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Acidified-flocculation process for harvesting of microalgae: Coagulant reutilization and metal-free-microalgae recovery

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HIGHLIGHTS

- Metal-free biomass and repeated coagulant use was achieved by lowering pH.
- High harvesting efficiency more than 98% was achieved using recycled coagulant.
- Extraction yield and FAME contents reached to 32% and 289 mg/g cell, respectively.

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ABSTRACT

Chemical flocculation is considered to be an overall low-cost and up-scalable process for harvesting of microalgae. In this study a new flocculation approach utilizing metal coagulant ($Fe_2(SO_4)_3$) and sulfuric acid (H_2SO_4) was introduced for harvesting of *Chlorella* sp. KR-1, which overcome two main issues of contamination and reuse of coagulant. Reduction of pH successfully released precipitates attached to the microalgae, and the remaining acidic solution containing recovered ferric ions could be reused for harvesting up to three times with high, better-than 98% efficiencies. Moreover, the acid-treated microalgal biomass could be directly used for lipid extraction without additional catalyst. High extraction yields of around 32% were achieved with FAME conversion efficiencies of around 90%. The integrated approach devised in the present study is expected to make the best use of the age-old yet effective harvesting means of flocculation, which can be a practical and economical option in microalgal biorefinery.
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1. Introduction

Microalgae, offering several advantages over conventional oil crops such as high productivity, non-edibility and high lipid content, have been considered to be an attractive feedstock for sustainable production of biofuel (Milano et al., 2016). The process of biodiesel production from microalgae biomass mainly comprises cultivation, harvesting (and drying), lipid extraction, and biodiesel conversion. In order to make the commercialization of microalgal biodiesel feasible, every step of the process needs to be improved, though far more work is required for the cultivation and harvesting steps (Barros et al., 2015). Especially, harvesting is energy-intensive, mainly because of the small size of microalgal cells and their negatively charged surfaces, both of which facts lead to a stable, sedimentation-resisting colloidal suspension. Since the typical final cell concentration of cultivated microalgae (mass concentration less than 2 g/L in photobioreactors; far less in open ponds) is too low to be directly used in the subsequent oil-extraction step, an efficient biomass-concentration technique is essential. Depending on the biomass/water ratio, concentrating methods can be classified as harvesting (1–5%), dewatering (5–25%) or drying (greater than 25%) (Barros et al., 2015).

There are various methods of microalgal harvesting; centrifugation, filtration, flotation, flocculation, magnetic separation and electrical processes or their combinations (Kim et al., 2015a). Centrifugation is the most conventional means, providing biomass concentrations up to a dewatering level of 25% with high recovery more than 95% when a centrifugal force equivalent to 5000–10,000 g-force is applied. Its main drawbacks are the high financial and energy costs for applying high g-force and low scalability

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