Potentiality of microalgae cultivation in foam for the production of valuable compounds

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BACKGROUND

Cultivation in foam has been proved to be an innovative alternative in which high productivities and high energy savings can be achieved compared to conventional algal photobioreactors. Microalgae can be sources of natural surfactants which might facilitate their cultivation in foam-bed photobioreactors, but the natural algal ability to produce them and their effectiveness vary among species. Unless natural foam production by the microalga cultivated is sufficient, the success of algal cultivation in foam would require suitable combinations of microalgal strains and surfactants.

Surfactants contain a hydrophilic and a hydrophobic part, being capable of interacting with the charged microalgal surface and the gas bubble. These interactions might have an impact on the quality of the microalgal biomass and its posterior applications.

Apart from the presence of the surfactant, physico-chemical conditions of the foam differ largely from the ones in liquid: (i) larger illuminated surface to volume ratio, (ii) enhanced mass transfer, and (iii) possible mechanical stress induced by the bubble burst. Altogether might influence microalgal growth and biochemical composition and, therefore, cultivation in foam could be seen as a tool for directing the algal metabolism to the production of valuable products.

INTERACTIONS BETWEEN ALGAE AND SURFACTANT

Interactions between algae and surfactant proved to be specific and therefore they needed to be particularly addressed. In this sense, during the Miracles Project (http://miraclesproject.eu) research was carried out in order to identify potential microalgal strains, as well as adequate surfactants for the cultivation in stabilized-foam (Figure 1). In this sense, Chlorella sorokiniana was shown to be a good candidate to be cultivated in foams stabilized by the Pluronic F68 surfactant (Figure 2).

RESULTS AND PROSPECTS

The physico-chemical environment to which the microalgal cells are exposed in a foam-bed system, related to the system configuration and to the presence of a surfactant, has been demonstrated to influence the microalgal growth and biochemical composition. Improved CO2 transfer, better light integration and/or improved nutrient uptake might be behind the optimal growth observed (Figure 4).

Chlorella sorokiniana reached very high cell densities, up to 23 g L-1, while maintaining an optimal photosynthetic efficiency. The analysis of the biochemical composition interestingly revealed a certain degree of nutrient depletion at the end of the batch cultivation as result of the enhanced growth. Consequently, storage compounds were strongly accumulated even during “non-stressed” conditions. Exposure to stress conditions as N-starvation resulted in the same biochemical profile although it strongly compromised cell viability.

Apart from the benefits related to the high cell concentration, the algal metabolism seems to be more intensively directed to the accumulation of energy storage compounds while achieving a high productivity. Benefits related to water and energy savings, combined with a high biomass productivity and an interesting metabolite profile are promising results for cultivation in foam.

MIRACLES PROJECT

Four foam-bed photobioreactor prototypes were designed and built to carry out the experiments in foam (Figure 3).