A STUDY ON PRODUCTION OF EMULSIFIED BIODIESEL

MUHAMMAD ASYRAF BIN JUSOH

UNIVERSITI MALAYSIA PAHANG

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MUHAMMAD ASYRAF BIN JUSOH

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EXAMINERS APPROVAL DOCUMENT

UNIVERSITI MALAYSIA PAHANG
FACULTY OF MECHANICAL ENGINEERING

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Signature
Name of Examiner: Wan Anuar wan Hassan
Date:

SUPERVISOR'S DECLARATION

I hereby declare I have checked this report and in my opinion, this report project is adequate in terms of scopes and quality for the award of the Degree of Bachelor of Mechanical Engineering with Automotive Engineering.

Signature:
Name of Supervisor: Mr. Amir Bin Aziz
Position: Lecture of Mechanical Engineering Faculty
Date:

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own, except for quotations and summaries, which have been duly acknowledged. The report has not been accepted for any other degree and is not concurrently submitted for award of other degree.

Signature:
Name: MUHAMMAD ASYRAF BIN JUSOH
ID Numbers: MH09052
Date: 18 JUNE 2013

Dedicated To My Family

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ABSTRACT

Diesel engine is a preferred power source that is used for power plant and major source for inland transportation. Diesel engine power plants are preferred where power has to be generated in small quantity or used as standby sets, which are required for commercial use. The uses of diesel engine can cause pollutants such as damage ozone layer, enhance green house effect and produce acid rain because of the production Particulate Matter (PM), Smoke Density (SD), Oxides of Nitrogen (NO_x) and other danger gases. Biodiesel is the alternative fuel for internal combustion engine, which can reduce HC, CO, CO_2, SO_2, and PM emission. However, the uses of biodiesel can produce NO_x emission. The emulsified biodiesel is the fuel, which can solve the NO_X emissions. Emulsified biodiesel is combination of water and biodiesel with present of addition of surfactant. The objective in this study is to find out the optimum formulation and method to produce the highest emulsion stability of emulsified biodiesel. The study scope are study the optimum method of production, effect of the water and biodiesel contain, variation volume Span 80 and Tween 80, variation mixing speed, variation mixing time and types of biodiesel to the stability of emulsified biodiesel. Emulsified biodiesel produce by using the Mechanical Stir Machine and form the emulsified biodiesel types O/W phase. The biodiesel are produce from the palm oil. The volume of biodiesel, water and surfactant are measure by using syringe. From the experiment the uses of 95 % of biodiesel and 5 % of water can produce highest stability emulsion because the present of high volume of biodiesel fuel. The most suitable mixing time and mixing speed are 15 minutes and 700 rpm. The optimum volume Span 80 and Tween 80 are 0.7 ml and 1.5 ml. Both of surfactant are lipophilic and hypophlilic. The lipophile are function for absorb oil phase and hydrophilic absorb water phase. Both of the surfactant determine by the Hypophilic Lipophilic Balance (HLB) value. The biodiesel B20 can produce highest stability emulsified biodiesel. As the conclusion, to produce emulsified biodiesel, use 93 % of biodiesel and 5 % of wate, 1 % Tween 80 and 1 % Span 80 with using biodiesel B20.

ABSTRAK

Engine diesel merupakan sumber tenaga yang digunakan untuk loji kuasa dan sumber utama untuk pengakutan darat. Loji kuasa engine diesel merujuk dimana kuasa yang menjana quantiti yang kecil dan digunakan untuk bersedia yang memerlukan penggunaan komersial. Penggunaan engine diesel boleh menyebabkan pencemaran seperti kerosakkan lapisan ozon, kesan rumah hijau dan hujan acid kerana terhasilnya PM, kepadatan asap, NO_X dan lain-lain gas berbahaya. Biodiesel merupakan minyak alternative untuk pembakaran dalam engine yang boleh mengurangkan pencemaran HC, CO, CO_2, SO_2, PM. Walau bagaimanapun, penggunaan biodiesel boleh meningkatkan pencermaran NO_X. Biodiesel beremulsi boleh menyelesaikan pencemaran NO_X. Biodiesel beremulsi ialah gabungan air dan biodiesel dengan kehadiran surfactant. Objective kajian ini, untuk mencari formula dan method yang sesuai untuk menghasilkan biodiesel beremulsi yang paling stabil. Fokus kajian ini adalah method penghasilan yang sesuai, kesan penggunaan isipadu air and biodiesel, isipadau Span 80 dan Tween 80, kelajuan mencampur, masa mencampur dan jenis biodiesel. Biodiesel beremulsi dihasilkan menggunakan mesin pengacau dang menhasilkan biodiesel beremulsi O/W. Biodiesel dihasilkan dari minyak sawit. Isipadu air, biodiesel dan surfactant diukur menggunakkan picagari. Daripada experiment, 95 % biodiesel dan 5 % air boleh menghasilkan biodiesel beremulsi yang stabil kerana kehadiran isipadu biodiesel yang tinggi. Masa dan kelajuan untuk campuran adalah 15 minit dan 700 rpm. Isipadu Span 80 dan Tween 80 adalah 0.7 ml dan 1.5 ml. Kedua-dua surfactant adalah lipophilic dan hypopilic. Lipophilic berfungsi untuk serap phasa minyak dan hypophilic serap phasa air. Kedua-dua surfactant dinyatakkan dengan "Hypophilic lipophilic Balance (HLB)". Biodiesel B20 boleh menghasilkan biodiesel beremulsi yang paling stabil. Sebagai kesimpulanya, untuk menghasilkan biodiesel beremulsi , gunakan 93 % biodiesel, 5 % air, 1 % Tween 80 dan 1 % Span 80 dengan menggunakkan biodiesel B20.

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LIST OF ABBREVIATIONS

NO_X	Nitrogen Oxide
PM	Particulate Matter
HC	Hydrocarbons
CO	Carbon Monoxide
CO_2	Carbon Dioxide
SO_2	Sulphur Dioxide
B10	Biodiesel B10
B20	Biodiesel B20
B30	Biodiesel B30
B50	Biodiesel B50
B100	Biodiesel B100
NAOH	Sodium Hydroxide
DOC	Diesel Oxidation Catalyst
ULSD	Ultra Low Sulfur Diesel
APT	Alternative Petroleum Technology
O/W/O	Oil in Water and In Oil
O/W	Oil in Water
ASTM D 4743	Test Method for Efficacy Of Solvent System For Dissolving Water Formed Deposits
ASTM D445	Standard Test Method for Kinematic Viscosity of Transparent And Opaque Liquid
HLB	Hypophilic Lipophilic Balance

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Renewable energy sources are known as alternative energy sources have the potential to supply energy services with almost zero emission because it is clean and environmentally safe. Renewable energy also produces lesser or slight level of greenhouse gases and other pollutants as compared with the fossil energy sources they substitute.

Alternative fuels such as biodiesel are generally discuss in much country to increase environmental responsiveness and the expanding cost of diesel fuel. Biodiesel is one of the renewable energy that produces from the natural sources to decrease the air pollution. The improvement of the alternative diesel fuels was focused by the requirement to decrease the environment impact of emissions without modifying engine.

Current research on biodiesel fuel is an emulsified biodiesel (P.Grimes 2011). From the research finding, the emulsified biodiesel can be used to reduce the nitrogen oxide (NO_X) emission and particulate matter (PM) emission (P.Grimes 2011). Emulsified biodiesel is the combination of water and biodiesel with addition of surfactant. The water in the emulsified biodiesel can neutralize the nitrogen oxide during the combustion. The surfactant function as an additive to help the water and biodiesel soluble in mixture. In this study, the biodiesel will be test with various methods to find the optimum formulation and method, which can produce an emulsified biodiesel that has optimum emulsion stability.

The study will focus on various parameters that affected the emulsion stability such as the volume of surfactant, stirring speed, mixing time, types of biodiesel and contain of water and biodiesel. The result of each experiment will combine and would form the optimum formulation, which has highest emulsion stability.

1.2 PROBLEMS STATEMENT

The substances that cause air pollution are called pollutants. Pollutants that are pumped into our atmosphere and nonstop pollute the air are called primary pollutants. Examples of pollutant are carbon monoxide from the vehicle exhausts and sulfur dioxide from the combustion of coal. Air pollutants generally happen as a result of gaseous discharges from industry and vehicle. Effect of air pollution is acid rain which is the mixture of wet and dry deposition from the atmosphere containing higher than normal amounts of nitric and sulfuric acid. The sources of acid rain are sulfur dioxide and nitrogen oxide. Sulfur dioxide is a colorless, discreet gas released as a item for consumption of combusted fossil fuel containing sulfur. While the nitrogen oxide is a hazardous, gas because this gas attacks the membranes of the respiratory organ and increase the probability of respiratory illness.

The green house effect is one of the examples of air pollution. The green house effect is the natural process where the atmosphere traps part of the sun's energy, a required process to remain the planet warm enough. The anthropogenic raise in greenhouse gases such as carbon dioxide that can increase the effect dramatically and cause anthropogenic environment change. The impact of the green house effect are reduce agricultural productivity, increase the water shortage throughout the global and increase the sea level some part of world due to excess heating of air.

Then, to control the air pollution, biodiesel was introduced to use on the diesel engine. Biodiesel is an alternative fuel similar to the conventional or fossil diesel. Biodiesel can produce from the vegetable oil, animal oil, tallow and waste cooking oil. The current study show that biodiesel fuel can reduce hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), sulphur dioxide (SO_2) and particulate matter (PM) emission. However, biodiesel fuel can increase the nitrogen dioxide (NO_2). To solve this problem a new research on the biodiesel fuel had been study to create a new fuel, which is emulsified biodiesel.

Emulsified biodiesel is a combination of water, biodiesel and surfactant. The water in emulsified biodiesel capable to neutralize the NO_x from diesel engine. Currently, there were lack of information regarding the formulation and detail method on producing high stability of emulsified biodiesel. Thus, there must be effort to gain knowledge on optimum formulation and method to produce emulsified biodiesel.

1.3 OBJECTIVE

To find the optimum formulation and method to produce the emulsified biodiesel.

1.4 PROJECT SCOPES

The scopes of this study are:

I. Study the optimum method to produce emulsified biodiesel.
II. Study the effect of variation water and biodiesel contain.
III. Study the effect of variation Span 80.
IV. Study the effect of mixing speed.
V. Study the effect of mixing time.
VI. Data analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION ON BIODIESEL

Biodiesel is an alternative fuel for internal combustion engine which have several advantages such as oxygenated, biodegradable, non-toxic, renewable, low carbon and environmentally friendly fuel (D.H. Qi, 2010). Biodiesel is the best applicant for diesel fuel in diesel engine. Biodiesel burn similar to petroleum diesel as it involves synchronized pollutant (Demirbas, 2007). Biodiesel also can help reduce greenhouse gas emission, as well as public health risk associated with air pollution (Lele, 2005). In the biodiesel fuel actually has high oxygen content which can give the enhancement of the burning efficiency, reduction of particulate matter (PM), carbon monoxide (CO) and hydrocarbon (HC) compared the using of the diesel fuel.

The biodiesel characteristics can give the improvement of engine combustion efficiency. (Cheng Yuan Lin, 2007) reported that the burning of biodiesel would generate about 10% more NOx emission compare with diesel. The another effect of increasing NO_X emission is the percentage of biodiesel. For example, as mention by P. Grimes(P.Grimes 2011), the using of the 20% volume of biodiesel in the fuel blend (B20) show that the NO_x emission will increase around 3% while the using of 100% volume of biodiesel in the fuel blend (B100) the emission of NO_x produce about 17%.

However, the disadvantage of biodiesel fuel are the increasing the nitrogen oxides (NO_X) emission (C.H Cheng, 2008). This is cause by the high contain of oxygen in biodiesel which will produces larger of the NOx emissions from the diesel engine. The emission of NO_x increase depend the high oxygen content in the biodiesel fuel

(Yung Sung Lin, 2011). The another disadvantage of biodiesel are high viscosity, lower energy content, higher cloud point and pour point, lower engine speed and power, injector coking, engine compatibility and high cost (Demirbas may, 2007).

In Malaysia, the main source of biodiesel is palm biodiesel. The physic-chemical properties of palm biodiesel meet the necessity of diesel engine combustion. The advantage of palm biodiesel is cheaper than both soybean biodiesel and corn biodiesel (Yuan Chung Lin, 2006). The another source to produce biodiesel fuel is renewed from waste cooking oil. The source of waste cooking oil is lower price and extra improvement of falling waste oil disposal (C.H Cheng, 2008). This oil contain some degradation product of vegetable oils indicate that differences between used and unused fat are not very great in most cases simple heating and removal by filtration of solid particles suffices for subsequent trans-esterification (Lele, 2005).

2.1.1 Method to Produce Biodiesel

Transesrerification is a chemical reaction process during which the oil combine with alcohol, usually ethanol or methanol , in the existence of a catalyst to form fatty ester and glycerol (A. Bulent Koc).Transesterification is a familiar technique for biodiesel production from vegetable oils and animals fats. The transesterification process minimize the viscosity of oil which is higher than petrol-diesel. The examples of catalyst use in the transesterification are methanol, butanol, ethanol, propanol and amyl alcohol (Lele, 2005).

Yung Sung Lin (Yung Sung Lin, 2011) state catalyst type NAOH less expensive compare KOH and has slighter molar weight and its salt are less soluble in methyl ester. To produce biodiesel from castor oil using transesterafication, 1000 ml of pretreated castor oil, 300 ml of methyl alcohol and 5 g of NAOH were mixed in ambient temperature. The mixture will stirred for 1 hour without heating as good solvability is existing in alcohol trasnsesterification. The product were approved to settle overnight before removing the glycerin, which had settled at the bottom in a separation funnel. The crude biodiesel was washed, neutralized and distilled to obtain pure methyl ester CBD (Yung Sung Lin, 2011).

(Cheng Yuan Lin, 2007) stated there are three type of catalyst that can be used in transesterification reaction, a strong alkaline catalyst, a strong acid and enzyme. The main advantage of using a strong alkali as catalyst are shorter reaction time and less amount of catalyst required in the mechanized process of the transesterification. The method that mention by (Cheng Yuan Lin, 2007) by using electromagnetic stirrer, 1 % of an alkali catalyst, sodium hydroxide (NaOH) and methanol. The mixture will stirred to form of sodium methoxide and water. The raw material will mixed with methyl alcohol with ratio 1:6. The mixture of sodium methoxide and water will pour into a reaction vessel to mix with raw material by mean of mechanical homogenizer to carry out the transesterification reaction. The reaction temperature is set about 60 ^{0}C to put off the methanol vaporizing from the reacting mixture. The process of the transesterification process take about 50 min to complete. The mixture will separated into two layer using the difference in gravity between these layer of coarse biodiesel and glycerol through centrifugation. The unreacted methanol will isolated from the coarse biodiesel through distillation at 70 ^{0}C. The other impurities in the coarse biodiesel are washed away by adding 50 % petroleum ether and 10% distilled water to obtain the initial biodiesel product. One percent hydrogen peroxide is then add to the initial biodiesel and stirred by mechanical homogenizer in a reaction tank about 10 min. Distillation method used to remove the un-reacted impurities, water and methanol and the biodiesel are produce.

The another method to produce biodiesel is Ultrasound-assisted transesterification. Ultrasound extraction technique can reduce the extraction time and solvent amounts and produced higher extraction efficiency with less environment impact than convention extraction. In this method, low frequency ultrasound energy for biodiesel production and compared the result with conventional production process. Ultrosound -assisted transesterification use three different types of alcohol and NaOH as a catalyst. The ultrasonication show the affirmative effect on transesterafication process and can reduce the process time and saved energy in biodiesel manufacture (A. Bulent Koc).

The equipment required are convertor, horn, and reactor. The ultrasonic wave was generated from transducer in the convertor part and transmitted to the horn tip to cause the cavitations in the mixture of oil and methanol. Ultrasonic power and frequency applied at 1500 W and 20 kHz respectively into reaction mixture of 9:1 methanol to oil molar ratio. For the homogeneous transesterification system, the oil heated at 100 ^{o}C and fed into the ultrasonic reactor to mix with solution of 0.5 % NaOH catalyst in methanol. The ultrasonic reaction time about 10, 20, and 30 sec. After reaction, glycerol was separated by gravitation and methyl ester was cleaned to remove the access alkali, methanol and water (Siriporn Larpkiattaworn, 2010).

2.2 INTRODUCTION AN EMULSIFIED BIODIESEL

An emulsion can defined as the mixture of two immiscible liquids wherein droplets of one phase involve the dispersed or internal phase are encapsulated within sheets of another phase. The emulsified fuel is one of the potentially efficient techniques to decrease exhaust emission from diesel engine. The water in diesel emulsified formulation are reported can reduce the emissions of NO_x,SO_x, and CO (H M Herzwan, 2012). Furthermore the emulsion technology significant can reduce the particulate matter (PM) emission about 42% compared using the ULSD fuel (P.Grimes, 2011).

The study made by (P.Grimes, 2011) reported that 6.5% (by mass) water content in the emulsified B20 biodiesel fuel effectively neutralized any NO_x emissions. The function of water in emulsified fuel has been confirm to play an important role in conventional liquid fuel engines. This is because rapid evaporation of water broke fuel into smaller droplets and hence increase their surface area causing well-mixed air and fuel droplets when the temperature of water in the diesel emulsified diesel in the cylinder went up to 105 ^{o}C (Kang Shin Chen, 2010).

(H M Herzwan, 2012) mention that, by utilizing 20% until 40% of water, the fuel consumption will be increase due to the large decrease in the combustion efficiency. The emission of NO_x decrease when use emulsified biodiesel by the introduction of liquid water in the combustion process. The vaporization and sensible water heats can reduce the local adiabatic flame temperature and NO_x formation (O. Armas 2005). Mastoshi Iwai (Iwai, 2011) state that the combustion gas temperature decrease due to evaporation heat of water in emulsified biodiesel which lead to reduction of NO_X formation.

The Alternative Petroleum Technologies (APT) (P.Grimes, 2011) had proved that the emulsion technology effective to decrease the NO_x emission fuel in the regular diesel fuels. Emulsion technology also can alleviate the NO_x emission increase in biodiesel fuels (P.Grimes, 2011). The study made by (D.H. Qi 2010) they had run twenty five tests emulsified biodiesel on diesel engine and each one of the test in triplicate to investigate the emission from the combustion of diesel engine. The test includes the various of range of the biodiesel and water contents in the fuel. B20 is refer to the 20% biodiesel in the diesel blended and B20 mixed with water with present of surfactant use for the engine test (P.Grimes, 2011). The results of the experiment to test the emission of emulsified biodiesel, the emulsification was efficient in reducing the emissions level of CO, HC, NOx, and smoke, prolonging the service life span for lube oil, and recovering the anti-wear characteristics of engine components (D.H. Qi, 2010).

2.3 METHODS ON PRODUCTION OF EMULSIFIED BIODIESEL.

2.3.1 External Force Emulsification by Using a Static Mixer.

The static mixer can use to blend two or more liquid into a homogenous mixture because of the ability can split and fold the products to achieve a blended output . The static mixers consist of the motionless mixer elements with crossbars fitted in a housing tube. Multiphase applications working with static mixers are the blending of a constant liquid phase and a immiscible liquid phase. The Reynolds number would characterizes the fluid dynamics flow in the static mixer. The flow in the mixers would be laminar flow or turbulent flow (N. Kiss, 2011). The application of turbulence in a tubular membrane can increase the flow rate and pressure drop at the same flow rate (Andras Koris, 2005).

In the study by (N. Kiss, 2011) the first step to produce emulsion, water will heat at 801 ^{o}C. A quantity of 0.5–5 % of the solid polyvinyl alcohol (PVA) is dissolve in the water. The dissolution time varied from 1 hours until to 2 hours and depending on the PVA concentration. For the organic phase will prepare as following step. Firstly, the poly lactic co glycolic acid (PLGA) is dissolve in ethyl acetate at 0.0931–0.2297 g/ml. The active pharmaceutical ingredient (API) will dissolve in benzyl alcohol at 0.34 g/ml. After dissolution of both solid materials in the organic solvents, both of solutions will mixed, and the resulting organic phase will store at 201 ^{o}C for 3 hours. In the emulsion production, the organic and the aqueous phases will supply and start to mix in the fed tube downstream of the Y-shaped junction of the two fed lines. Further, downstream, the emulsification of the organic in the aqueous phase took place in the SMX mixer elements. The produced emulsion will collect in a reservoir vessel and characterize the emulsion.

2.3.2 Emulsion via Ultrasonic Technology

Instruments based on ultrasonic spectroscopy have recently been developed to measure the disperse phase volume fraction and droplet size distribution of emulsions. These instruments have major advantages compare traditional methods, such as light scattering, electrical pulse counting, and microscopy (N. Herrmann, 1999). The principal mechanism of demulsification via ultrasonic irradiation is the displacement effect. Under ultrasonic irradiation, the water and the oil particles of the emulsion can move to wave loops, collide, and consequently become bigger particles that can be separate by gravity (X. G. Yang 2009).

In study by (X. G. Yang, 2009) the first step to produce emulsion, the crude oil will add into a beaker and stirred homogeneously. Then, the stir crude-oil emulsions are extracting into several special graduated cylinders and 10 ml of emulsions are place in each cylinder. After that, half of the samples prepare are directly heat to demulsify in a water bath. The rest of the cylinders are placed in the same water bath, but after a period of ultrasonic irradiation. Lastly, the volume of water depositing to the bottom which can be read from the scale on the special graduated cylinder every 5 minutes. The water content of the crude oil emulsions can measure by distillation technology (ASTM D 4006-81).

2.3.3 Emulsion via Conductive Method

In the study by (Jingjing Jiang, 2013) paraffinic oil solutions containing a certain amount of Brij 30 which mix with different concentrations of electrolyte solutions in an ice-salt bath with a magnetic stir at 600 rpm. The systems will heat regularly by heating the bath. The conductivity of the resulting mixtures measure as a function of temperature using a Leici DDS-307 conductivity meter. A Pt/platinised electrode with a cell constant of 1.02 cm^{-1} that will determine by using standard KCl solutions. The temperature of the mixture regularly increase from 5 ^oC to 80 ^oC.

For the production an emulsion, the amount of Brij 30 will weight in a 50 ml glass beaker at room temperature and oil will add into the beaker with a pipette then they are mix homogeneously with magnetic stirrer. The next step, an aqueous phase will gently add into the mixture with another pipette normally the volume of a sample is 20 ml. After that, the glass beaker with sample will mount in a thermostat vessel which was settled at the ambient temperature. The samples will emulsified using a WiseTis HG-15D digital homogenizer and operate at 5000 rpm for 3 min. Types of emulsions will determine by measure the electrical conductivity. Large conductivity values indicate O/W emulsions and low values indicate W/O emulsions. The obtained emulsions will conserve in glass tubes which inner diameter is 1.8 cm and length is 15 cm and carefully sealed under constant temperature (Jingjing Jiang, 2013).

While the study by (K. I. Al Malah, 2000) a mother buffer phosphate solution which 0.01 Mol and pH 7 have prepare by using de-ionized water. The pH will measure by using a pH-meter. The bovine serum albumin (BSA) protein will dissolve in 40 ml buffer and poured into the glass cell. The original conductivity of the BSA solution will record by using a conductivity meter. An oil will add to the BSA solution. The two phases will normalize about 1.5 minutes at speed 18,600 rpm. The conductivity will regularly record under control temperature which is at 25 ^oC to 288 ^oC during the homogenization period and 10.5 min after stopping the homogenizer. Figure 2.1 show the schematic diagram conductivity measurements of emulsion that was study by (K. I. Al Malah, 2000).

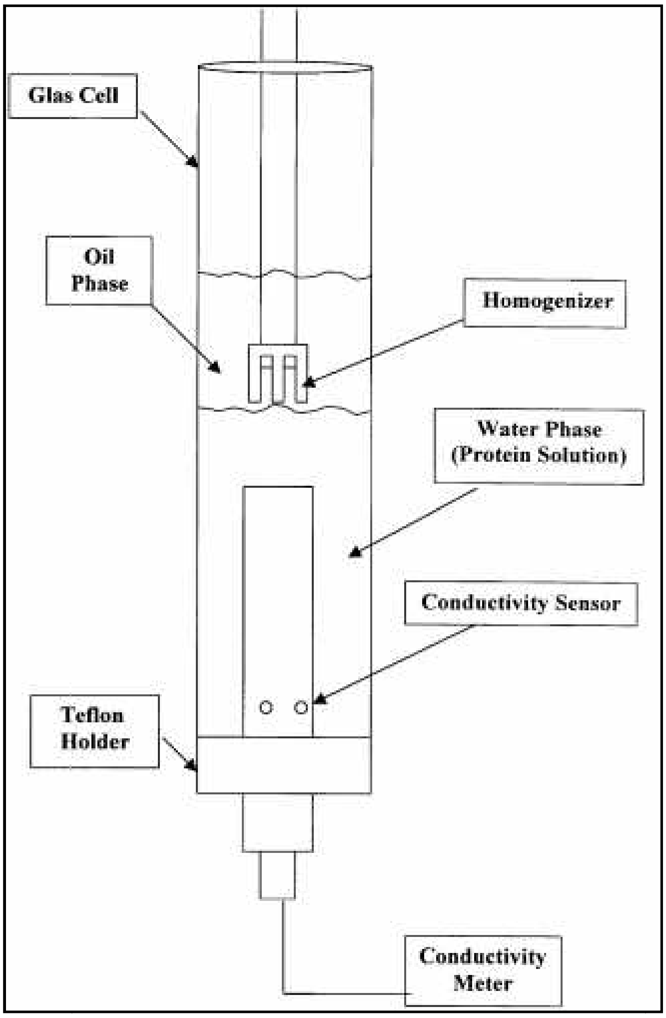

Figure 2.1: Schematic diagram conductivity measurements of emulsion

Sources: K. I. Al Malah (2000).

2.4 ADDITIVE IN EMULSIFIED BIODIESEL

To get a stable mixture of diesel and water, a surfactant is mixed along with diesel and water to make water-in-oil emulsion fuel. Emulsification of these three different liquid produced a white and creamy solution (H M Herzwan 2012). The purpose of surfactant addition is to decrease oil and water superficial tension, activate their surfaces and capitalize on the superficial contact area to make micro-emulsions (D.H. Qi 2010). Surfactants agents are amphipathic substances with lyophobic and lyophilic groups making them able of adsorbing at the interfaces between liquids, solids, and gases. They are able to form self-associated clusters, which normally lead to organized molecular assemblies, monolayers, micelles, vesicles, liposomes and membranes (M. Nadeem, 2006). The surfactant decrease the surface tension between water and oil, maximizing their superficial contact area, and activate their surfaces (Cheng Yuan Lin, 2007). This is because a surfactant has both a hydrophilic group and a lipophilic group. The lipophilic group in the surfactant will absorb the oil phase whereas the hydrophilic group will absorb the water phase (Cheng Yuan Lin, 2007).

The new production surfactants are Gemini, Viscoelastic and Non-migratory. The emulsion fuels with varying contents of water and diesel were prepared and stabilized by conventional and Gemini surfactant. From the experiment, the Gemini surfactant prove the emulsion stabilized have much greater and assault distributed water droplets (M. Nadeem, 2006). The biggest reduction in PM, $NO_{x,}$ CO and SO_X emission was achieved by the emulsion stabilized when use the surfactant type Gemini that have containing about 15% water contents (H M Herzwan, 2012). The advantage of Gemini surfactant has a long hydrocarbon chain, an ionic group, a spacer, a second ionic group and another hydrocarbon tail which are also known as double tailed surfactants and are significantly more surface-active than conventional surfactants (M. Nadeem, 2006).

The another types of surfactant are Span 80 and Tween 80. Span 80 and Tween 80 have many advantage over ionic surfactant including increase stability formulating flexibility and wider compatibility. They are established in mild acids, alkalis and electrolytes and do not react with ionic ingredient or actives. By combination of Span 80 and Tween 80 at different ratio, formulators are capable to produce systems with a wide HLB range to emulsified biodiesel (Cheng Yuan Lin, 2007). Certain Span 80 and Tween 80 are also high effective solubilises, dispersing agent and wetting aids. Span 80 and Tween 80 are the key emulsified biodiesel agent for the number of application . Span 80 excellent for water in oil emulsification of hydrocarbons and is particularly useful in aerosol system while the Tween 80 are hydrophilic in natural and are soluble in water and dilute solution of electrolytes (Cheng Yuan Lin, 2007). The solubility of Tween in aqueous solution increase with the degree of ethoxylation. Table 2.1 shown the example of formulation for emulsified biodiesel.

Table 2.1 : Example formulation to form emulsified biodiesel

No	**Biodiesel (%)**	**Water (%)**	**Surfactant**			**Reference**
			Span 80 (g)	**Tween 80 (g)**	**Gemini (%)**	
1	90	10	11.8	2.2	NA	(Cheng Yuan Lin 2007)
2	90	10	10.5	3.5	NA	(Cheng Yuan Lin 2007)
3	90	10	9.2	4.8	NA	(Cheng Yuan Lin 2007)
4	90	10	7.9	6.1	NA	(Cheng Yuan Lin 2007)
5	90	10	6.5	7.5	NA	(Cheng Yuan Lin 2007)
6	90	10	5.2	8.8	NA	(Cheng Yuan Lin 2007)
7	90	10	3.9	10.1	NA	(Cheng Yuan Lin 2007)
8	90	10	2.6	11.4	NA	(Cheng Yuan Lin 2007)
13	95	5	NA	NA	1	(M. Nadeem 2006)
14	90	10	NA	NA	1	(M. Nadeem 2006)
15	85	15	NA	NA	1	(M. Nadeem 2006)
16	79	20	NA	NA	1	(H M Herzwan 2012)

2.5 PROPERTIES OF EMULSIFIED BIODIESEL

The emulsified biodiesel prove that fuel viscosity affect the hydraulic injection control system, causing an advanced injection and in consequence, advanced combustion process. For the increase viscosity of emulsified biodiesel tends to advance injection timing in some injection system due to the modification of the dynamics of the command hydraulic system (O. Armas, 2005). Viscosity is an important factor affecting the quality of biodiesel atomization (Yung Sung Lin, 2011). The viscosity can increase proportional to the ratio between surface area Sp/Se. The term of Se is the surface area of emulsified biodiesel and the term of Sp is the sum of surface area of distributed water droplets and both areas being assumed spherical (O. Armas, 2005).

The kinematic viscosity, specific gravity, and carbon residual of the emulsified biodiesel were larger compared with neat biodiesel (Cheng Yuan Lin, 2007). The addition of ethanol causes the lower viscosity of the emulsified biodiesel compared to biodiesel, which improved vaporization and atomization in better mixing with air and leads to absolute combustion (D.H. Qi, 2010). The surface tension and viscosity of most liquids reduce with temperature. The enlarged kinetic energy imparted to surface molecules at higher temperatures will tend to overcome the net attractive force of the bulk liquid (M. Nadeem, 2006). The physical properties of biodiesel droplets significantly affect the quality of atomization where the viscosity, density and surface tension are the main factor.

In addition, the two phase (W/O) biodiesel emulsion was found to have a smaller mean droplet size, lower volumetric fraction of the dispersed phase than the three phase (O/W/O) biodiesel emulsion, and the highest heating value among the test fuels (Cheng Yuan Lin, 2007). The emulsified biodiesel have density that is a little smaller than that obtain from averaging the fuel and water densities. This is because the density value of emulsified biodiesel depends on the amount air bubbles in the emulsion as a result of the preparation process (O. Armas, 2005).

2.5.1 Equipment for Properties Fuel Test

Figure 2.2: Pensky- Martens Closed Tester

Figure 2.2 shows the Pensky-Martens Closed Tester which is used to test the flash points properties of the emulsified biodiesel. The value of the flash point is used for the classification of flammable and combustible materials needed for safety and shipping regulations. The standard procedure for measuring the flash point for diesel and biodiesel fuels follows ASTM D93 standard. The tested emulsified biodiesel will test on the Pensky-Martens Closed Tester to find out the flash point.

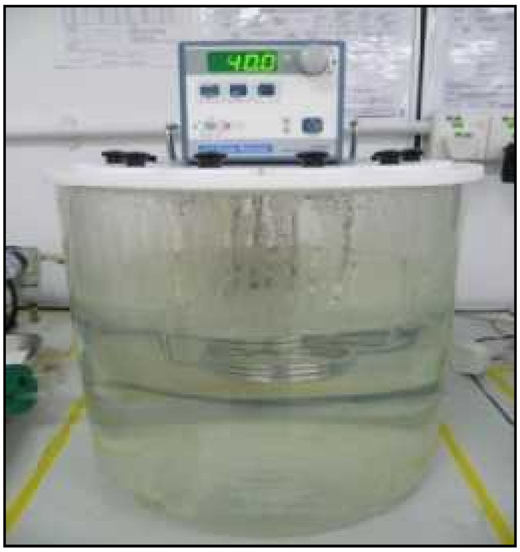

Figure 2.3: Digital Constant Temperature Kinematic Viscosity Bath

Figure 2.3 shows the Digital Constant Temperature Kinematic Viscosity Bath which use to investigate the Kinematic Viscosity of emulsified biodiesel. The Digital Constant Temperature Kinematic Viscosity Bath will measure of resistance to flow of a liquid. The measure of resistance to flow of a liquid is important for consistency, injector flow, and good atomization. Technically, it is the ratio of the shear stress to the shear rate for a fluid. The standard procedure for measuring kinematic viscosity in diesel or biodiesel fuels follows ASTM D445 standards.

Figure 2.4: Cloud & Pour Point

Figure 2.4 shows the equipment Cloud and Pour Point which is use to test the properties of Cloud & Pour Point of the emulsified biodiesel. The cloud point is an important property for biodiesel since biodiesel fuels typically have higher cloud points. For example crystals begin to form at higher temperature, than standard diesel fuel. This feature has implications on the use of biodiesel in cold weather applications. The pour point also has implications for the handling of fuels during cold temperatures.

Figure 2.5: Portable Density/Gravity Meter

Figure 2.5 shows the Portable Density or Gravity meter which is use to test the Density of emulsified biodiesel. The measure of the density has the objective of restricting the use of some materials as raw material for biodiesel production. The densities are usually independent, and they exert a great influence in processes such as the injection of fuel and its preparation for the automatic ignition.

Figure 2.6: Bomb Calorimeter

Figure 2.6 show the Bomb Calorimeter which is use to test the Energy Content of emulsified biodiesel. The energy of emulsified biodiesel is an important quantity because it's being able to measure the efficiency of fuel. The energy of emulsified biodiesel content is the amount of heat produced by the burning of 1 gram of a substance and is measure in joules per gram (J/g). The energy content of biodiesel is an indication of the energy chemically bound in it and in the combustion process it is converted into heat energy. The Portable Octnae Meter use to test the Cetane Number of emulsified biodiesel. This octane tester capable to measure cetane level of fuels according to ASTM D 4743

CHAPTER 3

RESEARCH METHODOLOGY

This chapter will describe further on the experiment which is the tools, materials, and procedure use to run the experiment to study the stability of the emulsified biodiesel. All the details and related discussion on the process and methods involve in the project are described. The process flow of the project is illustrated using flow chart. The chart is fundamental for this project as both chart explained every step to achieve the objective of the project.

3.1 PROJECT FLOW CHART

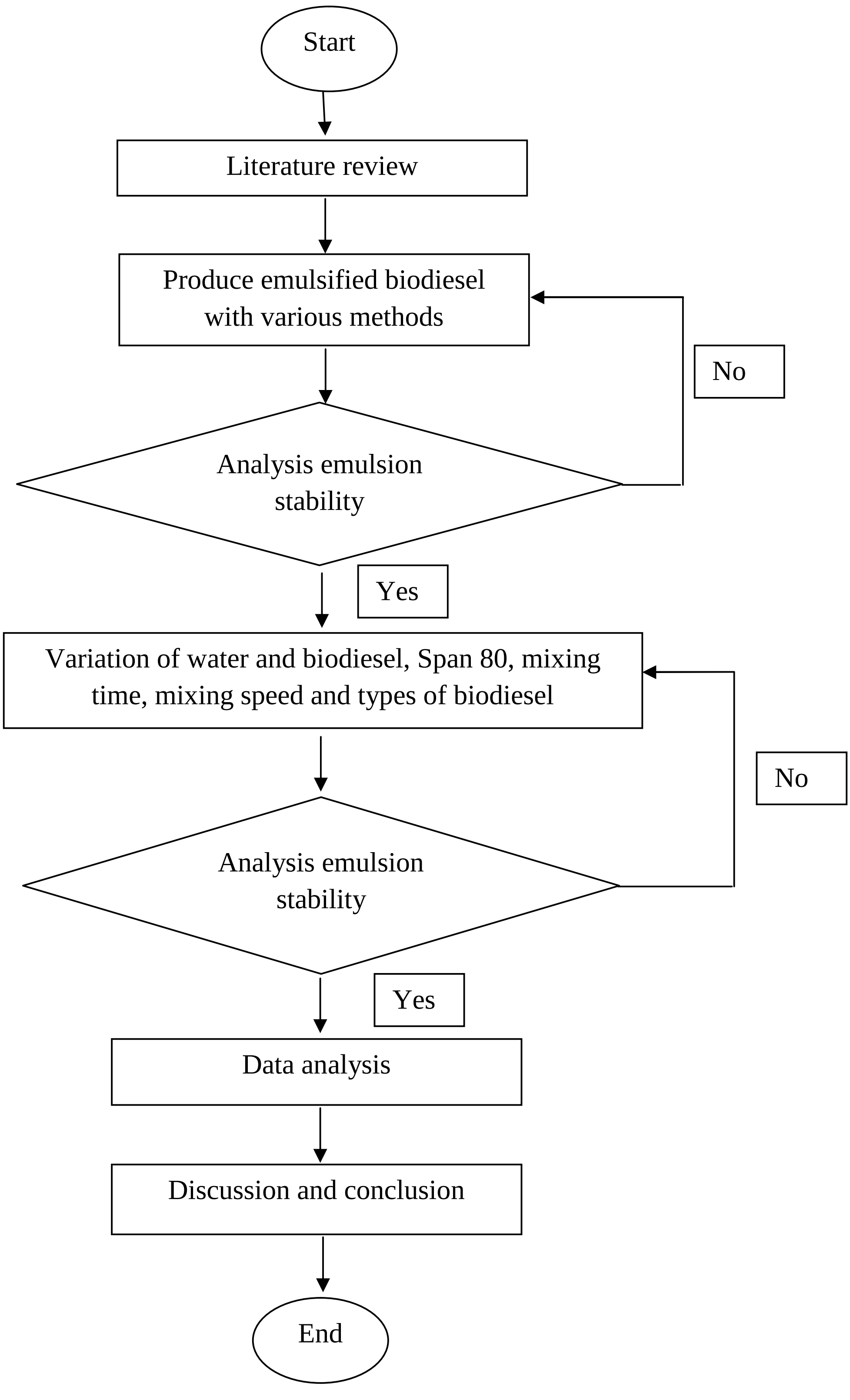

Figure 3.1: Flow Chart

Figure 3.1 shows a flow chart to study the emulsified biodiesel. In this study, the focus job is to study the stability of the emulsified biodiesel. Firstly, study on the fundamental of the emulsified biodiesel. The summary from the several of the sources will form literature review.

Second step, produce the emulsified biodiesel in different method, formulation and test the emulsion stability. The result from this experiment will show the best formulation and method to produce optimum emulsion stability.

After production of the emulsified biodiesel, the fuel will test the stability. The fuel will store in glass bottle for the stability test. The emulsified biodiesel will record from the finish production until the emulsified biodiesel separate. The longest time to separate is the best stability of the emulsified biodiesel.

For each experiment will record. The parameter record is time for the emulsified biodiesel separate with various of manipulated response. All the data will key in the table and will use to draw the graph. From the graph, will show the best emulsified biodiesel. From the graph, can compare the emulsified biodiesel with different method and formulation.

All the result will conclude and the reasons of the result will discuss in chapter Discussion and Conclusion. The conclusion will prove the experiment to achieve the objective of the project.

3.2 FACILITIES AND EQUIPMENTS

3.2.1 Mechanical Stir Machine

Figure 3.2 shows a Mechanical Stir Machine is model RW20 Digital which use the electricity sources for the operation. The power of the mechanical stir machine is 72 W and 220-240 V. The maximum rotation speed is 2100 rpm and the minimum rotation speed is 200 rpm. It consist a blade, which has diameter of 5 cm. The Mechanical Stir

Machine use to mix the emulsified biodiesel. The accuracy of stirring speed is ± 20 rpm.

Figure 3.2: Mechanical Stir Machine

3.2.2 Syringe.

Figure 3.3 shows the syringe which is use to measure the volume of the Span 80, Tween 80, biodiesel and water. The syringe is the most suitable to use because can measure the small volume of liquid and more accurate. The accuracy of the syringe is ± 0.2 ml.

Figure 3.3: Syringe

3.2.3 Metallurgical Microscope

Figure 3.4 show the Metallurgical Microscope which is use to observe the microstructure of the emulsified biodiesel. The computer connected to the Microscope to capture the picture the can observed under the microscope. The IM7100 Metallurgical microscope has the MA816/ 10 Siedentopf-type trinocular head. The MA816/ 10 is use an 80/ 20 beam splitter that can be engaged for photomicroscope which is 100% to eye tubes or 80% to phototube and 20% to the eye tube. Each microscope head has the eye tubes inclined at 30 degrees with the left eye tube having graduated diopter settings. The interpupillary distance on the viewing heads is adjustable between 53mm - 75mm. 10X Super Wide field High Eye point eyepieces are standard, and 15X and 20X eyepieces are also available as an option. A Super Wide field High Eye point 10X focusable eyepiece that accepts standard 25mm reticules is also available.

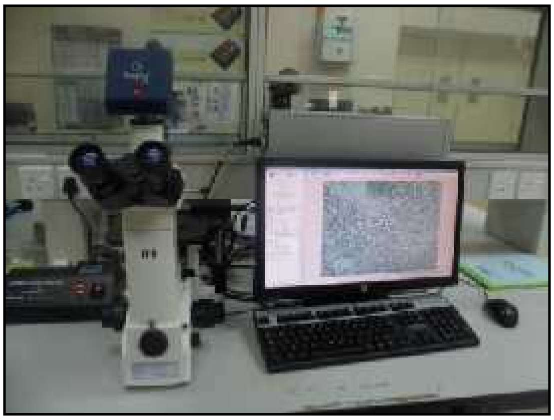

Figure 3.4: Metallurgical Microscope

3.3 MATERIALS

3.3.1 Biodiesel B20

Figure 3.5 show the biodiesel B20 which contain 20 % of biodiesel and 80 % of diesel fuel. This biodiesel produce from the palm oil and buy form the Klang, Selangor.

The diesel fuel can get from the Petro stations area Pekan, Pahang. The properties of biodiesel B20 show at the table 3.1.

Figure 3.5: Biodiesel B20

Table 3.1: Properties Biodiesel B20

Parameters	Properties
Flash point (^oC)	110
Viscosity (mm^2/s)	4.514
Density (Kg/m^3)	845
Acid Value	0.02
Moisture Content (%)	1.16
Cloud Point (^oC)	16
Pour Point (^oC)	-7
Cetena Number	78.2
Energy Content (MJ/kg)	45.714

3.3.2 Distilled Water

The distilled water use to mix into the mixture of the biodiesel B20, Span 80 and Tween 80. The distilled water can buy from the spare part car shop area Pekan, Pahang. The properties of the distilled water at table 3.2 below.

Table 3.2: Properties Distilled Water

Parameters	**Properties**
Density (x1000 Kg/m^3)	1
Viscosity (Pa-s)	$7.98\text{x}10^{-4}$
Kinematic Viscosity (m^2/s)	$8.01\text{x}10^{-7}$
Surface Tension (N/m)	$7.12\text{x}10^{-2}$
Bulk Modulus (GPa)	2.26
Thermal Expansion Coefficient ($/^oC$)	$2.94\text{x}10^{-4}$

3.3.3 Surfactant

Figure 3.6 shows the surfactant Span 80 and figure 3.7 show the surfactant Tween 80. The surfactant have been use to produce emulsified biodiesel. The function of the surfactant to help the water and biodiesel oil soluble in the mixture. The Span 80 produce by the dehydration of sorbitol. Esterification with fatty acids in a controlled chemical process gives reproducible material at the quality expected from the Croda. In addition, Tween 80 are hydrophilic in a natural and soluble in the water. The combination of the Span 80 and Tween 80 can develop the stability of the emulsified biodiesel. The table 3.3 shows the properties of the Span 80 and Tween 80.

Figure 3.6: Span 80

Figure 3.7: Tween 80

Table 3.3: Properties Span 80 and Tween 80

Types of surfactant	**Span 80**	**Tween 80**
Density (kg/m^3)	0.099	0.106
Molar mass (g/mol)	428.60	NA
Hydroxyl Value	193 - 209	45-55

3.4 EXPERIMENTS PROCEDURES

3.4.1 Methods to Produce Emulsified Biodiesel

The objective of this experiment is to find the optimum method to produce emulsified biodiesel. For this experiment there were five different methods were applied. The optimum method was selected due to highest emulsion stability. Emulsion stability increase, the longest time taken for phase separation.

For the first method, water and biodiesel mix in the beaker and stir with the Mechanical Stir Machine at speed 800 rpm. After the mixture of water and biodiesel blended perfectly, the surfactant add to the mixture until all the mixture complete soluble. The second method, water and biodiesel mix in the beaker and stir using Mechanical Stir Machine at 800 rpm. The surfactant will add in the mixture water and biodiesel. The mixture will stir until the complete soluble. Third method for production emulsified biodiesel, biodiesel will stir with Mechanical Stir Machine at 800 rpm. During the biodiesel stir, the surfactant will add into the biodiesel until the surfactant and biodiesel soluble. After that water will add into mixture biodiesel and surfactant. The mixture will stir until the mixture completely soluble. This method most similar with method was used by Cherng Yuan Lin (Cheng Yuan Lin 2007).

For the fourth method, the biodiesel, water, and surfactant mix in the beaker then stir by using Mechanical Stir Machine at speed 800 rpm. The mixture stir until complete soluble. The fifth method , biodiesel will blended in the beaker. During the biodiesel blended, water will add into the biodiesel. Lastly the surfactant add into mixture water and biodiesel. The mixture will stir until completely soluble. All the method will stir at 15 minutes with speed 800 rpm. The best method will be choosing to produce emulsified biodiesel for the next experiment.

3.4.2 Effect of Variation Water and Biodiesel B20 Contain On Emulsion Stability

The first experiment for emulsified biodiesel, to investigate the stability of the emulsified biodiesel when produce with different contain of water and biodiesel. The longest time of the emulsified biodiesel change for phase separation is the highest emulsion stability. The result of experiment will carry out the optimum percentage of water and biodiesel to use for production of the emulsified biodiesel.

The method to proceed this experiment begins with pour the biodiesel B20 into beaker. The biodiesel B20 will pour at 100 ml in the beaker. To produce emulsified biodiesel that contain 5 % of water, the biodiesel B20 will remove at 5 ml from the beaker by using syringe. Same method will use for the production of emulsified biodiesel that contain 10 % and 15 % of water. The biodiesel B20 will stir using Mechanical Stir Machine at speed of the rotation is 800 rpm. The mixture will blended at 15 minutes. During the biodiesel B20 stir, the surfactant of Span 80 and Tween 80 will add into biodiesel B20. The volume surfactant Span 80 and Tween 80 will measure by using syringe and will pour in the biodiesel B20. The volume of Span 80 was fixed at 0.4 ml. When the mixture of biodiesel B20 and surfactant soluble, the water will add into the mixture. After 15 minutes, the mixture of emulsified biodiesel stop stirring and will store in the glass bottle. The emulsified biodiesel will observe until the emulsified biodiesel separate. The time of the emulsified biodiesel produce and the separation time of the emulsified biodiesel will record. The experiment will repeat three time to get the accurate result. The experiment repeated same method for another volume of water and biodiesel. Table 3.4 show the volume of water and biodiesel that use in this experiment.

Table 3.4: The volume of water and biodiesel

Formulation	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
B20 (ml)	95	95	95	95	90	90	90	90	85	85	85	85
Water (ml)	5	5	5	5	10	10	10	10	15	15	15	15
Tween 80 (ml)	1.5	1.6	1.7	1.8	1.5	1.6	1.7	1.8	1.5	1.6	1.7	1.8

3.4.3 Effect of Variation Span 80 to Emulsion Stability

The experiment to test the emulsion stability of the emulsified biodiesel with different volume of the Span 80 to get the optimum volume of Span 80 to produce the highest emulsion stability. The objective of this experiment to investigate the optimum volume of the Span 80 for production emulsified biodiesel. The optimum volume of Span 80 mean that the most suitable volume Span 80 to produce highest emulsion stability of the emulsified biodiesel. The excess or less volume Span 80 will affect to the emulsion stability of emulsified biodiesel. From this experiment, the result will show the best volume of Span 80 to produce emulsified biodiesel.

The method to run this experiment, firstly the biodiesel B20 will pour in to beaker at 95 ml. The biodiesel will stir with Mechanical stir Machine at mixing speed 800 rpm. The mixing time is 15 minutes. The volume of the Tween 80 was fixed 1.5 ml. The Tween 80 will add into the biodiesel B20 mixture. The Span 80 will add to the mixture at 0.4 ml. Both of the surfactant must add into mixture during biodiesel B20 stir. This is because to avoid the surfactant not completely soluble in the biodiesel B20. When the surfactant complete soluble in the biodiesel, water will add into the mixture. The surfactant and water add into the biodiesel by using syringe. The Mechanical Stir Machine will stop after the mixture of emulsified biodiesel stir at 15 minutes. The emulsified biodiesel will store into glass bottle. The experiment will repeat as the same step for the volume Span 80 0.5 ml, 0.6 ml, 0.8 ml and 1.0 ml. Each of the experiment will repeat about three time to get the accurate result. The emulsified biodiesel will observe until phase separation. The separation time of the emulsified biodiesel will record. Table 3.5 shows the volume of Span 80 that was use in the experiment.

Table 3.5: The volume of the Span 80

Formulation	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**
B20 (ml)	95	95	95	95	95	95
Water (ml)	5	5	5	5	5	5
Span 80 (ml)	0.4	0.5	0.6	0.7	0.8	1.0

3.4.4 Effect of Variation Mixing Speed to Emulsion Stability.

The experiment to test the emulsion stability of the emulsified biodiesel with different mixing speed of the mixture to get the optimum speed for the high emulsion stability of the emulsified biodiesel. The objective from this experiment is to investigate the emulsion stability of the emulsified biodiesel when use different mixing speed of the production an emulsified biodiesel. The different mixing speed can give the different emulsion stability of the emulsified biodiesel because the mixing speed can effect to the soluble mixture of the emulsified biodiesel. The emulsified biodiesel that show the longest time for phase separation will show the optimum speed of Mechanical Stir Machine for production emulsified biodiesel.

The method to run this experiment begins with pour 95 ml biodiesel B20 into the beaker. The biodiesel B20 measure by using syringe. The biodiesel B20 will stir by using Mechanical Stir Machine. The mixing speed of emulsified biodiesel will use at 700 rpm, 800 rpm, 900 rpm, 1000 rpm and 1200 rpm. For the first experiment use 700 rpm to stir the mixture of the emulsified biodiesel. The Span 80 and Tween 80 will add to the biodiesel B20 during the biodiesel B20 blended. The volume of Span 80 and Tween 80 was fixed at 0.6 ml and 1.5 ml. When the surfactant have soluble in the biodiesel B20, water will add into the mixture. After 15 minutes the Mechanical Stir Machine will stop and the emulsified biodiesel will store in the glass bottle. The emulsified biodiesel will observe until the emulsified biodiesel change to phase separation. The time of the emulsified biodiesel stirring and the separation time of the emulsified biodiesel will record. The experiment will repeat three time to get the accurate result. The experiment will repeat same method for the mixing speed at 800 rpm, 900 rpm, 1000 rpm and 1200 rpm. Table 3.6 show the speed to produce emulsified biodiesel use in this experiment.

Table 3.6: Mixing speed

Formulation	**C1**	**C2**	**C3**	**C4**	**C5**
Speed of stir (rpm)	700	800	900	1000	1200
B20 (ml)	95	95	95	95	95
Water (ml)	5	5	5	5	5

3.4.5 Effect of Variation Mixing Time to Emulsion Stability

The experiment to test the emulsion stability of the emulsified biodiesel with different mixing time of production. This experiment to find the optimum time to produce the highest emulsion stability of the emulsified biodiesel. In this experiment, the mixing time of the emulsified biodiesel will set as the manipulated variable. The mixing time of the emulsified biodiesel have set 10minutes, 15 minutes, 30 minutes, 45 minutes, and 60 minutes. From this experiment, the longest separtion time of the emulsified biodiesel will show the highest emulsion stability of the emulsified biodiesel.

The method to run this experiment begins with pour 95 ml of biodiesel B20 into the glass beaker. The biodiesel B20 will measure using syringe. After that, the biodiesel B20 will stir by using Mechanical Stir Machine at speed 800 rpm. During the biodiesel B20 stirring, add 1.5 ml Tween 80 and 0.7 ml Span 80 into the biodiesel B20. The volume of Span 80 and Tween 80 was fixed at 0.7 ml and 1.5 ml. When the mixture of biodiesel B20, Span 80 and Tween 80 soluble, water will add into the mixture. The water have measured by using syringe and pour in to mixture by using syringe. The mixing time of the mixture have set at 15 minutes by using stopwatch. After 15 minutes, the Mechanical Stir Machine stop and the emulsified biodiesel will store in the glass bottle. Observe the change of the emulsified biodiesel until the emulsified biodiesel separate. The separation time of the emulsified biodiesel will record. The experiment repeat three time for the accurate result. The experiment repeat with same method for 10minutes, 30 minutes, and 45 minutes of the mixing time for production emulsified biodiesel. Table 3.7 shows the mixing time that was used.

Table 3.7: Mixing time of emulsified biodiesel

Formulation	**DI**	**D2**	**D3**	**D4**
Time to stir (mint)	10	15	30	45
B20 (ml)	95	95	95	95
Water (ml)	5	5	5	5

3.4.6 View The Microstructure Of Emulsified Biodiesel.

The experiment to view the microstructure of emulsified biodiesel using the Metallurgical Microscope. The objective of this experiment to capture the view of the microstructure emulsified biodiesel. The specimen of the emulsified biodiesel will drop on the glass plate and put on the lenses of the microscope. The zoom of the microscope adjust until the microstructure view clearly. The light of the microscope will adjust to get the best view. The view of the microstructure-emulsified biodiesel will view on the screen of computer that connect to the microscope.

3.4.7 Effect of Variation Types of Biodiesel To The Emulsion Stability

The experiment of the effect of variation types of biodiesel to compare the emulsion stability when produce the emulsified biodiesel by using different types biodiesel. The result of experiment will carry out the most suitable types of biodiesel to produce the highest emulsion stability. The different types of biodiesel can effect the stabilization of emulsified biodiesel because each of the types of biodiesel had different of the properties.

The method to proceed the experiment starting by using the biodiesel B20 pour in the beaker at 95 ml. The biodiesel B20 will stirring by using the Mechanical Stir Machine at speed 1000 rpm. The surfactant Span 80 and Tween 80 will add into the biodiesel B20 at 0.6 ml and 1.5 ml. The volume of Span 80 and Tween 80 was fixed at 0.6 ml and 1.5 ml. When the mixture of biodiesel and surfactant soluble, water will add into the mixture. The mixture of emulsified biodiesel will blended at 15 minutes. The emulsified biodiesel will store in the glass bottle to observe the separation. The separation time of the emulsified biodiesel will record. The experiment repeat by using same method with using the biodiesel types B10, B30, B50 and B100. Table 3.8 shows the table use in this experiment.

Table 3.8: Types of biodiesel

Formulation	**E1**	**E2**	**E3**	**E4**	**E5**
Types of Biodiesel	B10	B20	B30	B50	B100
Biodiesel (ml)	95	95	95	95	95
Water (ml)	5	5	5	5	5

3.5 HLB CALCULATION

The Hyrophilic lipophilic balance (HLB) number give the meaning of the emulsifier is optimal in a water oil system where the properties of the oil match with the surfactants. The formulation HLB will use to produce the emulsified biodiesel. The HLB use to measure the mass surfactant will use. From the journal Effects of emulsification variable on fuel properties of two and three phase biodiesel emulsion by Cherng Yuan and Shiou An Lin (Cheng Yuan Lin 2007), the best stability emulsified biodiesel used HLB 13.

$$HLB = \frac{(H_A \text{ x } W_A) + (H_B \text{ x } W_B)}{(W_A + W_B)}$$

H_A : HLB of Span 80

$H_{B:}$ HLB of Tween 80

W_A : Mass of Span 80

W_B: Mass of Tween 80

$$\text{HLB} = \frac{(4.3 \times 0.7) + (15 \times 1.5)}{(0.6 + 1.5)}$$

HLB = 12

From the calculation, the HLB use in this experiment is 12 compare with the journal by Cherng Yuan Lin (Cheng Yuan Lin 2007). The final volume of the Tween 80 use is 1.5 ml and the final volume for Span 80 is 0.6 ml. The HLB from the experiment is most similar with the HLB from the theoretical.

CHAPTER 4

RESULT AND DISCUSSION

4.1 PRELIMINARY RESULT

4.1.1 Methods to Produce Emulsified Biodiesel

Table 4.1: Methods to produce emulsified biodiesel

Methods	**1**	**2**	**3**	**4**	**5**
Biodiesel B20 (ml)	95	95	95	95	95
Water (ml)	5	5	5	5	5
Span 80 (ml)	0.7	0.7	0.7	0.7	0.7
Tween 80 (ml)	1.7	1.7	1.7	1.7	1.7
Emulsion stability (h)	11	13	28	20	19

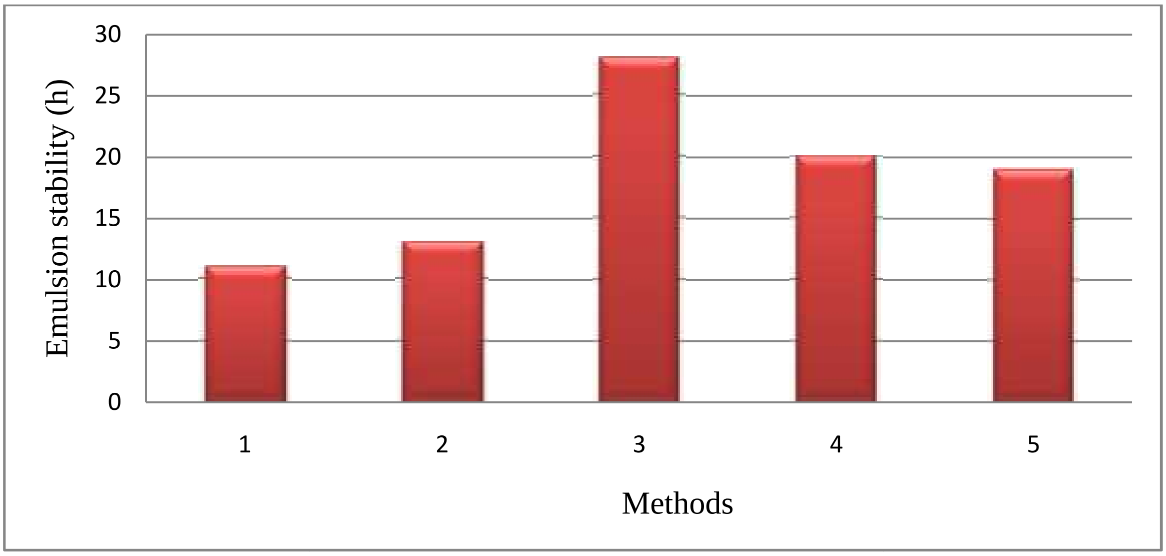

Figure 4.1: Emulsion stability against method to produce emulsified biodiesel

Figure 4.1 show emulsion stability against method to produce emulsified biodiesel. The graph shows the highest stability of an emulsified biodiesel when used method three which took 28 hour to phase separation. The graph have prove the method to produce emulsified biodiesel that was used by Cheng Yuan Lin (Cheng Yuan Lin, 2007). The emulsified produce by using method number three, the mixture in the emulsified biodiesel complete soluble.

4.2 EFFECT OF VARIATION WATER AND BIODIESEL B20 CONTAIN ON EMULSION STABILITY.

Table 4.2: Water and biodiesel content

Formulation	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
B20 (ml)	95	90	85	95	90	85	95	90	85	95	90	85
Water (ml)	5	10	15	5	10	15	5	10	15	5	10	15
Tween 80 (ml)	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	1.8	1.8
Span 80 (ml)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Emulsion stability (h)	11	4	2	9	3	2	7	3	1	4	2	2

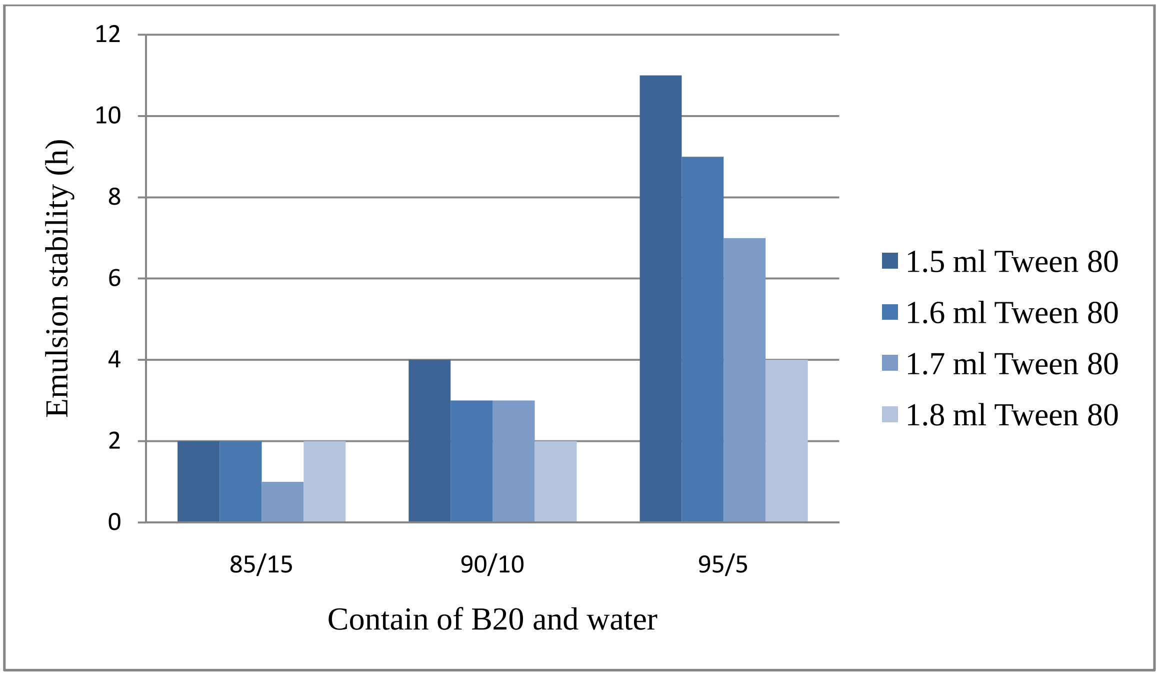

Figure 4.2: Emulsion stability against water and biodiesel contain.

Figure 4.2 show the emulsion stability against water and biodiesel contents. In this experiment the percentage of biodiesel B20 are use 85 %, 90 % and 95 %. While the percentage of water are use 15 %, 10 %, and 5 %. Each of the percentage of biodiesel and water test with 1.5 ml, 1.6 ml, 1.7 ml, and 1.8 ml of Tween 80 and 0.4 ml Span 80. In this experiment shows that formulation A1 have highest emulsion stability which take 11 hours to separate. The formulation A1 has highest emulsion stability due the present of the high volume of the fuel. The highest present of fuel in emulsified biodiesel can increase the stabilization of emulsion.

The lowest emulsion stability is formulation A9 which took only 1 hour for phase separation. This is happen because the surfactant Span 80 and Tween 80 not have enough volume for bonding attraction when the biodiesel that have excess of water. The excess of water can make the stability of emulsified biodiesel decrease when the hydrophilic emulsifier not enough to dispersed water phase in the emulsified biodiesel.

4.3 EFFECT OF VARIATION SPAN 80 TO EMULSION STABILITY

Table 4.3: Volume of Span 80

Formulation	B1	B2	B3	B4	B5	B6
B20 (ml)	95	95	95	95	95	95
Water (ml)	5	5	5	5	5	5
Tween 80 (ml)	1.5	1.5	1.5	1.5	1.5	1.5
Span 80 (ml)	0.4	0.5	0.6	0.7	0.8	1.0
Emulsion stability (h)	11	151	120	361	118	45

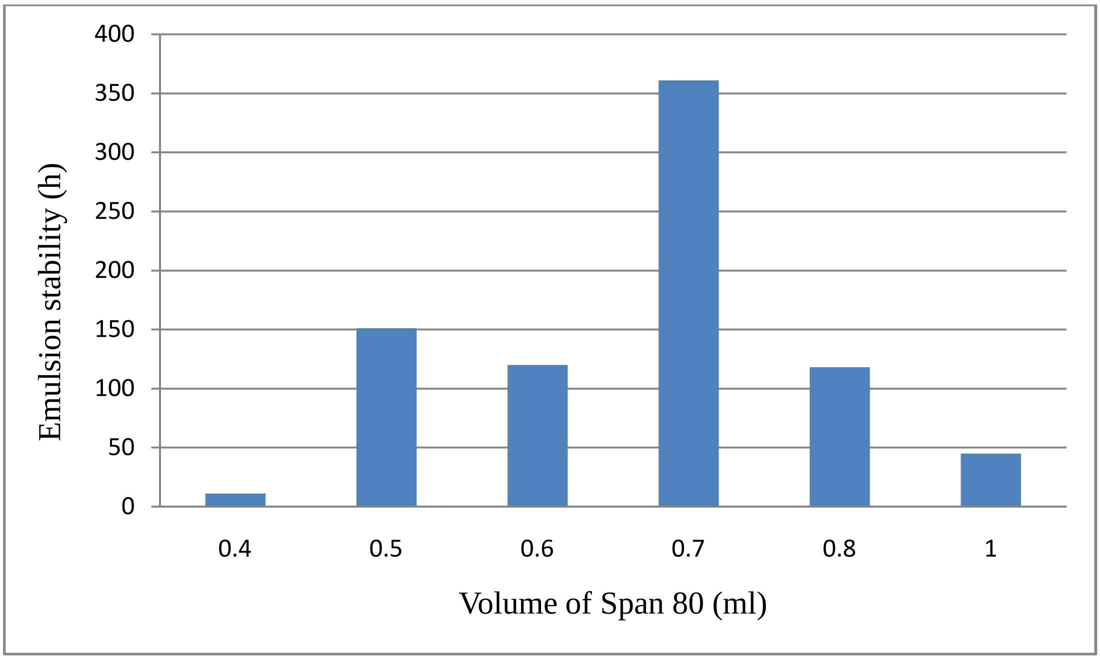

Figure 4.3: Emulsion stability against volume of Span 80

Figure 4.3 show the emulsion stability against volume of Span 80. In this experiment, Span 80 with range between 0.4 ml to 1 ml test on the 95 % of biodiesel B20 and 5 % of water. The volume of Tween 80 was set constant at 1.5 ml. From the experiment, formulation B4 shows the longest time for the emulsified biodiesel for phase separation. This is show the emulsified biodiesel mixture have the highest emulsion stability compare using other volume of Span 80. Span 80 is a lipophilic emulsifier (Cheng Yuan Lin, 2007). The function of the lipophilic to absorb the oil phase in the emulsified biodiesel. The emulsified biodiesel have high stability when use Span 80 at 0.7 g because the oil phase in the emulsified biodiesel can enhances the adhering effect between the outer biodiesel phase and the O/W phase.

The lowest emulsion stability of emulsified biodiesel was formulation B1 which took only 11 hours for phase separation. Form the figure 4.3 after 0.7 ml Span 80, the stabilization of emulsion decrease. This is happen because the excess of the quantity Span 80 in mixture emulsified biodiesel cause the stability lower. The excess or less the uses of Span 80 cause the emulsified biodiesel decrease emulsion stability because the excess or less of the lipophilic emulsifier.

4.4 EFFECT OF VARIATION MIXING SPEED TO EMULSION STABILITY.

Table 4.4: The stirring speed**.**

Formulation	**C1**	**C2**	**C3**	**C4**	**C5**
Stirring speed (rpm)	700	800	900	1000	1200
B20 (ml)	95	95	95	95	95
Water (ml)	5	5	5	5	5
Tween 80 (ml)	1.5	1.5	1.5	1.5	1.5
Span 80 (ml)	0.6	0.6	0.6	0.6	0.6
Emulsion stability (h)	240	120	23	40	39

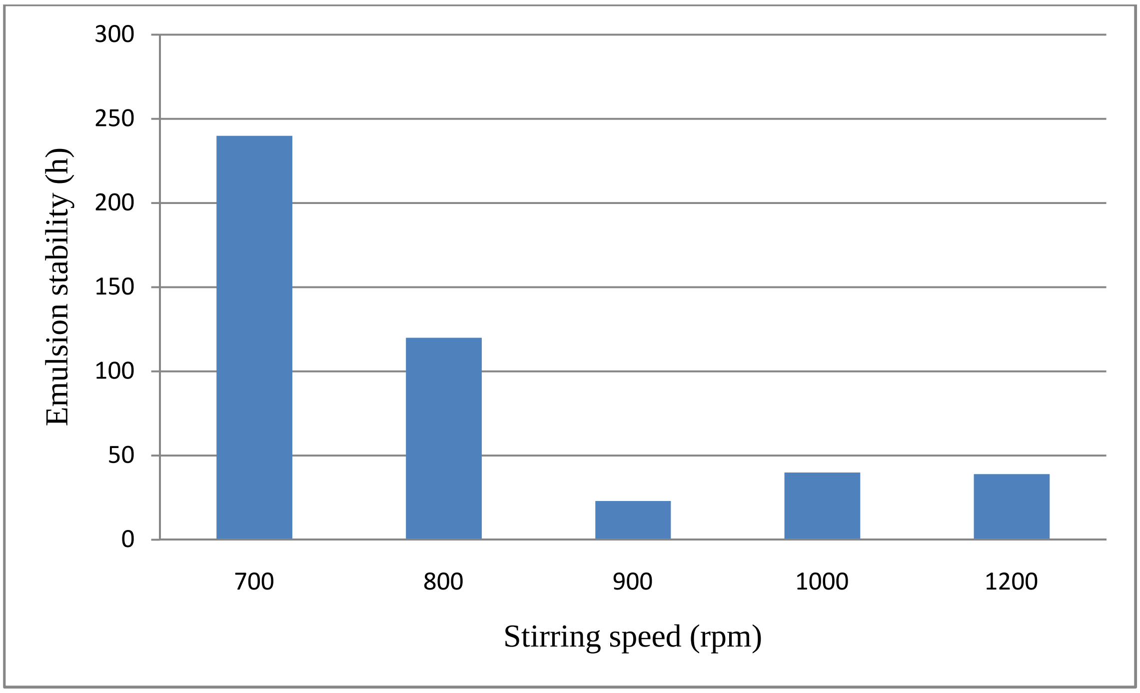

Figure 4.4: Emulsion stability against stirring speed

Figure 4.4 shows the graph emulsion stability against stirring speed. In this experiment, the speed test are 700 rpm, 800 rpm, 900 rpm, 1000 rpm and 1200 rpm. The graph shows the highest emulsion stability at stirring speed of 700 rpm which took 240 hours for phase separation. The highest stability happen when the greater relative velocity among all kinds of liquid element such as droplet and packing are affected by the rotation speed. The coalescence-dispersion of the liquid element will enhance the mixing efficiency of the emulsified biodiesel (Youzhi Liu, 2011).

The lowest emulsion stability when applied 900 rpm of stirring speed which took 23 hours for phase separation. The stirring speed more than 900 rpm have produce less emulsion stability because the extent of reduction in mass transfer resistances at high rotational speed was compensated for by a reduction of the residence time in the emulsified biodiesel (Youzhi Liu, 2011).

4.5 EFFECT MIXING TIME TO THE EMULSION STABILITY.

Table 4.5: The mixing time of emulsified biodiesel

Formulation	D1	D2	D3	D4
Mixing time (mint)	10	15	30	45
B20 (ml)	95	95	95	95
Water (ml)	5	5	5	5
Tween 80 (ml)	1.5	1.5	1.5	1.5
Span 80 (ml)	0.7	0.7	0.7	0.7
Emulsion stability (h)	148	361	170	145

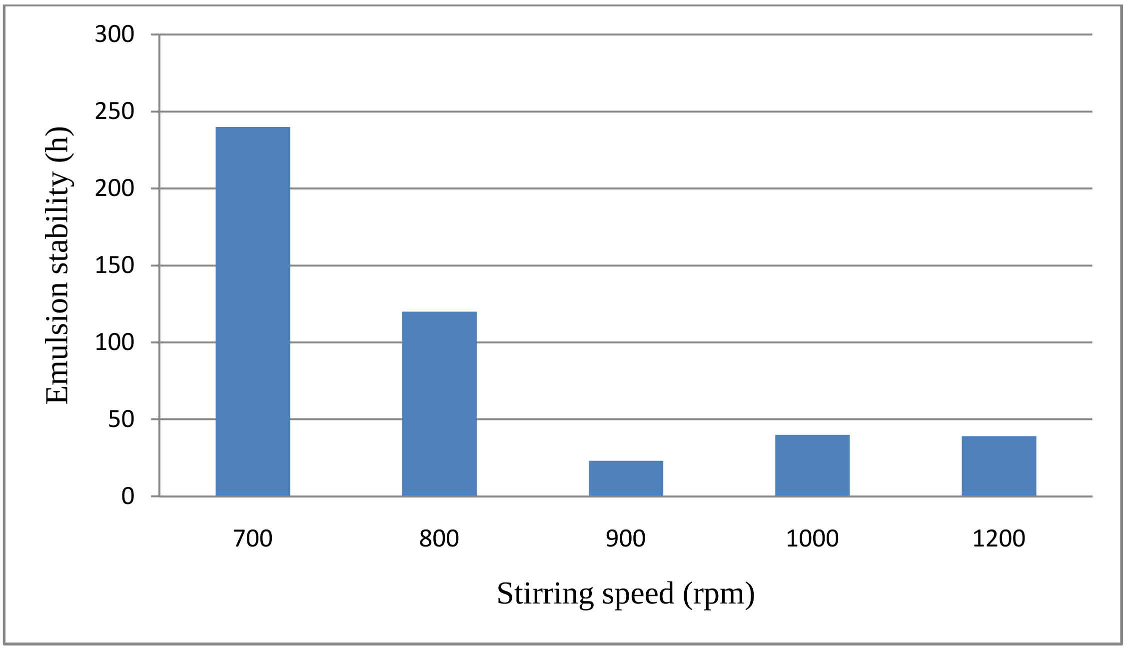

Figure 4.5: Emulsion stability against graph mixing time

Figure 4.5 shows the graph emulsion stability against graph mixing time. This experiment to find the most suitable mixing time for emulsified biodiesel production. The highest emulsion stability when applied 15 minutes for the mixing time which took 361 hours for phase separation. This is because emulsified biodiesel was stir at suitable condition which make vigorous impingement and homogeneous dispersion of the two liquid and result good condition in mixing efficiency. When the emulsified biodiesel mixing 10 minutes, 30 minutes and 45 minutes, the emulsion stability decrease because the emulsified biodiesel had stir in the condition are not suitable which make the liquid not dispersion of the two liquid water and biodiesel.

Figure 4.6: Photograph O/W emulsified biodiesel for 15 minutes mixing time.

Figure 4.7: Photograph O/W emulsified biodiesel for 30 minutes mixing time.

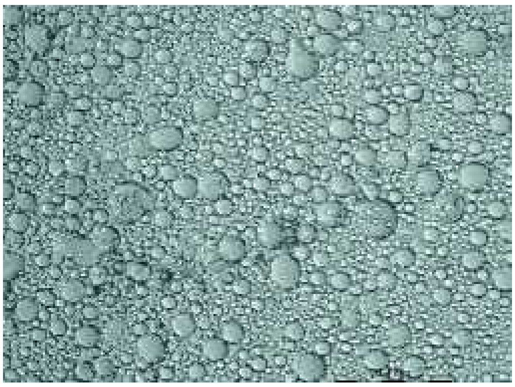

Figure 4.8: Photograph O/W emulsified biodiesel for 45 minutes mixing time.

Figure 4.6 until figure 4.8 shows the photograph of the O/W emulsified biodiesel. From the figure 4.6 until 4.8, the size of burble emulsified biodiesel for mixing 15 minutes smaller compare mixing time 30 minutes and 45 minutes. The emulsified biodiesel which mixing 15 minutes has highest emulsion stability compare emulsified which mixing 30 minutes and 45 minutes because the bonding in the mixture more stabile. The emulsified biodiesel which mixing 45 minutes has large size of the burble and have less emulsion stability because weak of the bonding in the mixture.

4.6 EFFECT VARIATION TYPES BIODIESEL TO THE EMULSION STABILITY

Table 4.6: Different types of biodiesel

Formulation	**E1**	**E2**	**E3**	**E4**	**E5**
Types of Biodiesel	B10	B20	B30	B50	B100
Biodiesel (ml)	95	95	95	95	95
Water (ml)	5	5	5	5	5
Tween 80 (ml)	1.5	1.5	1.5	1.5	1.5
Span 80 (ml)	0.6	0.6	0.6	0.6	0.6
Emulsion stability (h)	145	361	8	9	5

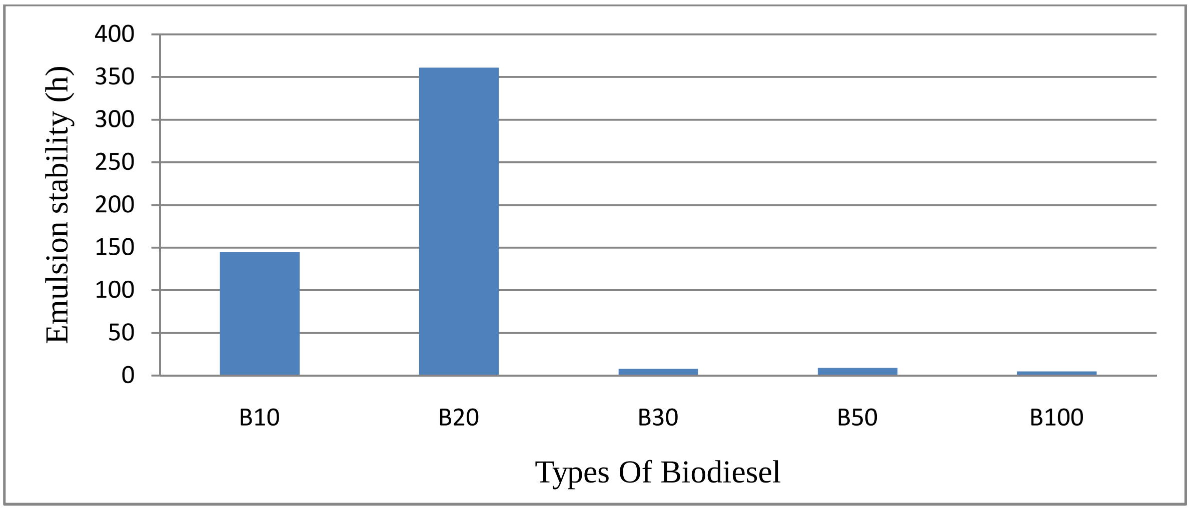

Figure 4.9: Emulsion Stability against types of biodiesel

Figure 4.9 show the graph, emulsion stability against types of biodiesel. The emulsified biodiesel that used biodiesel B20 have highest stability. The lowest emulsion stability when used biodiesel B100, B50 and B30. The present of the diesel fuel can increase emulsion stability of the emulsified biodiesel. The stability emulsified biodiesel increase as the increase quantity of diesel fuel. From this experiment, the biodiesel B20 is the most suitable use for the production of the emulsified biodiesel.

4.7 FORMULATION OF EMULSIFIED BIODIESEL.

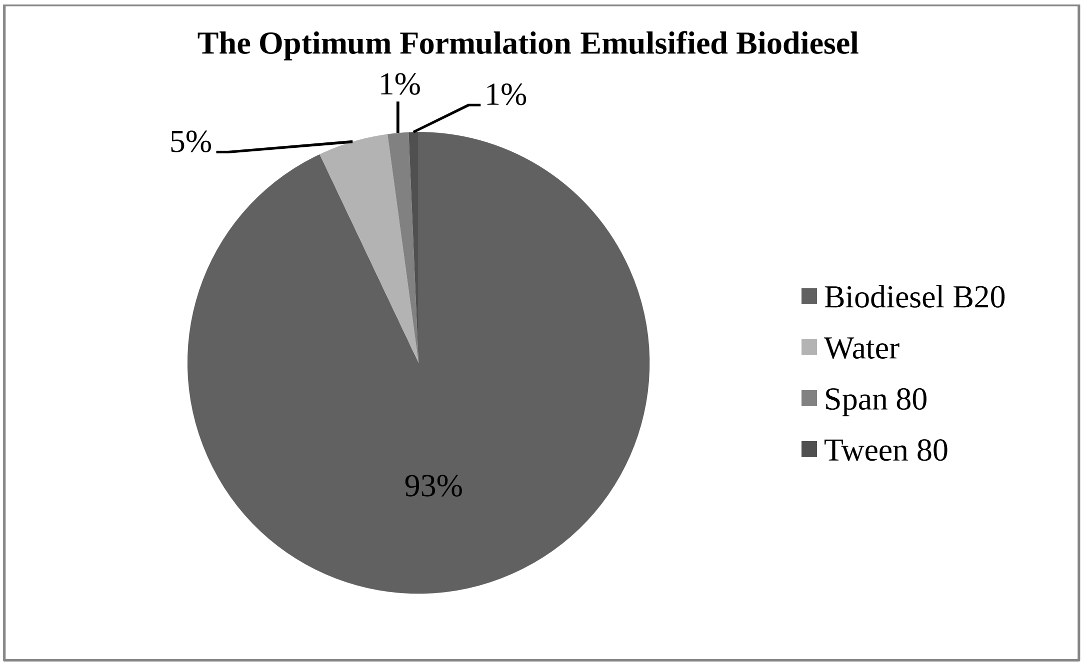

Figure 4.10: The optimum formulation emulsified biodiesel

Figure 4.10 shows the Pie Chart the best formulation emulsified biodiesel. From the figure 4.10 show the biodiesel B20 use about 93 % use to produce emulsified biodiesel. The percentage use for water is 5 % and 1 % for surfactant Span 80 and Tween 80. From the previous experiment, this formulation emulsified biodiesel take 361 hour to separate. The time for stir the emulsified biodiesel is 15 minutes. From the experiment to test the most stability of emulsified biodiesel with different time, 15 mint of stir show the best stability of emulsified biodiesel. From there, the most suitable for the time to stir is 15 minutes. While the speed of the stir is 700 rpm. From the experiment to study the stability emulsified biodiesel with different speed of stir. The best stability when the emulsified biodiesel stir at 700 rpm. From result of experiment, the speed at 700 rpm the most suitable for stir mixture emulsified biodiesel. This formulation born from the experiment formulation D2.

Figure 4.11: Emulsified biodiesel after production

Figure 4.12: Emulsified biodiesel at phase separation

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The objective of the study is to find out the optimum formulation and method to produce the highest emulsion stability for emulsified biodiesel. In this study, the stability of the emulsified biodiesel test with different contain of water and biodiesel B20, variation stirring speed, mixing speed, volume of Span 80, and volume of Tween 80.

There are several conclusion that can be drawn from the experiment of the project. From the various of experiment, 95 % biodiesel B20 and 5 % water show the highest emulsion stability of the emulsified biodiesel. The most suitable quantity of the Span 80 and Tween 80 are 0.7 ml and 1.5 ml. From the experiment, the longest time for the emulsified biodiesel separate which is 361 hour equal to 15 days.

In addition, the lowest emulsion stability of emulsified biodiesel when 85 % of biodiesel B20 and 15 % of water used. This is happen because the bonding of the emulsified biodiesel weak when contain of the water excess in the emulsified biodiesel. These make the chemical bonding between biodiesel and water weak.

At the end of the project, the best formulation of the emulsified form. The quantity of the biodiesel B20, water, Span 80 and Tween 80 was convert to the percentage and present in the Pie chart. The best formulation emulsified biodiesel is 93 % of biodiesel B20, 5 % of water, 1 % Span 80 and 1 % Tween 80. The best method to produce emulsified biodiesel is the biodiesel stir first. During the biodiesel stir, the

Span 80 and Tween 80 add to the biodiesel B20. The last method is add the water when mixture biodiesel and surfactant soluble.

5.2 RECOMMENDATIONS

There were several recommendations that could be considere for next research which are stated as follow:

i) For the improve the experiment, test the different types of the biodiesel such as biodiesel made up from the soya bean, fat oil, wasted cook oil and other source. From this experiment, the result of the stability of the emulsified biodiesel can compare to get the best material to produce emulsified biodiesel.

ii) Furthermore, the further experiment can use water in the gas state. From this experiment, we can study the best emulsified biodiesel that produce using water solid state or gas state. The various method and formulation need to study improve the stability emulsified biodiesel.

iii) For the further study of emulsified biodiesel, the emulsified biodiesel have store in the measuring beaker and set constant day for the observation. At the final day of the observation, the change of the emulsified biodiesel record. The parameter for record is the volume of the water separate from the oil. From this method, the result of the change emulsified biodiesel more accurate.

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