PREPARATION OF BIODIESEL FROM PALM OIL IN WASTEWATER POND

A. Timyamprasert [1] , V. Punsuvon[2,3] , K. Chunkao[1] , R. Nokkaew[3]

[1]College of Environment, Kasetsart University, Bangkok, Thailand 10900
[2]Department of Chemistry, Faculty of Science, Kasetsart University, Bangkok, Thailand 10900
[3]Center of Excellence-Oil Palm, Kasetsart University, Bangkok, Thailand 10900

Abstract:

The objective of research was to prepare biodiesel from palm oil in wastewater pond of palm oil mill plant for value-adding of waste palm oil and reducing the environmental problem. Since the high free fatty acid content in waste palm oil, so two-step process reactions were required for producing biodiesel. The first step was esterification using sulfuric acid as catalyst in the reaction between free fatty acid and methanol to reduce free fatty acid from 48-55% to lower than 2%. In the second step, transesterification using potassium hydroxide as catalyst in the reaction between the product from the first step and methanol. The results showed that the optimum condition for esterification step was found to be 20:1 molar ratio of methanol to free fatty acid, 5% by weight of sulfuric acid based on free fatty acid and 120 minutes of reaction time. The product from esterification step was further react in transesterification step to produce biodiesel. The final results showed that the maximum purity of biodiesel was about 80-87% and the quality of biodiesel met the standard community biodiesel following ASTM standard.

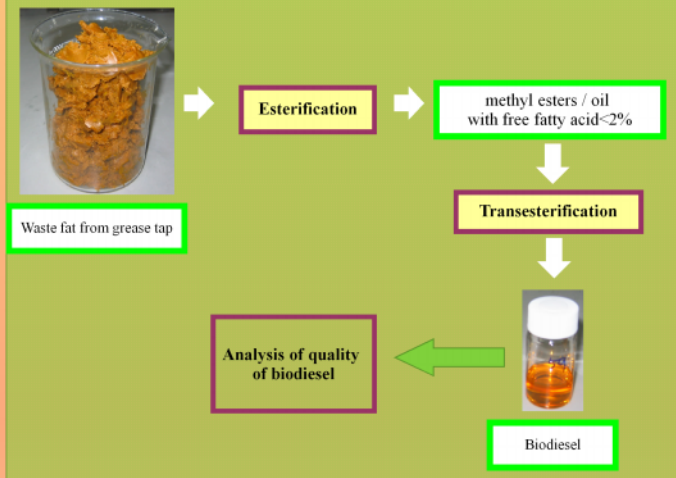
Introduction:

Biodiesel production from abundant bio-source has drawn the attention of the academic as well as the industrial community in recent year. In many countries, biodiesel is receiving and upsurge interest as an alternative and renewable energy due to diminishing petroleum reserves, increasing fuel prices and rising environment concerns [1]. In addition, biodiesel is better than diesel fuel in terms of sulfur content, flash point aromatic content and biodegradability [2]. Biodiesel can be make from renewable source such as edible oil, but the high value of edible oil as a food product make the high cost in biodiesel production. Therefore, exploring ways to reduce the cost of raw material that is the main interest in recent biodiesel research.

Palm oil in the wastewater pond is one factors of low cost raw material for making biodiesel. This palm oil leaks about 1-2% from the milling process and drains into waste water pond. In Thailand, it finds that the amount of leaked palm oil in the wastewater pond is more than 2,000,000 tones / year. The current applications of waste palm oil are to use in the low-grade soap production and boiler fuels. The use of waste palm oil can reduce the cost of biodiesel production which makes them of high potential alternative feed stock.

The waste palm oil usually contains high amount of free fatty acid (FFA) that is not converted to biodiesel product by one step (the alkaline catalyzed process). Because it causes to produce soap that prevent the separation of biodiesel from glycerin fraction. So, the two-step catalyzed processes are suitable for biodiesel production from waste oils. The first step is esterification step that uses acid catalyze to reduce FFA in the waste palm oils to less than 2%. The second step is transesterification step that uses alkaline catalyze to change the triglyceride that remain in waste palm oil to mono-ester or biodiesel.

Methodology:



Results and Discussion :

The properties of waste palm oil as raw material

The fatty acid composition of waste palm oil are very important to identify the carbon chains and its properties. Palmitic acid (C16:0) is major of fatty acid composition in raw material that see in table 1. Saturated and unsaturated fatty acids are 55.62% and 44.37%, respectively. The average molecular weight of fatty acid and waste palm oil are 271 g mol^{-1} and 885 g mol^{-1}, respectively.

Table 1 Fatty acid composition of waste palm oil

Fatty acids name	Chemical structure	Fatty acids (%wt.)
Myristic acid	C14:0	0.87
Palmitic acid	C16:0	47.40
Palmitoleic acid	C16:1	1.12
Stearic acid	C18:0	4.29
Oleic acid	C18:1	36.30
Linoleic acid	C18:2	6.95
Erucic acid	C20:0	3.06

Acid catalyzed esterification step

Esterification step was used in order to pretreatment of waste palm oil by converting to high FFA content to FAMEs. The initial FFA content of waste palm oil was 48.62% that high FFA for biodiesel process by one step. Therefore, the maximum limit of FFA was 2% which esterification step can reduce it. The important factors of esterification step were amount of acid catalyze, molar ratio of methanol to FFA in waste palm oil and reaction time.

Effect of H_2SO_4 amount effect

The optimum of H_2SO_4 amount was 2% FFA. The H_2SO_4 catalyst was varied in the range of 1-7 % wt. The results showed in table 2, 5-7% of H_2SO_4 amount were less than 2% FFA but 5% of H_2SO_4 amount was selected, because it had low amount of catalyst to give an acceptable FFA content (table 2).

Molar ratio of methanol to FFA effect

It was one of the important factors effecting to reduce FFA content from the waste palm oil. The esterification step needs more value of methanol than transesterification step, in order drived the reaction towards completion. This research studied molar ratio of methanol to FFA, it was varied the ratio between 10:1 - 40:1. The results showed that, the optimum ratio was 20:1 (table 2).

Reaction time effect

In order to complete the esterification step, sufficient contact time must be provided. The reaction time at 120 min was selected the optimum condition because it used the less time to reduce FFA in less than 2% (table 2).

Table 2 Three factors effect on amount of acid catalyze, molar ratio of methanol to FFA in waste palm oil and reaction time that base on FFA content.

Amount of H_2SO_4 (% wt)	FFA (% wt)	Molar ratio of Methanol : FFA	FFA (% wt)	Reaction time (min)	FFA (% wt)
0	48.62	10:1	3.18	30	5.42
1	43.95	15:1	2.27	60	3.14
2	31.71	20:1	1.62	90	2.29
3	18.07	25:1	1.33	120	1.63
4	2.61	30:1	1.20	150	1.64
5	1.62	35:1	1.21		
6	1.44	40:1	1.50		
7	1.31				

Alkaline catalyzed transesterification step

The transesterification into biodiesel (methyl esters) used KOH for alkaline catalyst. The condition was 10:1 molar ratio of methanol to oil, 1% KOH, 60 min of reaction time at 60°C and 700 rpm of stirring rate. The properties of biodiesel product were 87% of methyl esters content, 4.57 cSt of viscosity@40°C, 171 °C of flash point and 0.78 mg KOH/g of acid value.

Table 3 The percentage area of fatty acid in free fatty acid product

Fatty Acids component	Chemical structure	Retention time (min)	Area (%)
Decanoic acid	(C10:0)	5.257	4.24
Lauric acid	(C12:0)	7.035	39.23
Myristic acid	(C14:0)	9.050	17.79
Palmitic acid	(C16:0)	11.369	15.93
Stearic acid	(C18:0)	13.131	3.88
Oleic acid	(C18:1)	13.268	11.73
Unknown acid	-	3.247	4.58

From table 3 showed the fatty acids composition in free fatty acid product, the highest value to least value were lauric acid, myristic acid, palmitic acid, oleic acid, decanoic acid, stearic acid and unknown acid, respectively. So, the free fatty acid product was saturated fatty acid.

Conclusion :

Biodiesel product of the waste palm oil produced by two-step catalyst that were the esterification step and transesterification step. The optimum condition of esterification step was 20:1 ratio of methanol to FFA , 5% H_2SO_4 amount and 120 min of reaction time which it reduced FFA into less than 2%. The quality of biodiesel meet the community biodiesel standard that can be used as fuel in agricultural machine.

Acknowledgement:

The authors are thankful to Ministry of Energy, Thaind for financing this research.

Reference :

[1] Hayyan, A.; Zahngir Alam, Md.; Mirghani, M.E.S.; Kabbash, N.A.; Siran, Y.M.; & Tahiruddin, S. (2010). Sludge palm oil as a renewable raw material for biodiesel production by two-step process. *Bioresource Technology*. 101: 7804-7811.

[2] Wang, Z.M.; Lee, J.S.; Park, J.Y.; Wu, C.Z.; & Yuan, Z.H. (2008). Optimization of biodiesel production from trap gease via acid catalysis. Korean *J.l Chem. Eng.*: 25(4): 670-674.