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Kinetic and thermodynamic studies on the extraction of bio oil from *Chlorella vulgaris* and the subsequent biodiesel production

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ABSTRACT

This research article investigates the extraction of bio-oil from *Chlorella vulgaris* algae which is then subjected to biodiesel production. To evaluate the maximum oil content, four different pretreatment methods and solvent systems were inspected. Among them, maximum oil yield was obtained from ultrasonic pretreated biomass followed by methanol and methyl tertiary butyl ether solvent extraction. Physico-chemical properties of the bio-oil were analyzed as per AOAC Official Methods. The experiments were then designed to determine how variation in different process parameters influences extraction. From these results, kinetic and thermodynamic parameters were also analyzed. The positive values of ΔS and ΔH and the negative value of ΔG indicate that this process is endothermic, irreversible and spontaneous, respectively. The extracted bio-oil was then subjected to acid catalyzed reaction for biodiesel production. A yield of 98.2 wt% biodiesel was obtained at the optimized condition. Fuel properties were analyzed as per ASTM methods.

KEYWORDS

Biodiesel; bio-oil; extraction; kinetics; microalgae; thermodynamics

Introduction

Depletion of conventional sources of fuel and their detrimental effects on the environment have led to the need for finding new alternative energy sources. Recent research in this area validates biodiesel as one of the potential replacements. Biodiesel does not have harmful contents like sulfur and aromatics and it can be used directly in existing diesel engine with or without any technical modification (Saydut et al., 2016). Furthermore, it helps in reducing unburned hydrocarbons, carbon monoxide and particulate matter to a very great extent. It also aids in increasing energy stability thereby leading to a decrease in ecological footprint (Saydut et al., 2008).

Biodiesel or Fatty Acid Methyl Ester (FAME) is produced by transesterification of oil and fats from plants and animals. Currently, it is commercially produced from seeds of sunflower, soybean, jatropha, rapeseed, palm, canola, cotton, Pongamia, etc. (Felizardo et al., 2006; Baysal et al., 2014) but the quantity of oil produced from these crops is very limited. This clearly suggests that these oil crops cannot replace conventional liquid fuels in the future. In this situation, microalgae are the only feedstock having the potential to completely replace fossil diesel. Moreover, these algae do not require land and space unlike other agricultural crops and it can produce 15 times more oil per hectare than conventional crops (Ashokkumar et al., 2014). Algae can grow in saline water, sewage and effluent that were previously deemed unusable. Moreover, they are relatively aquatic photosynthetic organisms accounting for 50% of photosynthesis. The presence of a wide range of photosynthetic pigments that harvest light energy gives a distinct characteristic color to algae. By removing excess carbon dioxide they play a crucial role in the global carbon cycle. Their efficient absorption and conversion of solar energy into chemical energy make them a reliable biodiesel source.

Chlorella vulgaris is a unicellular phytoplankton containing relatively high bio-oil content and has been known to mankind for centuries. It is a

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