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USING SWITCHABLE SOLVENTS FOR SIMULTANEOUS MICROALGAE LIPIDS' EXTRACTION AND BIODIESEL PRODUCTION

by

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Date & Venue

12:00 PM

Wednesday, 13 June 2018

Room 40, Building F3

Abstract

Biodiesel produced from microalgae biomass has been pursued as a possible replacement to petroleum diesel. Among the main steps in microalgae biodiesel production are the drying and cell walls disruption, which are energy intensive and/or time consuming, and oil extraction, which is conventionally done using toxic organic solvents that contaminate the left over biomass and require additional solvent recovery. Therefore, these steps are considered the major obstacles facing the commercialization of microalgae biodiesel. In this work, switchable solvents (SSs), which can reversibly alter their hydrophobicities, have been tested for oil extraction and biodiesel production. Three switchable solvents, namely N,N-dimethylcyclohexylamine (DMCHA), n-ethylbutylamine (EBA), and dipropylamine, were used to extract oil from wet microalgae, while avoiding the drying step. Their effectiveness was compared to that of conventional organic solvent, *n*-hexane, and hydrophobic ionic liquid, 1-Butyl-3-methylimidazolium hexafluorophosphate [Bmim][PF_6]. The optimum extraction protocol was determined for the switchable solvent that showed the highest performance. The switchable solvent was also used for simultaneous extraction-reaction process, in which oils are extracted from wet microalgae and enzymatically converted to biodiesel using the same solvent in the same reaction cell. The successful use of a single solvent for extraction-reaction from wet biomass has never been reported in literature, which has a significant effect on the simplification of biodiesel production from microalgae. A parametric study was performed using the response surface methodology (RSM) to evaluate the effects of temperature (in the range of 15-55 ^{o}C) and solvent program, consisted of cell disruption and extraction periods (in the range of 0-3 hrs) on the oil extraction yield. The results were used to develop a statistical model to predict the oil yield under different conditions and to optimize the process. In addition, effects of the solvent program and methanol to oil ratio on the simultaneous extraction-reaction process were also tested with and without the use of immobilized enzyme. At the same extraction conditions, the extracted oil yields from wet biomass were 12.35±3.18%, 6.95±1.34% and 13.30±0.42% using EBA and dipropylamine with 1:1 v/v water and DMCHA, respectively. Using *n*-hexane, and [Bmim][PF_6], resulted in insignificant yields of 0% and 0.70 ± 0.28%, respectively. The SSs were also shown to be effective in simultaneous oil extraction and biodiesel production, and superior to [Bmim][PF_6]. By the addition of Novozyme®435 enzyme, with DMCHA, the fatty acid methyl esters (FAMEs) yield increased by 33% from 19% when no enzyme was used to 25%. .

Keywords: Switchable solvents; Polarity-switching; Cell disruption; Effective extraction; Biodiesel; Simultaneous Extraction-Reaction.