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Enhanced phototrophic biomass production through the addition of hydrogen

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Motivation

Microalgae production has gained a lot of attention in recent years. As stated by the European Commission, there is a general interest to unlock algae potential increasing sustainable production, safe consumption, and innovative use of biomass[1]. Eukaryotic algae and cyanobacteria can transform CO_2 into organic carbon, using light as the sole energy source. Up to 10% of this energy can be captured but in general microalgal outdoor production systems rarely exceed 6%[2]. Therefore, the productivity and economics of microalgae production depend heavily on the capacity of the photobioreactor to achieve an ideal volume to surface ratio that will increase the capture of light and in consequence the areal productivity.

As an alternative to light-dependent systems, it has been suggested that hydrogen could act as an additional reductive power that would add up to photosynthesis. *Synechocystis sp.* has been reported to be capable of using hydrogen as a supplementary energy source next to light. (Figure 1). This was correlated with the activity of bidirectional hydrogenases that can oxidize hydrogen and use the spare electrons to enhance productivity under low light intensity[3]. However, it is still unknown to what extent hydrogen addition can add up to photosynthesis, under which conditions, and if it is a common feature among other microalgal species.

The motivation of this research is to investigate what are the effects of using hydrogen as a supplementary source of energy to enhance the phototrophic growth of biomass.

Research goals

To fully explore the effect of hydrogen supplementation on biomass production of phototrophic organisms, the research goals of the project are to:

1. Determine the biochemical changes and productivity of *Synechocystis sp*. after supplementing hydrogen in a batch system.
2. Understand the mechanism of hydrogen uptake and the role of light requirements.
3. Evaluate the effect of hydrogen supplementation on different algal species.
4. Scale-up the production system into a continuous reactor and posteriorly into an industrial setup.
5. Perform a techno-economic analysis of the production process.

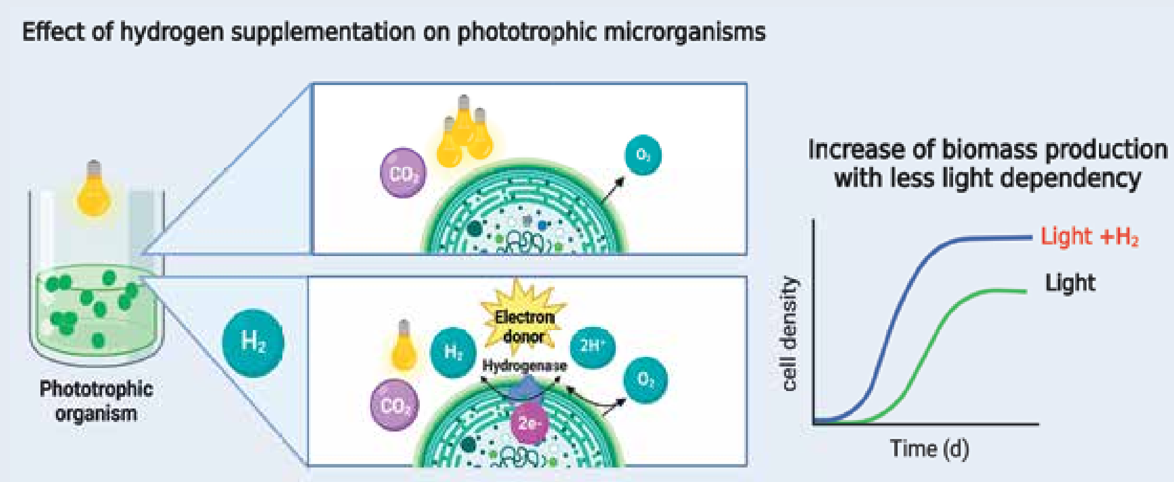

Figure 1. Effects of hydrogen supplementation on Synechocystis sp. (Created with Biorender).

Technological challenge

To increase the biomass production using hydrogen as a supplementary energy source, an axenic culture of *Synechocystis sp*. will be firstly grown on batch systems at laboratory scale. This will allow monitoring factors such as growth rate, biomass composition, and transcriptomic changes that could reveal potential benefits and difficulties of the process. Other experimental conditions, such as gas and medium composition, light intensity, and temperature could be optimized.

Finally, scaling-up the process will allow determining the feasibility of this approach on continuous and large-scale production systems (Figure 2). The influence of hydrogen supplementation on the production's costs and benefits will also be assessed.

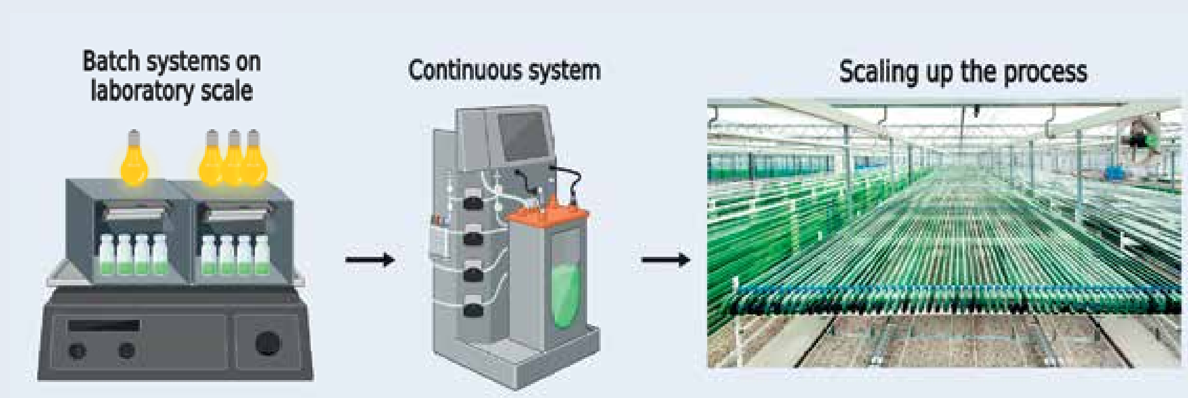

Figure 2. Schematic representation of different stages of a scale-up process with phototrophic microalgae. Going from left to right: batch system, continuous system, and large-scale production system. (Created with Biorender)

References

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