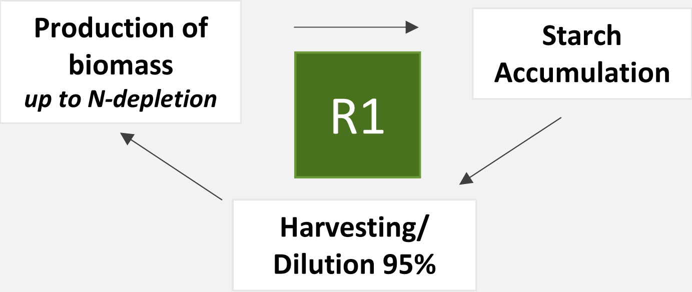
Starch Accumulation

R2

[OPTIMAL CONDITIONS]

[STRESSFUL CONDITIONS]
- *High light intensity*
- *N-starvation*

1-reactor strategy (1R-S)



Production of biomass
up to N-depletion

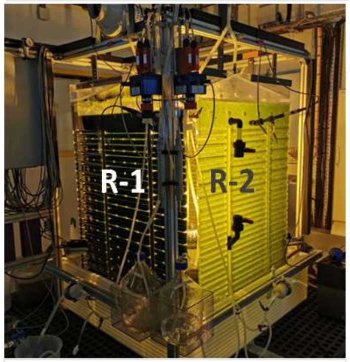
R1

Starch Accumulation

Harvesting/ Dilution 95%

Pilot Scale

2x 25L Flat Panel PBRs

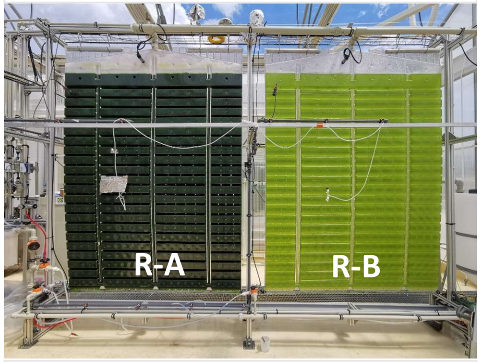


Artificial Light

- T set point = 25 °C
- 200 nL/h gas flow (2% CO_2)
- Light intensity 240 $\mu E/m^2/s$
- 20h:4h light:dark

Semi-industrial Scale

2x 180L Flat Panel PBRs



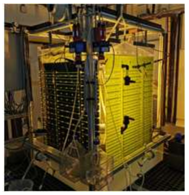
Natural Light

- T_{max} set point = 30 °C
- 1500 nL/h gas flow (2% CO_2)
- Natural light (9h:15h L:D) (+ optional artificial light of 30 $\mu E/m^2/s$ (R-A) or 185 $\mu E/m^2/s$ (R-B))

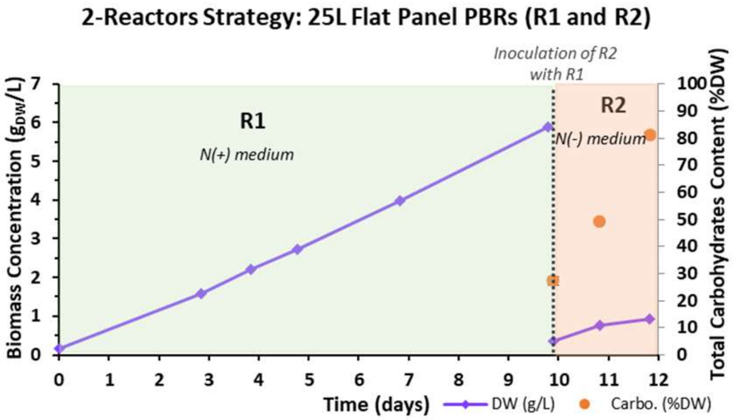
Culture Medium: Adapted Beijrink medium, with and without $NaNO_3$

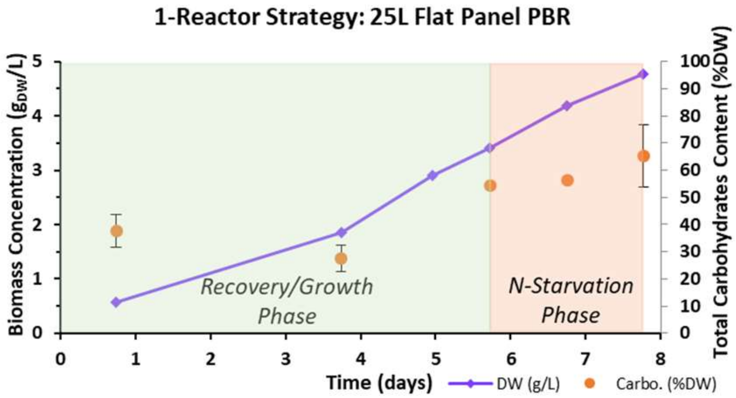
Daily sample analyses :
- OD@880nm + [DW]
- $[NO_3^-]$, $[PO_4^{3-}]$, $[SO_4^{2-}]$)
- Carbohydrates content (Dubois method[6])

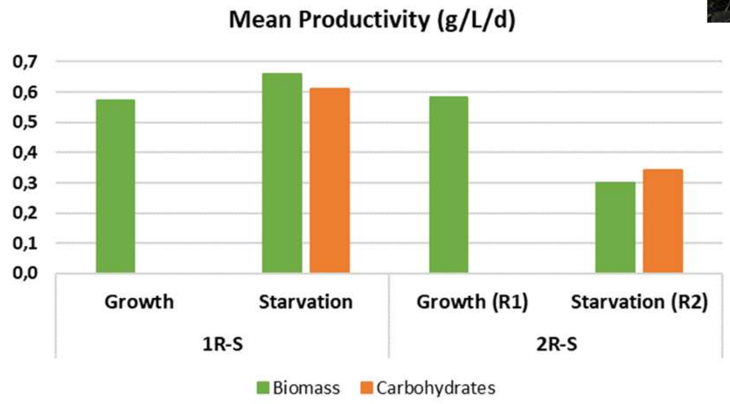
Results – Pilot Scale



Objective: Optimization of the carbohydrates-enriched biomass production at pilot scale (25 L PBRs), under artificial light: 1-reactor vs 2-reactors strategy







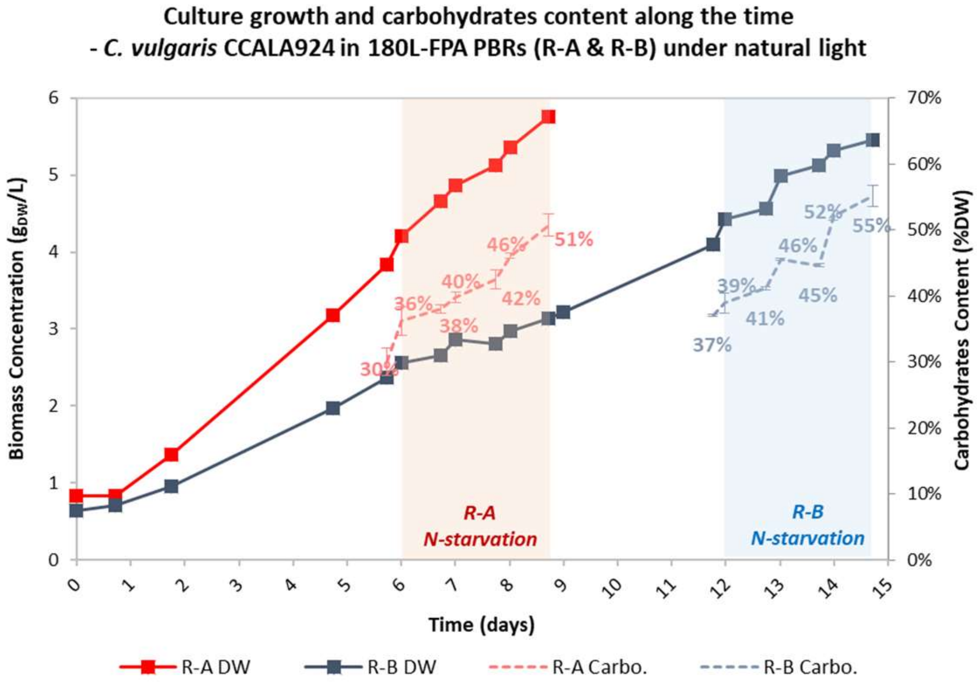
Decision factor	2R-S	1R-S
Biomass concentration	☒	☑
Carbohydrates content	☑	☒
Carbohydrates productivity	☒	☑
Resources (man-power, utilities, etc.)	☒	☑

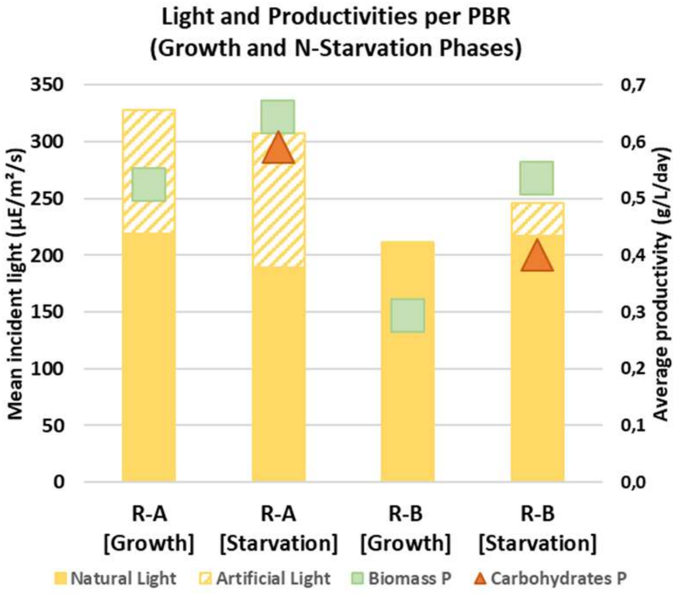
Results – Semi-industrial Scale

Autumn 2021

South of France *(greenhouse)*

Objective: **Validation of the 1-reactor strategy at pre-industrial scale (180L PBRs) under natural light and with additional artificial light**





- Artificial light crucial to boost biomass productivity and to compensate the lack of natural light in the starvation phase in R-A

Conclusion and outlook

Conclusions

- **Total carbohydrate** content raised up to a range of **65-80 $\%_{DW}$** for both strategies at **pilot scale** under **artificial light**, confirming that **nutrient-deprivation** plays a crucial role on starch accumulation.
- **1R-S was selected** for the upscaling due to its **good productivity**, and versatility to operate with the available **utilities** and **man-power**.
- Results were validated at **semi-industrial** scale under natural light (up to **$55\%_{DW}$** carbohydrates content). **Extra artificial light** showed to be **essential** to improve the system performance in Autumn/Winter season.

Ongoing and future work

- Production process under natural light is under a continuous optimization;
- Different **starch purification** schemes are under development, in order to effectively include *C. vulgaris* feedstock into the production of biodegradable bio-based plastics.

This project has received funding from the Bio Based Industries Joint Undertaking (JU) under grant agreement No 887474. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio Based Industries Consortium.

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No 862910 (SEALIVE). This output reflects only the author's view and the European Union cannot be held responsible for any use that may be made of the information contained therein.

Thank you for your attention

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