Biodiesel Production From Palm Oil Mill Effluent (Sludge)

By

Faezah Binti Isa

6992

Dissertation submitted in partial fulfillment of the requirement for
the Bachelor of Engineering (Hons.)
Chemical Engineering

JANUARY 2009

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CERTIFICATION OF APPROVAL

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Approved by,

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(Mr.Mohammad Tazli Azizan)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

JANUARY 2009

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and the original work contained herein have not been undertaken or done by unspecified sources or persons

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ACKNOWLEDGEMENT

Praise to the Almighty God for his mercy and kindness that the author has successfully completed this project within the time provided. Throughout these 2 semesters, it has greatly benefited the author in various aspects especially in engineering knowledge applied. Experiences gained are believed to be very useful to the author in her future career and endeavors. Hopefully all the information gained from this project may benefit others especially UTP students and staff for references. The successful completion of this project has been made possible through the help and support of many individuals and organizations.

The author would like to express the highest gratitude to her FYP supervisor, Mr.Mohammad Tazli B. Azizan for giving the author an opportunity to acquire knowledgeable experiences throughout this project. The author would like to extend her deep appreciation to her supervisor, with his guidance and advised has helped the author a great deal in completing this project. Author also appreciates for those their names are not included who either directly or indirectly help to this project.

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ABSTRACT

Biodiesel which is also defined as alkyl-esters is produced from vegetable or animal oil through transesterification process. In this process, triglycerides contained inside the vegetable oil will react with alcohol to form alkyl-esters. Currently, the biodiesel plants in especially in Malaysia produce biodiesel from refined bleached de-odorized palm oil (RBDPO). As a result, the economical profits that can be obtained is greatly reduced as the cost of production is spread across four aspects, extraction of palm oil from palm fruits to become crude palm oil (CPO), refining it to become RBDPO, treating it with alcohols to become FAME, and further refining it to become biodiesel. This research is conducted to observe the possibility of palm oil effluent sludge (POME) into biodiesel. Palm oil refinery in Malaysia produces ton of effluent per day which can be converted to useful energy. The research begins by extensive literature review about biodiesel and also about the extraction of long chain fatty acid (LCFA) in effluent sludge. There are two types of sludge used which is sludge oil from sludge bin and sludge water from pond that was undergo aerobic digestion. One of the ways to extract oil is by using adsorbent such as zeolites and activated carbon. In normal atmosphere condition, sample is stirred at 200 rpm for 10 minutes and then extracted using petroleum ether. Another method is by using sample of sludge oil which being heated at 100 ^{0}C. Then, continued by filtration process to sieve the solid that diluted in the oil. Biodiesel process is conducted at 60 ^{0}C by using methanol and acid sulphuric as catalyst. Then, Free Fatty Acid (FFA) analysis and thin Layer Chromatography (TLC) to observe biodiesel produced.

CHAPTER 1
INTRODUCTION

1.1 Problem statement

Biodiesel is well known as alternative and renewable energy that is not only environmental friendly but also can be derived from many feedstocks such as algae, waste cooking oil, sunflower, soybean and biomass. The research upon biodiesel is made since the fossil diesel start to shrink. Although biodiesel has been widely used in U.S and other European countries, its implementation in Malaysia is still under development. Nowadays, the demand for crude palm oil has arisen due to growing industry of biofuel where palm oil is one of the principle feedstock for biodiesel. As the price of crude palm oil increases, the cost for production biodiesel is improved, therefore several methods have been conducted to find the alternatives which are less expensive.

An alternative method of producing biodiesel must be made in such a way that it maximizes profits, reduces cost, and yet at the same time doesn't take significant monetary assets to modify the current process. Therefore, it was suggested that any low quality Crude Palm Oil (CPO) should be directly converted to FAME as it would reduce the opportunity loss of profits from selling biodiesel. This is evident as direct conversion of CPO to become biodiesel would eliminate the need of refining CPO into RBDPO, thus greatly reduces costs. *(Faiz, 2007)*

In addition to that, CPO of lower grade like sludge palm oil (SPO having typical FFA values of 5% and above) should be treated so that it would greatly reduce the opportunity costs of processing high value RBDPO into biodiesel. Therefore, the following models were suggested:

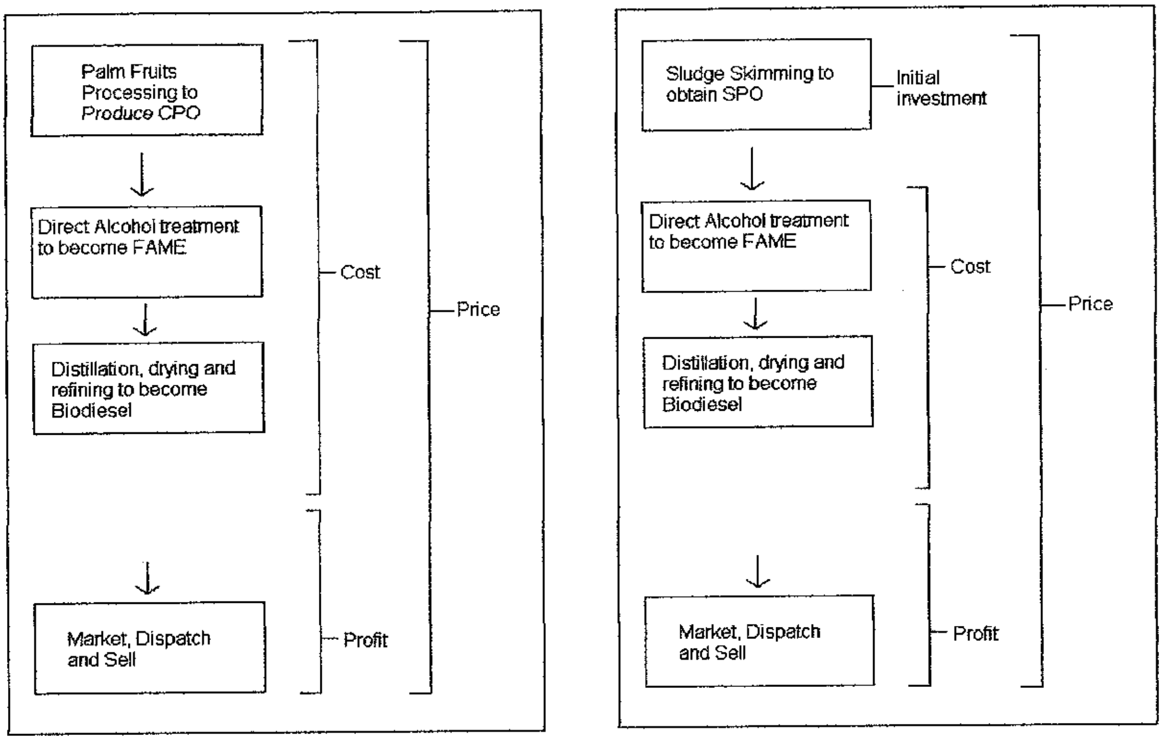


Figure 1: Model of Reduction cost for biodiesel production

Malaysia is known as the largest exporter for crude palm oil. Besides, it also produced palm oil effluent sludge which has great possibility to be turn into biodiesel. Palm oil effluent sludge contains variety of microorganism which utilize organic and inorganic microorganism that rich with nutrients and as source for energy. Study made by few researchers found palm oil effluent sludge contains approximately 20% ether of soluble grease and fats, which could be converted into fatty acid methyl esters (FAME). In short, the problem statement is to determine the potential of low grade CPO or knowingly as palm oil sludge for it to become biodiesel without refining the raw materials (hereby referred to as low grade CPO and SPO) to become standard CPO or RBDPO.

1.2 Objective and scope of work

Biodiesel can be produced from various feedstocks but during this study, the focus will be only on palm oil effluent sludge. Extensive research and study made by researchers has been analyzed to find the overview of the production biodiesel and how to extract lipid from sludge. The study will be divided into three phases. The first stage is extraction of lipid from palm oil sludge using solvent extractor mainly hexane and petroleum ether. Another method is just using drying method whereby sludge is heated at 100 ^{0}C to obtain the low grade oil and get rid all the water content. Then, next stage is biodiesel production from the oil collected using transesterification process by using Acid Sulphuric (H_2SO_4) as catalyst and methanol as the alcohol. Analysis on the quality of biodiesel produced such as yield of methyl ester is conducted using TLC and FFA analysis. While the main objectives for this study is to observe the yield of fatty acid methyl ester (FAME) or biodiesel that can be produce from palm oil effluent sludge and also to determine the technique to extract the lipid (triglycerides) from palm oil effluent sludge. Lastly, chemical and physical properties of the biodiesel produced will be examined.

CHAPTER 2
BIOFUEL

2.1 Demand

Biofuel is produced with aims to be the renewable fuel as a means of improving energy self reliance in local communities and as environmental project to promote a good environment practice among the mankind. There are two types of biofuel which is biodiesel and bioalcohol. They are both clean fuel and can be produced from available resources using simple equipment.

Biofuel is the best way of reducing the emission of the greenhouse gases. They can also be looked upon as a way of energy security which stands as an alternative of fossil fuels that are limited in availability. Today, the use of biofuels has expanded throughout the globe. Some of the major producers and users of biogases are Asia, Europe and America. Theoretically, biofuel can be easily produced through any carbon source; making the photosynthetic plants the most commonly used material for production. Almost all types of materials derived from the plants are used for manufacturing biofuel.

Malaysia is currently the world's largest producer and exporter of palm oil. Malaysia produces about 47% of the world's supply of palm oil. Malaysia also accounts the highest percentage of global vegetable oils and fats trade in year 2005. Besides producing oils and fats, at present there is a continuous increasing interest concerning oil palm renewable energy. One of the major attentions is biodiesel from palm oil. Biodiesel implementation in Malaysia is important because of environmental protection and energy supply security reasons. This palm oil biodiesel is biodegradable, non-toxic, and has significantly fewer emissions than petroleum-based diesel when burned.*(S. Sumath et.al, 2007)*

2.2 Production

One of the challenges faced by the researchers in the field is how to convert the biomass energy into the liquid fuel. There are two methods currently brought into use to solve the above problem. The first one, sugar crops or starch are grown and through the process of fermentation, ethanol is produced. In the second method, plants are grown that naturally produce oil like jatropha and algae. These oils are heated to reduce their viscosity which they can be directly used as fuel for diesel engines. This oil can be further treated to produce biodiesel which can be used for various purposes. Most of the biofuels are derived from biomass or biowaste. Biomass can be termed as material which is derived from recently living organism. Most of the biomass is obtained from plants and animals and also include their by products. The most important feature of biomass is that they are renewable sources of energy unlike other natural resources like coal, petroleum and even nuclear fuel. Some of the agricultural products that are specially grown for the production of biofuels are switchgrass, soybeans and corn in United States. Brazil produces sugar cane, Europe produces sugar beet and wheat whilst, China produces cassava and sorghum and the South-East Asia's produces miscanthus and palm oil while India produces jatropha.

2.3 Economic

The cost of biodiesel is higher than fuel diesel. In US, pure biodiesel is sold for about $1.50 to $ 2.00 per gallon before taxes and adds to $ 0.50 after taxes. Mix of 20% biodiesel and 80% diesel will cost about 15% to 20% more than pure diesel. A subsidy for the industry similar to that for the alternate fuel may be needed to the fuel. Improvements in the processing along with the use of raw materials such as waste cooking oil, effluent sludge may help reduce the cost. *"Biodiesel fuel"* <u>*www.ag.ndsu.edu*</u>

Marketing Year	Soybean Oil ($/gallon)	Yellow Grease ($/gallon)	Petroleum ($/gallon)
2004/05	2.54	1.41	0.67
2005/06	2.49	1.39	0.78
2006/07	2.47	1.38	0.77
2007/08	2.44	1.37	0.78
2008/09	2.52	1.40	0.78
2009/10	2.57	1.42	0.75
2010/11	2.67	1.47	0.76
2011/12	2.73	1.51	0.76
2012/13	2.80	1.55	0.75

Table 1: Projection for production cost for diesel fuel from different feedstock.
Source from "*Biodiesel cost and performance*", *http://www.eia.doe.gov*

Based on the table shown above, production cost of fuel diesel is raise from year to year. Therefore, the researcher and scientist are urge to find the best alternative feedstock that can reduce the cost. Hereby, effluent sludge come into business as it is seen as most of the promising raw material to be transform as next generation of energy resources.

2.4 Social Issues

In the last few years, storm of protest towards biofuel become bigger and at early 2008, global food crisis hit the world. It has been claimed that biofuels are even worst from fossil fuel where the production is driving millions of poor people into starvation. It was reported that tropical rainforests are being destroyed to make way for biofuels crop plantations, while good farmland is being used to raise biofuels crops instead of food. Therefore, it creates food shortages and driving up food prices, especially for the world's poor. Dozens of countries have seen food riots as prices soared out of reach and angry people took to the streets. Authorities estimated that the crisis has already driven at least 30 million more poor people to hunger, and warned that the numbers of the newly hungry could rise to as much as 290 million or even much higher.

A Worldwatch Institute reported "Biofuels for Transport" in 2007. It has been prepared for the German Federal Ministry of Food, Agriculture and Consumer Protection which emphasize for policies to promote small-scale, labour-intensive production of biofuels crops rather than large plantations of monocultures controlled by wealthy producers, who could drive farmers from their land.

2.5 Safety

Biodiesel offers enhanced safety characteristics when compared to other diesel alternatives, including petroleum, methanol, and natural gas. Biodiesel has a high flash point; it does not produce explosive air/fuel vapors; it has very low mammalian toxicity if ingested; and it is biodegradable. The emissions are also expected to be less toxic; however, no definitive data on this point is currently available

2.6 Malaysian Biofuel policy

The Malaysian Biofuel Policy was introduced on 10th August 2006 in accordance to the Kyoto protocol, which was introduced on December 1997. The policy is aimed to decrease the country's fuel import bill, decrease the green house effect and promoting further for usage of palm oil as the source for biodiesel

The Malaysian Biofuel policy introduced by the government has four main strategies which are to produce biodiesel fuel blended of 5% processed palm oil with 95% petroleum diesel. The next stage is to encourage the use of biofuel among the public where it involved with giving out incentives for oil Retail Company to provide biodiesel pumps at stations. More than that, this policy also strategies to set up palm oil biodiesel plant, which targeted to be built in Labu, Negeri Sembilan. Trough this policy, industry standard for biodiesel standard also can be established but this will be the responsibility of SIRIM. *"National Biodiesel fuel Policy", http://www.mpoc.org.my.*

The government will set up a demonstration mill for the production of biofuel for cold climates. This is strategy for the marketing of Malaysia's biofuel in the export market. The government will also award a contract to a plantation company to ensure a consistent supply of palm oil for the production of palm oil biofuel. Incentives will be given to automotive companies to produce biofuel-ready engines. Oil companies will be asked to cooperate with the Malaysian Palm Oil Board (MPOB) to create pioneer kiosks to encourage the use of biofuel on trial basis.

CHAPTER 3

BIODIESEL

3.1 What is Biodiesel

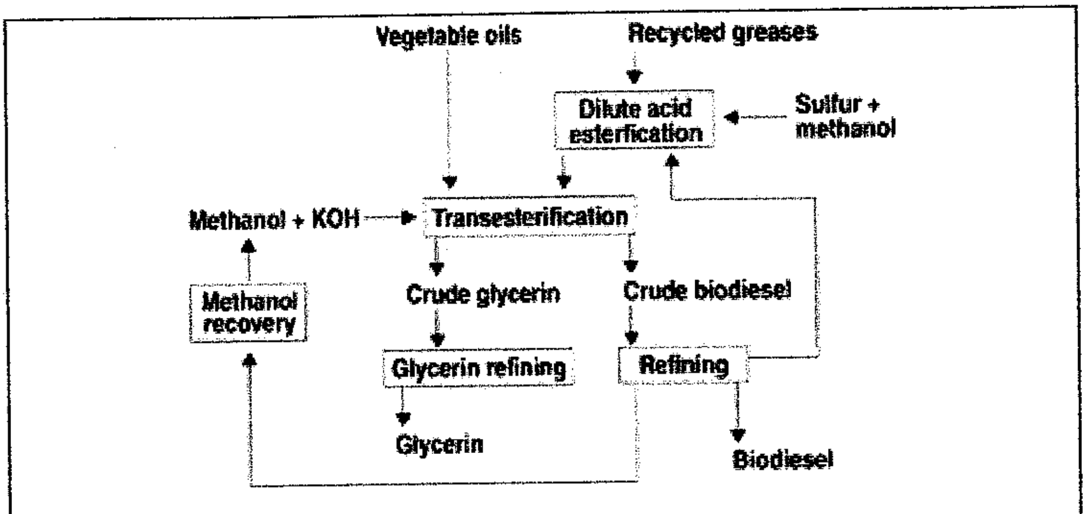
Renewable fuel is increasingly displaced fossil fuel and presently, biodiesel commercially produced in Germany, Italy, Austria, US and Malaysia. Biodiesel is composed of long-chain fatty acids with an alcohol attached, often derived from vegetable oils. It is produced through the reaction of a vegetable oil with methyl alcohol or ethyl alcohol in the presence of a catalyst.

Biodiesel is biodegradable and non-toxic which its acute oral LD50 (lethal dose) is greater than 17.4g/kg body weight. According to the National Biodiesel Board (USA), biodiesel degrades about four times faster than petroleum diesel. Within 28 days, pure biodiesel degrades 85% to 88% in water. *(Tan.C.Y, 2008)*

Commonly used catalysts are potassium hydroxide (KOH) or sodium hydroxide (NaOH) while high fatty acid sample will use acid sulphuric. The chemical process is called transesterification which produces biodiesel and glycerin. Chemically, biodiesel is called a methyl ester if the alcohol used is methanol. If ethanol is used, it is called an ethyl ester. They are similar and currently, methyl ester is cheaper due to the lower cost for methanol. Biodiesel can be used in the pure form, or blended in any amount with diesel fuel for use in compression ignition engines.

3.2 Kinetics of transesterification

There are several methods for biodiesel production such as pyrolisis, micro emulsion, and blending, however transesterification is the most common and regular method. **Figure 1** shows basic transesterification technology.



Source : http://www.ag.ndsu.edu

Figure 2. Basic transesterification technology.

The transesterification process of converting vegetable oils to biodiesel is shown in Figure 2. The "R" group represents the fatty acids, which are usually 12 to 22 carbons in length. The large vegetable oil molecule is reduced to about 1/3 its original size, lowering the viscosity making it similar to diesel fuel. The resulting fuel operates similar to diesel fuel in an engine. The reaction produces three molecules of an ester fuel from one molecule of vegetable oil.

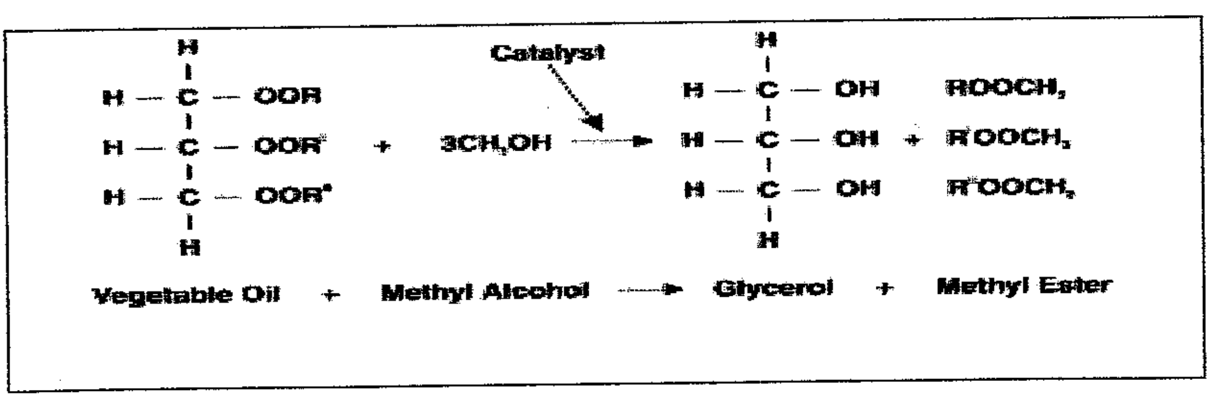


Figure 3: Transesterification of vegetable oils

3.3 Choice of catalyst

Catalyst is defined as substances that decrease the activation energy of a chemical reaction without itself being changed at the end of chemical reaction. Catalyst work by providing an alternative mechanism involving different transition state and reduce activation energy. The effect of this of this is that more molecular collisions have the energy needed to reach the transition state. Hence, catalyst can perform reactions that feasible, would not run without the presence of a catalyst, or perform them much faster, more specific, or at lower temperatures. This means that catalyst is reduced the amount energy needed. There are two types that commonly used in biodiesel which can be either homogeneous or heterogeneous. *(Tan.C.H, 2008)*

Alkali and Acids included in homogenous catalyst and normally use is sodium hydroxide, potassium hydroxide, sulphuric acid, and phosphoric acid. According to *Crabbe et.al (2001),* although alkali catalyzed transesterification perform faster than acid catalyzed transesterification, but the type of feedstocks determines the mode of catalyst. Study made by *(Wen.Y.L et. al., 2008)* such a process is challenging due to the presence of considerable undesirable components especially free fatty acids (FFAs) and water. Use of alkaline catalysts for transesterification of such feedstock is problematic because the alkali reacts with the FFAs to form large amounts of unwanted soap by-products which create serious problem of product separation and ultimately lower the yield substantially.

Homogeneous acid catalysts do not exhibit measurable susceptibility to FFAs, but are difficult to recycle and operate at high temperatures, and give rise to serious environmental and corrosion problems. Lipases are generally effective catalysts and are non-polluting, but they are expensive and there exist problems associated with their usage in the presence of FFAs and short chain alcohols (such as methanol and ethanol), which denature the enzyme to some extent. Glycerol, which is one of the products of the reaction, manifests a serious negative effect on the enzyme. (*Wen.Y.L et. al.,2008*).

Solid acid catalyst offer significant advantages of eliminating separation, corrosion, toxicity and environmental problem and therefore has attracted attention. Apart from recyclability and reusability, an ideal solid acid catalyst for biodiesel preparation should have high stability, numerous strong acid sites, large pores, hydrophobic surface and low cost *(Lotero et al., 2005).* Inorganic-oxide solid acids such as Zeolite and Niobic acid have low densities of effective acid sites and readily lose their activities under harsh conditions. In particular, these catalysts have small pore and thus are not suitable for biodiesel production because of the diffusion limitation of the large fatty acid molecules. Although strongly acidic ion-exchange resins such as Amberlyst-15 and Nafion-NR50 have abundant sulfonic acid groups, these resins are expensive and show bad stability.

Sulphated Zirconia, on the other hand, is an efficient solid acid catalyst but is expensive because Zirconium is rarely found; costly metal and high temperature are required for the calcinations and for reactivation of the catalyst. These limitations of the currently available solid acids have restricted their practical utility in biodiesel production. *(Kiss et al., 2006)*

CHAPTER 4

LIPID EXTRACTION

In order to produce biodiesel, the lipid must be available. Since the raw material is derived from various feedstocks, lipid extraction process needs to be understood. There are several methods of lipid can be conducted but the challenge is to find the most suitable and effective way. Since the main feedstock during this study is derived from palm oil effluent sludge, the characteristic and the component of the lipid should be determine.

4.1 Characteristic and component in lipid

All lipids are hydrophobic, that's the one property they have in common. This group of molecules includes fats and oils, waxes, phospholipids, steroids (like cholesterol), and some other related compounds. Fats and oils are made from two kinds of molecules: glycerol (a type of alcohol with a hydroxyl group on each of its three carbons) and three fatty acids joined by dehydration synthesis. Since there are three fatty acids attached, these are known as triglycerides. The main distinction between fats and oils is whether they're solid or liquid at room temperature and this is based on differences in the structures of the fatty acids they contain. Lipids are usually defined as those components that are soluble in organic solvents (such as ether, hexane or chloroform), but are insoluble in water. In industrial waste such as palm oil effluent sludge, it usually contains long chain fatty acid (LCFA). They will be treated aerobically and anaerobically before discharge into receiving body. (*Jerald et. al, 2004)*

During treatments, LCFA are degraded into shorter chain fatty acid and acetic acid. LCFA can inhibit too much microbial population and subsequently affect the treatment process stability. Analysis of the substrate LCFA and various products is important because the data are useful in the determining reactions kinetics and predicting the performance of waste treatment reactor. (*Jerald et. al, 2004)*

4.2 Anaerobic digestion process

Salminen et. al.(2002) described the anaerobic digestion of slaughter effluent, which has same polluting characteristic as POME. Lipid (fatty substances) is converted to long chain fatty acid (LCFA) during hydrolysis step by a process called β-oxidation. The report mentioned that LCFA are surface active matters that shown behavior of synthetic surfactants and prone to form floating scum.

Mendes et. al.,(2006) compared crude dairy wastewater treatment against enzymatic pretreated of sample using low-priced pancreatic lipases. The result show that hydrolyzed pretreated sample yield higher biogas, COD removal (>70%) compare to the crude sample. This may be caused by degradation of lipid into LCFA with the usage of pancreatic lipase.

Saatci et al.,(2003) studied the removal of total lipids (TL) and fatty acid (FA) from sunflower oil factory effluent using up flow anaerobic sludge blanket (UASB). After extraction with methanol and chloroform, total lipid and fatty acid samples were taken at influent and effluent of the reactor by a gravimetric method. They found that at organic loading rate between 1.6 and 7.8 kg COD/m^3 day and HRT between 2.0 and 2.8 days, the removal of total lipid and fatty acid were more than 70 %.

Neves et al., (2008) presented a method to extract, identify and quantify LCFA in solid and liquid phase using gas chromatography. They suggested that a fast and efficient method is needed to extract and quantify LCFA in liquid phase. They achieved standard deviation value below 15 % and mean LCFA recoveries more than 90 %.

4.3 Methodology to extract the lipid

Several methods have been developed to extract and analyze lipids and fats from various media. The formation of Fatty acid Methyl ester (FAME) is a routine method for LCFA analysis by Gas chromatography (GC). *(Jerald et. al, 2004)*

4.3.1 Chloroform/ Methanol

This is common method for extraction where according to Jerald, 2004, the mixture of methanol and chloroform has been used to extract acidic phospholipids. In this process, lysophospolipids and non esterified FA were extracted from tissue sample but low recoveries. In the research, *Jerald,et.al 2004* found recoveries for C6-C8 is about 95% confident while recoveries for C10-C14 is slightly lower and about 80% recovery at C12. However, chloroform is known as carcinogen even at low concentration. Under the 1986 US Environmental Protection Agency (EPA) Guidelines for Carcinogen Risk Assessment, chloroform is classified as Group B2, a probable human carcinogenicity to the animals.

4.3.2 Hexane/Methyl Toluene butyl ether (MTBE)

Adding MTBE to hexane increased the polar characteristic of the extracting solvent and significantly improved .In particular, the recoveries is about more than 95% confident for all carbon length except for C14 and C18:1. This method is more desirable since the pH adjustment and NaCl is added into the mixture, therefore the recoveries increase. *(Jerald et. al, 2004)*

4.3.3 *Lipomyces Starkeyi* Yeast

This is new technology which has potential of accumulation of lipids by yeast (*Lipomyces Starkeyi)*. On a synthetic medium, accumulation of lipids strongly depended on the Carbon and Nitrogen ratio. The highest content of lipids was measured at a C/N-ratio of 150 with yields to 68% while C/N-ratio of 60 only 40%. Within a pH range from 5.0 to 7.5 the highest lipid accumulation was found at pH 5.0 while the highest yield per liter was at pH 6.5. (*C. Angerbauer et.al , 2007)*

CHAPTER 5

PALM OIL EFFLUENT SLUDGE

5.1 Palm Oil in Malaysia

Oil palm (*Elaeis guianensis*) originated from Africa. It grows well in wet and humid place like Malaysia. Currently Malaysia is the largest exporter for crude palm oil in the world where over the last 25 years, from 2.57 million metric tones in 1980 increase to 16.5 million metric tons in year 2006. As the biggest producer and exporter of palm oil and palm oil products, Malaysia has an important role to play in fulfilling the growing global need for oils and fats in general. Crude palm oil, used palm oil and palm oil fatty acid mixture are three potential feedstocks for biofuel production in Malaysia. It may be produced using (1) Transesterification of palm oil into methyl/ethyl ester by reaction with alcohol. (2) Catalytic cracking of palm oil to lower molecular hydrocarbon products. *(Thiam.L.C, Subhash.B,2008).*

5.2 Refinery of the crude palm oil

The refining of crude palm oil commenced in the early 70s in response to Government's call for increased industrialization. The emergence of refineries marked the introduction of a wide range of processed palm oil products. A unique feature of the oil palm is that it produces two types of oil palm oil from the flesh of the fruit, and palm kernel oil from the seed or kernel. For every 10 tonnes of palm oil, about 1 tonne of palm kernel oil is also obtained. Several processing operations are used to produce the finished palm oil that meets the users' requirements. The first step in processing is at the mill, where the crude palm oil is extracted from the fruit.

The crude palm oil may be further refined (second stage of processing) to get a wide range of palm products of specified quality. The partly and wholly processed grades require little further treatment before use, offering end user a saving in processing costs. Palm oil may also be fractionated, using simple crystallization and separation processes to obtain solid (stearin) and liquid (olein) fractions of various melting characteristics. The different properties of the fractions make them suitable for a variety of food and non-food products.

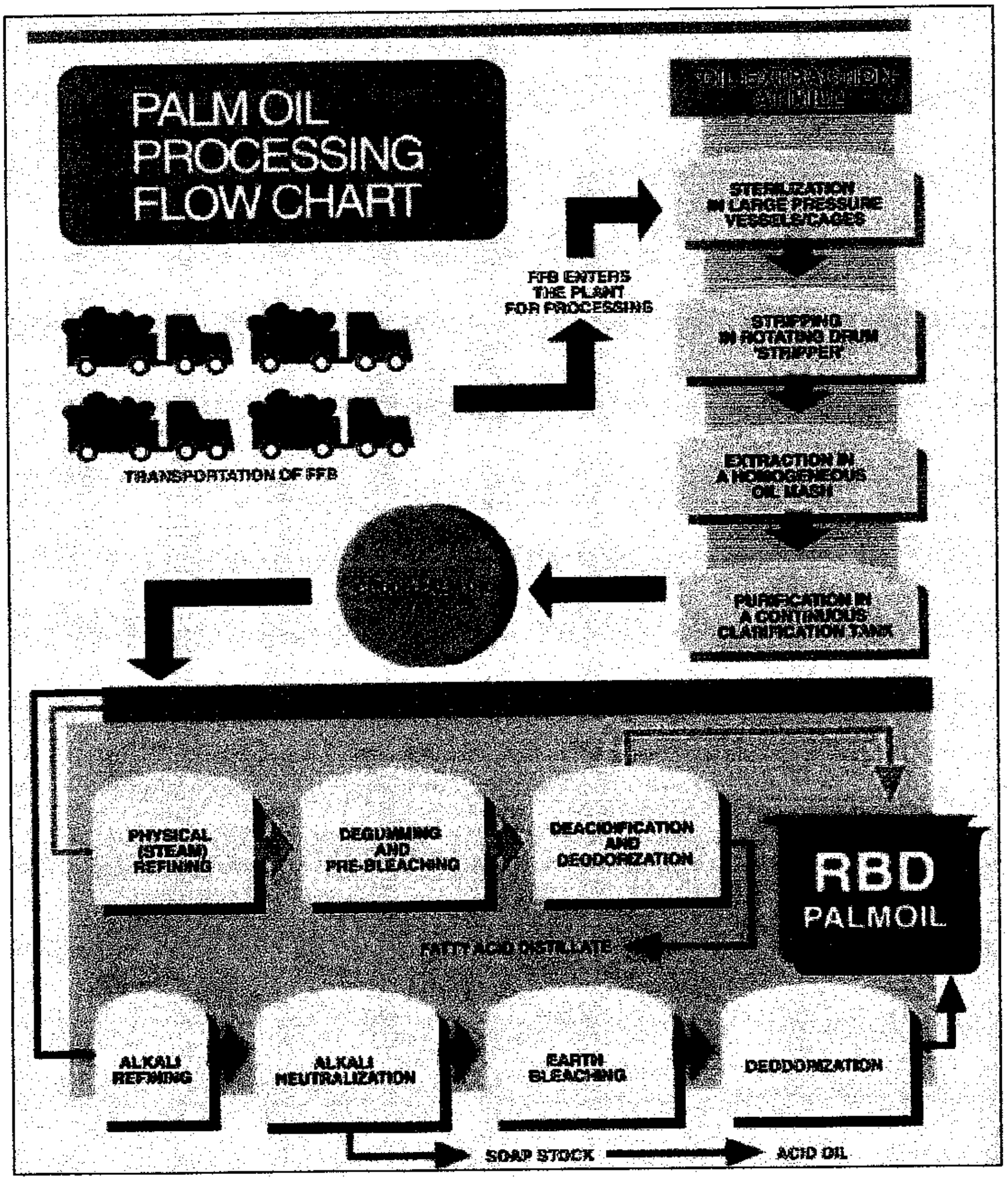


Figure 4: The process flow for the palm oil refinery. *(Source: http://www.mpoc.org.my)*

5.3 Palm oil biomass

Palm oil industry generates tonnes of biomass including oil palm trunks, oil palm fronds, empty fruit bunch, shells and fiber. Palm oil forms about 10% of the whole palm tree, while the other 90% remains biomass which is full of fiber and cellulose. Generally, the oil palm biomass like shells and fibers are the main sources of fuels for power generation in palm oil mills. These oil palm biomasses are burnt as fuels in the boiler to produce steam for electricity generation for the milling process as well as processing of palm oil fruits. *(Thiam. et.al,2008)*

Using proper technology, biomass can be converted into expensive and high value commodity chemicals and fuel. It contributes about 12% of energy supply for development in many countries. Various method and approach has been studied to convert this biomass into useful energy and one of the well known method is anaerobic process which will be explain further in this study.. *(Thiam.et.al,2008)*

5.4 Sludge

As palm oil industry gaining the major role in the economic in many countries, it also produces tonne of waste that can be converted into many useful product or as new energy alternatives such as palm oil mill effluent (POME) which can be used through anaerobic digestion to generate biogas. The biogas contains up to 70% by weight of methane.

Palm oil mill effluent (POME) is an important source of inland water pollution when released into local rivers or lakes without treatment. POME contains lignocellulolic wastes with a mixture of carbohydrates and oil. Chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of POME are very high and COD values greater than 80,000 mg l^{-1} are frequently reported. Incomplete extraction of palm oil from the palm nut can increase COD values substantially. *(N. Oswal et.al,2002)*

Research made by *C. Angerbauer et.al, 2007* found that conversion of sewage sludge into lipid yield about 68% of lipid with pH value 6.5 with carbon to nitrogen ratio about 150. This result has given confident for the other researchers to further improve the study and technique to collect the lipid from sludge as optimum as possible

Parameter	**Range**	**Average value**
Temperature (°C)	75–90	80
pH	4.0–4.8	4.5
Suspended solid, SS (mg/L)	11,500–22,000	17,927
Total solid, TS (mg/L)	36,500–42,600	39,470
Chemical oxygen demand, COD (mg/L)	30,000–50,400	40,200
Oil and grease (mg/L)	1300–4700	2658

Table 2: Typical characteristic of palm mill effluent

5.5 Treatments For Palm Oil Effluent Sludge

Palm Oil industry was established more than hundred years. Therefore, many research and technology was built to treat palm oil effluent sludge. Common process and technology that usually used is land disposal where it helps to improve soil structure and nutrient status, leading to expectation of fertilizer replacement and extra yield. (*B. J. Wood et.al, 2003)*

In a conventional palm oil mill, effluent (POME) contains a mixture of sterilizer condensate, separator sludge and hydrocyclone waste. The mixed POME is treated by anaerobic, aerobic/facultative processes before it is discharged. *(A.N.Ma et.al 2003)*. Besides, palm oil mill effluent also treated by tropical marine yeast (*Yarrowia lipolytica*). This yeast will help to reduce the content of oil in the effluent sludge and therefore the Chemical Oxygen Demand (COD) can be reduced. *(N.Oswal.et.al, 2002).*

5.6 Modern Anaerobic Digestion

Numerous researchers have examined an assortment of anaerobic digestion system to treat palm oil mill effluent (POME). Conclusively, all of the system proved to be effective with high percentage of organic content removal. Those research works successfully complete the anaerobic chains of reaction but none were focused to early phase of POME digestion.

Yacob et al., (2006) in their work studied the start-up operation of closed anaerobic at semi-commercial scale. The 500 m^3 closed digester used achieved more than 95 % COD removal in just 17 days of hydraulic retention time (HRT) at relatively high organic loading rate (OLR). When they tried to further reduce the HRT while maintaining the OLR the digester shown instability. They stated that the instability was due to accumulation of volatile fatty acid following the loading shock and washout of methanogens.

Najafpour et al., (2006) examined an up-flow anaerobic sludge fixed film (UASFF) to treat POME. They found that high COD removal efficiency of 89 % and 97 % at HRT of 1.5 days and 3 days respectively. The UASFF was feed with high OLR. They too highlighted that lowering the HRT without adjusting the OLR, lead to accumulation of vaporize fatty acid (VFA), which can be observed at effluent pH and methane yield.

CHAPTER 6

ANALYTICAL WORK & QUALITY ANALYSIS

6.1 Biodiesel Production

There are several methods to produce biodiesel and there are three basic routes to produce biodiesel from lipid to fatty acid methyl ester (FAME). First is base catalyzed transesterification of the oil. Followed by direct acid catalyzed transesterification of the oil and conversion of the oil to its fatty acids and then to biodiesel.

Most of the biodiesel produced today is done with the base catalyzed transesterification reaction. Several reasons because it is low temperature and pressure and it yields high conversion (98%) with minimal side reactions and reaction time. Besides, it is a direct conversion to biodiesel with no intermediate compounds and no exotic materials of construction are needed.

The basic process of base catalyzed production of biodiesel generally occurs by mixing alcohol & catalyst. The catalyst used is typically Sodium Hydroxide (NaOH) where it dissolved in alcohol using special agitator or mixer. Then, followed by reaction where it place in the closed reaction vessel, the oil or fat is added with temperature of 60 ^{0}C and pressure is 1 atm while reaction time is taken about 1 hour to 8 hour. The major product which is methyl/ethyl ester and glycerin is separated by settling the mixture. Since glycerin has higher density than biodiesel, it will settle at the bottom of the vessel. The excess of alcohol in the reaction is removed by using flash distillation and biodiesel is purified by washing gently with warm water to remove the residual catalyst or soaps.

6.2 Quality analysis

In order to observe the quality of biodiesel produce, certain analysis need to be conducted and the value must follow the American Society Testing and Material

(ASTM). Although this method does not yield as detailed as chromatography method but it is still useful in distinguish the types of methyl ester.

6.2.1 Determination of the viscosity

The viscosity of the biodiesel is important since it can greatly alter the combustion properties of the mixture. Study from *Chancellor College Biodiesel Research, University of Malawi* say that the esterification of vegetable oils produced a marked decrease in values of viscosity measured, and it was found that in general, the measured viscosities of methyl esters were approximately equal to the value measured for diesel over the range of temperatures considered. This would give an indication that the methyl esters, especially those of groundnut, soy bean and sunflower, are suitable as a possible diesel substitute. Viscosity specification from ASTM standard is 3.5-5.0 mm^2/s at 20 ^{0}C

6.2.2 Cloud point/pour point

Cloud point is the point which dissolved solids are no longer soluble and participating as second phase giving fluid a cloudy appearance while pour point is the lowest temperature at which it will pour or flow under prescribed condition where it is rough condition of the lowest temperature at which liquid is readily pumpable. This physical properties in really important especially in cold climate country and cloud or pour point is different depends to the feedstocks used

6.2.3 Oxidation stability

Oxidation stability is important to determine the life spend of biodiesel. Since biodiesel is consist of long hydrocarbon chain, the oxidation stability is usually shorter than common fuel diesel fuel. Analysis from *Golden Hope Biodiesel Sdn Bhd* shows average oxidation stability is about 11 hours at 110 ^{0}C

6.2.4 Free fatty Acid

The acid value of the oils or the esters gives an indication of the quantity of fatty acids present in the sample. The acid values obtained for vegetable oils reflect the high fatty acid content of the oils and the effect of esterification is to reduce the level of fatty acids greatly, and it was found that all methyl esters had acid values very much less than the ASTM levels which is 0.5 %

6.2.5 Moisture content

The water content of biodiesel determines the calorific value and, above all, the storage life of the fuel. Biodiesel with high water content has clearly lower oxidation stability. The lower the oxidation stability, the greater the probability that oxidation products will be formed during a long storage period. These could damage the motor, in particular the fuel injection system, by forming deposits. Usually, test will be conducted through Carl Fisher equipment.

6.3 Tools/ Equipment

6.3.1 Gas Chromatography (GC)/ High Performance liquid performance (HPLC)

It is used to determine types of fatty acids in oil that extracted from palm oil effluent sludge. Besides, it provide calibration curve for biodiesel testing and also to determine types of methyl esters in biodiesel. In GC, the mixture is separated mainly by boiling point and the structure of the individual compounds (polarity). The sample is usually dissolved in low concentrations organic solvent and then injected into GC. In biodiesel case, the sample must be derivative with a reagent to improve analysis because of glycerol content

6.3.2 TLC Chamber, Iodine Chamber, Capillary Tubes

To have a quick analysis on the existence of biodiesel especially methyl ester yield. TLC involves a stationary phase consisting of a thin layer of adsorbent material, usually silica gel, aluminum oxide, or cellulose immobilized onto a flat, inert carrier sheet. A liquid phase consisting of the phase solution to be separated is then dissolved in an appropriate solvent and is drawn up the plate via capillary action.

CHAPTER 7

UTP RECENT RESEARCH ON BIODIESEL FROM PALM OIL EFFLUENT SLUDGE

Extensive research had been conducted in the past three years regarding biodiesel in Universiti Teknologi PETRONAS. This research had been taken seriously since the energy demand nowadays is become very critical. Many feedstocks had been used such as jatropha, rubber seed and rambutan seeds. However, biodiesel from palm oil effluent sludge never being conducted and people start to realize that sludge is no more waste anymore but very valuable treasure.

In *2006 Widya Binti Kaderi* had conducted research about biodiesel from rubber seed using in-situ transesterification. In her study, she found that optimum condition obtained was by using acid sulphuric (1%) as the catalyst, methanol as the reactant and a sufficient time of 12 hours reaction. The biodiesel yield that she got is about 95%

Study that was done by Widya was continued by *Tan chi Ying, 2006* where she did on the optimization condition in situ transesterification from rubber seed. She concluded that solvent and catalyst play an important role in process of in-situ transesterification. The optimum condition in having highest yield of biodiesel is by using 1wt% H_2SO_4 as acid catalyst with ethanol extraction solvent in 4 hours of in-situ acid transesterification and continued by using 1wt% NaOH as alkaline catalyst with methanol in 2 hours of alkaline transesterification.

Another project work on in-situ transesterification of rubber seed has been done *by Foo Wen Jie, 2007*. In his project work, he investigated the effect of mixing alcohol and effect of stirrer speed at large scale process. According to him, Mangesh G. Kulkarni has reported that, alkaline transesterification with mixtures of methanol and ethanol is able to be carried out successfully. However, from his result, it is observed that 100% ethanol in acid esterification still gives the best result in the yield of biodiesel. Wen Jie findings also shows that the percentage of biodiesel will increase when the stirring speed increases. He has varied the stirrer speed from 125 rpm to 200 rpm and found that the highest amount of oil is obtained at 200 rpm. This is due to better contact between the reagents and solvents during the process.

CHAPTER 8
PROJECT METHODOLOGY

This section is to discuss about the experimental methodology, reagents and equipment used throughout the laboratory work. This project is divided into four phases as listed below.

Stage	Type	Description	Material & equipment used
1	Extraction	Two types of sludge are prepared which is sludge from pond and sludge oil from sludge bin. Adsorbent process is conducted using zeolites and petroleum ether is used as extractor. Operation condition is held at ambient temperature and pressure while stirrer speed is adjusted from 100 rpm until 250 rpm .Then filtration process is carried out manually using funnel	• Sludge oil/ water • Zeolites • Petroleum ether • Hexane • Sodium Sulphate • Alum • Funnel • Magnetic stirrer • Magnetic hot plate
2	Transesterifi-cation	Oil extracted from sludge will be used as feedstock for biodiesel production. Temperature is set at 60 ^{0}C at normal atmosphere. Ratio of oil to methanol is varied and acid sulphuric will be used as catalyst due to high contains free fatty acid in sludge oil.	• Magnetic hot plate • Magnetic stirrer • Acid sulphuric • Methanol • Sludge oil
3	Purification	In order to remove excess alcohol and solvent, purification using rotating evaporator is conducted at 80 ^{0}C	• Rotating evaporator equipment •

4	Quality Analysis	The biodiesel produce is undergoes two main analysis which is TLC and FFA	• TLC chamber • Iodine chamber • Iodine Crystal • Petroleum ether • Acetic Acid • Diethyl ether • Silica plate

8.1 Extraction Of Oil From Palm Oil Effluent Sludge (POME)

Objective

To extract oil from sludge to be used as feedstock in making biodiesel

Material/ Chemical

Alum, petroleum ether, zeolites, sodium sulphate

Methodology

Two samples of sludge are used during this project. One is taken from sludge bin and another one is taken from pond. 1L of sludge is poured to the beaker. Then, a known quantity of alum is added in flocculation step. Supernatant liquid is produced and used as feed in adsorption process. Then, 30 g of zeolites and the content of beaker is mix using flocculator. Reaction time is adjusted at 5 minutes and speed at 250 rpm. Then, the content is allowed to settle and separated using filtration process. Each sample is transfer in separating funnel and 30 ml of petroleum ether is introduced. The content is shaken vigorously for 2 minutes and allowed to settle down in 5 minutes. Aqueous layer is dripped into sample holder. Then, solvent layer is drained through a funnel that contains filter paper and 2 g of anhydrous sodium Sulphate. Then, sample is dried in oven for 24 hours to get rid the left over water.

8.2 Transesterification of sludge oil into biodiesel

Objective

To produce biodiesel from sludge oil

Material/ Chemical

10% of acid sulphuric, methanol, sludge oil,

Methodology

Sample of sludge oil need to undergo a few times of drying process to make sure all water can be getting rid. Then, sample is filtered and measured about 200 ml. After placed into conical flask, then, 100 ml of methanol was measured and mixed with the sludge oil in the flask. The mixture was left for 30 minutes before undergo acid esterification for certain period of time. After reaction and extraction, glycerol that was formed is removed and methyl ester is undergoing purification. The procedures were repeated few times by changing soaking period and ratio of methanol to sludge oil

CHAPTER 9
RESULTS & DISCUSSION

9.1 Extraction Of Oil From Palm Oil Mill Effluent Using Zeolites As Adsorbent And Petroleum Ether As Solvent

Methodology

250ml of sludge is weighed and placed inside the 500 ml beaker. The process is repeated until 5 samples are prepared. Then 10, 20, 30, 40, and 50g of zeolites is weighed and placed at each sample. Then, each sample is stirred and left for 1 hour to let the adsorption process occurred. After that, 30 ml of Petroleum Ether is introduced to extract the oil from the adsorbent. Then, content is shaken vigorously for 2 minutes and allowed to separate. Then repeat the process again with another 30 ml of petroleum ether for 2 times. Rotary evaporator separation is conducted to recover oil from the solution.

No	Ideal weight (g)	Actual weight (g)	Empty Beaker weight (g)	Beaker +sludge Weight (g)	Sludge (g)
1	10	10.016	116.703	296.563	179.860
2	20	20.029	102.480	277.196	174.716
3	30	30.145	106.650	281.867	175.217
4	40	40.456	101.249	278.516	177.267
5	50	50.423	117.543	297.758	180.215

Before the extraction

FFA = 8.4954%

Free Fatty Acid and Acid value analysis of sludge oil

No	Burette reading (mm)	FFA
1	0.6	13.24
2	0.4	8.258
3	0.7	10.32
4	0.7	8.175
5	0.6	10.73

Average FFA = 10.144

Standard deviation, σ =1.86538

Oil recovers from sludge

No	Before (g)	After (g)	Percentage (%)
1	179.860	26.212	14.574
2	174.716	36.428	20.84
3	175.217	99.582	44.65
4	177.267	97.881	56.833
5	180.215	80.468	55.216

Average oil collected = 38.4226 %

Standard deviation, σ =17.536

9.2 Extraction Of Oil From Palm Oil Mill Effluent Using Zeolites As Adsorbent And Hexane As Solvent

Methodology

200ml of sludge is weighed and placed inside the 500 ml beaker. The process is repeated until 5 samples are prepared. Then 10, 20, 30, 40, and 50g of zeolites is weighed and placed at each sample. Then, each sample is stirred and left for 1 hour to let the adsorption process occurred. After that, 30 ml of Hexane is introduced to extract the oil from the adsorbent. Then, content is shaken vigorously for 2 minutes and allowed to separate. Then repeat the process again with another 30 ml of hexane for 2 times. Rotary evaporator separation is conducted to recover oil from the solution.

No	Ideal weight (g)	Actual weight of zeolites (g)	Sludge (g)
1	10	10.016	189.374
2	20	20.029	180.448
3	30	30.145	181.626
4	40	40.456	183.743
5	50	50.423	183.096

Before the extraction

FFA =10.45%

Free Fatty Acid analysis of sludge oil

No	Burette reading (mm)	FFA
1	0.6	13.24
2	0.4	8.258
3	0.7	10.32
4	0.7	8.175
5	0.6	10.73

Average FFA= 10.1446%

Standard deviation, σ= 1.865

Oil recovers from sludge

No	Before	After	Percentage (%)
1	189.374	55.471	29.29
2	180.448	61.772	34.23
3	181.626	61.823	34.03
4	183.743	73.995	40.27
5	183.096	74.692	40.79

Average oil collected: 35.722%

Standard deviation, σ = 4.308

9.3 Extraction Of Oil From Palm Oil Mill Effluent (POME) Using Drying And Filtration Process

Methodology

250 ml of sludge is weighed and placed in oven for 1 hour at 80 ^{0}C to get rid all the moisture and water content. Then, filtration process is conducted to get rid the entire suspended solid inside the sludge. After drying and filtration, the sample is weighed again

Results

	Sample 1	Sample 2	Sample 3
Before drying / filtration	286.470	279.840	285.463
After drying / filtration	90.565	101.232	96.755
Yield (%)	31.614	36.175	33.894
FFA (%)	10.235	11.897	9.877

Average of oil collected = 33.894 %

Average FFA = 10.6697 %

9.4 Transesterification of Biodiesel using Palm Oil Sludge

Catalyst	: Acid Sulphuric
Alcohol	: Methanol
Catalyst Strength	: 10%
Reaction Time	: 16 hours
Ratio (oil: alcohol)	: The alcohol is put in excess

Methodology

20ml of sludge oil is weighed which is about 18.45g. The transesterification was done with methanol under the presence of 10% H_2SO_4. The temperature was set 60°C, which is still below the boiling point of methanol. Methanol is put in excess to make sure the process has forward reaction.

Results

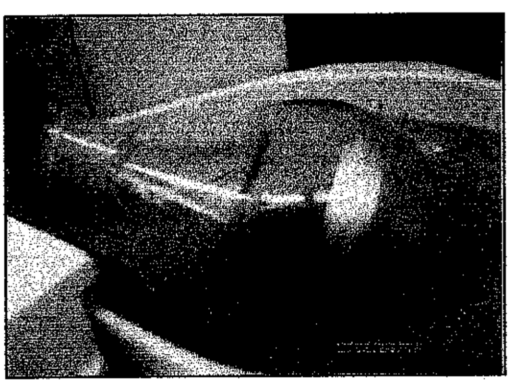


Figure 5: rotating evaporator to separate Solvent and oil

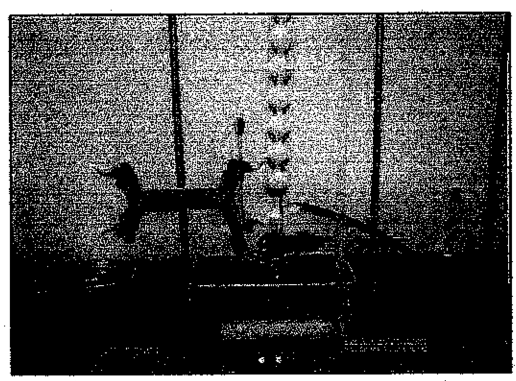


Figure 6: transesterification of biodiesel

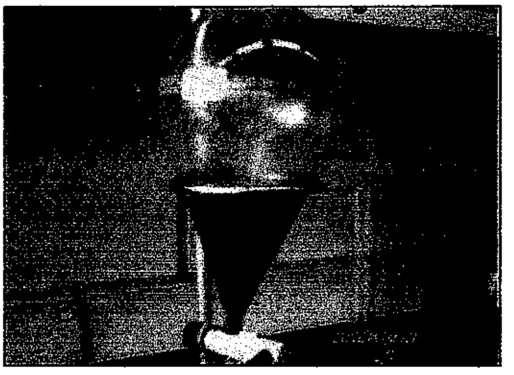


Figure 7: Separation of biodiesel and glycerol

FFA = 3.879 %

TLC Analysis =

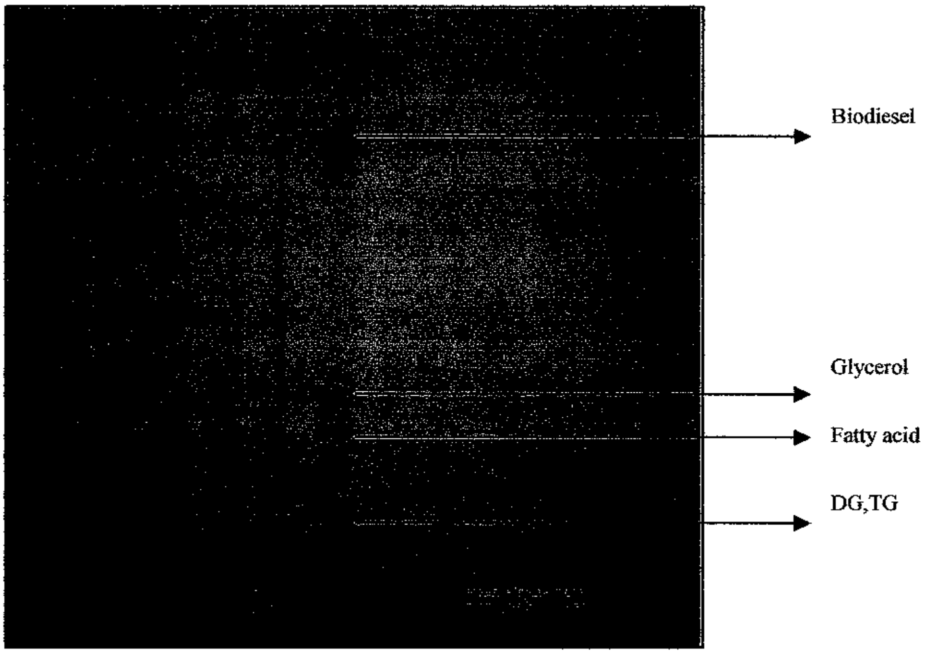


Figure 8: Thin Layer Chromatography

9.5 Transesterification of Biodiesel using Palm Oil Sludge

Catalyst	: Acid Sulphuric
Alcohol	: Methanol
Catalyst Strength	: 10%
Reaction Time	: 12 hours, 14 hours, 16 hours, 24 hours
Ratio (oil: alcohol)	: 1:10

Methodology

20ml of sludge oil is weighed which is about 18.45g. The transesterification was done with methanol under the presence of 10% H_2SO_4. The temperature was set 65°C, which is still below the boiling point of methanol.

Results

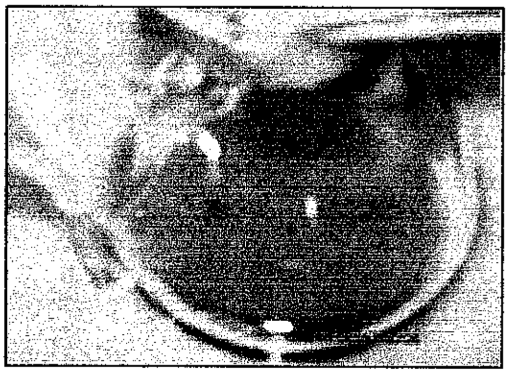


Figure 9: Sudden greenish during the initial of experiment

Figure 10: Biodiesel is failed to be produced after long period of reaction

9.6 DISCUSSIONS

Figure below shown the sample of oil that extracted from palm oil ill effluent, from the physical observation, oil collected is a little bit darker compared to ordinary palm oil and exhibit uncomfortable smell. From 250ml of the original sample, oil that extracted is only about 30% to 40%. This result is much better than study made by Professor *A.L Ahmad, 2004* from USM where his team found the content of oil in residual palm oil mill is about 0.6-0.7 % while the rest is including suspended solid and the rest 98% is water.

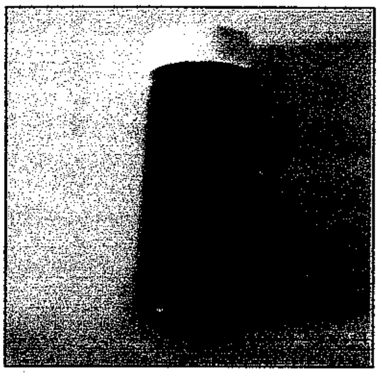


Figure 11: original palm oil

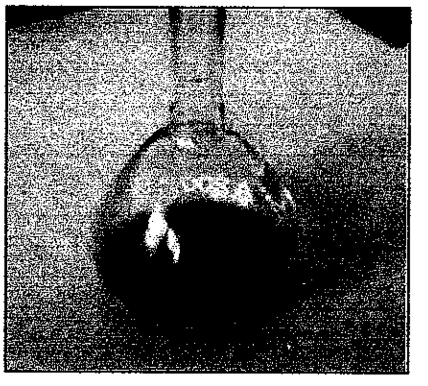


Figure 12: oil extracted from sludge bin

Since sample that had been taken for this analysis is come from the sludge bin, it has higher quantity of oil. Besides, this sample itself called as primary sludge since it has not undergoes any aerobic or anaerobic process. This explain why yield for this extraction quite higher than study made Professor *A.L Ahmad, 2004.*

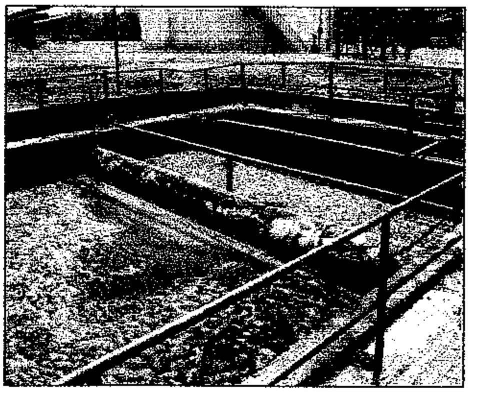


Figure 13: Sample is taken from Sludge Bin

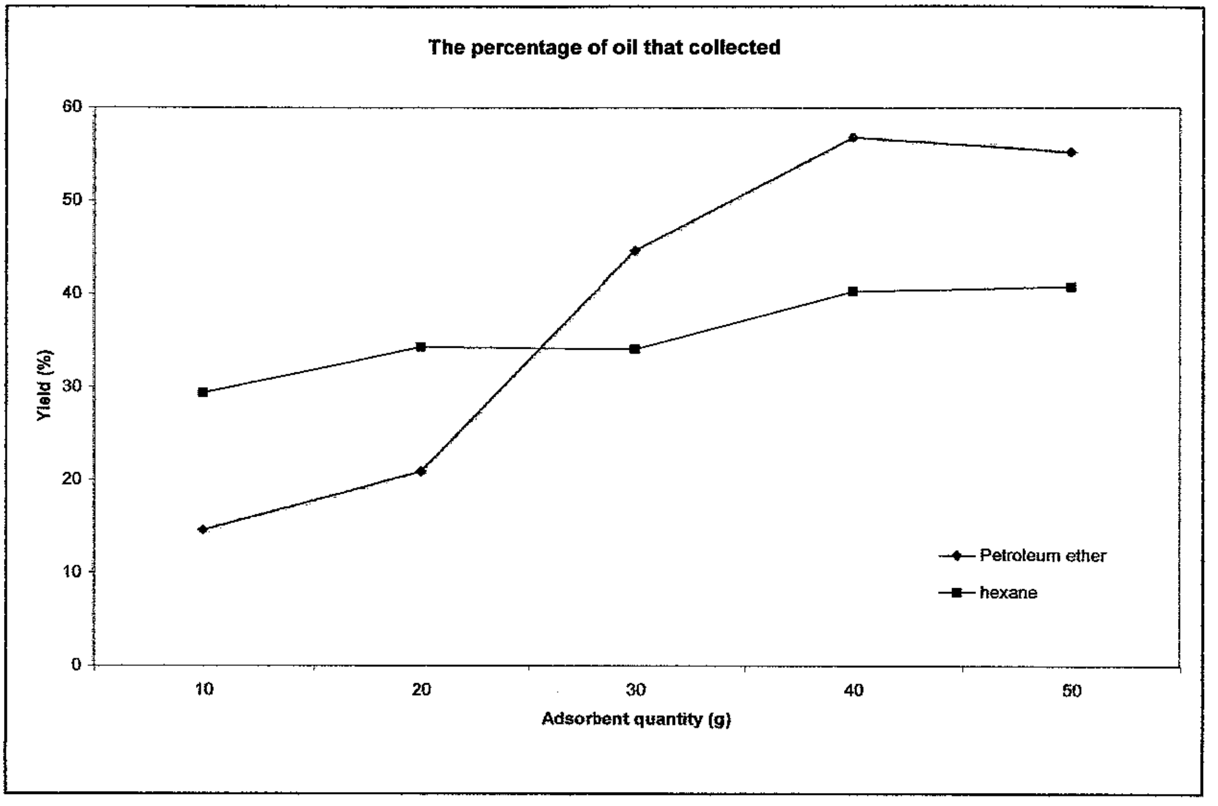


Figure 14: Comparison of oil collected using different solvent

Graph above shows a comparison between petroleum ether and hexane as solvent for extraction oil from the adsorbent which is zeolites. As the quantity of zeolites increase, oil collected is also increase. This can be explained by the behavior of zeolites itself.

As known, process of extraction of oil in this study is using adsorption process by zeolites. Adsorbent as zeolites contain hydrophobic surface that can strongly adsorb oil & grease. On the other hand, the internal porosity of the zeolites also create adsorption force as well as adsorption surface area as what had been studied by *L.A.Ahmad et .al, 2006* in adsorption of oil & grease using rubber powder. These forces cause large and small molecules of dissolved organic molecules to be deposited and adsorbed from the solution onto the molecules-sized pores. At equilibrium, most of the oil and grease molecules in the solution were adsorbed on the surface and in the intermolecular pores.

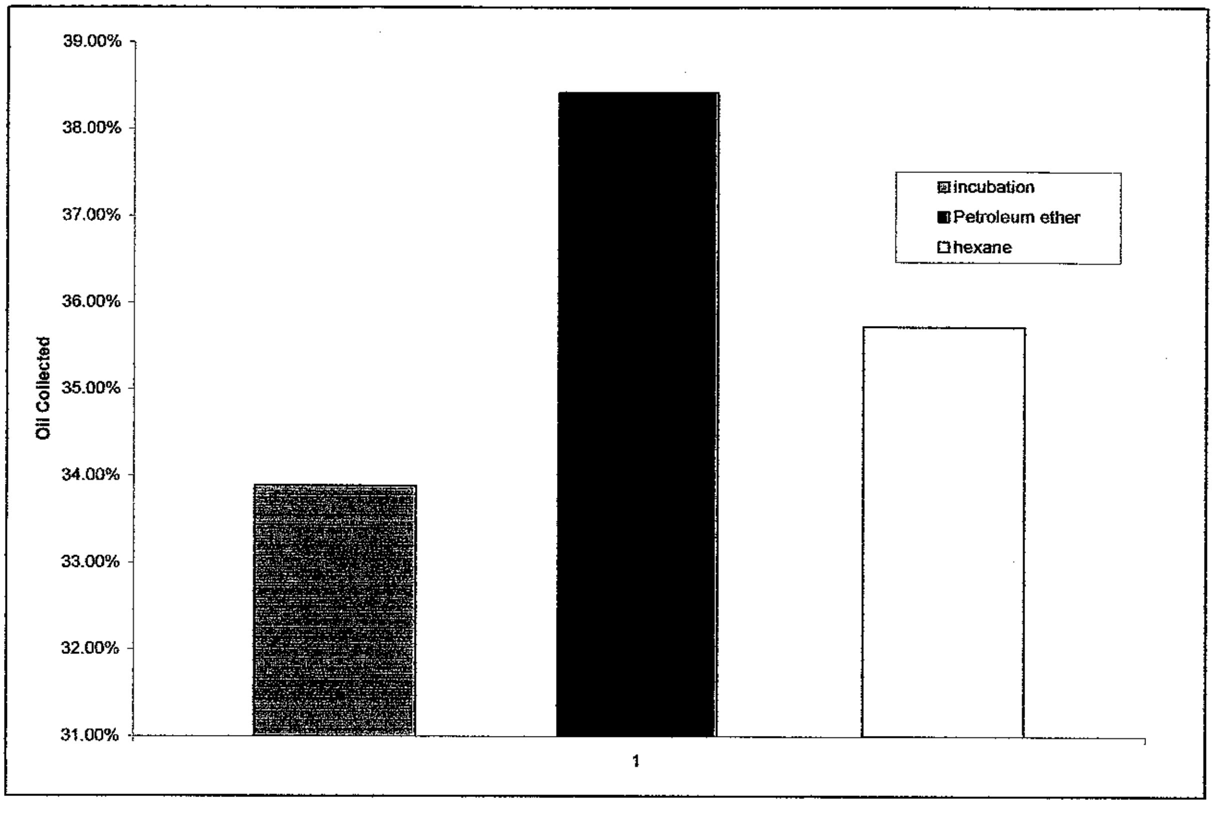


Figure 15: Oil Collected Through Different Process and Adsorbent

Graph tabulated above is average of oil collected from incubation or drying process while another two is extraction process using zeolites but different solvents. From the first observation, petroleum ether is the greatest solvent followed by hexane. Both extraction process yield more oil rather than incubation process only. Even though the process of extraction is a bit costly and took a longer a period of time but the results is satisfying since it yield more. However, comparing the average, both three processes actually produce about 33% to 35% oil which is more less the same.

Research by *Stephan et.al, 2006* found that sludge contain microorganism whose cell membrane contain phospholipids. It is hypothesized that solvent mixture helps to disrupt the lipid membrane which is held together through hydrophobic interactions and it is protected by polar head group. Therefore, from this research, by using petroleum ether and hexane, it is believe that cell membrane may be broken during the process. Then oil cell will easily dissolve into the solvent

9.6 Transesterification of sludge oil to produce biodiesel

There were 5 runs in different condition which were tested and further analyzed during the entire experiment. Tabulated below are all run conducted.

No	Catalyst (acid strength=10%)	Alcohol	Reaction Time (hours)	Ratio (alcohol: sludge oil)
1	Acid sulphuric	Methanol	16	Alcohol put in excess
2			12	10.1
3			18	
4			20	
5			24	

Based on the literature review, methanol and ethanol and ethanol are most commonly used in transesterification process. However, in this research, alcohol used is only methanol since the objective is only want to produce biodiesel and not yet into process of optimization. Sludge oil contain high Free Fatty Acid (FFA) and *Faiz, 2007* suggested acid sulphuric as the catalyst to avoid saponification. The strength of catalyst is taken at the average which is 10% because *Widya, 2006* discussed low strength of catalyst might not be sufficient to provide enough catalytic activity to convert triglyceride to methyl ester.

Yield was calculated upon completion of the filtration process. As most of the samples were recorded by weight, yield was also done as weight of product over weight of raw materials. For the success experiment, yield that calculated is around 20%. This show a promising potential for low grade sludge oil to be converted into biodiesel at a large scale.

In general, improved conversion is achieved by adding extra alcohol. Since methanol is a lower weight alcohol, it has higher polarity and therefore separation is much easier. Since this is the first investigation done for transesterification of sludge, the optimum condition was not confirmed yet. During the first and second trial of executed the transesterification process, all the experiments were failed to show desired product.

There are many factors that can contribute for the failure of analysis, first, contents of oil extracted from sludge is not yet analyzed by GC to see whether it has component of triglycerides or palmitic acid. Since the sample for this biodiesel is sludge oil, the reaction condition had been made some adjustment. First, methanol has been put in excess to make sure the reaction move forward and the reaction time is increase up to 16 hours. By using this reaction condition, slight amount of biodiesel is produced as analyze through TLC. This result obtained is comparable with the result obtained by *Faiz, 2007*. However, it has huge different in the reaction time since *Faiz, 2007* only took 6 hours to produce biodiesel

In the other experiment, reaction is only carried out for longer period of time but the ratio of alcohol to sample maintained at 10:1, surprisingly biodiesel couldn't be achieved. *Widya, 2006* discussed in his findings that sulphuric acid did help in extracting triglycerides from the rubber seeds and therefore it is expected to have more capability to produce biodiesel from the extracted triglycerides if more time was given. Thus, experiment was carried out at longer period next time between 16 hours to 24 hours.

However, *Iskandar, 2008* discussed in his finding that transesterification is reversible process; longer reaction time will not produce a high yield of biodiesel. Then, it is believed that longer reaction time will lead to the saponification reaction and thus limiting the amount of biodiesel yield but this only happen for base catalyst only. Since the reaction time is the most concerning issue, further experiment will be conducted in future by increase the strength of acid but reduce the reaction time

Another factor that may contribute to the failure of this experiment is because of the reaction temperature. The heating process is very hard to control since it may raise and reduce greatly in the ambient temperature. Since the reaction time took more than 12 hours, water need to be to up consistently to avoid them from dried. The solution for this problem is replacing the water with silicon oil.

CHAPTER 10
RECOMMENDATION & CONCLUSION

10.1 Recommendation

a) Oil extracted from palm oil waste water pond contains high percentage of water which leads to unavailability for GC analysis. In order to dry up all water, a sample was placed in the oven for 1 hour at 100^0C.

b) Samples that was undergoes drying process is dried up fully and no oil left for analysis, therefore, instead using drying process, sodium sulphate is used to absorb all the moisture.

c) Content of oil collected is unknown and therefore GC analysis is must, however, the method and chemical is not available at the moment.

d) Adsorbent used to extract oil which is zeolites is very expensive and can not be reused, therefore another alternatives adsorbent is used which is activated carbon.

e) No biodiesel produced during transesterification process, so that the reaction time need to be extended to 8hours until 12 hours

f) Temperature couldn't be constant and therefore the setup equipment needs to be improved. Instead of using beaker and flask, water bath shaker seems a good alternatives.

g) Due to a long period of reaction time, catalyst strength should be increase to 50% while alcohol ratio is increase to 1:25

10.2 Conclusion

Biodiesel is an alternative renewable energy where its utilization in replacing existing diesel from fossil resources, can contributes in solving problems such as air pollution and global warming. Biodiesel offers lots of advantages not only to the environment but also to the economical growth of the nation. There are various sources that can be used as the raw material. Since biodiesel price is become expensive, new exploration need to be done to find new resources which not only environment friendly but also less competing with food for mankind. From the objective of this study, palm oil effluent sludge had shown as promising alternatives feedstock for second generation of biodiesel energy fuel which is cheaper and always available. Extraction using solvent which is Hexane and Petroleum Ether is succeed to extract oil with help from zeolites as the adsorbent. Study and literature review from the past paper shows that extraction of lipid from palm oil effluent sludge is possible and production biodiesel can be produced if the extraction is success. All the research and findings obtained will be used to optimize the production of biodiesel as well as to develop a cost effective system.

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