Comparison of organic solvent in oil extraction from marine dry microalgae for methyl ester production

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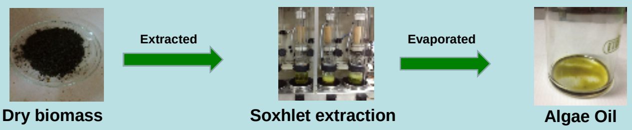
Abstract: The effect of extraction by different organic solvents (polar and nonpolar) on oil content from the dry biomass of marine *Chlorella* sp. was investigated. The soxhlet extraction method was applied for the oil extraction and iso-propanol, ethanol, chloroform: methanol (1:2 v/v), chloroform were used as polar solvents and hexane was used as nonpolar solvent. After 5 hours of extraction, the oil content was recorded. The highest oil content at 26.17% was obtained from the extraction with chloroform: methanol (1:2 v/v). In addition, all extracted oils were converted into fatty acid methyl ester (FAME) by acid catalyzed transesterification. Scanning electron microscope (SEM) images were used to study cell structures before and after the soxhlet extraction. Fatty acid composition, iodine value and cetane number were used to predict the quality of biodiesel. Fourier Transform infrared spectroscopy (FT-IR) was used to study the chemical structure of extracted oil and biodiesel.

Introduction:

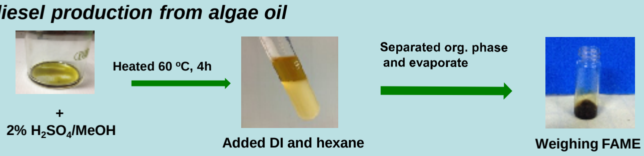
Microalgae biodiesel is generally done by three methods. The first method is a two-step protocol in which microalgae oil are extracted with organic solvent and converted into biodiesel using a catalyst. The second method is directly produces biodiesel from microalgae biomass using an acid catalyst at atmospheric pressure and ambient temperature. The third method is one step conversion to biodiesel at high temperature and pressure in the absence of a catalyst. Each method has innate advantages and disadvantages for example, method 2 requires high concentration of sulfuric acid since moisture content (MC) is a limiting factor for conversion efficiency. The method 3, MC can be ignored under supercritical or subcritical condition however the organic acids and heterocyclic nitrogen compounds from the degradation of protein and carbohydrate are produced during the operation. These impurity substances make the lower quality of biodiesel. This work is interested on the method 1 for produced to large scale. Various studies in different solvents extraction in dry and wet microalgae had been experimented.

Materials and Methods:

*1. **Gravimetric Analysis of Oil content***



2. Biodiesel production from algae oil



3. Biodiesel production from algae oil

4. Estimation of biodiesel properties

$$SN = \frac{\Sigma (560x A_i)}{Mw_i} \quad (1)$$

$$IV = \frac{\Sigma (254xDx A_i)}{MW_i} \quad (2)$$

$$CN = 46.3 + \frac{5458}{SN} - 0.225xIV \quad (3)$$

Acknowldgement:

This work was supported by the Higher Education Research and National Research University Project of Thailand, office of Higher Education Commission, we also would like to thank the center of Excellence-oil Palm, Kasetsart University for partial support of this research

Results:

1. SEM analysis

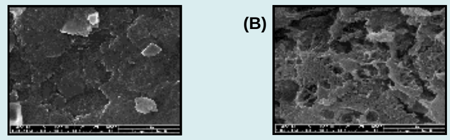


Figure 1 Scanning electron microscope (SEM) images of *Chlorella* sp biomass before oil extraction (A) and after oil extraction (B)

2. FT-IR spectrum of oil yield and FAME yield

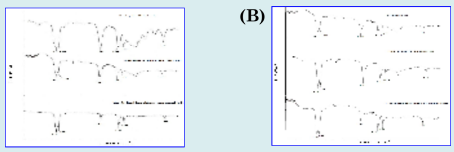


Figure 2 FT-IR spectrums of crude palm oil and algae oil (A) and spectrums of crude palm oil biodiesel and algae biodiesel (B)

3. Percentage of oil yield and FAME yield

Solvents	% Oil yield	% FAME yield
Hexane	4.03 ± 0.63	75.93 ± 2.79
Chloroform	3.41 ± 0.32	47.87 ± 1.28
Iso-propanol	7.96 ± 0.78	45.53 ± 0.62
Ethanol	13.86 ± 2.87	32.86 ± 0.68
Chloroform : methanol (1 : 2 v/v)	26.17 ± 2.72	84.60 ± 3.39

4. Percentage of oil yield and FAME yield

Fatty acids	%
C 14:0	4.35
C 16:0	27.00
C 16:1	8.58
C 18:0	4.82
C 18:1	22.5
C 18:2	12.79
C 18:3	13.80
C 20:0	1.38
C 22:2	3.41
Saponification value (mg KOH/g)	207
Iodine value (gI_2/g)	95
Cetane	51

Conclusions:

1. SEM images revealed that solvent extraction could destroy the cell membrane of microalgae, positively resulting in high oil yield recovery.
2. The chemical structure study by FT-IR of chloroform: methanol (1:2 v/v) extracted oil and its biodiesel showed similar chemical structure as crude palm oil and its biodiesel, suggesting that microalgae oil can be used as feedstock for biodiesel production.
3. Chloroform: methanol (1:2 v/v) was considered as the promising solvent in oil extraction from dry microalgae based on yields of oil and FAME when compared with other solvents.
4. The microalgae biodiesel qualities estimated on SV, IV and CN values had desirable value within the requirement of ASTM and EN standard.