FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

SASIDHARAN A/L ARUMUGAM

BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (AUTOMOTIVE TECHNOLOGY) WITH HONOURS

2021

Faculty of Mechanical and Manufacturing Engineering Technology

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

SASIDHARAN A/L ARUMUGAM

Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

2022

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

SASIDHARAN A/L ARUMUGAM

A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

Faculty of Mechanical and Manufacturing Engineering Technology

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2022

DECLARATION

I declare that this Choose an item. entitled “Tensile Properties Of HDPE Exposed To Biodiesel” is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	
Name	:	SASIDHARAN A/L ARUMUGAM
Date	:	18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours.

Signature :

Supervisor Name : EN. HAIRUL BIN BAKRI.

Date : 18/1/2022

DEDICATION

My dissertation is dedicated to my family and many friends. A special thanks to my beloved parents, Arumugam and Lecthumy, whose words of support and persistence continue to echo in my ears. Kalaivani, Nethiyasri, and Devandran, my sisters and brother, have never left my side and are very precious to me. I shall be eternally thankful for everything they have done for me, particularly Pavithiran's help in developing my technological abilities, Eeswaran's many hours of proofreading, and Tan's assistance in mastering the leader dots. I dedicate this work to my dearest friends, and I thank them all for being there for me during the project. You've both been my biggest supporters. ACKNOWLEDGEMENTS I would want to express my gratitude to my committee members who went above and beyond the call of duty.

ABSTRACT

Biodiesel is an alternative diesel fuel made from plant oils and animal fats. It is made up of monoalkyl esters that are produced when triglycerides in oil or fat are stimulated to react with simple monohydric alcohol. Transesterification of oils with short-chain alcohols or esterification of fatty acids create biodiesel. HDPE (high-density polyethene) is a plastic resin produced by copolymerizing ethylene with a tiny quantity of another hydrocarbon. HDPE is widely utilized as a primary material in the film, pipe, and container sectors. In this study, HDPE storage tank is used for Biodiesel production. However, HDPE as a storage tank for Biodiesel production has a problem with degradation and a decrease in strength. From the hardness test, B10 under 50 °C shows the highest decrement value compared with other HDPE samples, and B30 under room temperature shows the lowest decrement value compared with other HDPE samples. From the tensile test, the young modulus of B10-RT is the highest compared with other HDPE samples in week 1, and the young modulus of B10-T50 is the highest compared with other HDPE samples in week 2. High young modulus changes its shapes only slightly.

ACKNOWLEDGEMENTS

First and foremost, I would like to thank and praise to the God, my Creator, my Sustainer, for everything I received since the beginning of my life. I would like to extend my appreciation to the Universiti Teknikal Malaysia Melaka (UTeM) for providing the research platform. Thank you also to the Malaysian Ministry of Higher Education (MOHE) for the financial assistance.

My utmost appreciation goes to my main supervisor, Mr Hairul Bin Bakri for all his support, advice and inspiration. His constant patience for guiding and providing priceless insights will forever be remembered.

Last but not least, from the bottom of my heart a gratitude to my friends for encouragements and who have been the pillar of strength in all my endeavors. I would also like to thank my beloved parents for their endless support, love and prayers. Finally, thank you to all the individual who had provided me the assistance, support and inspiration to embark on my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

HDPE is a thermoplastic substance made up of carbon and hydrogen atoms that are bonded together to produce high molecular weight products. The British employed it to insulate radar wires during World War II, which was its initial commercial application of HDPE. In 1953, Erhard Holzkamp and Karl Ziegler of the Kaiser Wilhelm Institute created high-density polyethylene (HDPE). Catalysts and low pressure were used in the process, which is the foundation for the creation of a wide range of polyethylene compounds. (Gibson, 1963). High Density Poly Ethylene is one of the most desirable materials for future storage tanks (HDPE). It's also a little tougher and opaque, and it can endure somewhat greater temperatures of 120 °C or 248 °F for less duration. Because of its flexibility, HDPE fuel tank can be used to store Biodiesel. This material is recognized for its excellent chemical resistance as well as its ability to decrease fuel penetration. (Nurul Komariah *et al.*, 2017) .According to a recent research by Christensen and L.McCormick (2014), biodiesel blends stored in polyethylene fuel tanks were stable for 380 days when kept at 23 °C, while formation of peroxides and acids was found after 56 days of storage at a higher temperature (80 °C). However, tests involving the storage of biodiesel blends in HDPE and other polymeric materials are currently ongoing. Besides this, the regarding of project towards Biodiesel is production of Biodiesel from waste cooking oil and storage of waste cooking oil for a maximum of two months for vehicle used at the university. The most common storage tank for Biodiesel production is HDPE. A complete research is needed on the capability of HDPE as a storage tank that required for the construction of such reactors.

1.2 Problem Statement

HDPE as storage tank for Biodiesel production undergoes the process of degradation and decrease in strength. HDPE storage tank may be failure by external factors such as stress crack caused by heat and pressure but however HDPE storage tank that contain Biodiesel has low performances due to exposure of Biodiesel to HDPE. So, a detailed study is needed to see the effect of using HDPE as a storage tank.

1.3 Research Objective

There are some objectives that need to be achieved from this project, which are:

i) To determine the tensile and hardness properties of HDPE immersed in Palm Oil Biodiesel

ii) To investigate the effect of Biodiesel concentration on the performances of HDPE

1.4 Scope of Research

There are a few guidelines proposed to ensure that this project meet the objective requirement based on the work scope of the project. The scopes are:

I. Concentration of Palm Oil Biodiesel are B10 (10% pure biodiesel and 90% is FAME) and B30 (30% pure biodiesel and 70% are FAME)

II. Storage temperature under 27°c or room temperature and 50°C

III. Storage durations is up to 336 hours approximately 2 weeks

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Two organic chemists from the Imperial Chemical Industries Research Laboratory were evaluating several compounds on March 27, 1933. The white, waxy material R.O Gibson and E.W. Fawcett were testing would turn out to be a revolutionary chemical that would transform the world, much to their astonishment. Polyethylene became a reality. In an autoclave, the researchers started a reaction between ethylene and benzaldehyde. Their testing container appeared to have sprung a leak, allowing all of the pressure to escape. There was a white, waxy material that looked suspiciously like plastic. The scientists found that the pressure loss was caused in part by a leak, but that the major reason was the porosity, after carefully repeating and assessing the experiment. A year later, the material's first practical application as a film was discovered. HDPE was developed by Karl Ziegler of the Kaiser Wilhelm Institute and Erhard Holzkamp in 1953. HDPE was first manufactured as a pipe two years later, in 1955. It was originally employed as an undersea cable coating, then as a key insulating material for military applications such as radar insulation. This is because it was so light and thin that it allowed radar to be installed on airplanes, greatly decreasing the weight. The substance's identity was kept a closely guarded secret. Polyethylene became a huge popularity with customers after the war. . It was the first plastic to sell more than a billion pounds per year in the United States. It is now the world's most widely used plastic. Polyethylene currently possesses good moisture-vapor, chemical, and electrical resistance. It's used to make Containers for biodiesel, wire cable insulation, pipe, linings, coatings, and engineered films, among other things. It's used in a wide range of products, including power transmission, consumer goods, packaging, electronics, and household items. Its main drawback is its lack of mechanical strength, unless it is aided with scrim reinforcement. As technology advances, its usefulness improves, produce it the high effective use of natural resources such as petroleum and natural gas. Nana Hinsley (2015). Polyethylene is the most widely manufactured polymer in the world, with approximately 90 million metric tons produced each year. Nowadays, HDPE is highly demand material that has been use as storage tank for Biodiesel production.

Figure 2.1 The raw material of HDPE

2.2 Biodiesel

Biodiesel is made from biomass, which is a renewable energy source. Transesterification of animal fat or oil can be used to make it. It's produced from soybean, cottonseed, canola, and corn oil, as well as recycled cooking greases like yellow grease and animal fats like cow tallow and pig lard, and various combinations of these components. Transesterification is the process of converting triglycerides into fatty acid alkyl ester in the presence of another alcohol and a catalyst with glycerol as a byproduct. It has also been proposed to carry out for supercritical temperatures, a chemical reaction occurs. without the need of a catalyst. Biodiesel is sustainable and biodegradable since it is manufactured completely from vegetable oil or animal fats. Biodiesel also has a low Sulphur content, as well as polycyclic aromatic hydrocarbons and metals. Diesel fuel generated from petroleum can contain up to 20% polycyclic aromatic hydrocarbons. Polycyclic aromatic hydrocarbons are up to three orders of magnitude more soluble in water than straight chain aliphatic hydrocarbons for an equal amount of carbon atoms. Biodiesel is a safe option for transit and storage since it does not contain polycyclic aromatic hydrocarbons. (Vasudevan and Briggs, 2008)

2.2.1 Type of Biodiesel

Biodiesel comes in a variety of concentrations and can be mixed. B5 (up to 5% biodiesel) and B20 (up to 20% biodiesel) are the most prevalent (6 percent to 20 percent biodiesel). B100 (pure biodiesel) is most commonly used as a blend stock for lesser blends and is seldom utilized as a transportation fuel. Biodiesel blends including B100 have been effectively utilized in underground mining equipment. Biodiesel's potential to minimize emissions and human exposure to this criterion pollutant has prompted the industry to use greater biodiesel mixes. B20 is a popular blend because it offers an excellent mix of economy, emissions, cold-weather performance, compatibility of materials, and solvent capabilities. Although B20 with 20% biodiesel content has 1% to 2% less energy per gallon, it is reported that B20 apparent difference in performance or fuel efficiency. Biodiesel also offers certain emissions advantages, particularly for engines made with biodiesel.(Sarno and Iuliano, 2019).

2.2.2 Method of Biodiesel Production

Biodiesel manufacturing can take place on a batch or continuous basis. Most companies favour batch size production because it is simple, cost-effective, and requires less skilled employees. Transesterification can be accomplished in a variety of ways. The lab scale batch reactor is the most widely utilized among them.

2.2.2.1 Batch reactor technique on a lab scale

A reflux condenser, a magnetic stirrer, and a round bottom flask with three or two necks are used in the majority of these reactors. For the production of biodiesel, this sort of reactor is employed in labs. The three necked round bottom flask shown in Figure 2.2.2.1 is linked to the condenser, thermometer, and Erlenmeyer.

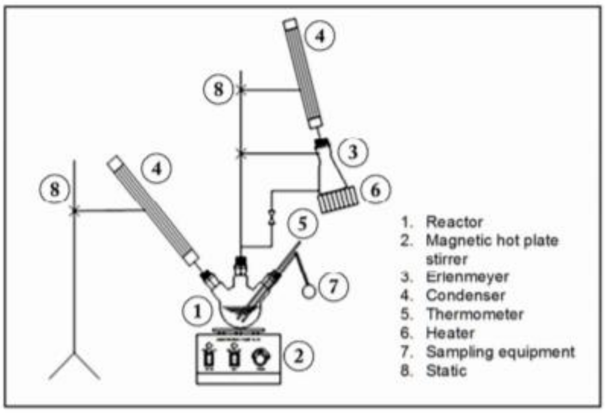


Figure 2.1 Batch reactor for transesterification

The catalyst is combined with alcohol after the titration that determines the amount of catalyst required for the reaction, after that, it's combined with oil in the reactor. continually stirred. When the reaction is finished, the result is a two-layer product that is separated using a separating funnel. Biodiesel is on top, while Glycerol is on the bottom. The generated biodiesel is then rinsed with water to eliminate any not react with alcohol or catalyst. By reacting with Na2SO4, the water in the product can be eliminated. When utilizing methanol as an alcohol, the reaction temperature is usually kept between 55 and 650 degrees Celsius. The ethanolysis of animal fat takes place at a temperature of 300°C. It was claimed that Using a 6:1 methanol to oil ratio, NaOH 1percent wt/wt as catalyst, and a 60 1 °C temperature for 1 to 3 hours while continually stirring at 300 rpm, 80 percent yield of Biodiesel could be generated from WCO in a lab scale batch reactor.

2.2.2.2 Pilot Scale Reactor method

Around 100 litres of biodiesel are processed in a trial facility. The elements impacting the reaction, such as reaction temperature, type and quantity of alcohol utilized, agitation rate, catalyst type, and original oil properties, were investigated in a study using a pilot scale facility for the manufacture of biodiesel. Using UVO with 3 percent FFA, a 6:1 molar ratio of methanol to oil, and a catalyst NaOH concentration of 0.5 percent w/woil an optimization procedure was carried out to produce a yield of 94.3 percent biodiesel with a density of 0.875 g/cm3.

Figure 2.2 depicts the layout of the pilot plant as well as an image of it. A pilot plant is constructed consisting of a Jacketed stainless steel reactor with a 100-liter capacity R1 as shown in figure 2.2. WCO is filtered by filter F1 before being injected into the reactor. This is a fully automated procedure. The catalyst and reagent are kept in two tanks, D1 and D2, and are supplied to the reactor automatically based on volume and FFA percent. To remove waste material residues, the biodiesel is filtered through an ionic resin filter F2, and wastes the bottom of the reactor is cleaned of reaction products.. All characteristics are tracked by a touch screen interface for a computerized system.

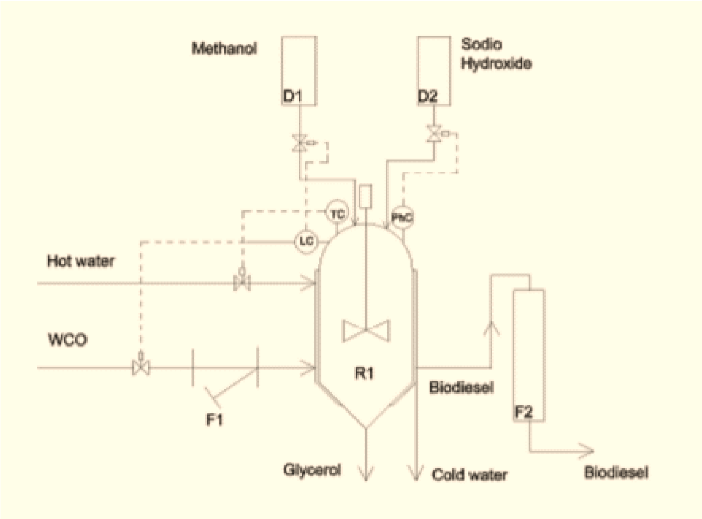


Figure 2.2 The configuration of the pilot plant

2.2.2.3 Method of using a bubble column reactor

This reactor is really beneficial for making biodiesel from low value alcohol and lipids. As a result, it is possible that the feedstock and production costs may be lowered. At a temperature of 120 °C and a pressure of 10 bar, a conversion of 95% was obtained in less than 2 hours using a bubble column reactor with a less grade vegetable oil including higher percentage of water and an FFA and also Methanol until oil molar ratio below than 3:1.

Figure 2.3 Pilot plant for biodiesel production

Figure 2.3 depicts a bubble column reactor in schematic form, illustrating the bubbling activity of the reactor as well as the transfer of water and methanol from the liquid to the vapour phase. A glass column jackets the bubble column reactor. The reactor is generally run at 120 degrees Celsius with 180 millilitres of lipid from the feedstock. The column's top is open to the elements, allowing alcohol and water to flow freely through the reactor and into a fume hood where the tests are conducted. To produce a catalytic solution, sulfuric acid was combined with a little amount of alcohol. A peristaltic pump adds this solution to the reactor at the top during the first 5 minutes of the reaction. Methanol is vaporized using heat exchangers. Alcohol is pumped using syringe pumps.

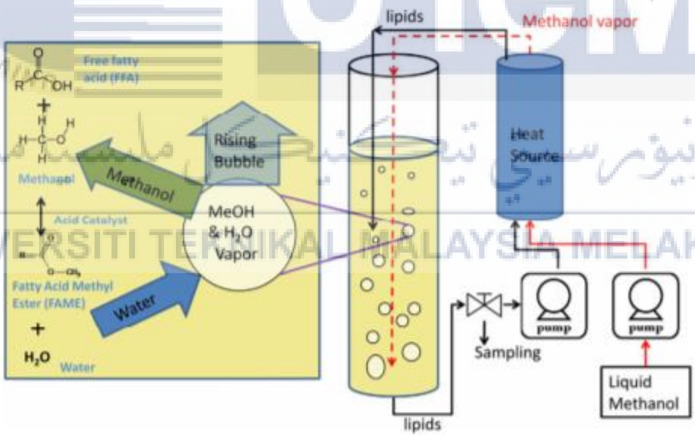


Figure 2.4 The bubbling activity of the reactor, as well as the transfer of water and methanol from the liquid to the vapour phase, are depicted in this schematic.

2.2.2.4 Microwave Methodology

The heat for the reaction is provided by a microwave oven in this approach. Figure 5 depicts the microwave reactor's setup.

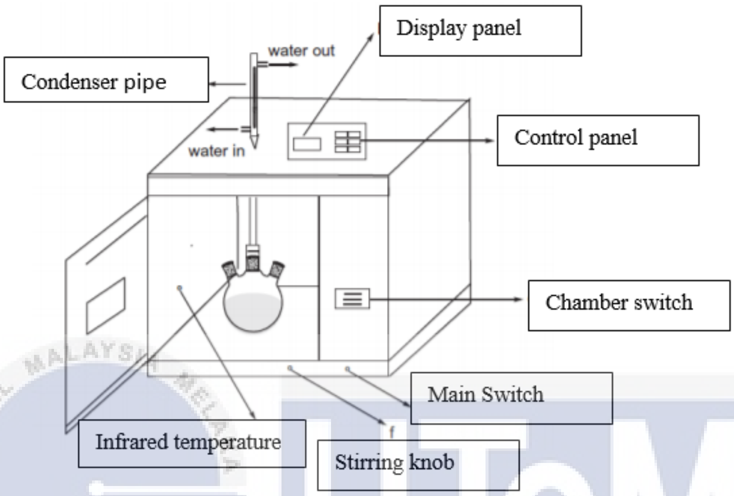


Figure 2.5 The microwave accelerated reaction mechanism is depicted

Traditional heating esterification (THE) was compared to cation ion exchange resin particles catalytic membrane with microwave aided esterification (MAE) discovered that MAE requires less reaction time, temperature, energy, and methanol additive than other methods. Under the ideal circumstances of reaction temperature 60°C, methanol or acidified oil mass ratio 2.0:1, catalytic membrane loading 3 g, microwave power 360W, and reaction period 90 minutes, FFA conversion reached 97.4%. Microwave biodiesel synthesis is therefore a quick, green, simple, and successful method with the benefits a quick reaction period, a low mass ratio of methanol or acidified oil, simplicity of operation, lower energy usage, and lower production costs. In this procedure, catalysts that are heterogeneous can be used to get around the limits of liquid acid catalysts.

2.2.2.5 Method of electrolysis

This method, which includes that at the anode and cathode, water is hydrolyzed, may directly use feedstock with a high water content. Figure 2.6 depicts photographic pictures of an electrolytic cell and the biodiesel manufacturing device. There are two graphite electrodes separated by 15 millimetres in the image. The electrolytic-assisted cell is filled with reactants.

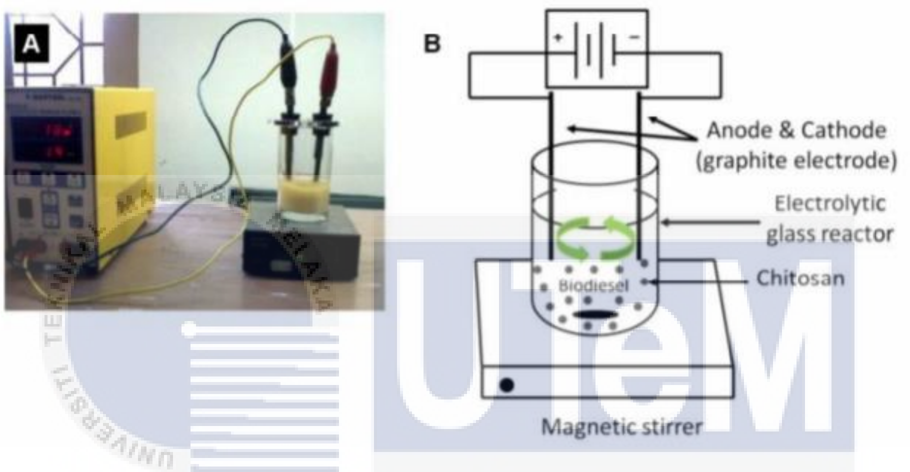


Figure 2.6 Pictures of an electrolytic cell (A) and a biodiesel manufacturing equipment

The electrolysis method was used to investigate the common usage of Chitosan (Organo metallic catalyst) for Biodiesel. The combined usage of the electrolysis procedure and 10% chitosan applied in 4 hours resulted in a conversion of 59.1 percent. The electro-assisted cell was filled with a reaction mixture including frying oil, methanol, Tween 80, chitosan, deionized water, and NaCl as a supporting electrolyte. Methanol to oil molar ratio was changed to 24:1 and co-solvent to methanol molar ratio to 100:1. The concentration of NaCl in the sample was 0.56 percent wt/wt. Electrolysis was performed at room temperature with an 18 V constant voltage (DC). A magnetic stirrer was used to agitate the reaction mixture. (Sarno and Iuliano, 2019)

2.3 HDPE

High-density polyethylene (HDPE) is a kind of plastic with a high density. It's a popular thermoplastic resin that's produced from natural gas or acquired through petroleum refining. Polyethylene may be formed into polymer chains at low or high pressure (polymerization). High Density Poly Ethylene is one of the most favored materials for future storage tanks (HDPE). Because of its flexibility, an HDPE fuel tank might be utilized for fuel storage. This material is recognized for its excellent chemical resistance as well as its ability to decrease fuel penetration.

2.3.1 Type of HDPE

High density polyethylene, which provides longer chains with fewer side branches more crystallinity and therefore rigidity, hardness, strength, and heat resistance are all improved.. HDPE comes in a variety of forms.(Colin Cronin,).

2.3.1.1 HDPE blow-molded

Blow molding is a manufacturing technique in which plastic is melted and shaped into a preform. The heated preform is then pushed against a mold cavity with the help of compressed gas. Milk and detergent containers are frequently made via blow molding.

2.3.1.2 Injection-molded HDPE

Material is delivered into a heated barrel, mixed, and forced into a mould cavity in an injection-mold process. The plastic solidifies and cools to the shape of the mould cavity. The cavity is usually made of steel or aluminum and is particularly tailored to produce the desired shape's characteristics. Butter and yoghurt containers are frequently made via injection molding.

2.3.1.3 HDPE in Variety of Colour and Texture

When HDPE is heated, it can also include colour pigments that are blended in. The term "natural HDPE" refers to a tone that is transparent or semi-translucent. These bottles have strong barrier qualities and rigidity, making them ideal for packing perishable goods like milk. Because the pigments assist enforce chemical resistance, coloured HDPE containers offer superior stress fracture resistance. They are often used for goods with lengthy shelf life, such as laundry detergent and shampoo.

2.3.2 Application of HDPE

After heating to a very high temperature, high density polyethylene (HDPE) is a form of plastic that can be moulded into a number of shapes. It's tough, as shown by its high strength-to-density ratio, and its density may be adjusted to meet the demands of different applications. HDPE is also resistant to a wide variety of chemicals. The following are a few of the most popular applications for high-density polyethylene (HDPE).(TANGENT, 2019).

2.3.2.1 Containers

Because HDPE does not leach into its environment, it may be used to build containers that are suitable for storing a huge range of chemicals. HDPE is commonly used in beverage containers such as milk jugs and reusable water bottles. HDPE, as previously noted, is chemically resistant, making it ideal for storing shampoo, conditioner, laundry detergent, and antifreeze. HDPE is included in even the recycling containers we use at home. HDPE delivers security and resistance in all of its holding activities without damaging the environment.

2.3.2.2 Pipes and Coverings

HDPE pipes benefit from the same characteristics that make it so helpful in containers. HDPE pipes are chemically resistant, allowing them to convey a wide range of liquids and serve as an outer cover for cables and wires. HDPE can resist temperatures ranging from -220°F to 180°F when appropriately reinforced for this purpose. Sewer, water, and gas pipes, as well as coatings over automobile wires, are examples of HDPE applications.

2.3.2.3 Plastic Lumber

HDPE is included in plastic timber, a type of structural building material. Utilized, recycled bottles are frequently used in this process, giving post-consumer trash a new lease on life. Depending on the purpose at hand, plastic timber might be flexible or stiff. Smaller things, such as playground components and furniture, are made of softer materials since they do not have to support a lot of weight. Professionals can make plastic timber stronger with reinforcing made of materials such as fiberglass for decks and coastal retention. People may use it as an effective alternative to more conventional but more difficult to maintain materials like wood, stone, or concrete because of its flexibility. It might also be used in conjunction with these other materials to increase the water resistance of a construction, as moisture cannot permeate into HDPE.

2.4 Issues and Challanges of HDPE as Biodiesel Storage Tank

High-density polyethylene (HDPE) is a popular thermoplastic used to make containers for storing and transporting hazardous materials, as well as polymeric fuel storage tanks. Because of its strong chemical and environmental resistance, HDPE is one of the most often utilized thermoplastics for biodiesel and other fuel tank uses. The sorption behavior of the fuels on the polymer, such as kinetics and ultimate equilibrium concentration, is the initial physical effect of the fuels on the polymer. Only a few research has been conducted on the chemical consequences of long-term immersion of HDPE in biodiesel-induced degradation.

2.5 Types of Tests for measure and analyze the issues and challenges of HDPE as Biodiesel Storage Tank

Fully submerged bulk tensile test specimens are used to simulate the physical effects of fuel sorption on HDPE. Partially submerged specimens are used to investigate the chemical effects on polyethylene. For example, deterioration, to guarantee a strong oxygen supply at the air-fuel interface and a much longer exposure. The tensile test was used to examine the degradation-induced changes. A more thorough post-fracture examination was carried out using optical and scanning electron microscopy. The extent of fuel and polymer oxidation with increasing storage duration was studied using FT-IR/ATR spectroscopy to track the carbonyl group development.(Erdmann, Böhning and Niebergall, 2019).

2.5.1 The Tensile test

The tensile tests performed with the use of pneumatic sample holders and a software tester. All tensile tests conducted in a controlled environment with a relative humidity of 50% and a testing speed of 5 mm/min. By measuring the initial cross-sectional areas of the specimens before the tensile test, the nominal tensile stress was determined. The swelling impact was taken into consideration for the specimen's sorbet with fuel. All experiments were carried out in at least three different ways.

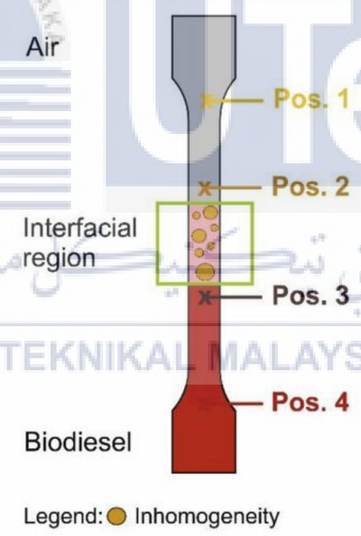


Figure 2.7 After being partially immersed in biodiesel, a tensile test specimen is sketched.

2.6 Summary

From the literature review, history and development of HDPE as Biodiesel storage tank is discovered from the initial use until now. The biodiesel is a kind of diesel fuel produced using long-chain unsaturated fat esters obtained from plants or animals. The material that made up of HDPE is used as a storage tank for Biodiesel production according to the previous study. The physical and chemical effects on the usage of HDPE as Biodiesel storage tank need to solve using several method of study. The tensile test was used to examine the degradation induced changes. By the end of this study, the physical and chemical effects on the HDPE as Biodiesel storage tank can be observed and reduce the effects so can use the HDPE as storage tank for longer duration of time. Due to its adaptability in preventing oxidation, degradation, and chemical resistance, biodiesel is proven to be more stable in HDPE tanks for this experimental project.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is a crucial component in which the approach used to reach the research's goals and objective are described. To guarantee that the plan meets its objectives, it is critical to take the proper approach. Methodology is used to ensure that the project's progress follows a logical path from the beginning to the end. Several experiments are presented in this chapter, including tensile and shear tests, with the goal of this experimental programme being to understand mechanical behaviour and establish material characteristics for future numerical analysis. HDPE was chosen as the material to be studied experimentally. Because of its high strength and good fatigue resistance, HDPE is one of the most commonly used non-metal materials in industry, with its application primarily in the production of containers. The tensile were carried out using the UTeM testing machine. At UTeM, all specimens are generated by a machine to ensure specimen correctness.

3.2 Flow chart

The progress planning for the bachelor's degree project is demonstrated in figure 3.1. This is the sequence in which the project will proceed and be completed. Preparing the flow chart is crucial to achieving that this project is completed on time.

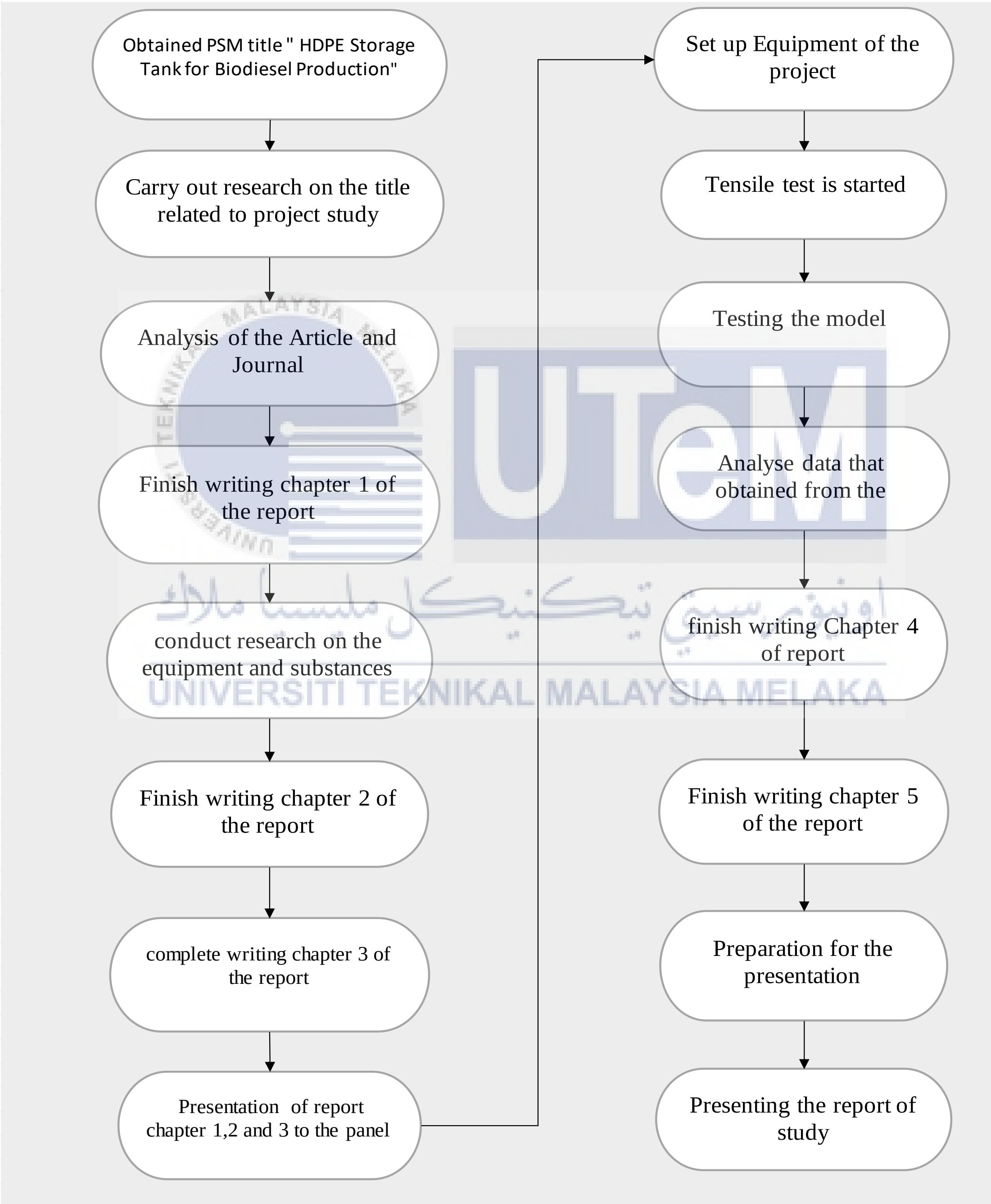


Figure 3.1 The flow chart of the entire process of the project

3.2.1 Tensile test flowchart

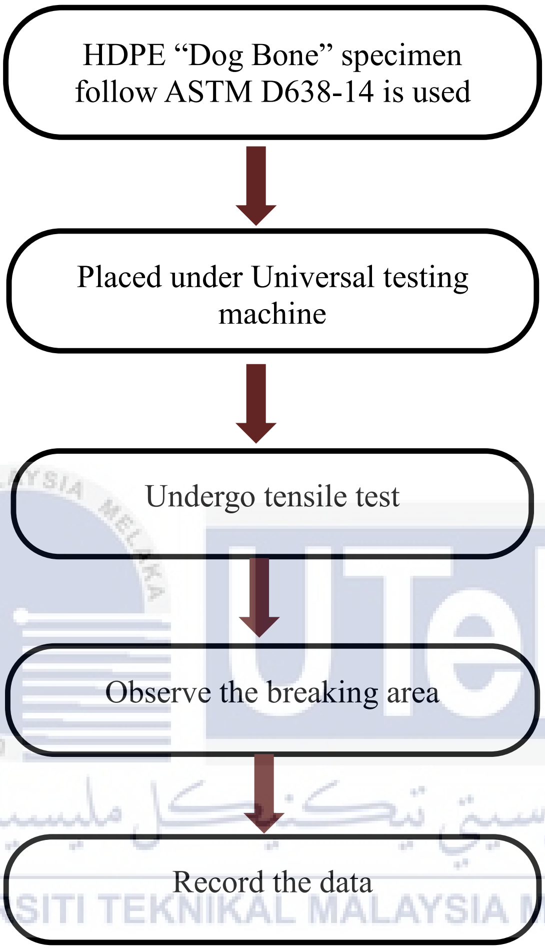


Figure 3.2 The flow chart of tensile test according to ASTM D638-14

3.3 Preparing HDPE samples

Specimen processing is the science of transforming basic polymer into materials in a particular shape, such as a "dog bone.". The hot press method is used to treat HDPE specimens. Hot pressing is a powder metallurgy technique that involves applying high pressure and low strain rates to generate a powder compact at a temperature high enough to promote processes of sintering and creep. This is achieved by simultaneously applying heat and pressure. Below are several steps on producing the HDPE specimens to desired "dog bone" shape.

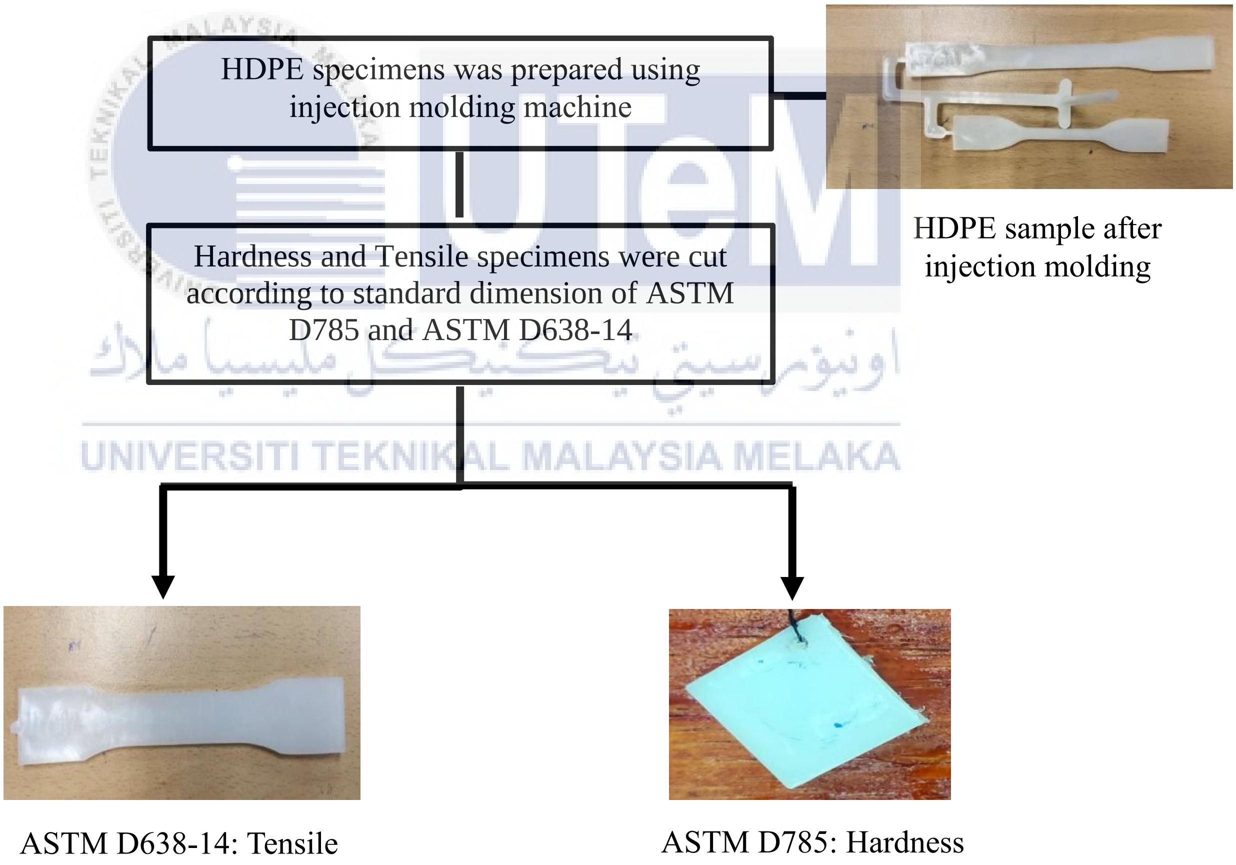


Figure 3.3 The process of making HDPE specimens

3.4 Immersion Test

Immersion tests are used to track the effect of the concentration of biodiesel on the performance of HDPE as well as other elements that might speed up the process. In the event of cycle tests, these tests may include alternate drying or immersions. In this study, the immersion test was conducted with a "dog bone" specimen of HDPE and a square-sized HDPE sample using two different concentrations of biodiesel, such as B10 and B30 at room temperature and 50 °C temperature. The test is conducted for 336 hours, or approximately 2 weeks. The data is analyzed every week for a duration of six weeks. Below are some procedures taken to conduct the immersion test:

- Pour the Biodiesel of B10 and B30 in the two oil bath under room temperature and two oil bath under 50 ºC temperature to ensure complete immersion
- Place the HDPE specimen inside the four oil baths filled with Biodiesel
- Then expose the two oil baths to room temperature and two oil baths to 50°C temperature for first 1 weeks
- Then fluorinate the containers to prevent permeation.
- Repeat the step for another 1week until week 2
- Then at the end time, remove and rinse the specimen and wipe dry

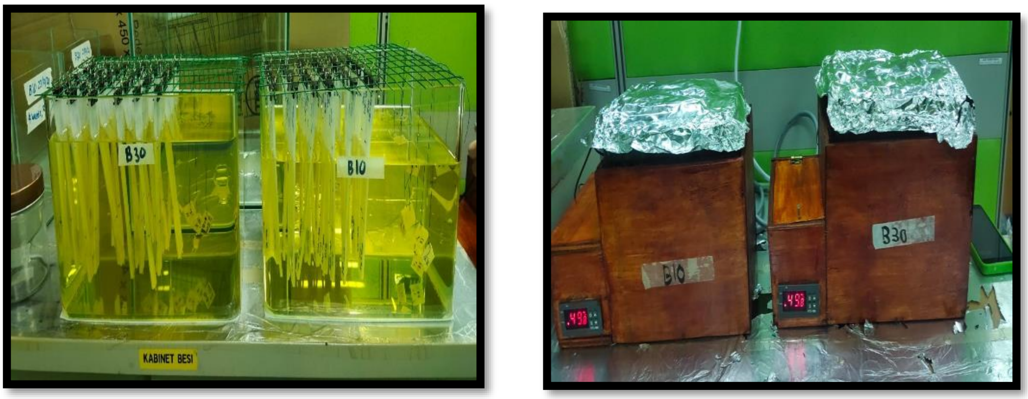


Figure 3.4 Immersion of HDPE samples in B10 and B30 in a room temperature oil bath and a temperature controlled oil bath at 50ºC.

3.5 Tensile test

In the longitudinal direction, a series of specimens were cut. Figure 20 and Table 3.1 illustrate the shape and size of the specimens utilized in this area of research. The ASTM D638-14 test standard is used in this experiment for the dog bone tensile specimens.

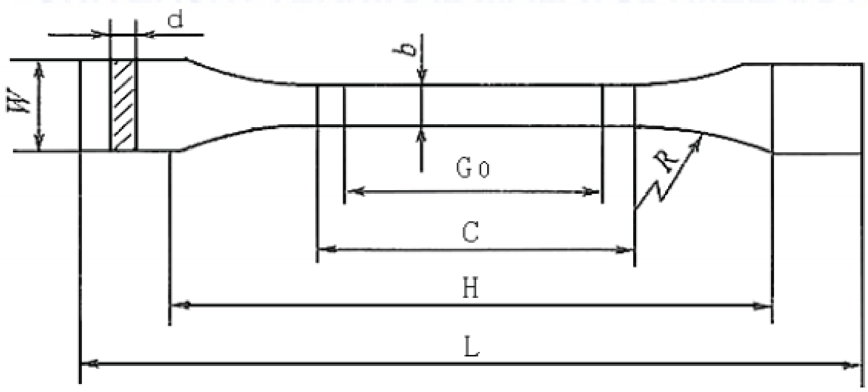


Figure 3.5 The geometry of dog-bone specimen

Table 3.1 The length and width of a dog-bone specimen

Symbol	Name	Dimension	Symbol	Name	Dimension
L	Total length	160mm	W	Width	18mm
H	The distance between the clamp	110mm	d	Thickness	3mm
C	The middle section length	70mm	b	Width in middle section	13mm
G_o	The gauge length	50mm	R	Radius	71mm

To assure the tensile test condition, the tensile test will be performed on a UTeM machine at extremely low loading rates of around 5 mm/min, as recommended by ASTM D638-14. During the operation, the bottom gripper remains motionless while the top gripper moves at a set rate. The specimen is positioned between the gripper and the clamp, which prevents the specimen from sliding. The tensile machine is connected to a computer running the Test Works software, which allows test results to be gathered and shown on the screen. At each time instant, the load and displacement sensors on the testing equipment output the load, extension, stresses, and strains.

Figure 3.6 INSTRON FLOOR MOUNTED MATERIAL TESTING SYSTEM (2000kN) for tensile test

3.6 Hardness Test

Hardness is a material's mechanical property that can be defined as the material's resistance to localized deformation. Several types of hardness testing with various shaped indenters are routinely used for polymer materials. The resistance to penetration by an indenter pushed into the material under a continuous load is the most common test method. The Vickers Hardness (HV) is determined by measuring the diagonal length of an indent in the sample material caused by the application of a load to a diamond pyramid indenter. Using a table or formula, the diagonals of the indent are measured optically to determine the hardness. Below is the procedure for conducting the hardness test using the Vickers Hardness Tester:

Before operating the equipment, make sure it's in good working order and safe to use.

Procedure for the Vickers Hardness (HV) Test

I. Prepare the testing machine

II. Take vickers indenter with four side pyramid and inserted into mounting device in testing machine.

III. Then place the HDPE specimen on support table and rotate the microscope length into working position.

IV. With the hunt wheel, adjust the height of support table until the test piece surface is focus on the screen.

V. Move test piece around on the support table until the roid spot for hardness test is displayed.

VI. Then click the start button on the monitor screen and the indenter will rotate and carefully touch the test surface.

VII. The test fall will slowly increase for specify value

VIII. After holding the test force for constant time, the indenter lift again and move to normal position.

IX. Then adjust the line on the screen to measure the hardness of the specimen

X. Finally, push the input key then the vickers hardness value is calculated automatically.

XI. The formula use is $Vickers\ Hatdness\ HV = \frac{Test\ Force\ (F)}{Surface\ area\ of\ indentation\ (A)}$

XII. Repeat the same steps on other HDPE specimens.

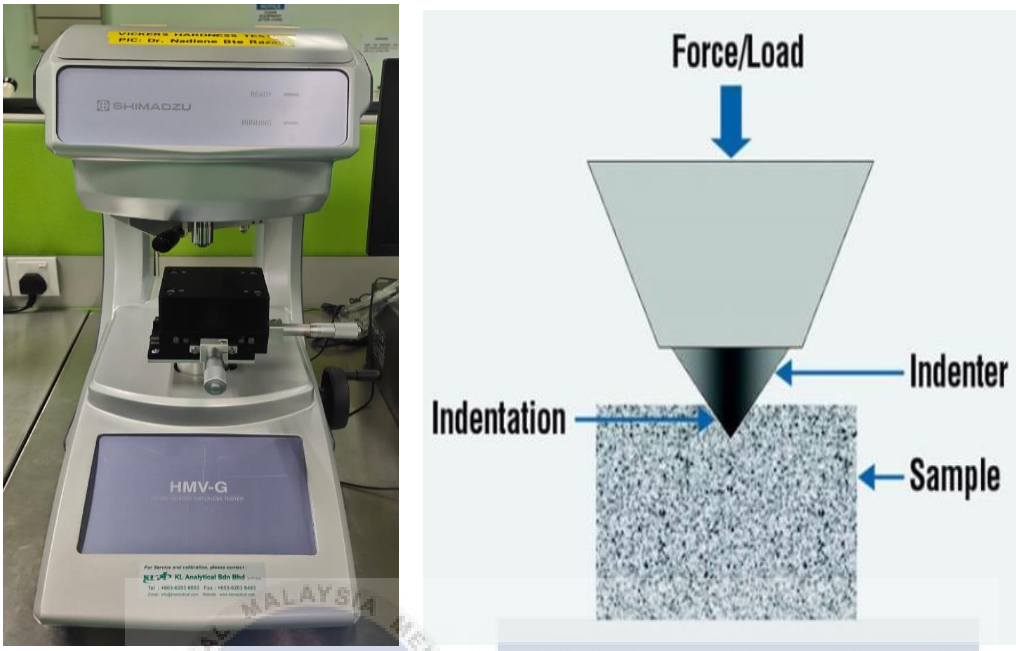


Figure 3.7 Vickers Hardness Tester and insight Tester

3.7 Gantt Chart

This project's Gantt chart is shown below. The purpose of the Gantt chart is to ensure that our project works smoothly and is completed on time before the deadline. A Gantt chart depicting the project's progress from beginning to conclusion is shown below.

3.8 Summary

To summarise this chapter, this project is running according to the fixed methodology. To generate this project, the parameters that affect the strength of the microstructure of HDPE are taken under observation. On behalf of this project, the tensile test was conducted to observe the strength of the microstructure of HDPE used as a storage tank for biodiesel production. The specimen of HDPE is produced using the injection moulding method. The tensile test is conducted using the INSTRON FLOOR MOUNTED MATERIAL TESTING SYSTEM (2000kN) in the UTeM lab by following the correct procedures. The immersion test is tested for 336 hours, approximately 2 weeks, as it is used to track the effect of the concentration of biodiesel on the performance of HDPE as well as other elements that might speed up the process. The hardness test is conducted to measure the mechanical properties of HDPE material using the Vickers Hardness Tester in the Amchal lab located at UTeM. Further studies and analysis are carried out in the next chapter.

CHAPTER 4 RESULT AND DISCUSSION

4.1 The weight of HDPE samples

In the experiment, the immersion test was conducted using two different biodiesel concentrations, B10 and B30, at room temperature and 50 °C. The samples weight is recorded before and after the immersion test is conducted for comparison. The weight of the samples is measured using an analytical balance because of its higher readability and the most exact measurement of 0.0001g. Five samples for each concentration of biodiesel are used at two different temperatures, and the measurement is taken three times per sample to obtain the average reading. While the immersion test is conducted, the weight of the samples is recorded every day for 336 hours, precisely two weeks.

Figure 4.1 The Analytical Balance that is used to measure the weight of the HDPE sample

Table 4.1 Data for week 0 at room temperature were averaged.

	HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
Week 0	B10-R1	6.9696	6.968	6.969	6.97
	B10-R2	6.98	6.9797	6.9803	6.98
	B10-R3	6.9802	6.9811	6.9803	6.98
	B10-R4	6.9802	6.9808	6.9809	6.98
	B10-R5	6.9808	6.9808	6.9801	6.98
	B30-R1	6.9794	6.9792	6.98	6.98
	B30-R2	6.98	6.9816	6.98	6.98
	B30-R3	6.9824	6.9824	6.9827	6.98
	B30-R4	6.9795	6.9795	6.98	6.98
	B30-R5	6.98	6.98	6.9814	6.98

Table 4.2 Average data for week 0 under a 50°C temperature.

	HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
Week 0	B10-T1	6.9754	6.9756	6.9754	6.98
	B10-T2	6.98	6.9792	6.9799	6.98
	B10-T3	6.9755	6.9756	6.9764	6.98
	B10-T4	6.9768	6.9779	6.9785	6.98
	B10-T5	6.9793	6.9786	6.9795	6.98
	B30-T1	6.9761	6.9757	6.98	6.98
	B30-T2	6.98	6.9824	6.98	6.98
	B30-T3	6.9762	6.9769	6.9768	6.98
	B30-T4	6.9782	6.9791	6.98	6.98
	B30-T5	6.98	6.98	6.9802	6.98

Table 4.3 Average data for week 1 in temperatures below 50 °C.

HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
B10-T1	7.3238	7.324	7.3241	7.32
B10-T2	7.33	7.3288	7.3285	7.33
B10-T3	7.2914	7.2919	7.2923	7.29
B10-T4	7.2972	7.2974	7.2967	7.30
B10-T5	7.2696	7.2689	7.2695	7.27
B30-T1	7.323	7.3223	7.32	7.32
B30-T2	7.31	7.3074	7.31	7.31
B30-T3	7.3119	7.3114	7.3115	7.31
B30-T4	7.2987	7.2987	7.30	7.30
B30-T5	7.32	7.32	7.3198	7.32

Table 4.4 Average data for week 1 under room temperature.

HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
B10-R1	7.1241	7.1241	7.1241	7.12
B10-R2	7.09	7.0915	7.0912	7.09
B10-R3	7.0913	7.0913	7.0901	7.09
B10-R4	7.091	7.0909	7.091	7.09
B10-R5	7.0969	7.0976	7.0972	7.10
B30-R1	7.0804	7.081	7.08	7.08
B30-R2	7.12	7.1141	7.11	7.11
B30-R3	7.1057	7.1057	7.1049	7.11
B30-R4	7.1329	7.1319	7.13	7.13
B30-R5	7.14	7.14	7.1368	7.14

Table 4.5 Average data for week 2 under room temperature.

HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
B10-R1	7.1842	7.1844	7.1844	7.18
B10-R2	7.10	7.1006	7.1006	7.10
B10-R3	7.1375	7.1375	7.1375	7.14
B10-R4	7.1512	7.1516	7.1516	7.15
B10-R5	7.1268	7.1268	7.1266	7.13
B30-R1	7.1769	7.1757	7.18	7.18
B30-R2	7.10	7.1006	7.10	7.10
B30-R3	7.1797	7.1802	7.1802	7.18
B30-R4	7.1585	7.1589	7.16	7.16
B30-R5	7.16	7.16	7.1626	7.16

Table 4.6 Average data for week 2 in temperatures below 50 °C.

HDPE Samples	Weight 1	Weight 2	Weight 3	AVG
B10-T1	7.4562	7.4563	7.4563	7.46
B10-T2	7.40	7.3978	7.3977	7.40
B10-T3	7.3829	7.3829	7.3829	7.38
B10-T4	7.4413	7.4419	7.4419	7.44
B10-T5	7.4162	7.416	7.4164	7.42
B30-T1	7.3652	7.3656	7.37	7.37
B30-T2	7.50	7.4958	7.50	7.50
B30-T3	7.4206	7.4204	7.4204	7.42
B30-T4	7.5444	7.5444	7.54	7.54
B30-T5	7.43	7.43	7.4274	7.43

Table 4.7 Overall outcomes for weeks 1 and 2 at room temperature

HDPE Samples	Week 0	Week 1	Week 2
B10-R1	6.98	7.12	7.18
B10-R2	6.98	7.09	7.10
B10-R3	6.98	7.09	7.14
B10-R4	6.98	7.09	7.15
B10-R5	6.98	7.10	7.13
B30-R1	6.98	7.08	7.18
B30-R2	6.98	7.11	7.10
B30-R3	6.98	7.11	7.18
B30-R4	6.98	7.13	7.16
B30-R5	6.98	7.14	7.16

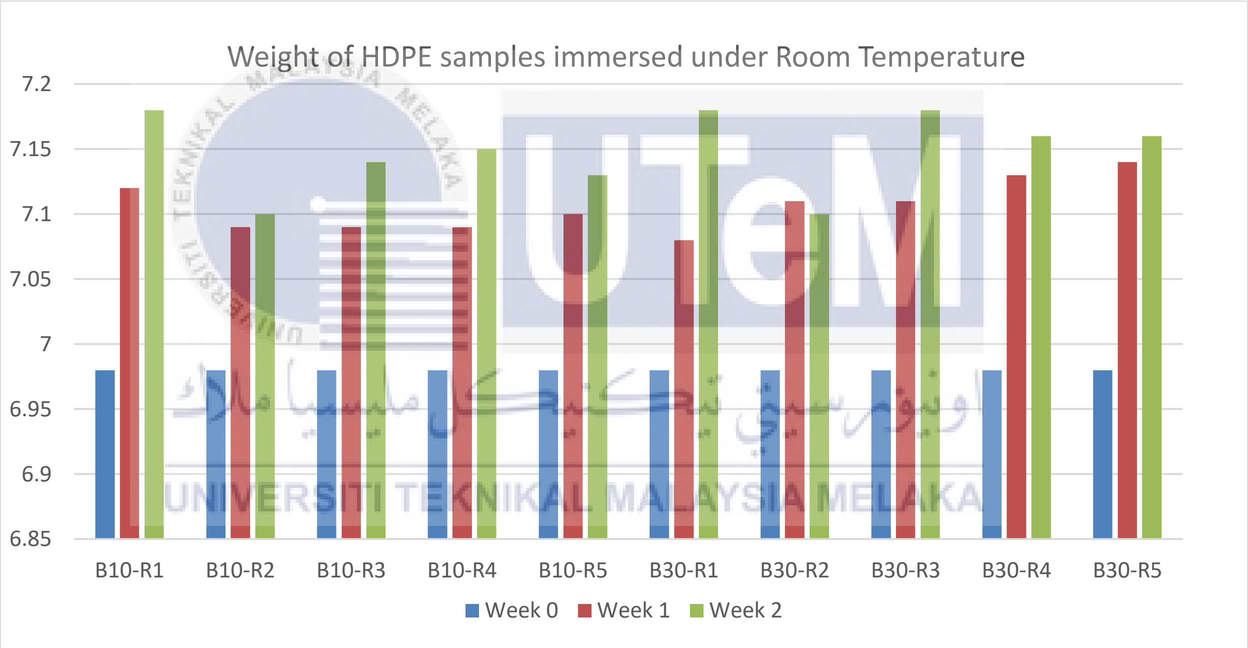


Figure 4.2 The weight of HDPE samples immersed in B10 and B30 at room temperature for 336 hours

Based on the result, the weight of HDPE samples immersed in B30 at room temperature increased from week 0 to week 2. The weight of the HDPE samples of B10-R1, B30-R1 and B30-R3 remained constant at 7.18g in week 2. The HDPE sample of B30-R1 gained a higher weight from Week 1 than other HDPE samples. It increases 0.10g from the weight of week 1 and has the highest increment value in week 2 compared to other HDPE samples. Besides this, the HDPE sample of B10-R2 shows the lowest increment value among other HDPE samples, and it increases only 0.01g in week 2 from the weight of week 1. However, the HDPE sample of B30-R2 shows a different trend compared to other HDPE samples. The weight of the HDPE sample of B30-R2 increased by 0.13g from its initial weight in week 1, but the weight dropped by 0.01g in week 2. So the weight will increase in week 1 but decrease in week 2. The weight of HDPE samples immersed in B10 and B30 gained more weight in week 2 when immersed at room temperature.

Table 4.8 Overall results for weeks 1 and 2 at temperatures below 50 °C

HDPE Samples	Week 0	Week 1	Week 2
B10-T1	6.98	7.32	7.46
B10-T2	6.98	7.33	7.40
B10-T3	6.98	7.29	7.38
B10-T4	6.98	7.30	7.44
B10-T5	6.98	7.27	7.42
B30-T1	6.98	7.32	7.37
B30-T2	6.98	7.31	7.50
B30-T3	6.98	7.31	7.42
B30-T4	6.98	7.30	7.54
B30-T5	6.98	7.32	7.43

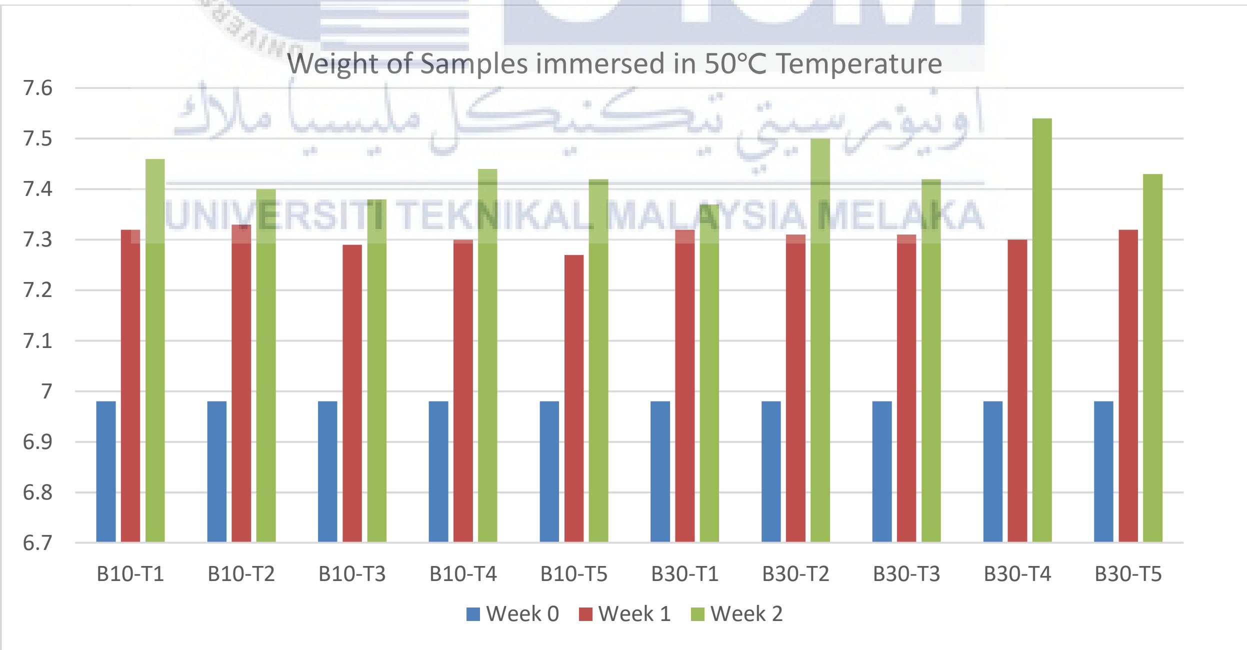


Figure 4.3 The weight of HDPE samples immersed B10 and B30 under 50ºC temperature for 336 hours

Based on the result, the weight of HDPE samples immersed in two different concentrations of biodiesel (B10 and B30) increased from week 0 to week 2. The HDPE sample of B10-T2 gained more weight in week 1 compared to other samples. The HPDE sample is immersed in B10 and it gains 0.35g from its initial weight. Besides this, the HDPE samples of B30-T4 gained more weight in week 2 than other HDPE samples. The HDPE sample is immersed in a B30, and the weight increases by 0.24g from the weight of week 1. The 30% concentration of biodiesel influenced HDPE samples to gain more weight in week 2 compared to the 10% concentration of biodiesel when immersed under 50°C temperature.

4.2 Hardness Test Result

The hardness test was carried out on the HDPE sample for two weeks. The dimension of HDPE samples for the hardness test is cut according to the standard ASTM_D785. The HDPE samples for the hardness test were immersed in B10 and B30 at room temperature and 50 °C. The immersion duration for the hardness test is 2 weeks, and the hardness test was conducted before and after the immersion test of HDPE samples in Biodiesel. The hardness test was conducted using the Vickers Hardness Tester in the Amchal Lab at Universiti Teknikal Malaysia Melaka (UTeM). The pressing force was fixed to HV0.05 (4990.3 mN), and the holding time was fixed to 90 s according to the standard of the ASTM_D785 Hardness Test. Each week, four samples and five points of reading are taken per sample during the conduct of the hardness test to obtain an average reading. The data was recorded.

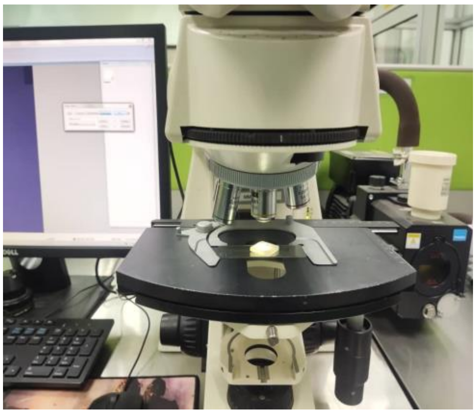


Figure 4.4 A HDPE sample is carried out using a Vickers Hardness Tester.

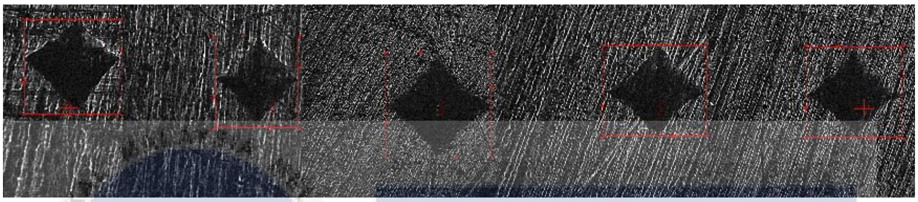
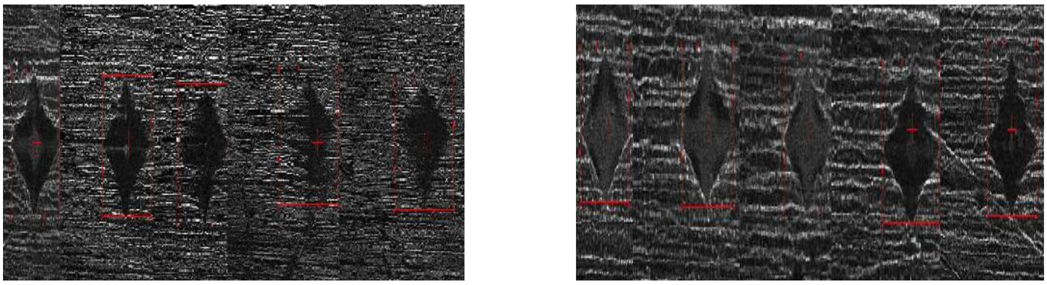


Figure 4.5 The Vickers Hardness Tester was used to perform a hardness test prior to the immersion test.

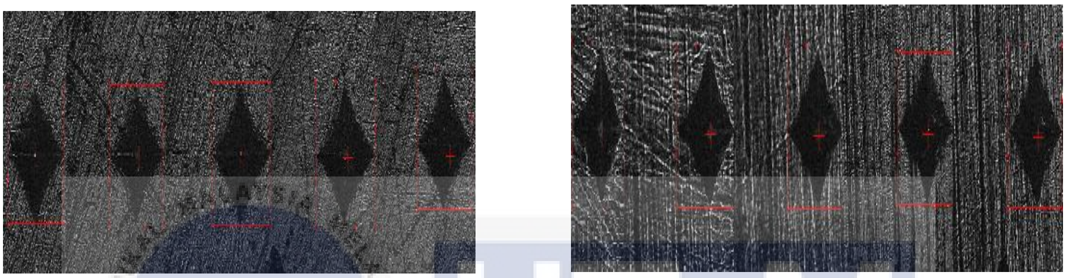
Table 4.9 Hardness test result of HDPE samples before immersion test

HDPE samples	Hardness (HV)
1	4.06
2	4.05
3	3.77
4	3.81
5	3.88
Average	**3.92**



B10-RT B30-RT

Figure 4.5 The result of the hardness test of week 1 under immersion of B10 and B30 under room temperature



B10-T50 B30-T50

Figure 4.6 The result of the Hardness Test of week 1 under immersion of B10 and B30 under 50 °C.

Table 4.10 The average result of the hardness test on HDPE samples before and after immersion on week 1

HDPE samples	Average Hardness (HV) results Week 0	Average Hardness (HV) results Week 1
B10-RT	3.92	3.49
B30-RT	3.92	3.57
B10-T50	3.92	2.88
B30-T50	3.92	3.27

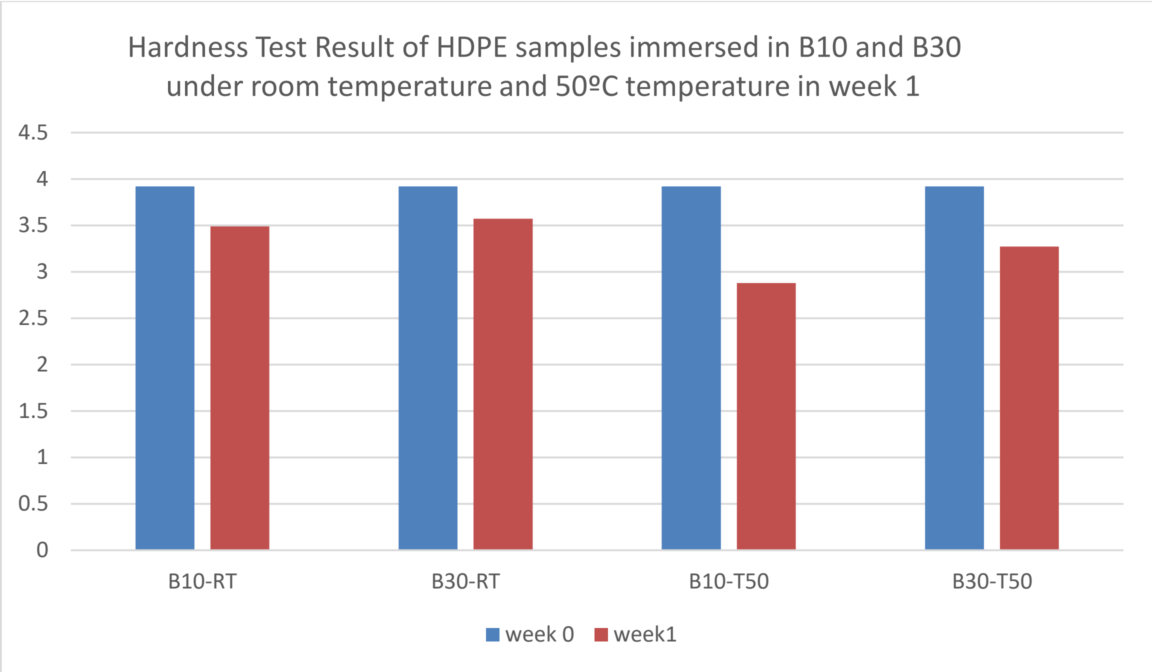
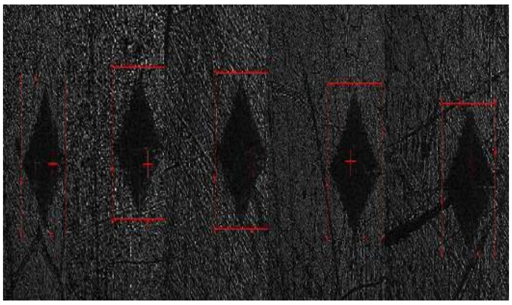
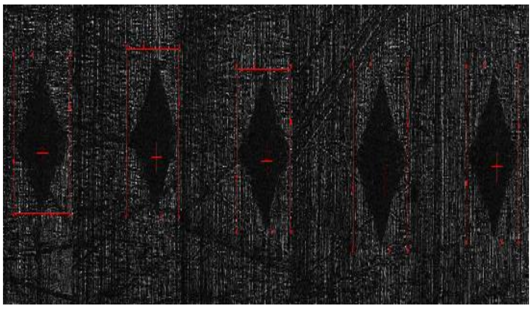


Figure 4.7 The result of the hardness test of HDPE samples before and after the immersion test of biodiesel in week 1

Based on the results in week 1, the hardness of HDPE samples immersed in B10 and B30 at room temperature and 50 ^{0}C temperature decreased in week 1 compared with the HDPE samples before immersion. The hardness of B10-T50 was reduced by 1.04 HV from week 0 to week 1, and it shows the highest decrement value compared with other HDPE samples under immersion at 50 ℃. The hardness of B30-RT reduces by 0.35 HV from week 0 to week 1, and it shows the lowest decrement value compared to other HDPE samples under immersion at room temperature. The hardness of HDPE samples is reduced more when immersed at 50 ℃ compared with room temperature.

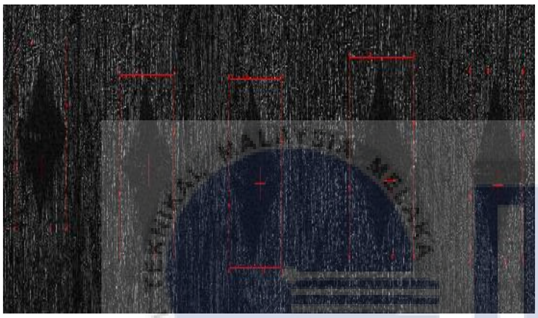


B10-RT

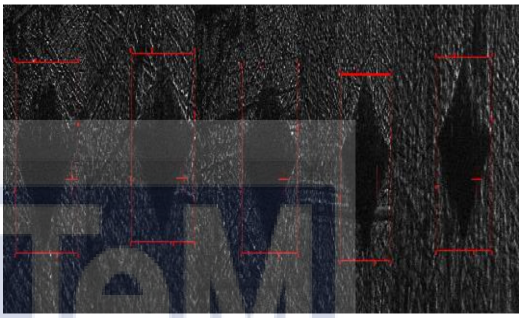


B30-RT

Figure 4.8 The result of Hardness Test of week 2 under immersion of B10 and B30 under room temperature



B10-T50



B30-T50

Figure 4.9 The Hardness Test result of week 2 under immersion of B10 and B30 at 50 °C.

Table 4.11 The average result of the hardness test on HDPE samples before and after immersion in week 1 and week 2

HDPE samples	Average Hardness (HV) Week 0	Average Hardness (HV) Week 1	Average Hardness (HV) Week 2
B10-RT	3.92	3.49	3.60
B30-RT	3.92	3.57	3.79
B10-T50	3.92	2.88	3.18
B30-T50	3.92	3.27	3.40

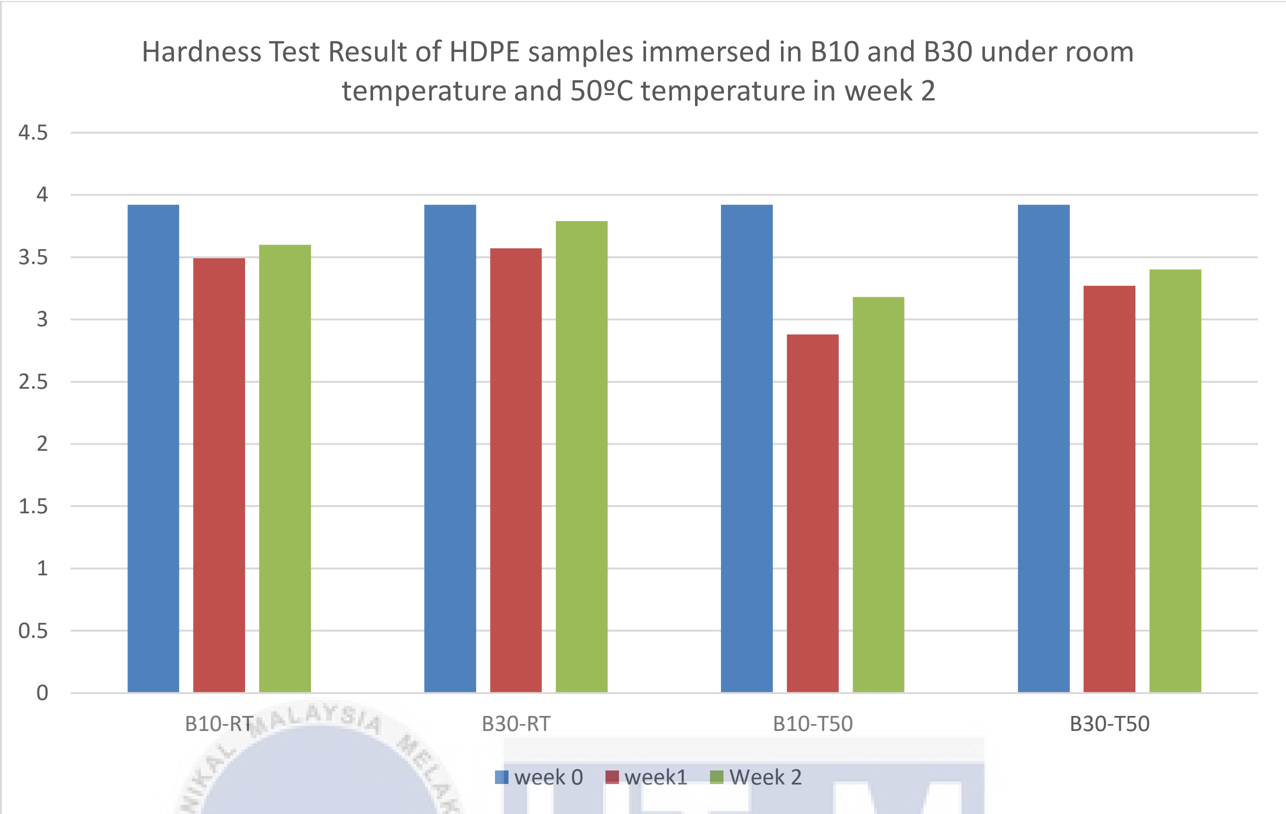


Figure 4.10 The result of the hardness test of HDPE samples before and after the immersion test of biodiesel in week 1 and week 2

According to the results of week 2, the hardness of HDPE samples immersed in B10 and B30at room temperature and 50 °C temperature increased compared to the hardness value in week 1. The HDPE sample of B10-T50 increased by 0.3 HV in week 2 compared with week 1. It shows that the HDPE samples gain the hardness in week 2 and it is the highest increment value compared with other HDPE samples that are immersed in biodiesel at 50 oC and room temperature. The hardness value of HDPE samples of B30-RT is almost identical to the initial hardness value of HDPE samples before immersion. It recorded 3.79 HV in week 2 and only a 0.13 HV difference with the HDPE sample before immersion in week 0. The hardness of HDPE samples influences the 10% and 30% concentrations of biodiesel that are immersed under 50 °C temperature compared with the immersion of B10 and B30 under room temperature.

4.3 Tensile Test Result

The tensile test is carried out on the HDPE samples for 336 hours, approximately 2 weeks. Each week, the data is recorded. The specimen used for the tensile test is moulded into a "dog bone" shape by injection moulding and the dimension is followed according to the standard ASTM D638-14. Each week, 20 HDPE samples in two different immersion temperatures were used to carry out tensile tests using the INSTRON Floor Mounted Material Testing System 2000kN in the Universiti Teknikal Malaysia Melaka (UTeM) lab. The cross-head speed of the machine is fixed at 5 mm/min according to the standard ASTM D638-14. The tensile test was carried out before and after the immersion of HDPE samples in B10 and B30 at room temperature and 50 °C.

Figure 4.11 The INSTRON Floor Mounted Material Testing System 2000kN and the HDPE samples necking after undergoing tensile test

Figure 4.12 HDPE samples before and after tensile testing in week 0 before immersion in B10 and B30 at room temperature and 50 °C.

B10-RT B30-RT B10-T50 B30-T50

Figure 4.13 HDPE samples after tensile testing on week 1 after immersion in B10 and B30 at room temperature and 50 °C

B10-RT B30-RT B10-T50 B30-T50

Figure 4.14 HDPE samples after tensile testing on week 2 after immersion in B10 and B30 at room temperature and 50 °C.

Table 4.12 The results for the tensile test before immersion in B10 and B30

HDPE Samples	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	23.12	0.18	0.13
2	22.34	0.17	0.13
3	20.11	0.18	0.11
4	17.99	0.16	0.11
5	22.70	0.18	0.12
Average	**21.25**	**0.18**	**0.12**

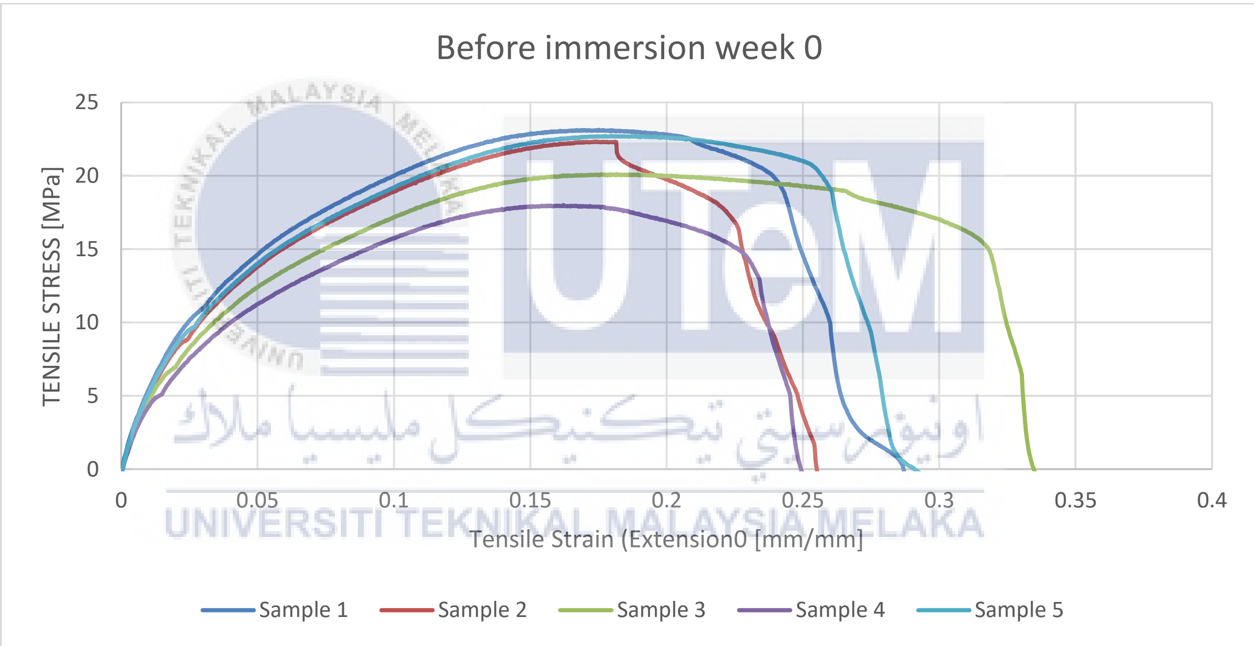


Figure 4.15 The results for the tensile test before B10 and B30

Table 4.13 The results for the tensile test under immersion of B10 under room temperature on week 1

HDPE Samples (B10_RT)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	24.34	0.24	0.10
2	21.88	0.26	0.084
3	23.39	0.21	0.11
4	24.59	0.14	0.17
5	23.81	0.20	0.12
Average	**23.60**	**0.21**	**0.12**

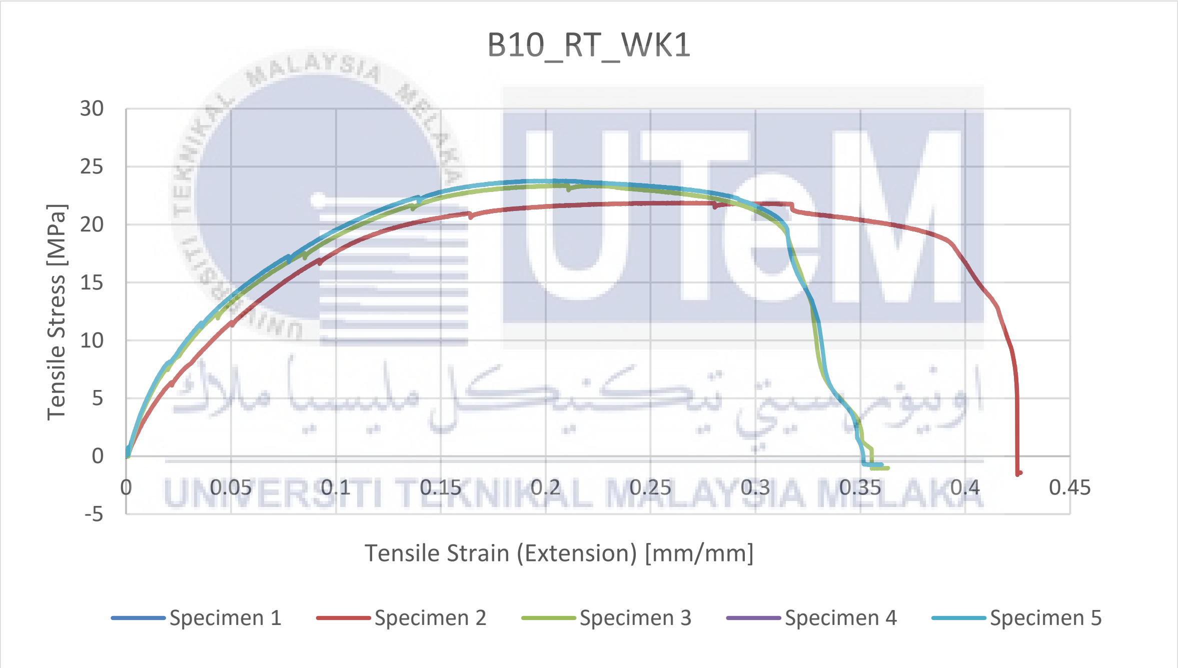


Figure 4.16 The results for the tensile test under immersion of B10 under room temperature on week 1

Table 4.14 The results for the tensile test under immersion of a B30 under room temperature on week 1

Samples (B30_RT)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	21.95	0.22	0.10
2	22.18	0.21	0.10
3	22.67	0.22	0.10
4	22.45	0.23	0.097
5	23.61	0.20	0.12
Average	**22.57**	**0.22**	**0.10**

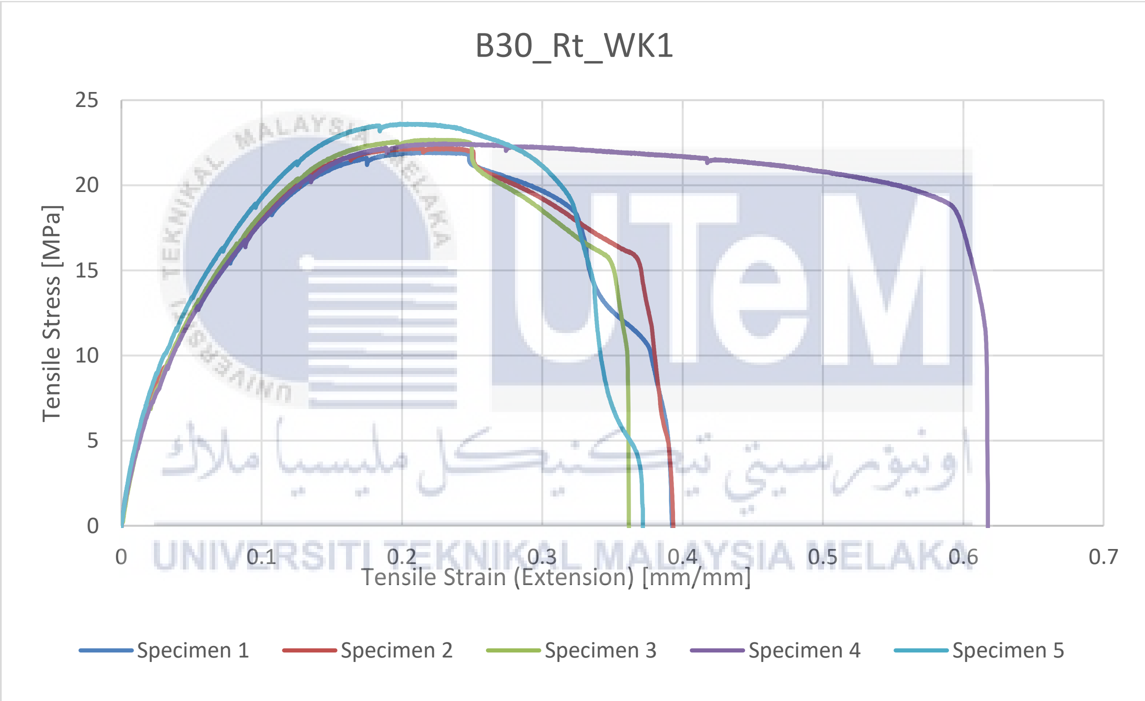


Figure 4.17 The results for the tensile test under immersion of B30 room temperature on week 1

Table 4.15 The results of the tensile test under immersion in at 50 °C temperature on week 1

Samples (B10_T50)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	23.42	0.21	0.11
2	22.46	0.25	0.090
3	19.17	0.21	0.089
4	21.57	0.25	0.085
5	22.75	0.24	0.094
Average	**21.87**	**0.23**	**0.094**

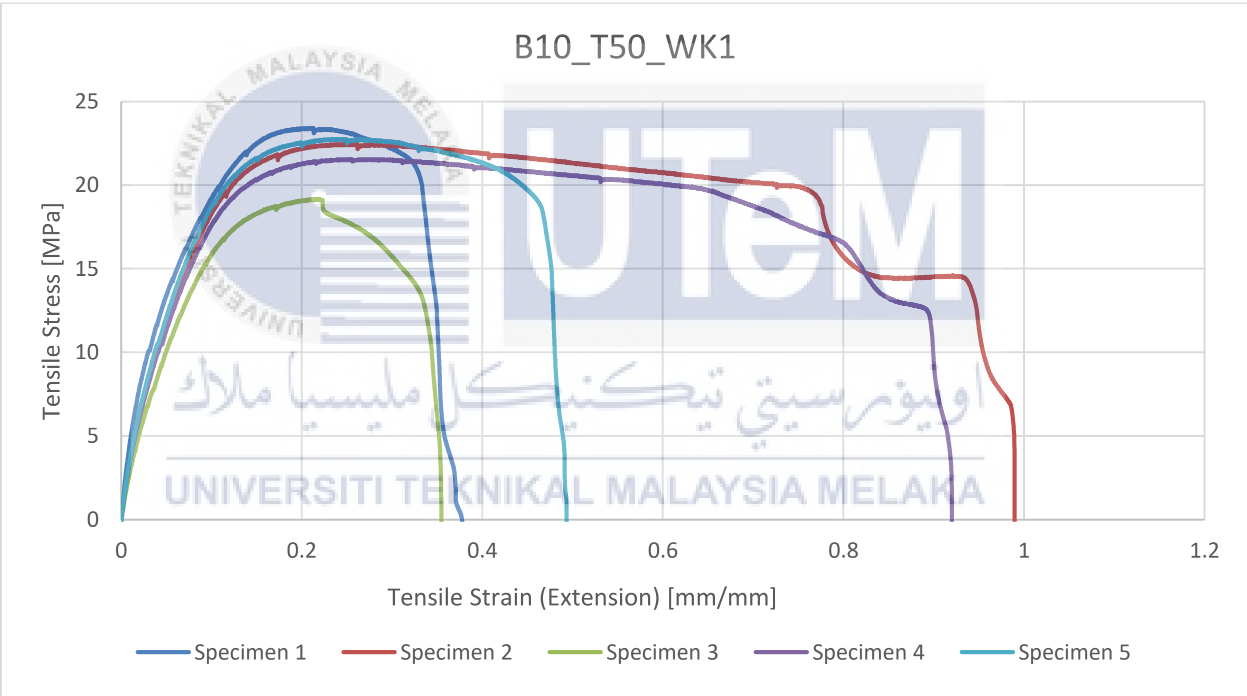


Figure 4.18 The results for the tensile test under immersion of B10 under 50°C temperature on week 1

Table 4.16 The results for tensile test under immersion of B30 under 50°C temperature on week 1

Samples (B30_T50)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	21.19	0.16	0.13
2	22.66	0.23	0.098
3	20.69	0.24	0.085
4	20.48	0.20	0.10
5	23.13	0.25	0.092
Average	**21.63**	**0.22**	**0.101**

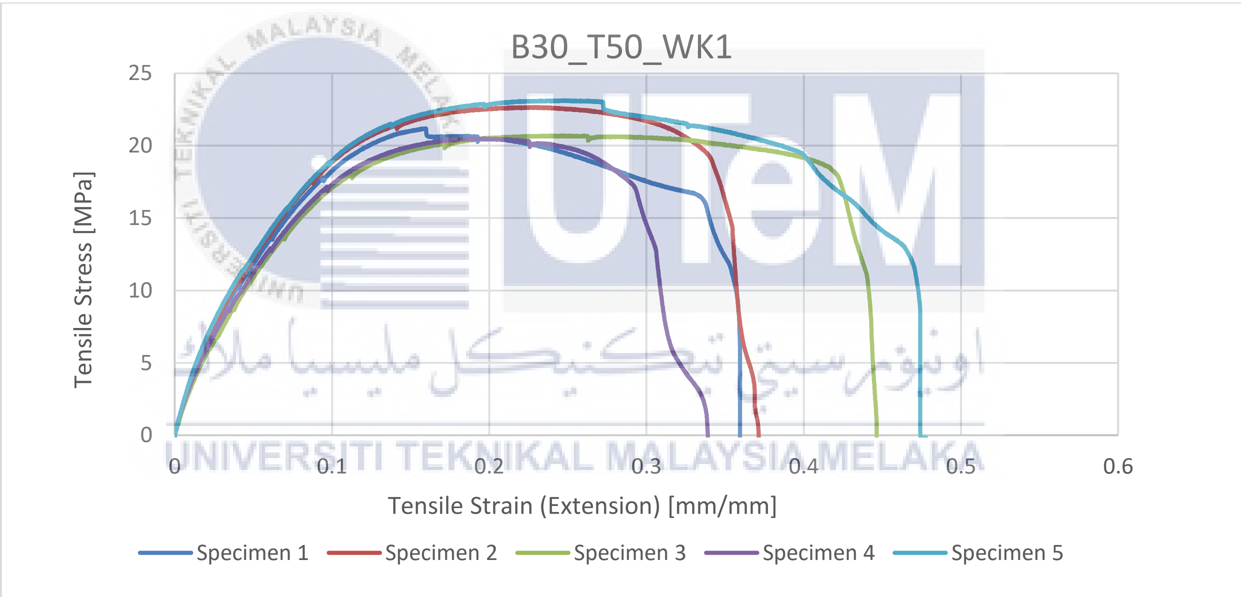


Figure 4.19 The results for the tensile test under immersion of B30 under 50°C temperature on week 1

Table 4.17 The results for the tensile test under immersion of B10 room temperature on week 2

Samples (B10_RT)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	25.36	0.22	0.12
2	26.61	0.19	0.14
3	25.69	0.20	0.13
4	27.65	0.22	0.12
5	25.59	0.21	0.12
Average	**26.18**	**0.21**	**0.13**

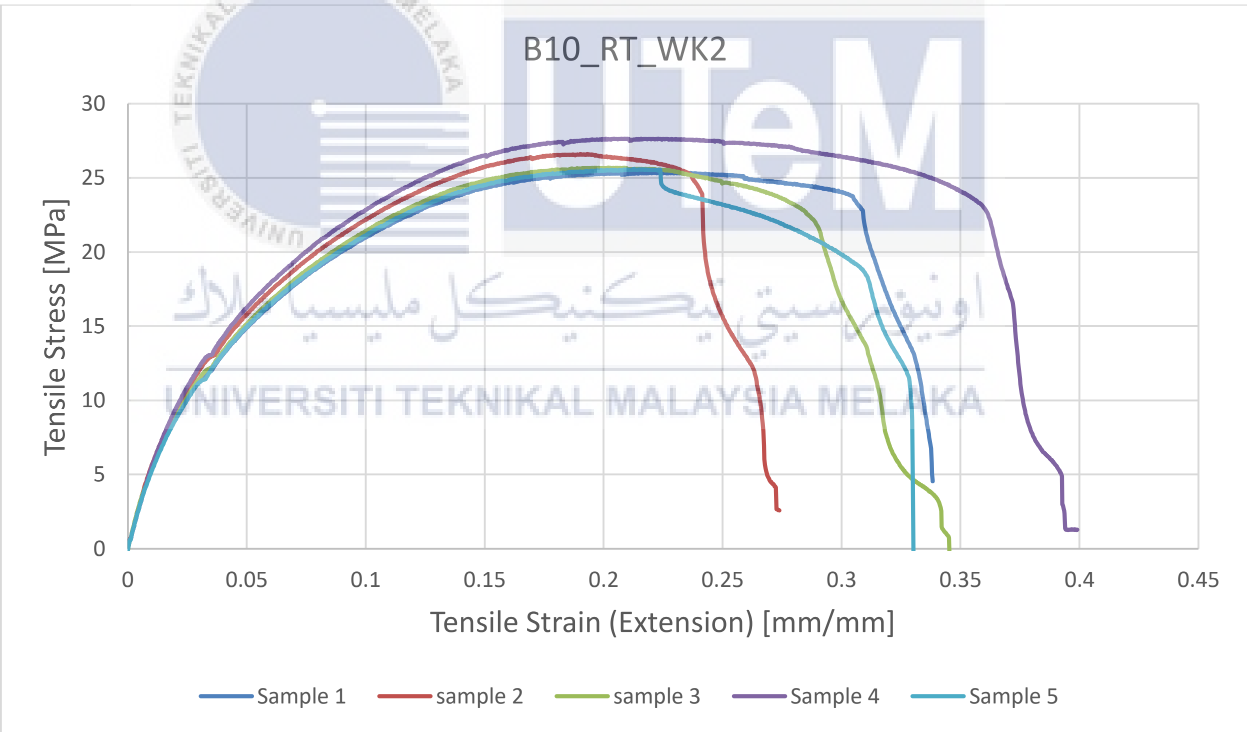


Figure 4.20 The results for the tensile test under immersion of B10 under room temperature on week 2

Table 4.18 The results for the tensile test under immersion of B30 under room temperature on week 2

HDPE Samples (B30_RT)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	24.71	0.27	0.090
2	23.69	0.24	0.097
3	24.36	0.26	0.092
4	24.51	0.21	0.12
5	22.16	0.27	0.081
Average	**23.89**	**0.25**	**0.096**

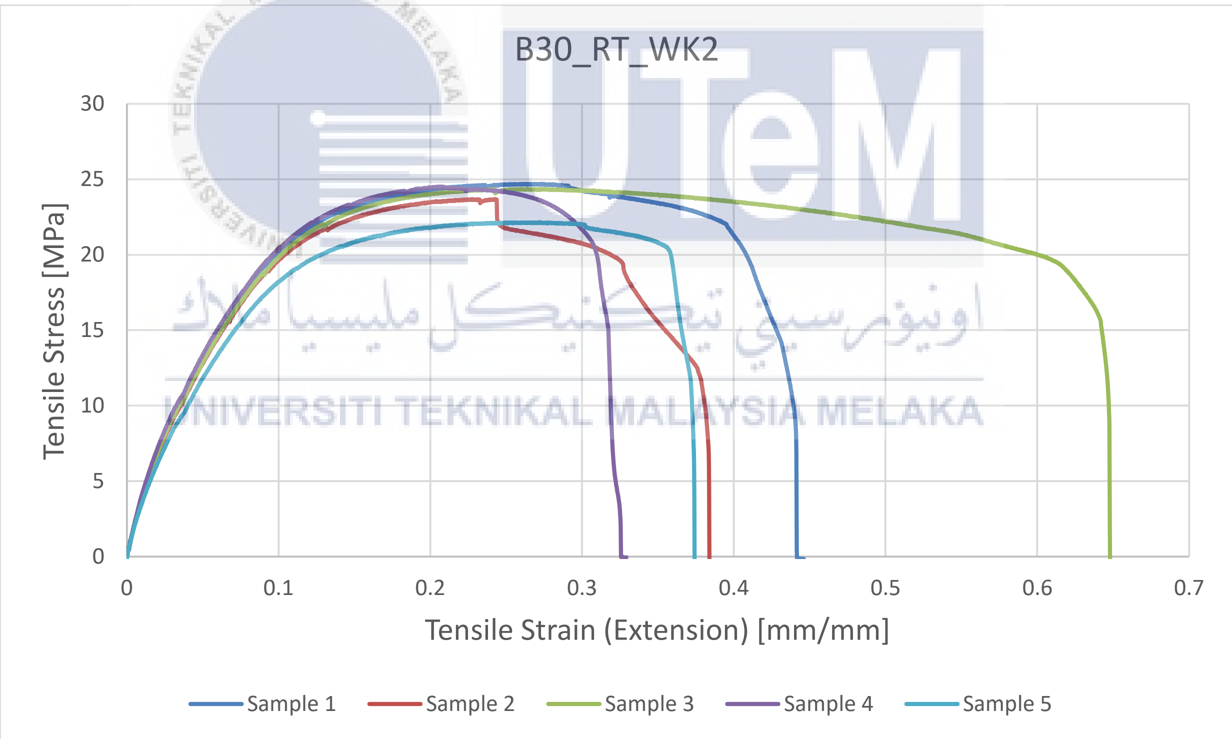


Figure 4.21 The results for the tensile test under immersion of B30 under room temperature on week 2

Table 4.19 The results of the tensile test under immersion in at 50 °C temperature on week 2

Samples (B10_T50)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	23.56	0.17	0.14
2	25.93	0.21	0.12
3	26.21	0.22	0.12
4	24.17	0.20	0.12
5	23.36	0.21	0.11
Average	**24.65**	**0.20**	**0.12**

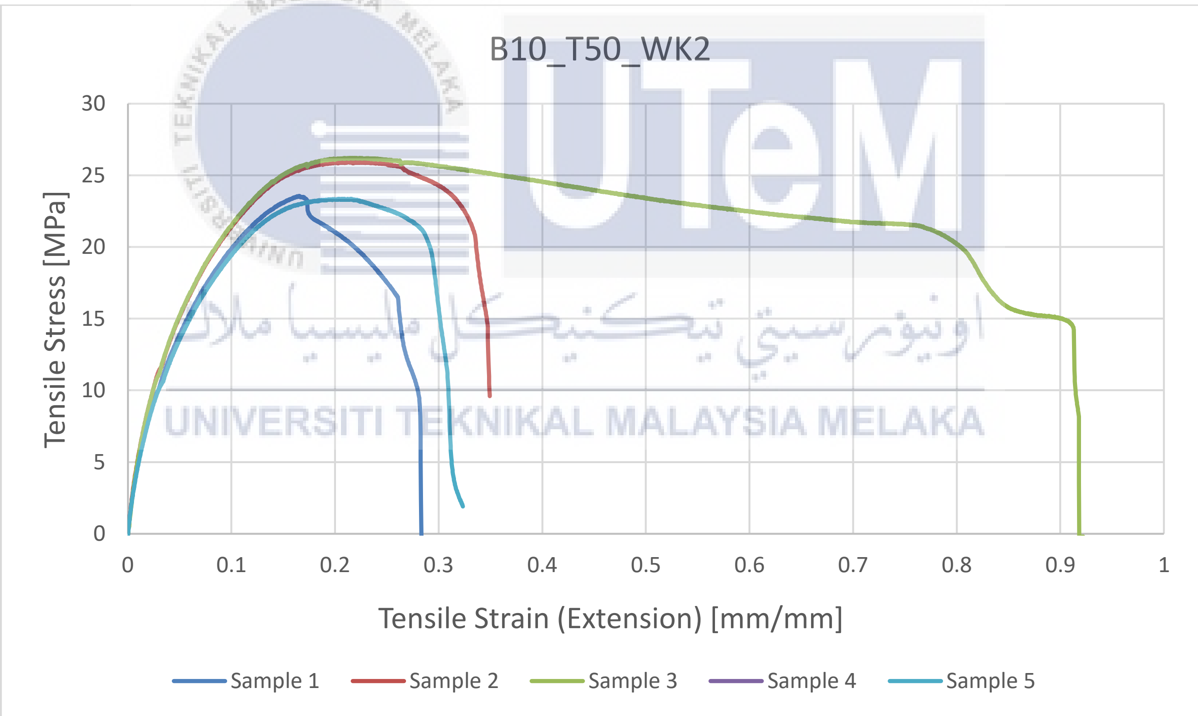


Figure 4.22 The results for the tensile test under immersion of B10 under room temperature on week 2

Table 4.20 Week 2 tensile test results under immersion of B30 under50 ºC temperature

Samples (B30_T50)	Tensile stress (MPa)	Tensile strain (mm/mm)	Modulus Young (GPa)
1	21.15	0.19	0.11
2	21.85	0.24	0.09
3	21.2	0.19	0.11
4	23.66	0.24	0.10
5	20.44	0.24	0.086
Average	**21.66**	**0.22**	**0.099**

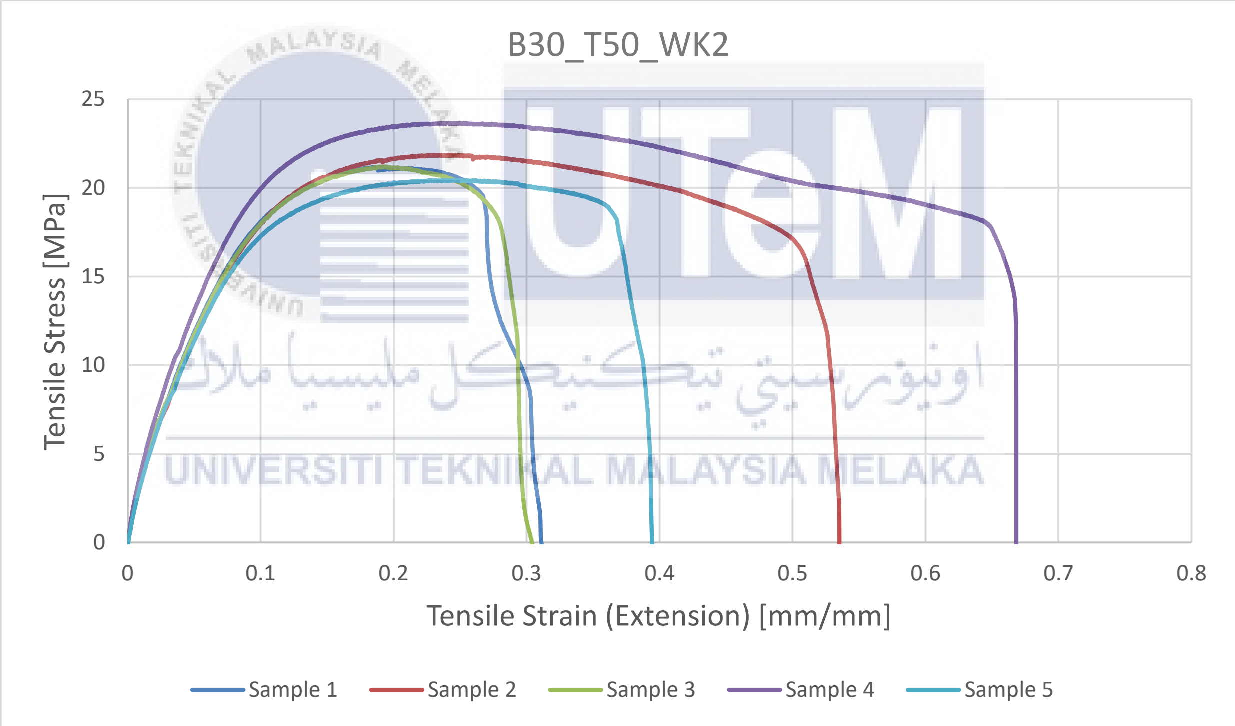


Figure 4.23 The results for the tensile test under immersion of B30 under room temperature on week 2

The tensile tests in weeks 1 and 2 show that the HDPE samples of B30-T50 in weeks 1 and 2 are immersed in B30 at a 50 ºC temperature are more ductile compared to other HDPE samples. The average Young Modulus of HDPE samples of B10-RT is 0.12 GPa, and that of B10-RT is 0.13 GPa. It shows the highest value of young modulus compared with other HDPE samples in week 1 and 2. The average value of the Young Modulus of HDPE samples of B10-T50 is 0.094 GPa, and that of B30-RT is 0.096 GPa. It shows the lowest Young Modulus value compared with other HDPE samples in week 1 and 2.

4.4 Summary

Based on the result, the weight of HDPE samples immersed in 30% biodiesel (B30) and 10% biodiesel B10 under room temperature increased from week 0 to week 2. The weight of the HDPE sample of B30-R2 increased by 0.13g from its initial weight in week 1, but the weight dropped by 0.01g in week 2. The B30 concentration influenced HDPE samples to gain more weight in week 2 than B10 when immersed under 50°C temperature. Besides this, the hardness results in week 1, the hardness of HDPE samples immersed in B10 and B30 under room temperature and 50 ℃ temperature decreased when compared with the HDPE sample before immersion, and for week 2, the hardness of HDPE samples that were immersed in B10 and B30 under room temperature and 50 °C increased compared with the hardness value in week 1. From here, it can be concluded that the hardness value decreased in week 1 and increased in week 2. Finally, the tensile tests in weeks 1 and 2 show that the HDPE samples of B30-T50 in weeks 1 and 2 are immersed in B30 under 50 °C are more ductile compared to other HDPE samples. The HDPE samples that are immersed in B10 at room temperature have the maximum value of Young Modulus. It shows that the HDPE sample is stiffer when immersed in B10 under room temperature. The stiffer the material, the higher the Young modulus.

CHAPTER 5 CONCLUSION

5.1 Conclusion

In conclusion, after managing to run all the experiments that were approached, we can conclude that the hardness properties of HDPE decrease when immersed in B10 and B30 under room temperature and 50 ℃ temperature for two weeks. When compared with the initial hardness value of HDPE samples before immersion, the hardness properties reduce in week 1 after immersion in B10 and B30 at room temperature and 50 ℃ temperature. However, the hardness properties tend to increase in week 2. Besides this, the tensile properties of HDPE from the test can conclude that due to decreased chain mobility at room temperatures of immersion under biodiesel, HDPE has better stiffness and ultimate tensile strength than at 50 ℃ temperatures of immersion under biodiesel. The molecules become more flexible at 50 ℃ temperatures and can deform in the direction of stress application. Lastly, B30 has more effect on HDPE's performance than B10. This can be proven when HDPE samples' hardness value that is immersed in B30 is higher than HDPE samples that are immersed in B10 at room temperature and 50 ℃ temperature. The B10 has more negligible effect on the performance of HDPE. In short, HDPE is robust and suitable for use as a storage tank for biodiesel production for long periods.

5.2 Recomendation

For further studies and improvements that can be taken in this experiment could be enhanced as follows:

I. Increase the immersion duration to up to 8 weeks on the HDPE samples.
II. Immersed the HDPE samples in a 100% concentration of biodiesel (B100) and conducted tensile and hardness tests.
III. Conduct a surface morphological test to examine the surface of HDPE samples immersed in biodiesel at room and 50 °C temperatures.
IV. Increase the immersion temperature to obtain different results.

REFERENCES

1. Colin Cronin (no date) Types of HDPE Plastic. Available at: https://www.ehow.com/list_7464711_types-hdpe-plastic.html .
2. Erdmann, M., Böhning, M. and Niebergall, U. (2019) 'Physical and chemical effects of biodiesel storage on high-density polyethylene: Evidence of co-oxidation', Polymer Degradation and Stability, 161, pp. 139–149. doi: 10.1016/j.polymdegradstab.2019.01.018.
3. Gibson, R. (1963) 'History of HDPE and HDPE pipe products', PE Specialisten Technology, pp. 1–2.
4. Nurul Komariah, L. et al. (2017) 'Storage tank materials for biodiesel blends; The analysis of fuel property changes', MATEC Web of Conferences, 101. doi: 10.1051/matecconf/201710102012.
5. Sarno, M. and Iuliano, M. (2019) 'Biodiesel production from waste cooking oil', Green Processing and Synthesis, 8(1), pp. 828–836. doi: 10.1515/gps-2019-0053.
6. TANGENT (2019) The Most Common Uses for High-Density Polyethylene (HDPE). Available at: https://tangentmaterials.com/the-most-common-uses-for-high-density-polyethylene-hdpe/ .
7. Vasudevan, P. T. and Briggs, M. (2008) 'Biodiesel production - Current state of the art and challenges', Journal of Industrial Microbiology and Biotechnology, 35(5), pp. 421–430. doi: 10.1007/s10295-008-0312-2.

APPENDICES

Appendix A Gantt chart of BDP 1

Project Activity Semester 1	MARCH			APRIL				MAY					JUNE		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project Planning															
Background research & Identify Problem Statement															
Define Objective & Scope															
Research & Literature Reviews															
Methodology & Survey															
Submission & Presentation of PSM 1									MID SEM BREAK						

Appendix B Gantt chart of BDP 2

Project Activity Semester 2	OCT				NOV					DEC				JAN	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Planning for project PSM 2	■	■							SEMESTER BREAK						
Discussion on chapter 4			■	■											
Conduct immersion test					■	■	■	■		■					
Conduct tensile, Hardness and Morphological test											■				
Discussion on chapter 5												■	■		
Report, Video and Summary submission														■	
Online Q&A session and Evaluation of Presentation															■

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA

TAJUK: TENSILE PROPERTIES OF HDPE EXPOSED TO BIODIESEL

SESI PENGAJIAN: **2020/21 Semester 1**

Saya **SASIDHARAN A/L ARUMUGAM**

mengaku membenarkan tesis ini disimpan di Perpustakaan Universiti Teknikal Malaysia Melaka (UTeM) dengan syarat-syarat kegunaan seperti berikut:

1. Tesis adalah hak milik Universiti Teknikal Malaysia Melaka dan penulis.
2. Perpustakaan Universiti Teknikal Malaysia Melaka dibenarkan membuat salinan untuk tujuan pengajian sahaja dengan izin penulis.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. **Sila tandakan (✓)

☐	SULIT	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia sebagaimana yang termaktub dalam AKTA RAHSIA RASMI 1972)
☐	TERHAD	(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
√	TIDAK TERHAD	

Disahkan oleh:

Alamat Tetap:

BLOK 41-16-07 PPR GOMBAK

SETIA 53100 WILAYAH

PERSEKUTUAN KUALA LUMPUR

Tarikh: 18 JANUARY 2022

Cop Rasmi: HAIRUL BAKRI
PENSYARAH
FAKULTI TEKNOLOGI KEJURUTERAAN
MEKANIKAL DAN PEMBUATAN
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Tarikh: 18/1/2022

** Jika tesis ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh laporan PSM ini perlu dikelaskan sebagai SULIT atau TERHAD.

Universiti Teknikal Malaysia Melaka
Hang Tuah Jaya,
76100 Durian Tunggal,
Melaka, Malaysia.

+606 270 1000
+606 270 1022
www.utem.edu.my

FAKULTI TEKNOLOGI KEJURUTERAAN MEKANIKAL DAN PEMBUATAN
Tel : +606 270 1184 | Faks : +606 270 1064

Rujukan Kami (Our Ref):
Rujukan Tuan (Your Ref):
Tarikh (Date): 31 Januari 2021

Chief Information Officer
Perpustakaan Laman Hikmah
Universiti Teknikal Malaysia Melaka

Melalui

Dekan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

Tuan

PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: SASIDHARAN A/L ARUMUGAM (B091810199)
Tajuk Tesis: TENSILE PROPERTIES OF HDPE EXPOSED TO BIODIESEL.

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"
"KOMPETENSI TERAS KEGEMILANGAN"

Saya yang menjalankan amanah,

EN. HAIRUL BIN BAKRI
Penyelia Utama/ Pensyarah Kanan
Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan
Universiti Teknikal Malaysia Melaka

SASIDHARAN ARUMUGAM

ORIGINALITY REPORT

15%	9%	5%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universiti Teknikal Malaysia Melaka Student Paper	3%
2	jocpr.com Internet Source	1%
3	www.globalplasticsheeting.com Internet Source	1%
4	eprints.utem.edu.my Internet Source	1%
5	repository.ntu.edu.sg Internet Source	1%
6	Maren Erdmann, Martin Böhning, Ute Niebergall. "Physical and chemical effects of biodiesel storage on high-density polyethylene: Evidence of co-oxidation", Polymer Degradation and Stability, 2019 Publication	<1%
7	Submitted to University of Iowa Student Paper	<1%

8	Submitted to Caledonian College of Engineering Student Paper	<1 %
9	Leily Nurul Komariah, Marwani, Sucia Aprisah, Yangia S.L Rosa. "Storage tank materials for biodiesel blends; the analysis of fuel property changes", MATEC Web of Conferences, 2017 Publication	<1 %
10	Submitted to Istanbul Bilgi University Student Paper	<1 %
11	Submitted to University Of Tasmania Student Paper	<1 %
12	repository.sustech.edu Internet Source	<1 %
13	Submitted to Anadolu University Student Paper	<1 %
14	Submitted to Georgia Institute of Technology Student Paper	<1 %
15	Submitted to Caloundra State High School Student Paper	<1 %
16	Submitted to UCSI University Student Paper	<1 %
17	link.springer.com Internet Source	<1 %
	eprints.kfupm.edu.sa	

18	Internet Source	<1%
19	Submitted to Kyungpook National University Student Paper	<1%
20	Submitted to South Tyneside College, Tyne & Wear Student Paper	<1%
21	discovery.ucl.ac.uk Internet Source	<1%
22	docplayer.net Internet Source	<1%
23	repository.tudelft.nl Internet Source	<1%
24	Submitted to INTO Queen's University Belfast Student Paper	<1%
25	Maurizio Carlini, Sonia Castellucci, Silvia Cocchi. "A Pilot-Scale Study of Waste Vegetable Oil Transesterification with Alkaline and Acidic Catalysts", Energy Procedia, 2014 Publication	<1%
26	afdc.energy.gov Internet Source	<1%
27	www.science.gov Internet Source	<1%

28	Submitted to New York Institute of Technology Student Paper	<1 %
29	Submitted to Higher College of Technology Student Paper	<1 %
30	Palligarnai T. Vasudevan, Michael Briggs. "Biodiesel production—current state of the art and challenges", Journal of Industrial Microbiology & Biotechnology, 2008 Publication	<1 %
31	www.iasj.net Internet Source	<1 %
32	Rudy Syah Putra, Yudi Antono, Kharis Pratama. "Carbon material@Chitosan composite as catalyst on the synthesis of FAME from used-cooking oil with electrocatalytic process", Journal of Physics: Conference Series, 2017 Publication	<1 %
33	Submitted to The University of Manchester Student Paper	<1 %
34	Submitted to Royal Melbourne Institute of Technology Student Paper	<1 %
35	Submitted to University of Wales Swansea Student Paper	<1 %

36	pure.southwales.ac.uk Internet Source	<1 %
37	Submitted to King Fahd University for Petroleum and Minerals Student Paper	<1 %
38	Submitted to National University of Singapore Student Paper	<1 %
39	www.mmu.ac.uk Internet Source	<1 %
40	Submitted to Glyndwr University Student Paper	<1 %
41	V.S.S. Venkatesh, Ashish B. Deoghare. "Fabrication and mechanical behaviour of Al-Kaoline metal matrix composite fabricated through powder metallurgy technique", Materials Today: Proceedings, 2020 Publication	<1 %
42	pdfs.semanticscholar.org Internet Source	<1 %
43	www.readbag.com Internet Source	<1 %
44	Submitted to University of Malaya Student Paper	<1 %
45	core.ac.uk Internet Source	<1 %

46	Scholar.sun.ac.za Internet Source	<1 %
47	Omprakash Sahu. "Characterisation and utilization of heterogeneous catalyst from waste rice-straw for biodiesel conversion", Fuel, 2021 Publication	<1 %
48	Submitted to Universiti Teknologi MARA Student Paper	<1 %
49	"Polymer Blends Handbook", Springer Science and Business Media LLC, 2014 Publication	<1 %
50	Www.mdpi.com Internet Source	<1 %
51	library.iugaza.edu.ps Internet Source	<1 %
52	www.ing.unitn.it Internet Source	<1 %
53	Laddawan Tumkot, Armando T. Quitain, Panatpong Boonnoun, Navadol Laosiripojana, Tetsuya Kida, Artiwan Shotipruk. "Synergizing Sulfonated Hydrothermal Carbon and Microwave Irradiation for Intensified Esterification Reaction", ACS Omega, 2020 Publication	<1 %

HAIRUL BAKRI
PENSYARAH
FAKULTI TEKNOLOGI KEJURUTERAAN
MEKANIKAL DAN PEMBUATAN
UNIVERSITI TEKNIKAL MALAYSIA MELAKA