Effectiveness of transesterification catalysts on biodiesel production from 11 types of oils

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Abstract:
Transesterification from 11 types of oils (soybean, palm, rice bran, Sunflower, corn, Camellia Oleifera, olive, Canola flower, sesame, animal and kitchen used oil) were studied. Biodiesel production by using NaOH, KOH, H_2SO_4, HCL and Sodium methoxide as catalysts were carried out. The reaction mechanism was proposed and the separate effects of reaction temperature, molar ratio of methanol to oil, mass ratio of catalyst to oil and repeated experiments were investigated. The results showed that the yield of biodiesel production by Sodium methoxide catalyst was accessed in Canola flower oil and had percentage of yield more than others. The test results of heating value of Canola flower oil biodiesel was 48,043 kJ/kg, pH 5-7 and viscosity 0.7-4 Centistokes. The results proved that transesterification of Canola flower oil to biodiesel using Sodium methoxide as a catalyst is a commercially viable way to decrease the costs of biodiesel production.

Keywords: *transesterification; biodiesel; catalyst; oils*

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1. Introduction

Transesterification is the chemical reaction between a triglyceride and an alcohol in the presence of a catalyst and consists of three consecutive reversible steps: transformation of triglyceride in diglycerides, of these in monoglycerises, which transform monoalkyl-esters and glycerol (Sharma and Siwgh, 2007). Transesterification from 11 types of oils (soybean, palm, rice bran, Sunflower, corn, Camellia Oleifera, olive, Canola flower, sesame, animal and kitchen used oil) were studied.

2. Material and Methods

2.1 Materials

Eleven oils as soybean, palm, rice bran, Sunflower, corn, Camellia Oleifera, olive, Canola flower, sesame and animal were taken from the market. Used oil was taken from King Mongkut University of Technology North Bangkok Canteen. The chemicals used including methanol (CH_3OH), hydrochloride (HCL), sodium hydroxide (NaOH), Hydrosulfuric (H_2SO_4) and potassium hydroxide (KOH) in pellet form, and sodium sulfate in powder form.

2.2 Transesterification of 11 Oils

The 11 oils reacted with methanol in the presence of catalysts to produce methyl esters of fatty acids (biodiesel) and glycerol (Fig.1). The oils were precisely quantitatively transferred into an Erlenmeyer flask immersed in water bath shaker. Then specific amount of catalysts (by weight of crude oils) dissolved in the required amount of methanol were added.

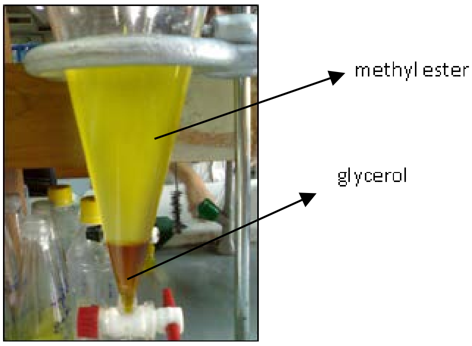


Fig. 1 The reaction of biodiesel and products.

The reaction flask was kept in the water bath under constant temperature with defined agitation throughout the reaction. At the defined time, samples were taken out, cooled, and the biodiesel (i.e. the methyl ester in the upper layer) were separated from the by-product (i.e., the glycerol in the lower layer) by settlement overnight under ambient condition. The percentage of biodiesel yield was determined by comparing the weight of up layer biodiesel with the weight of oils added.

3. Results and Discussion

The properties of diesel and biodiesel were based on standard ASTM D975 ASTM D6751 composition HC*a* (C10-C21) FAME*b* (C12-C22) as showed in Table 1.

Table 1 Values for the American Society for Testing and Materials (ASTM) Standards of Maximum Allowed (Barabás and Todoruţ, 2011)

Property	Diesel	Biodiesel
Kin. viscosity (mm^2/s)at 40 °C	1.9-4.1	1.9-6.0
specific gravity (g/mL)	0.85	0.88
flash point (°C)	60-80	100-170
cloud point (°C)	-15 to 5	-3 to 12
pour point (°C)	-35 to -15	-15 to 16
water (vol %)	0.05	0.05
carbon (wt %)	87	77
hydrogen (wt %)	13	12
oxygen (wt %)	0	11
sulfur (wt %)	0.05	0.05
cetane number	40-55	48-60
HFRR*c* (ím)	685	314
BOCLE*d* scuff (g)	3600	>7000

a Hydrocarbons. *b* Fatty acid methyl esters. *c* High-frequency reciprocating rig. *d* Ball-on-cylinder lubricity evaluator.

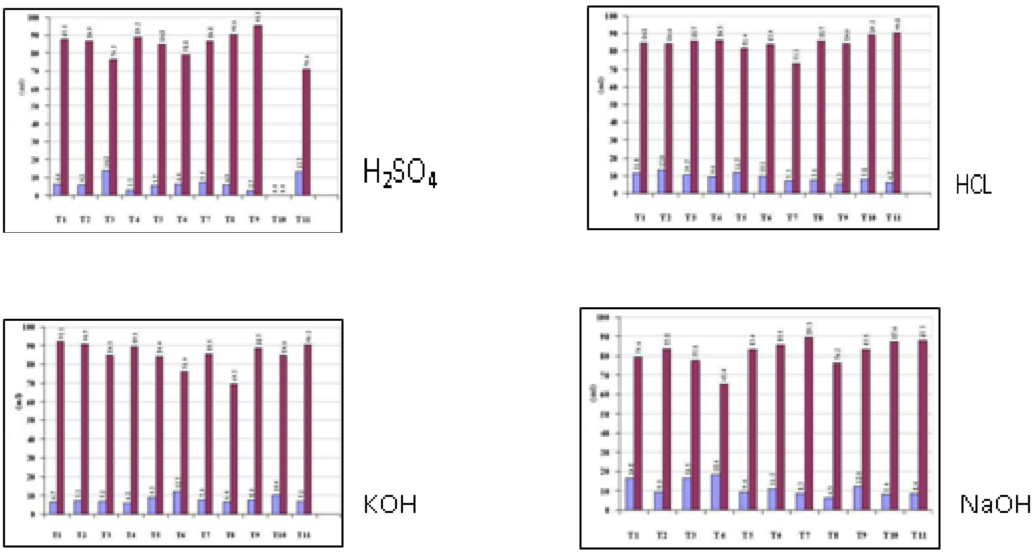


Fig. 2 Effectiveness of catalysts and yields of biodiesel from various oils.

Yield of biodiesel can be influenced by types of catalyst that used in the reactions. In this experiment, only 4 types of catalyst were used as HCL, H_2SO_4, NaOH and KOH. The reactions were carried out by using 0.5% of catalysts, 1:1 oil to methanol molar ratio for 2 hours mixing at room temperature. The yield of biodiesel by using HCL, H_2SO_4, NaOH and KOH as catalysts as showed in Fig. 2. The results showed that KOH gave the best yield as 85% (average from 11 oils), compared with H_2SO_4, HCL. NaOH catalysts that gave 83.8%, 81.2% and 80.7 % of biodiesel yield respectively.

The highest viscosity of 11 oils was 4.6 and the lowest was 1.7 centistokes from biodiesel made from canola oil and sunflower oil respectively as shown in Table 2.

Table 2 Viscosity volume of 11 oils

Types of oils	**pH**	**Density**		**Viscosity**	
		g/cm^3	**kg/m^3**	**centipoises**	**centistokes**
Corn	6.18	0.83	830	1.8	2.2
Canola	5.50	0.93	930	34.	46.
Sesame	5.83	0.76	760	3.0	4.0
Soybean	6.22	0.98	980	1.8	1.8
Sunflower	6.00	1.08	1,080	1.8	1.7
Palm	6.07	0.92	920	2.4	2.6
Olive	6.19	0.73	730	2.4	3.3
Camellia Oleifera	6.63	0.86	860	1.8	2.1
Rice barn	6.20	0.90	900	2.4	2.7
Animal	6.54	1.31	1,310	2.4	1.8
Used oil	6.00	0.85	850	2.4	2.8

The standard test of viscosity for biodiesel by ASTM D6751 and heating volume of biodiesel was measure by using Bomb calorimeter under ASTM D6751(Barabás and Todoruţ, 2011).

Heat of combustion was transferred to cooling water around Bomb calorimeter. Water temperature was measured by thermometer. Amount of heat transfer was calculated by Eq. (1).

$$Q = mc\,(T_1 - T_2) \qquad (1)$$

Where Q = Fuel combustion heat
m = mass of water in Calorimeter
c = specific heat of water
T_1 = water temperature before combustion
T_2 = water temperature after combustion

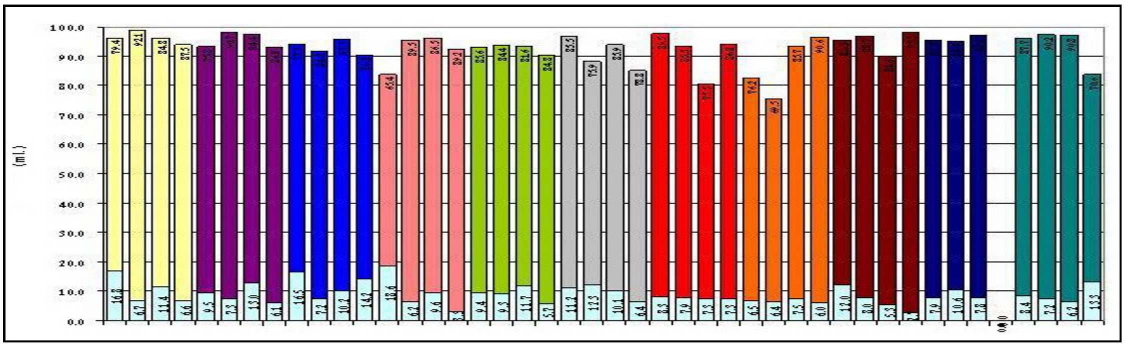
Fuel thermal energy can be determined from Eq. (2).

$$HHV = (\Delta T.w) - e\,/g \qquad (2)$$

Where HHV = Combustion heat
ΔT = heat increasing temperature (^oC)
w = 1,724.187 (cal/^oC)
e = combustion heat correction factor = 2.3 (cal/cm) × combustion wire length (cm)
g = fuel sample weight (g)

Heating value of 11 natural oils (soybean, palm, rice bran, Sunflower, corn, Camellia Oleifera, olive, Canola flower, sesame, animal and kitchen used oil) was showed in Table 3.

Biodiesel production can be affected by the amount of catalyst used in the reactions. In this experiment, different types of oils as soybean, palm, rice bran, Sunflower, corn, Camellia Oleifera, olive, Canola flower, sesame, animal and used oil were tested. Fig. 3 showed biodiesel yield from using different oils.



soybean/ palm/ rice /sunflower/ corn/camellia/olive/Canola /sesame/animal/ used oil

Fig. 3 Yields of biodiesel made from 11 oils

The results of heating value showed the highest value from Canola flower oil biodiesel was 48,043.03kJ/kg, and the lowest value was 24,591.11 kJ/kg from biodiesel made from sunflower oil as show in Table 3.

Table 3 Heating value of 11 oils

Types of oils	ΔT (°C)	Heating value (kJ/kg)
corn	3.813	27,558.45
canola	3.351	48,043.03
sesame	3.025	31,692.08
soybean	3.134	32,860.21
sunflower	2.923	24,594.11
palm	3.182	25,568.29
olive	1.580	24,092.03
Camellia Oleifera	5.039	37,675.33
Rice barn	3.429	24,762.65
animal	4.031	37,798.35
Used oil	5.933	37,539.36

4. Conclusion

From the comparison of different oils for making biodiesel, the results showed that Sodium methoxide catalyst was the best access in Canola flower oil and had the maximum percentage yield. The test results of heating value of Canola flower oil biodiesel was 48,043.03 kJ/kg, pH 5-7 and viscosity 0.7-4 Centistokes. The results proved that transesterification of Canola flower oil to biodiesel using Sodium methoxide as a catalyst is a commercially viable way to decrease the costs of biodiesel production. In addition, palm oil is the lowest cost to make biodiesel because palm tree can grow easily and harvest with high yield in tropical zone such as Thailand. Then, this research was just only search for the best catalyst for making highest yield in various oils. Furthermore, the economic condition should be in consideration.

5. References

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