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A novel method to harvest microalgae via co-culture of filamentous fungi to form cell pellets

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ABSTRACT

While current approaches have limitations for efficient and cost-effective microalgal biofuel production, new processes, which are financially economic, environmentally sustainable, and ecologically stable, are needed. Typically, microalgae cells are small and grow individually. Harvest of these cells is technically difficult and it contributes to 20–30% of the total cost of biomass production. A new process of pelletized cell cultivation is described in this study to co-culture a filamentous fungal species with microalgae so that microalgae cells can be co-pelletized into fungal pellets for easier harvest. This new process can be applied to microalgae cultures in both autotrophic and heterotrophic conditions to allow microalgae cells attach to each other. The cell pellets, due to their large size, can be harvested through sieve, much easier than individual cells. This method has the potential to significantly decrease the processing cost for generating microagal biofuel or other products.

1. Introduction

Producing biofuels and bioproducts via microalgae is promising; however, new technical processes must be developed to capitalize on the economically feasible potential of accumulating bioproducts and biofuel inside microalgae biomass. For instance, many microalgae (e.g., *Chlorella vulgaris*) are capable of accumulating a high content of lipids that can be converted to different forms of "drop-in" fuels such as biodiesel (Fakas et al., 2009; Heredia-Arroyo et al., 2011). Microalgae can rapidly accumulate lipids, which fit the industrial needs for biofuel production, with either autotrophic growth or heterotrophic growth mode. For the autotrophic growth mode, microalgae assimilate the carbon dioxide from the atmosphere as their carbon source, and sunlight in most cases as their energy source. The heterotrophic growth of microalgae cells uses organic carbon, for instance glucose, to support their carbon and energy need. Past studies for large-scale cultivation of algae relied on open-pond systems, which made it difficult to successfully cultivate algae due to the high downstream processing cost. Open-pond cultures are only commercialized to produce some value-added health food supplements such as feed and reagents (Chisti, 2007). Photobioreactors are developed to achieve higher productivity and to maintain monoculture of algae; however, the unit cost of microalgae production in these enclosed photobioreactors are actually much higher than those achievable in open-pond cultures despite photoreactors' higher biomass concentration and better control of culture parameters (Lee, 2001).

The algae cell harvest from cultivation broth has always been one of the major obstacles for the algae-to-fuel approach. Microalgae cell harvest is technically challenging, especially considering the low concentration (typically in the range of 0.3–5 g/L), the small size of the oleaginous algal cells (typically in the range of 2–40 μm), and their similar density to water (Li et al., 2008). Oleaginous microalgae cells are usually suspended in water and do not easily settle by natural gravity force due to their negative surface charges. The recovery of microalgae biomass generally requires one or more solid–liquid separation steps, and usually accounts for 20–30% of the total costs of production (Uduman et al., 2010a).

How to harvest microalgae cells from cultivation broth is dependent on the characteristics of the microalgae, such as size and density (Olaizola, 2003); and harvesting usually requires a separate step after the cell cultivation. All of the available harvest approaches, which include flocculation, flotation, centrifugal sedimentation, and filtration, have limitations for efficient, cost-effective production of biofuel (Shelef et al., 1984). For instance, flotation methods, based on trapping algae cells using dispersed micro-air bubbles, is limited in its technical and economic viability. Most conventional and economical separation methods such as filtration and gravitational sedimentation are widely applied in wastewater treatment facilities to harvest relatively large (>70 μm) microalgae such as *Coelastrum* and *Spirulina*. However,

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