Bioresource Technology 129 (2013) 177–181

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Cultivation of *Chlorella vulgaris* on wastewater containing high levels of ammonia for biodiesel production

P.J. He [a,*], B. Mao [a], C.M. Shen [a], L.M. Shao [a], D.J. Lee [b,c], J.S. Chang [d,e,f]

[a] State Key Laboratory of Pollution Control and Resource Reuse, College of Environmental Science and Engineering, Tongji University, Shanghai 200092, China
[b] Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei 106, Taiwan
[c] Department of Chemical Engineering, National Taiwan University, Taipei 106, Taiwan
[d] Department of Chemical Engineering, National Cheng Kung University, Tainan 701, Taiwan
[e] Research Center for Energy Technology and Strategy, National Cheng Kung University, Tainan 701, Taiwan
[f] Center for Bioscience and Biotechnology, National Cheng Kung University, Tainan 701, Taiwan

HIGHLIGHTS

- ▶ Composition of microalgal cells depends on the composition of the wastewater feeds.
- ▶ FAME composition of the cultivated *C. vulgaris* is suitable for biodiesel production.
- ▶ Increasing NH_4^+-N yielded additional short-chain and saturated fatty acids.

ARTICLE INFO

Article history:
Received 17 May 2012
Received in revised form 6 September 2012
Accepted 31 October 2012
Available online 19 November 2012

Keywords:
Wastewater treatment
Chlorella vulgaris
Biodiesel production
Fatty acids
Ammonia

ABSTRACT

The feasibility of cultivating *Chlorella vulgaris* with wastewater containing high ammonia nitrogen concentrations was examined. The average specific growth rate of *C. vulgaris* was 0.92 d^{-1} at 17 mg L^{-1} NH_4^+-N, but declined to 0.33 d^{-1} at NH_4^+-N concentrations of 39–143 mg L^{-1}. At 39 mg L^{-1} NH_4^+-N, lipid productivity reached a maximum value (23.3 mg L^{-1} d^{-1}) and dropped sharply at higher NH_4^+-N levels, which demonstrated NH_4^+-N should be controlled for biodiesel production. C16 and C18 fatty acids accounted for 80% of total fatty acids. Increasing NH_4^+-N from 17 to 207 mg L^{-1} yielded additional short-chain and saturated fatty acids. Protein content was in positive correlation with NH_4^+-N content from 17 mg L^{-1} (12%) to 207 mg L^{-1} (42%). Carbohydrate in the dried algae cell was in the range of 14–45%, with a peak value occurring at 143 mg L^{-1} NH_4^+-N. The results demonstrate that product quality can be manipulated by NH_4^+-N concentrations of the initial feeds.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Microalgae are a potential substrate for the production of biofuel, since it grows much faster than other energy crops (Minowa et al., 1995). Their oil contents are in the range of 20–50% of dry weight and the biodiesel can be consumed in a carbon-neutral manner (Chisti, 2007). Microalgae also represent a protein source in quality equal or superior to that of other high-quality plant proteins (Becker, 2004). The present cost of producing biodiesel from microalgae is ten times higher than the cost of crude oil (at 100$ per barrel) (Chisti, 2008), due in part to the cost of nutrients for microalgal cultivation (Chen et al., 2011).

The use of wastewater to cultivate microalgae provides an effective means of recycling nitrogen and phosphorus and to produce lipids and proteins (Spolaore et al., 2006). For example, microalgae were cultured on livestock fecal effluent following anaerobic digestion and lipid production at a rate of 17 mg L^{-1} d^{-1} was observed (Woertz et al., 2009). Feng et al. (2010) set up a semi-continuous process to cultivate *Chlorella vulgaris* on artificial wastewater, yielding a lipid production rate of up to 147 mg L^{-1} d^{-1}. Wang et al. (2010) cultivated *Chlorella* sp. on anaerobically-digested dairy manure and determined the lipid profiles of the cells. They found that the two most abundant fatty acids were octadecadienoic acid (27.2–33.4%) and hexadecanoic acid (20.6–26.0%) respectively. The potential of protein-rich microalgae residues as a nutrient additive in livestock feeds has also been investigated (Dubinsky et al., 1980) and Ehimen et al. (2011) studied the potential of recovering methane from post-transesterified microalgae residues.

Microalgae, cultivated under various feed conditions, can differ in their intracellular composition (Yeh et al., 2010). Since effluents

* Corresponding author. Tel./fax: +86 021 65981383.
E-mail address: solidwaste@tongji.edu.cn (P.J. He).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.10.162