Estimation of Microalgae Biodiesel Quality Based on Fatty Acid Compositions

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ABTRACT:

Microalgaes are feedstocks for second generation fuel that can be used as a renewable source of biodiesel with the potential to displace petroleum fuel. They produce oils with high lipid content, fast growing rates and capable of growing in saline waters. Six species of microalgae, *Nannochloropsis sp.*, *Chlorella sp.*, *Dunaliella sp.*, *Isochrysis galbana.*, *Tetraselmis sp.* and *Chaetoseros sp.* from marine were investigated in our work. The fatty acid compositions obtained from transesterification method were determined by gas chromatography with flame ionization detector (GC-FID). The chromatogram showed palmitic acid (C16:0), oleic acid (C18:1) and linoleic acid (C18:2) were the major acids in all species. In addition, fatty acid compositions were used to predict the quality of fatty acid methyl ester or biodiesel by empirical determination. Three values; saponification number (SN), iodine value (IV) and cetane number (CN) were obtained from determination. The result showed SN and IV were varied from 161.03 to 192.60 and 43.51 to 63.95 respectively. The CN value of every species were higher than 51 that limited for ignition property of fuel. In addition, fatty acid compositions obtained from methylation with boron trifluoride were compared the estimation CN value with transesterification method. Thus in this research, fatty acid composition suggested that our six species of microalgae can generate biodiesel with high quality.

OBJECTIVE:

To screen 6 microalgae species by investigated lipid content and fatty acid profile that used for estimating the biodiesel properties. The iodine value (IV), saponification number (SN) and cetane number (CN) were predicted from FAMEs composition by gas chromatography (GC).

METHOD:

Lipid content

Lyophilized algae powders

Lipid extraction CH_3Cl: MeOH: H_2O (1:1:0.9)

To dry CH_3Cl layer

Weighing with electronic balance

Fatty acid composition

Microalgae culture

Flocculation and Centrifuge

Lipid extraction CH_3Cl: MeOH: H_2O (1:1:0.9)

To evaporate CH_3Cl layer

Transesterification or Methylation with BF_3

To extract FAMEs with hexane

Purify by silica gel and elute 5% ethyl acetate in hexane

To evaporate

To analyzed FAMEs with GC-FID

Estimation of biodiesel properties

$$SN = \frac{\Sigma (560 \times A_i)}{MW_i} \quad (1)$$

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

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

A_i is the percentage, D is the number of double bond and MW_i is the molecular mass of fatty acid

CONCLUSIONS:

In this study different two method, transesterification with sodium methoxide and BF_3 method were applied for converting lipid to fatty acid methyl ester. It was observed that tansesterification method present the best result on fatty acid acid compositions. The result showed high amount of most identify fatty acid and less amount of unidentify fatty acid. While BF_3 method showed less amount of identify fatty acid and high amount of unidentify fatty acid. Both results indicate that transesterification method is better than BF_3 method in fatty acid composition analysis for wet microalgae sample.

The microalgae biodiesel qualities estimated on SN, IV and CN value have desirable value within the requirement of EN standard. In addition, *Chlorella* sp. is selected as raw material for our further study in biodiesel production process.

RESULT:

Table 1 Fatty acid profile of six microalgaes from transesterification and methylation with BF_3

Fatty acid (%)	Microalgae species					
	Nannochloropsis	*Chlorella*	*Isochrysis galgana*	*Tetraselmis*	*Dunaliella*	*Chaetoseros*
C12:0	0.00, (0.00)*	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)
C14:0	0.00, (3.59)	1.05, (1.24)	1.19, (23.25)	1.20, (5.50)	1.08, (1.50)	0.79, (17.55)
C14:1	1.44, (0.00)	0.27, (0.00)	0.45, (0.00)	0.24, (0.00)	0.32, (0.00)	0.48, (0.00)
C16:0	29.59, (4.10)	36.53, (1.91)	44.63, (2.86)	48.19, (1.80)	39.16, (3.11)	28.79, (27.74)
C16:1	0.00, (0.00)	0.48, (0.00)	0.55, (0.00)	0.48, (0.00)	0.69, (0.00)	0.75, (0.00)
C18:0	0.00, (0.00)	0.00, (11.47)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)
C18:1	38.22, (27.64)	41.82, (5.92)	37.20, (35.96)	34.25, (32.58)	36.06, (11.82)	45.40, (15.31)
C18:2n6c	2.85, (0.00)	10.85, (25.8)	8.47, (4.13)	8.70, (0.00)	10.42, (0.00)	10.11, (0.00)
C18:2n6t	7.02, (11.49)	0.00, (0.00)	0.00, (0.00)	0.00, (12.49)	0.00, (13.45)	0.00, (2.48)
C18:3n6	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (1.15)	0.00, (0.00)
C18:3n3	1.21, (8.71)	0.82, (11.78)	0.06, (1.24)	0.26, (5.85)	0.49, (23.29)	0.00, (5.18)
C20:0	0.00, (0.00)	0.00, (0.00)	0.16, (0.00)	0.26, (0.00)	0.06, (0.00)	0.25, (0.00)
C20:1n9	0.90, (0.00)	0.25, (0.00)	0.17, (0.00)	0.23, (0.00)	0.17, (0.00)	0.75, (0.00)
C20:2	1.12, (0.00)	0.40, (0.00)	0.37, (0.00)	0.02, (0.00)	0.29, (0.00)	1.08, (0.00)
C20:3n6	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)
C20:3n3	1.62, (0.00)	0.00, (0.00)	0.09, (0.00)	0.26, (0.00)	0.29, (0.00)	0.00, (0.00)
C20:4	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.00, (1.45)	0.00, (0.00)
C20:5	0.41, (0.00)	0.00, (0.00)	0.00, (0.00)	0.22, (0.00)	0.15, (0.00)	0.00, (4.27)
C22:0	0.00, (0.00)	0.00, (0.00)	0.19, (0.00)	0.77, (0.00)	0.00, (0.00)	1.54, (0.00)
C22:1n9	0.53, (0.00)	0.23, (0.00)	0.00, (0.45)	0.00, (0.00)	0.07, (0.00)	0.00, (0.00)
C24:0	0.00, (0.00)	0.00, (0.00)	0.00, (0.00)	0.28, (0.00)	0.00, (0.00)	0.00, (0.00)
C22:6	0.00, (0.00)	0.00, (0.00)	0.00, (1.08)	0.03, (0.00)	0.47, (0.00)	0.00, (0.00)
Unidentify	15.09, (43.49)	7.30, (42.60)	6.47, (31.04)	4.64, (41.78)	10.28, (41.92)	10.06, (25.26)

***( ) Amount of fatty acid (%) from methylation with BF_3**

Table 2 Percentage of lipid content and estimated parameter of microalgae biodiesel obtained from transesterification method and methylation with BF_3

Name	Lipid content (% dry wt.)	SN		IV		CN	
		Trans.[1]	BF_3[2]	Trans.	BF_3	Trans.	BF_3
Nannochloropsis sp.	5.85 ± 0.44	166.19	109.64	60.69	66.19	65.53	81.19
Chlorella sp.	16.46 ± 1.51	182.37	109.76	58.13	79.01	63.16	78.25
Dunaliella sp.	11.24 ± 1.13	177.02	112.20	54.54	101.60	64.87	72.09
Isochrysis galbana	7.45 ± 0.52	185.49	140.06	48.08	45.77	64.91	74.99
Chaetoseros sp.	5.12 ± 0.55	175.10	153.90	59.32	48.03	64.15	70.96
Tetraselmis sp.	9.47 ± 0.38	189.85	112.92	47.35	64.70	64.40	80.07

[1] Transesterification method and [2] Boron trifluoride method

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