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Enhanced lipidic algae biomass production using gas transfer from a fermentative *Rhodosporidium toruloides* culture to an autotrophic *Chlorella protothecoides* culture

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HIGHLIGHTS

- Efficient symbiotic system between yeast and microalgae cultures.
- Improvement of microalga growth.
- Efficient CO_2 fixation by *C. protothecoides*.
- Fatty acids source suitable to produce biodiesel.
- The association of bioreactors is a feasible way to supply CO_2 to algae culture.

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ABSTRACT

In order to produce single-cell oil for biodiesel, a yeast and a microalga were, for the first time, grown in two separate reactors connected by their gas-phases, taking advantage of their complementary nutritional metabolisms, i.e., respiration and photosynthesis.

The yeast *Rhodosporidium toruloides* was used for lipid production, originating a carbon dioxide-enriched outlet gas stream which in turn was used to stimulate the autotrophic growth of *Chlorella protothecoides* in a vertical-alveolar-panel (VAP) photobioreactor.

The microalgal biomass productivity was 0.015 g L^{-1} h^{-1}, and its lipid productivity attained 2.2 mg L^{-1} h^{-1} when aerated with the outlet gas stream from the yeast fermenter. These values represent an increase of 94% and 87%, respectively, as compared to a control culture aerated with air.

The CO_2 bio-fixed by the microalgal biomass reached an estimated value of 29 mg L^{-1} h^{-1} in the VAP receiving the gas stream from the fermenter, a value 1.9 times higher than that measured in the control VAP.

1. Introduction

Microorganisms are a promising feedstock for next generation biodiesel production as they can be grown using biotechnological processes, and can respond to the current biodiesel market demand (Li et al., 2008) overcoming the limitations of vegetable oil production.

Microbial oils (SCO) have many advantages when compared to other vegetable oils, e.g., faster growth rate, use of non-arable land and non-potable water, use of far less water, no competition with food crops, a non-seasonal production easier to scale-up, and possible daily harvest (Li et al., 2008).

The fermentation of yeasts is a successful case for microbial lipid production, since these microorganisms are able to grow at high rate and achieve high biomass concentration and lipid content, offering high biomass and lipid productivities. The classical fermenter, a cylindrical agitated tank, is a well-known device applied to grow yeasts. The yeast *Rhodosporidium toruloides* grown in stirred fermenters achieved 106.5 g/L biomass concentration with 67.5% (w/w) lipid content and a lipid productivity of 12.96 kg m^{-3} day^{-1} (Li et al., 2007). During fermentation, as a result of respiration, CO_2 is produced at a rate proportional to the growth rate of heterotrophs such as yeasts. This CO_2 is a ready carbon source for autotrophic cultivation of microorganisms such as microalgae (Wang et al., 2008). Microalgae, like plants, use photosynthesis for growth, and to do so they require light as energy and CO_2 as the carbon source. They can be grown in raceway ponds or closed photobioreactors such as the tubular or flat alveolar panel

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