THE MECHANICAL PROPERTIES OF PALM OIL FIBER REINFORCED POLYPROPLENE COMPOSITIES

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DECLARATION

I declare that this project report entitled “The mechanical properties of palm oil fiber reinforced polypropylene ” is the result of my own work except as cited in the references

Signature : ....

Name : ....

Date : ....

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honors.

Signature :. ....

Name of Supervisor : ....

Date : ....

DEDICATION

To my beloved parents,sibling and supervisor.

Thank you for all your support.

ABSTRACT

Natural fibers have been available for the replacement of luxury and non-renewed synthetic fibers in recent times as outstanding materials. In the last few years, many of the natural fiber used in the composite thermoplastic have been sisal, sugar cane, kenaf, palm oil and jute. Furthermore, the process of compounded materials between natural fibre and thermoplastic are for the applying it in the manufacturing of automotive, construction, furniture and goods industry. Palm Oil Fiber (POF) is a natural fiber with a good potential to strengthen thermoplastics and create a new top composite material. Therefore, this phenomenon was linked to this research which aimed at investigating the mechanical properties of polypropylene-backed POF (PP) as a matrix with varying weight of fibre, to identify PP-built physical properties of POF and to analyze the POF / PP composite microstructure. The process started with raw pineapple leaf preparation and was then alkalinized. By using the hot press and the cooling machine, POF and PP were combined with a hot compression process to create a sample. The samples have been developed for tensile tests (ASTM D3039), density tests (ASTM D792) and hardness tests (ASTM D2240) according to the standard requirements. The composition structure between fiber and matrix composite is investigated by the Scan electron microscope (SEM). The result showed a linear decrease in tensile testing and in maximum load for POF / PP composites with increasing fiber loading. The fiber loading was, however, up linearly with the density trend but decreasing with hardness. The study shows that the composition structure of POF / PP is best achieved by 10 wt % fiber loading.

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ABSTRAK

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Pada masa kini, serat semulajadi wujud sebagai bahan yang luar biasa yang menjadi bahan penting untuk menggantikan serat sintetik mewah dan serat tidak dapat diperbaharui.Sejak beberapa tahun kebelakangan ini, banyak serat semulajadi seperti sisal, pisang, kenaf, kelapa sawit dan jut telah digunakan sebagai pengukuhan dalam komposit termoplastik. Selain itu, proses bahan yang diperbuat antara serat semulajadi dan termoplastik kebanyakan digunakan dalam industri automotif,pembinaan,perkakas perabot dan lain-lain.Serat kelapa sawit juga mempunyai potensi yang besar untuk menjadi bahan-bahan penguat termoplastik dan menjadikan sebuah bahan komposit baru yang unggul.Tujuan kajian disebabkan semangat ingin tahu sifat mekanikal serat kelapa sawit apabila diperkuatkan dengan PP sebagai matriks.Kajian dilakukan dengan pelbagai nisbah PP dengan POF menganalisis struktur mikro POF / PP .Proses ini bermula dengan pendapatkan bahan mentah serat kelapa sawit dan kemudian dirawat dengan rawatan alkali.Mesin tekanan panas dan sejuk digunakan untuk meghasilkan sample komposit.Sample komposit tersebut akan diujikajikan dengan ujian tegangan (ASTM D3039), ujian ketumpatan (ASTM D792) dan ujian kekerasan (ASTM D2240).Mikroskop elektron pengimbas (SEM), digunakan untuk menyiasat struktur komposisi antara komposit serat dan matriks. Berdasarkan keputusan kajian mendapati ketumpatan meningkat secara mendatar tetapi kekerasan semakin berkurangan.Kajian ini menunjukan struktur komposit POF/PP yang terbaik adalah 10 wt%.

ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah S.W.T for giving me a chance to complete my research for this final year project with the title, “The mechanical properties of palm oil fiber reinforced polyproplene composites”.

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CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATIONS

Polymer Matrix Composites	-	PMC
Metal Matrix Composites	-	MMC
Ceramic Matrix Composites	-	CMC
Carbon and Graphic matrix composites	-	CGMC
Polypropylene	-	PP
Sodium Hydroxide	-	NaOH
High Performance Concrete	-	HPC
Palm Oil Empty Fruit Bunch	-	POFEFB
Palm Oil Fiber Empty Bunch	-	POFEB
Polyethylene	-	PE
Polystyrene	-	PS
Palm Oil Institute of Malaysia	-	MPOB
Fiber Reinforced Polymer	-	FRP
Palm Oil Empty Fruit Brunch	-	POEFB
Palm Oil Fibre	-	POF
Palm oil reinforced rubber composite	-	PORC

CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is the rich country with plenty of natural plants growing in the rainforest. Malaysia has many types of natural plants such as palm oil, kenaf, pineapple, orchid and others. Researchers take this opportunity to find out the benefits of natural plants and to develop new innovative and alternative products that are more environmentally friendly, cheaper and economical Most researchers find out the advantage of natural plant fiber to develop a new product. Natural fibers are generally known as vegetable fibers extracted from the plant's fruit, phloem, or leaf. Recently, many types of natural fibers are being studied to reinforce with polymer such as flax, hemp, jute, straw, wood fiber, rice hunks, sugar and bamboo cane, grass, reeds, ramie, empty fruit bunch, sisal, coir, kapok, banana fiber, pineapple leaf fiber and papyrus. Most of the natural fiber is used for automotive components, clothes and construction. Many researchers studied the advantages of natural fiber reinforcement with polymer such as polystyrene (PS), polyester, epoxy, polyethylene (PE) and polypropylene (PP). On the morphology and properties of polypropylene (Dikobe & Luyt, 2009), polypropylene (PP) has been found to be one of the most widely used product polymers in many areas, such as home appliances, industrial applications and automotive components. The characteristic PP is low impact strength, the module properties of Young, low temperature and high temperature loading conditions. Method for improving the PP properties by mixing and mixing it with other polymers.

Composite material is defined when two or more different materials combine to create new physical and chemical properties for better results. The good things about combining materials are their high strength and rigidity. (Paul Wambua, Jan Ivens, Ignaas

Verpoest, 2003) conducted natural fiber replacement studies in fiber-reinforced plastics. They were research on the mechanical properties of polypropylene reinforced by kenaf, coir, sisal, hemp and jute. They found the natural resource reinforced with polypropylene had found tensile strength and module increases with increasing fiber volume fraction They also found some natural fiber that can cover high impact strength and can replace the glass as alternative materials. (H. Ku, H. Wang, N. Pattarachaiyakoop & M. Trada, 2011) studied the tensile properties of natural fiber reinforced polymer composites. They found that the strength and stiffness of natural polymer fiber composite was strong but dependent on the amount of fiber. They also found that the tensile strength and module will increase when the fiber weight ratio rises to a certain amount. This shows that natural fiber reinforcement with polymer can have a good impact on industry in finding alternative materials that are more economically and environmentally friendly.

Malaysia is rich with different plants and climate equator. This climate offers the opportunity to become the second largest palm oil plantation after Indonesia. Production based on palm oil is about 90 million tons of lignocellulosic biomass including oil palm trunk, palm fronds and empty fruit bunches. Production of palm oil produces a lot of waste such as coir and trunk palm oil. Malaysia is setting up the Palm Oil Research Institute of Malaysia (MPOB) to maximize palm oil production and reduce palm oil waste. Therefore, in thermoplastics and thermoset, many researchers discover and conduct research to investigate the effects and benefits of palm oil coir fibers(Maya Jacob, Sabu Thomas, K.T. Varughese, 2003) presented the mechanical properties of natural rubber composites reinforced by sisal / oil palm hybrid fiber. The effect of fiber loading, fiber ratio and alkaline treatment in a study. The show palm oil reinforced rubber composites (PORC) is had strong strength when load applied on it. This PORC show had a strong durability to any condition. The composites tensile and tear strength properties depend on the fraction of the volume. This study was very useful with high quality composite strength. Recently, palm oil fiber is suitable for the manufacture of automotive component belt conveyor, rope hand break and rope break due to mechanical properties. The PORC can also be applied to building construction because it has strong durability and hard to damage.

Saxena & Pappu, 2011, presented recent trends and future potential on natural resource composite materials that discovered the benefits of natural fiber reinforcing composite polymers. This substitution offers many advantages such as lower cost, energy savings, reduced tool wear and tear, high stability for manufactured parts, good insulation properties, renewable, easy to recycle, no toxicity material and reduced fossil fuels. This natural fiber is also used in automobiles such as trim parts, various panels, shelves and brakes that attract in the automotive industry due to its weight reduction of 10 percent, energy production of 80 % and cost reduction of 5 %.

Based on the findings, palm oil coir fiber as natural fiber has an advantage used to reinforce polymer composites. Few researchers presented composites using natural fiber such as palm oil and bamboo fiber. Therefore, this research focuses on the mechanical properties of POF/ PP applied to automotive components, glass, building construction and others.

1.2 PROBLEM STATEMENT

The Industrial Revolution transition took place around 1760 from the manufacturing method to the machine. The industrial revolution continued until today. The modern era, the trend automotive industries have competed to launch new cars with a variety of sophisticated features to attract customer buy car from their brand. Mostly, today's automotive industries are using synthetic materials to manufacture parts of automotive components such as aluminum, glass, steel, copper, rubber, iron, plastic steels and others. These parts are used to create dashboard needles, wiring, engine block and gears for transmission. However, the uncertainty price of synthesis materials nowadays will have a bad impact on the cost of automotive production and decrease the profit of the automotive industry.

1.3 OBJECTIVE

1.3.1 To investigate the mechanical properties palm oil fibre reinforced with polypropylene(PP) as matrix with varying fiber weight fraction.

1.3.2 To identify the physical properties of polypropylene (PP) reinforced palm oil fiber.

1.3.3 To analyze the microstructure of palm oil fiber polypropylene (PP) composites.

1.4 SCOPE

The scope of research are:

1.4.1 Preparation of Palm Oil Fiber Empty Fruit Brunch

1.4.2 Treatment of fiber-alkaline treatment (NaOH solution)

1.4.3 Preparation of polypropylene (PP)

1.4.4 Preparation of sample (composite material) – Compounding of POF and polypropylene polymer by using ball mill and hot press machine.

1.4.5 Testing to find out mechanical properties

(i) Tensile test (ASTM D3039)

1.4.6 Investigate and testing the physical properties:

(i) Density test (ASTM D792)

(ii) Hardness test (ASTM D2240)

(iii) Microstructure analysis (SEM)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The chapter covers an overview of previous research on composite, natural fiber, palm oil and polypropylene. The purpose of this study is to link the theory of fiber-reinforced polymer composite with the research's main objective. This chapter will review studied exploring palm oil and the advantages of natural fiber and method or material influence the mechanical properties of composites among various polymers.

2.2 Composite

Based on research (Klaus Friedrich & Abdul Hakim A. Almajid, 2012), composite materials have a bright future in high-range, extremely light machine components in the automotive and aerospace industries. Thermoplastics are more advantageous than thermoset because it has low processing costs, ease of moulding complex parts, flexibility, toughness and good mechanical properties. Refer to table 2.1, nowadays the trend towards the manufacture of cars using quantities of composites for hybrids and battery electric vehicles to reduce mass and extend driving range. The advantages of composite in automotive and aerospace can reduce weight production by 20-40 percent, reducing tooling costs, reducing assembly costs, corrosion resistance, and reducing noise vibration hardness and higher damping. The industry is more composite-focused because it has innovation capable of adding low-cost value and safer structure because it has higher specific energy absorption.

Table 2.1: Properties of conventional metals and some advanced composite in automotive industry.

Material	Density(ρ) g/cm3	Tensile Modulus(E)	Tensile Strength (σ)	E / ρ	σ / ρ
Al 6061-T6	2.70	68.9	310	25.7	115
SAE 1010 steel (cold steamed)	7.87	207	365	26.3	46.4
Ti-6Al-4V	4.43	110	1171	25.3	26
Polyamide66	1.14	2	70	1.75	61.4
Unidirectional HS carbon fiber/epoxy	1.55	138	1550	88.9	1000
Unidirectional E-glass fiber/epoxy	1.85	39.3	965	21.2	522
Unidirectional aramid fiber/epoxy	1.38	75.8	1378	54.9	999
Quasi-isotropic carbon fiber/epoxy	1.55	45.5	579	29.3	374
Random glass	1.55	8.5	110	5.48	71

M. Assarar,2010 presented the effect of water ageing on mechanical properties and damage between flax-fiber and glass fiber. The flax fiber is from natural fiber such as hemp, sisal, bamboo and jute to reinforcement with polymer. The research founds out the failure stress properties is slight decrease with immersion time. The both fibers are durable and not easy lost mechanical properties. This show composite suitable to apply in manufacturing industry, automotive and construction where material usually exposed to unpredict weather.

Based on the studies by (Alireza Ashori, 2016) has mentioned that composite contain plant fiber and thermosets or thermoplastic. The unique and superior feature in any plant fiber composite reinforce with thermoplastic have high strength and stiffness cost, low density and low carbon dioxide emission, biodegradability and annually renewable. The composite more environment friendly in industry automotive. Many components made from composite materials such as trim parts in dashboards, door panels, parcel shelves, seat cushions, backrests and cabin linings. The plant fiber composite enhances mechanical strength and acoustic performance, reduce material weight, energy/fuel consumption and processing time, lower production cost, improve passenger safety and shatterproof performance under extreme temperature changes, and improve biodegradability. The plant fiber had high potential to research and develop in green industry.

2.3 Natural Fiber

Fiber can be defined as hair-like materials that are continuous filaments or discrete elongated pieces that are like thread pieces. The fibers can be spun into filaments, thread, rope and matted into sheets to make paper or felt. Fibers can be used as a composite material component. Fibers are two types; natural fibers and synthetic fibrate researchers are more focused on producing composite products based on natural fiber.

Natural fibers are plant and animal substance extracts. Five categories of natural plant fibers are seed fiber, leaf fiber, bast fiber, fruit fiber and stalk fiber. The fiber of seeds collected from seeds. The leaf fiber extracted from a leaf's cells. The bast fiber extracted from the cells of the plant's outer cell layers. Fruit fiber collected from plant fruits such as coconut coir fiber and palm oil coir fiber. Stalk fiber extracted from plant stalks such as bamboo.

Table 2.2: Mechanical properties of some important natural fiber.

	Tensile Strength	**Elongation**	**Toughness**
Fiber	(MPa)	(%)	(MPa)
Sisal	580	4.3	1,250
Pineapple	640	2.4	970
Banana	540	3.0	816
Coir	140	25.0	3,200
OPEFB fiber	248	14	2,000
Palm oil mesocarp fiber	80	17	500

Refer to article (M.S Sreekala M. G. Kumaran, Sabu Thomas,1997) Table 2.2 above shows the mechanical properties of palm oil and other natural fibers had the potential to develop and innovate the product in industrial packaging, automotive and construction. Natural fibers are low cost, light weight, low density, less pollution attracts interest from the researcher to find the best alternative to replace some component with low cost but superior mechanical properties, especially in the automotive and aerospace industries.

Rozyanty Rahman, Syed Zhafer & Firdaus Syed Putra,2016 conducts a study of differential mechanical properties between natural fiber and polymer-reinforced synthetic fiber. The famous natural among researchers are flux, hemp, jute, sisal, kenaf, coir, banana, and henequen, while the famous synthetic fiber is glass, carbon, and aramic. Four factors influence the mechanical properties of composite based on the article. The first factor is properties of fiber. Second factor is properties of polymer matrix. Third is ratio of fiber to polymer matrix. Fourth is orientation and geometry of fiber in composite. With ad chemical treatment, hydrophilic nature of natural fiber can improve adhesion between reinforcement and matrix resin. The ratio and type of chemical treatment affects the mechanical properties of the composite and the thickness of the plate. Table 2.3 shows the effect of natural fiber treatment on plate thickness.

Table 2.3: The result effect natural fiber after treatment.

Fiber	Treatment	No. of ply	Stacking sequence	Thickness(mm)
Hemp	Untreated	4	[0/90]1s	1.364
Hemp	Alkaline treatment NaOH 1%	4	[0/90]1s	1.511
Hemp	Alkaline treatment NaOH 5%	4	[0/90]1s	1.679
Hemp	Silane treatment 1%	4	[0/90]1s	1.471
Hemp	Silane treatment 5%	4	[0/90]1s	1.460
Hemp	Silane treatment 20%	4	[0/90]1s	1.450

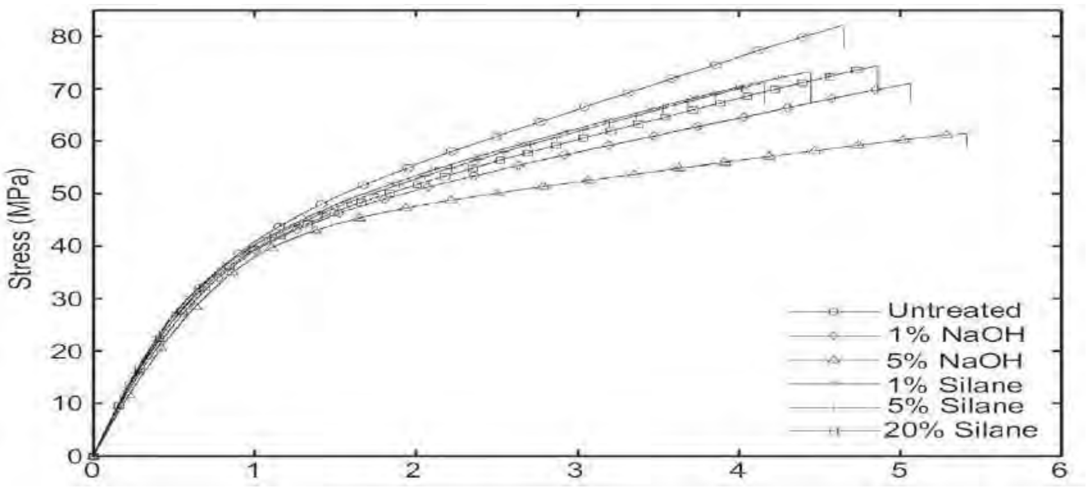


Figure 2.1: The result tensile stress versus strain curves for six different configurations of hemp-epoxy composites.

Based on the table above, the untreated hemp-epoxy fiber shows the highest tensile stress while the 5 % NaOH treatment shows the lowest tensile stress. This shows the different type and ratio of treatment influences the properties of tensile stress.

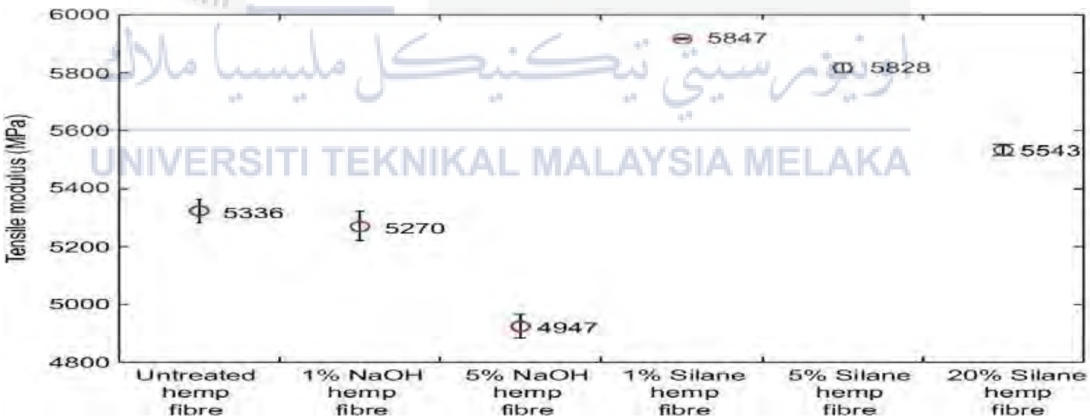


Figure 2.2: The result tensile modulus of hemp-epoxy composites.

The 1 % silane hemp fiber shows the highest tensile module based on the table above, while the 5 percent NaOH hemp fiber treatment shows the lowest tensile module. This shows the different type and treatment ratio influences the properties of the tensile module.

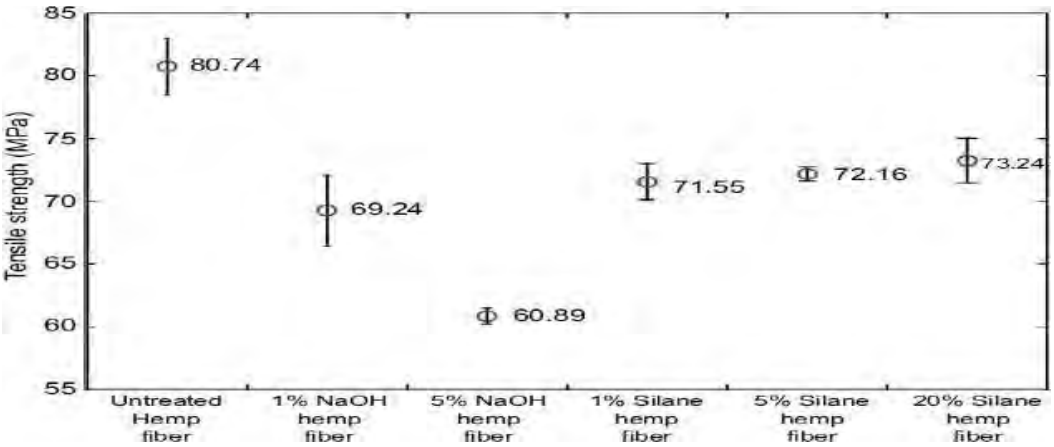


Figure 2.3: The result tensile strength of hemp-epoxy composites.

The untreated hemp fiber shows the highest tensile strength based on the table above,while 5 % NaOH hemp fiber treatment shows the lowest tensile strength. This shows thedifferent type and treatment ratio influence the properties of the tensile module.

Natural fibers are now famous among researchers because natural fiber composite has many advantages such as enhanced corrosion resistance, environmentally friendly, raw material availability and ease of manufacturing. (Ashwin Sailesh, R.Arunkumar, S.Saravanan, 2016) conducts a study on the mechanical properties of kenaf / aloe vera / jute fiber reinforced with epoxy resin. The mechanical properties testing involves tensile strength, flexural strength and impact strength. The researcher found the stacking sequence of the fiber as the interaction between the reinforcing fiber and the matrix plays a major factor in determining the properties of the composite material. Table 2.4 shows the laminate plate sequence to determine the mechanical properties of the natural composite fiber.

Table 2.4: The different sequence of laminate plate before experiment.

Laminating Plates	Stacking Sequence
Plate 1	K-J-A-J-K
Plate2	A-K-J-K-A
Plate 3	J-K-A-K-J
Plate 4	J-A-K-K-K-A-J

A: Aloe Vera

Fiber J: Jute

Fiber

K: Kenaf Fiber

Table 2.5: The result mechanical properties with different sequence of laminate plate.

No, Plate.	Ultimate Tensile Strength (MPa)	Flexural Strength (MPa)	Impact Strength (J / mm2)
1	45.593	55.871	0.0097
2	56.107	68.039	0.0097
3	51.718	63.297	0.0076
4	64.906	94.806	0.0128

Table 2.5 above shows that plate number three is the best sequence plate because it has the highest ultimate tensile strength, flexural strength and impact strength compared to other plate. The different sequence of natural fiber plate influences the mechanical properties of composites.

2.4 Palm oil fiber

The main palm oil fiber is waste from the vascular bundle of palm oil in empty fruit bunch. The oil palm fiber can also be found in trunk, leaf and other parts. The advantages of oil palm fiber are cheap, very low humidity, environmentally friendly and biodegradable. The oil palm fiber is superior material. It can be used for cushion material, erosion control mat, paper, pulp, fertilizer and composite. Many researchers are studying the potential of the oil palm fiber composite industry to produce more low-cost, environmentally friendly, quality product. Palm oil empty fruit bunch (POEFB) refers to waste product from process product cooking oil extracted from fruit bunch. The oil palm fiber is non-hazardous, biodegradable and environmentally friendly. In Table 2.6, POEFB shows the superior mechanical properties that can produce innovation products to benefit industry in low-cost and durable products. The researcher focuses more on investigating the reinforcement of palm oil fiber in thermoset, thermoplastic and elastomer. These fibers show high ultimate tensile strength and initial module because they have high cellulose content and low microfiber angle. The POEFB easily acquires the mechanical properties to describe the industrial potential. (M. Jawaid a, H.P.S. Abdul Khalil A. Abu Bakar P. Noorunnisa Khanam, 2010), conducts a study on chemical resistance, void content and tensile properties of oil palm / jute fiber reinforced polymer hybrid composites. They described the mechanical properties of oil palm fiber as shown in table 2.6:

Table 2.6: The table show properties of palm oil fiber

Properties of palm oil fiber	
Chemical constituents (%)	
Cellulose	65
Hemicellulose	-
Lignin	19
Ash content	2
Physical properties of oil palm fiber	
Diameter mm	150–500
Density g/cc	0.7–1.55
Tensile strength (MPa)	248
Young's modulus (MPa)	6700
Elongation at break%	14
Microfibrillar angle (_)	46

M.S Sreekala M. G. Kumaran, Sabu Thomas, 1997 discovered the differentiation of the mechanical properties of oil palm between OPEFB fiber and oil palm mesocarp fiber. Table 2.7 shows the data obtained from the researcher:

Table 2.7: The table show different mechanical properties between OPEFB and oil palm mesocarp fiber.

Fiber	Tensile Strength (MPa)	Young's Modulus (MPa)	Elongation at Break (%)
OPEFB			
Untreated	248	2,000	14
Alkali-treated	224	5,000	16
Silane-treated	273	5,250	14
Oil palm mesocarp fiber (fruit fiber)			
Untreated	80	500	17
Alkali-treated	64	740	6.5
Silane-treated	111	1,120	13.5

Based on his research OFEFB show the cellulosic more than mesocarp fiber. The palm oil mesocarp fiber contains a higher percentage of ether-soluble and caustic soda-soluble matter. The treatment give good impact to OPEFB fiber is more mesocarp fiber because it improves the strength and reinforcing ability of these fibers. Find the right treatment also important because different treatment because give different impact Alkali treatment decreases tensile strength but increases silane treatment.

Extracted from empty fruit brunch, trunk and fruit nut, the palm oil fiber. Palm oil fiber palm oil fibers are porous, short in length and low in cellulose content, making extraction easier. (Humphrey Danso, 2017) conducts a study of the potential of natural fiber such as coconut, oil palm and bagasse in the manufacture of product building materials. The researcher found the lowest water absorption of palm oil fiber than coconut and bagasse. The palm oil fiber only absorbs 54 % in one day and 103 % in fourteenth day, while bagasse absorbs 153 % in one day and 219 % in fourteenth day. The researcher also found tensile strength palm oil fire soil reinforcement block in wet drop from 110 MPa to 50~53 MPa while in damp drop up to 60~65 MPa in 120 days. Maybe the oil palm fiber reinforces with polymer can obtain better mechanical properties because the main factor materials determine composite's mechanical properties.

2.5 Polypropylene

Thermoplastic is a polymer that can melt back into liquid. Many types of thermoplastics in industry such as polyethylene, polystyrene, polypropylene and others. Usually, polypropylene is used in industry to produce many applications, especially in the automotive industry. The benefits of polypropylene (PP) are rough and usually resistant to many chemical solvents, base and acid. PP is characterized by lightness, strength, toughness and resistance to thermal deformation. The team of designers and manufacturers value these characteristics to consider PP is one of the most valuable and satisfactory thermoplastic resins to be applied in any application. PP can also fit with any film and fiber to create superior composites of strength and high optical qualities.

Based on her studies (Dakina, 2012), glass fibers are used as reinforcement with polymer composites because their characteristics have high electrical insulating properties, low sensitivity to moisture and high mechanical properties. PP also has advantages because it is resistant to lightweight materials, durable, moderately inexpensive and chemical resistant. Glass fiber PP composites are subjected to two impact tests (ASTM-E23) and three-point tests (ASTM-D618). From the test results, mechanical 15 properties of car bumpers are improved after glass fiber reinforcement, which increases impact strength from (85Kj / m2) to (498Kj / m2) and compressive strength from (51MPa) to (310MPa). The optimum percentages of reinforcement was 70 %.

Dehong Wang, Yanzhong Ju, Hao Shen & Libin Xu, 2019 conducts a study on the mechanical properties of high-performance reinforced concrete (HPC) with basalt fiber and polypropylene fiber. Polypropylene fiber can increase HPC's compressive strength, flexural strength, and splitting tensile. The mixed two fibers, which are 0.15 percent basalt fiber and 0.033 percent polypropylene, can also have the maximum impact on mechanical properties of HPC. The mixed basalt fiber and polypropylene reinforced HPC fiber increases compressive strength by 14.1 percent, flexural strength by 22.8 percent, and slitting strength by 48.6 percent compared to HPC without fiber.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This methodology chapter to explain the progress start from literature review about natural composite, natural fiber and polymer review until report analysis to get the mechanical properties of palm oil fiber reinforcement polypropylene composites. Flow chart as shown below in Figure 3.1 to briefly workflow the final project for these two semesters which begin from literature review until report analysis. Next, the materials were prepared such as palm oil fiber and polypropylene for this project and undergo several processes to get the sample. The samples were being tested and analyzed to obtain the result about the sample properties.

This chapter have three stage to obtain the mechanical properties:

i) Raw material preparation

ii) Sample preparation

iii) Testing

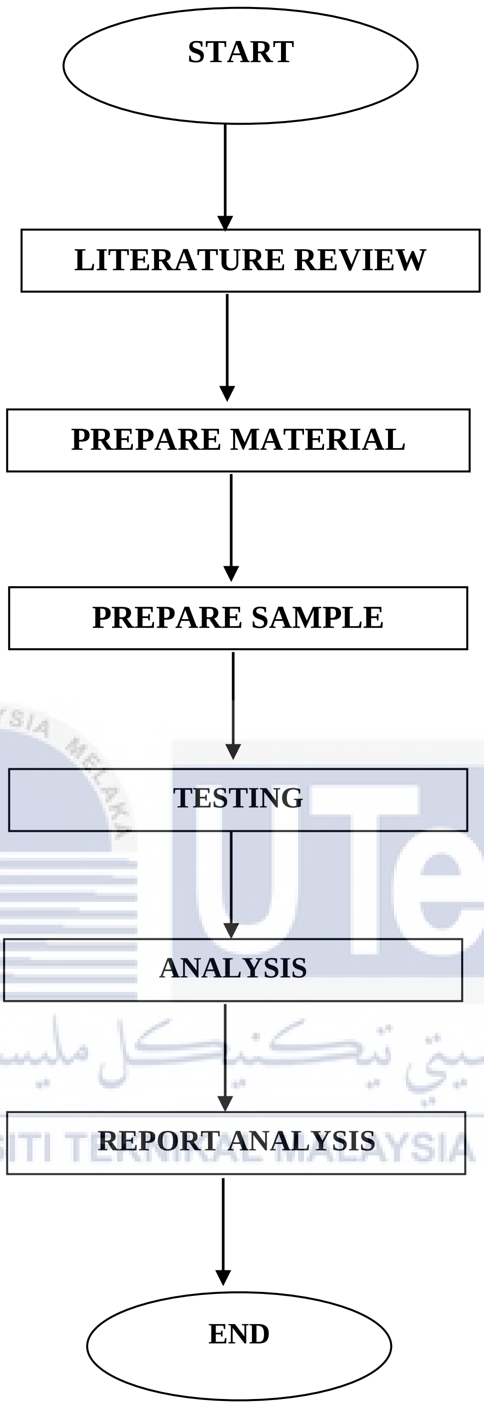


Figure 3.1: The flow chart methodology

3.2 . Raw material preparation

3.2.1 Preparation of Palm oil Fiber (POF)

This POF obtain from the palm oil empty coir from palm oil factory. The process is beginning with separate the palm oil fiber (POF) from palm oil empty fruit bunches (POEFB). The separation process for palm oil fiber from the empty fruit is use mechanical method. The mechanical more effective to separate the palm oil fiber form palm oil empty bunch (POEFB). First process is separate the fruit palm oil and bunch. The separation process is use machine crushing with certain temperature to simplify separation process POF from POEB. The separation process done at palm oil factory. The figure 3.1 below show the POF after the separation process:

Figure 3.2: The palm oil fiber empty fruit brunch

Figure 3.3: The machine crusher machine to extract POF from POEB

This project needs alkaline treatment to keep the fiber at least more than two months for prevent it rusting. The alkaline was treated with chemical agent which is sodium hydroxide (NaOH) solution to remove hemicellulose and lignin components from natural fiber to get better purified cellulose result. The advantages of this treatment are can increase fiber surface roughness providing physical interlocking between fiber and matrix which affected the mechanical properties of the composites.

Figure 3.4: Sodium hydroxide (NaOH) in pallets form

The fibers were treated with immersed it in 5% aqueous alkali (NaOH) for 30 minutes. When POF were cleaned, the fibers were chopped less than 1 cm by using scissors which help to gain a smaller size or random – discontinuous form. After that, washed the fibers several times with distilled water and dried it at 60 °C for 24 hours by using oven and under the sun. When POF were fully dried, the excess lignin and cellulose fiber are removed manually.

Figure 3.5: The POF was cutted less than 1 cm

Figure 3.6: The process drying under the sun

3.2.2 Preparation of Polypropylene (PP)

Polypropylene (PP) is a thermoplastic polymer widely used in automotive and furniture industry. The application PP mostly use for packaging and labelling in industry. For this final year project, PP is used as a matrix to reinforce with the fiber to create new materials and obtain new mechanical properties. Before PP compound with POF, it through several process to create new materials.

The PP was beginning with weighed the polypropylene using electronic weigh balance machine to get the weight around 12g and the crushed it into pulverize machine for 500 seconds. The result from the crush the PP was turn to the flakes shape. The process continued with blend the PP using blender. Next, PP was continued with blended it until become powder and filtered it by using a sieve size 500µm to get the uniformly size. The sieve was shake by using the shaker machine. This process was repeated until the PP weighed around 100g for this project.

Figure 3.7: Electronic weighing balance machine

Figure 3.8: The pulverize machine to crush PP.

Figure 3.9: The raw material of Polypropylene (PP) polymer.

Figure 3.10: The PP after crushed turn to flake shape.

Figure 3.11: The blender used to blend PP

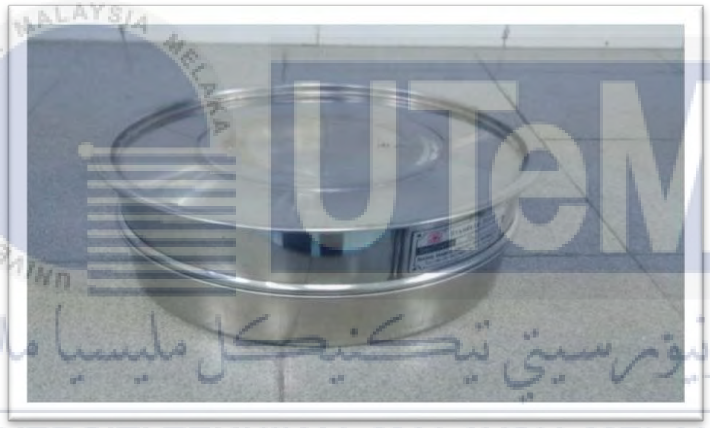


Figure 3.12: Sieve 500µm.

Figure 3.13: The shaker machine

Figure 3.14: The powder of PP

3.3 Sample Preparation

3.3.1 POF/PP Composite Preparation

In this research, need to provide four sample POF/PP composite with different ratio.

Table 3.1: The ratio of POF/PP composite sample

SAMPLE POF/PP	Weight Percentage (POF/PP)
10/90	1.6g/14.4g
20/80	3.2g/12.8g
30/70	4.8g/11.2g
40/60	6.4g/9.6g

The ratio for each sample as table above is based on weight percentage. The POF/PP was mixing up by using ball mill machine. In this process, the POF and PP were mixed into a round bottle with different size carbon steel balls and then ball mill machine will rotate the bottle in 45 minutes. Each bottle was labelling with 10%,20%,30% and 40%.

Figure 3.15: The ball mill machine.

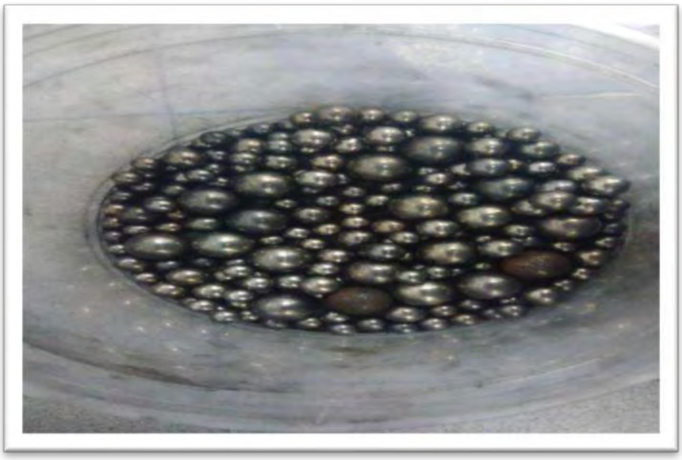


Figure 3.16: Carbon steel balls

Figure 3.17: The compounded composite POF/PP

After that, the mixture raw materials put into the mould. 140mm X 60mm.Next, the set the temperature hot compress at 170 °C. The compounded composites at compress machine were preheat for 15 minutes for transfer heat to mould and then compress it at 300 psi for 5 minutes. The cooling process start set up to 15 minutes after hot compress process. The compounded composites were pressed by using hot compress machine to fabricate sample with thickness of 2.0 mm according to the specification that are required in testing sample.

Figure 3.18: The hot press process.

Figure 3.19: The cooling process.

After done with hot compress and cooling process, the mould that filled with compounded composite were removed from the hot compress machine and then placed it to H-Frame, to take out the POF/PP composite sample from the mould use hydraulic power machine. The size of POF/PP composite sample that were obtained from the fabrication process is 140 mm x 60 mm x 2 mm.

Figure 3.20:H-frame used to carry out the POF/PP composites

Figure 3.21: The POF/PP composites

3.3.2 Testing Sample Preparation

POF/PP Composites samples with thickness 2.0 mm were prepared for tensile test specimens, density test specimen, hardness test specimen and microstructure analysis. These entire samples were cut to the shape that is required according to standards of testing sample.

3.4 Testing

There are four testing methods that were used in this study based on American Standard Testing Methods (ASTM) which are Tensile Test (ASTM D3039), Density Test (ASTM D792), Hardness Test (ASTM D2240) and Microstructure analysis (SEM).

3.4.1 Tensile Test (ASTM D3039)

Tensile testing is performed against the composite specimen based on ASTM D3039 to measure the force required to break and extend a composite POF / PP polymer specimen to determine which specimen stretches or extends to that point of breakage.

POF / PP composite samples have been cut using Table cutter machine into the dimension required for this testing for this testing. A thin flat strip of material composite specimen with a length of 140 mm, a width of 25 mm and a thickness of 2 mm is mounted in the handles of the Instron Universal Testing Machine (Model 5585H) controlled by the Blue Hill 2 load test software and activated at constant head-speed tests of 2 min / mm.

Figure 3.22:The POF/PP composites cutted to specific dimension.

Figure 3.23: The Table cutter machine

Specimens were placed and fixed it in the grips of Instron Universal Test Machine at a specified grip separation and pulled until rupture occurred. The test speed can be determined the specification time of time to failure (1 to 10 minutes) of materials. Then, the values of tensile stress, tensile strain and the percentage of elongation were obtained from the stress-strain curve diagram.

Figure 3.24: Instron Universal Testing Machine 8872

Figure 3.25: The position POF/PP composite on tensile test.

Figure 3.26: POF/PP composite samples ruptured after tensile test

3.4.2 Density Test (ASTM D792)

Density test described the determination of the specific gravity and density of solid plastics. This testing method, to determine the mass of a specimen of the solid plastic in air. The thickness of specimen is 2 mm. The specific gravity is calculated because to identify a material, to follow physical changes in a sample and to indicate degree of uniformity among different specimens.

The specimens were testing by using a digital electronic densimeter (MD- 300S). Firstly, the specimen's apparent mass was measured and then, the specimens were immersed in a liquid. The value of specific gravity and volume can be obtained.

Figure 3.27: Take the mass of composite POF/PP.

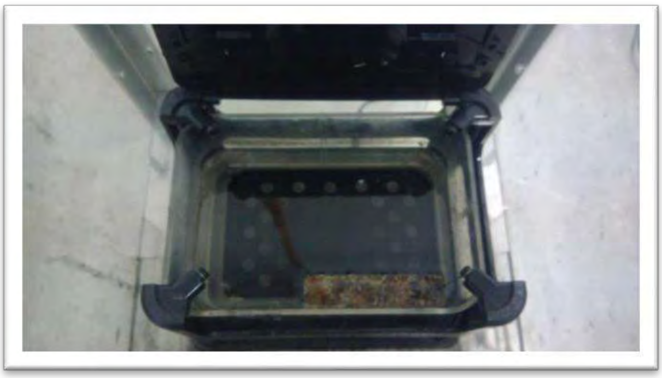


Figure 3.28: Immersed the composite in liquid

Figure 3.29: Take the reading density of POF/PP composites.

3.4.3 Hardness Test (ASTM D2240)

The durability test is measured using the ASTM D2240-based analog Shore scale "D" type Durometer. This method measures the sample indentation depth and provides an empirical durability value the specimen surface should be flat, and the thickness should be 2.0 mm. The measurement should be taken from the edge of the sample at least 12 mm because at the edge of the sample the hardness characteristics tend to change.

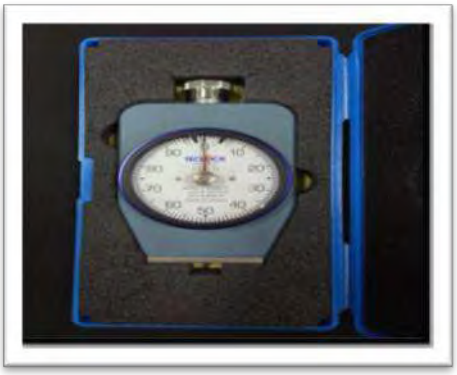


Figure 3.30: The Analogue Shore Scale D-type Durometer.

3.4.4 Microstructure Analysis (SEM)

The conventional light microscope is the most commonly used microscope. Not all material transmits light, however, so the researcher decided to look with an optical microscope at the surface of the specimen, namely Scanning Electron Microscope (SEM).

SEM was used to expose the orientation of thermoplastics reinforced by fiber and to obtain information on bonding between fibers and matrix. With an electron beam, the surface was examined and scanned. SEM can create a visual image of a large magnification scale that makes it possible to observe the irregular surface of materials.

SEM was used in this research to study the formation bonding between matrix and fiber, the orientation of thermoplastic reinforced fiber, and the condition of thermoplastic reinforced fiber in various percentage loading. The JEOL JSM-6010PLUS / LV SEM used in this research. Before performing SEM, samples were divided into 10 mm x 10 mm dimensions for each percentage load The sample was then tied together with different percentage loading and placed on a platinum-coated stub or auto fine coater (JEOL JEC-3000FC). In the auto fine coater, the sample were vacuumed to prevent interference of scanning picture due to the existence of air. After that, the samples were inserted into the scanning barrel. Due to the existence of air, the sample was vacuumed in the auto fine coater to prevent scanning image interference.

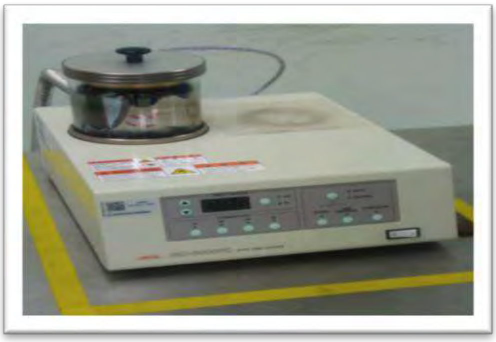


Figure 3.31: Auto Fine Coater

Figure 3.32: Sample coated with platinum.

Figure 3.33: Scanning Electron Microscope (JEOL JSM-6010PLUS/LV)

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter covers the mechanical properties, physical properties and analyzes PP composite microstructure reinforced by palm oil fiber.

4.2 Effect of Mechanical Test

One of the goals of this research was to study the mechanical properties of reinforced Palm Oil Fiber (POF) reinforced PP composites.

Table 4.1: Tensile properties of the POF/PP

POF Loading (wt%)	Maximum Load (N)	Tensile stress, σ (MPa)	Tensile strain, Ɛ (mm/mm)
10	894.859	11.931	0.0409
20	616.018	8.214	0.0203
30	555.334	7.404	0.0203
40	505.129	6.735	0.0248

The percentage load result for the POF / PP composite sample tensile test is shown in Table 4.1. This tensile test can determine the value of maximum load, tensile stress and tensile strain. All values differ when undergoing elongation or stretching process depending on the percentage loading capacity.

Figure 4.1 shows the result in natural fiber composite between maximum load and percent load during the tensile test. Based on the graph, POF's 10 wt % maximum load percentage is the highest value among others, which is 894,859 N, while POF's 40 wt % load is the lowest, 505.129 N. The second maximum load is 20 wt % 616,018 N followed by 30 wt %, which is the maximum load of 555,334 N. The pattern for this graph decreases as the POF / PP composite with less fiber content can execute a high maximum load than the POF / PP composite with more fiber content. The maximum load is the highest at .10wt % load because this sample has a low fiber quantity, so the elasticity is the highest It can withstand higher maximum load for a long time to fracture. The sample with 40 wt % of fiber was a bit excessive and the PP matrix has a difficult situation to flow through each fiber while the fiber is more easily revealed to environmental degradation. Thus, the composition was difficult to produce, and the composite became fragile.

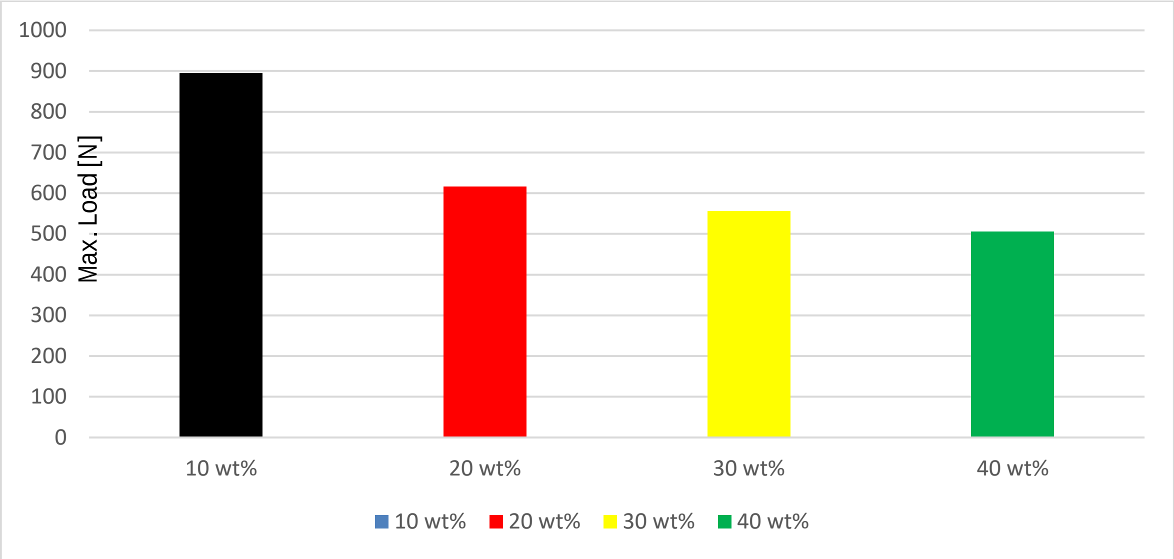


Figure 4.1: The graph of maximum load (N) against percentage of POF loading

Figure 4.2 shows the result between the maximum load (MPa) tensile stress against the POF (wt %) percentage load. Tensile stress at maximum load for 10 wt % loading of POF is the highest value of 11.931 MPa, according to the results obtained. However, 6.735 MPa is the lowest value of tensile stress at maximum load for 40 wt % loading of POF. The second highest tensile stress which is 20 wt % with value 8.214 MPa followed 30 wt% with value 7.404 MPa. The pattern of the graph showed that increasing the fibre loading reduced the tensile strength. This is because the POF/PP composite that have less fibre are more elastic than POF/PP composite that have more fibre. Also, the addition of fibres were disturbing the PP segment mobility and causing the plastic turn to be more brittle.

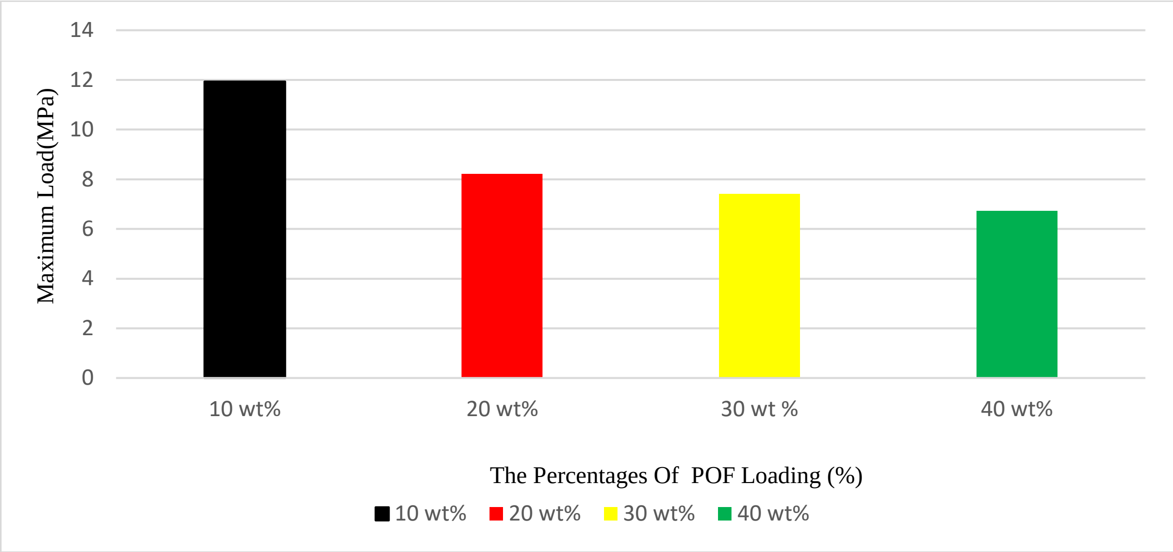


Figure 4.2: The graph of tensile Stress at maximum load (MPa) against of the percentages of POF loading (%)

Based on the Figure 4.3 shows the result between Load (N) against Extension (mm) during tensile test for the POF/PP composite sample with different percentage of loading (wt%). According to the graph below, the result stated the different pattern for the different percentage loading. 10 wt% shows the highest value tensile stress pattern for this graph, second highest tensile stress is 20 wt% and followed by 30 wt% which tensile stress value is 0.203 mm/mm. Lastly the lowest value tensile stress is 40 wt%. For the 10 wt% have the lowest value of fibre in the POF/PP composite sample. Thus, the ductility level is the highest, so it can be extended with the highest maximum level than others percentage fibre loading before it ruptured. The samples that have more percentage loading of fibre tend to easily rupture because of their low ductility.

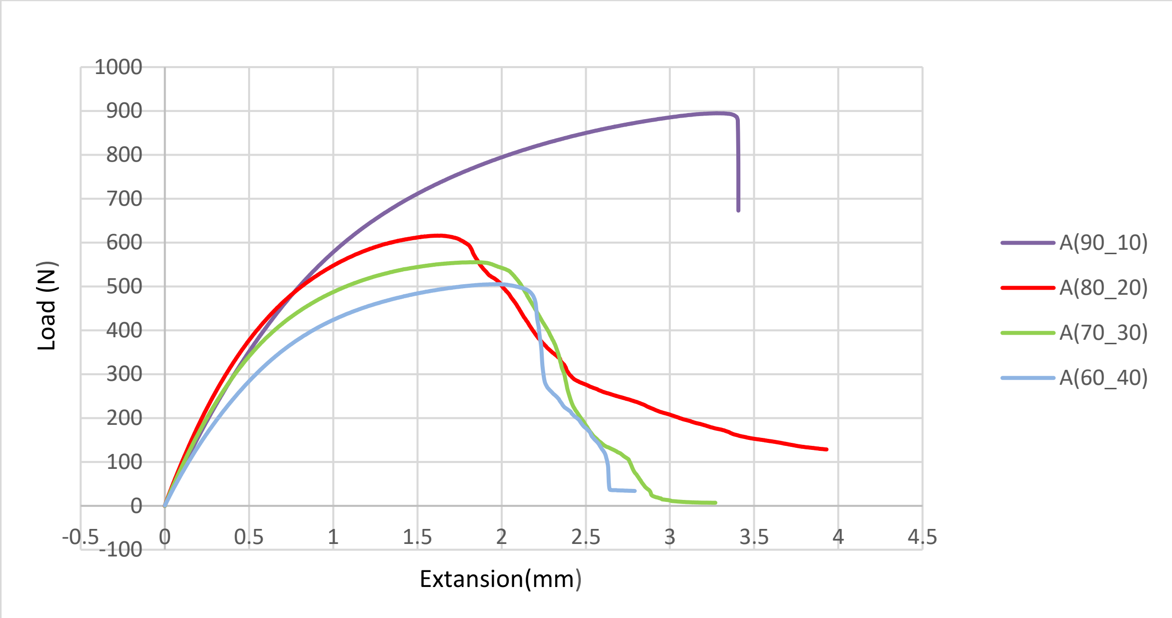


Figure 4.3: The graph of load (N) against extension (mm) with the different percentage of fibre loading (wt%).

The graph shows the result of tensile testing between tensile stress (MPa) against strain stress (mm / mm) to define the mechanical properties of POF / PP composite based on Figure 4.4 below. Due to low ductility, the fibers show a brittle failure.

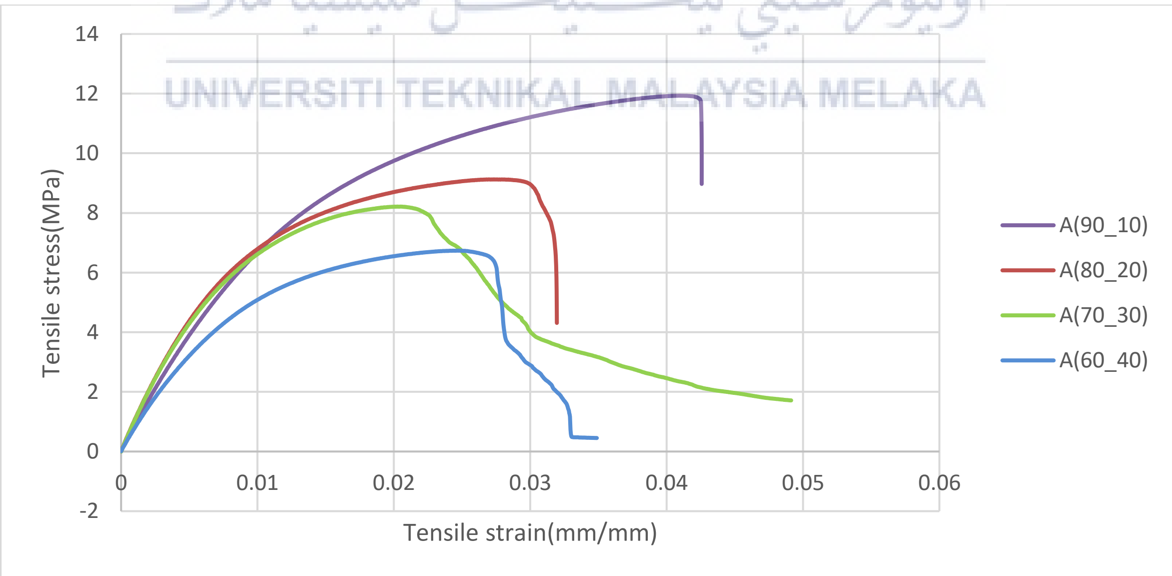


Figure 4.4: the graph shows the result of tensile test between tensile stress (MPa) against strain stress (mm/mm).

4.3 Effect of Physical Test

The purpose of this research was to study the physical properties of PP composite enhanced by Palm Oil Fiber (POF). Physical testing is important to ensure that the composi te can be applied especially in aerospace and automotive in accordance with industry specif ications.

Table 4.2 and Figure 4.5 show the density results and the percentage of POF loading for POF / PP composite. Based on the table below, the result shows that with the increase in POF loading, the density value increases. For the 10 wt % of POF loading has the lowest density value of 0.9310 g/cm3 while the highest density of 40 wt % of POF is 1.0040 g/cm3. The second highest density is 20 wt %, which is 0.9730 followed by 30 wt % with 0.9890 g/cm3.This growing trend has been achieved as a result of the increase in fiber content that affects the composition in the composite. When there are many fibres content, the space between fibre and matrix are much closer which indicate the composition is more pack. Therefore, it causes the POF/PP composite which has high fibre content is denser than water. The characteristic palm oil fiber is hydrophilic. The more palm oil fiber, more water will absorb to composite.

Table 4.2: Density properties of the POF/PP.

P0F loading (wt%)	Density (g/cm^3)
10	0.9310
20	0.9730
30	0.9890
40	1.0040

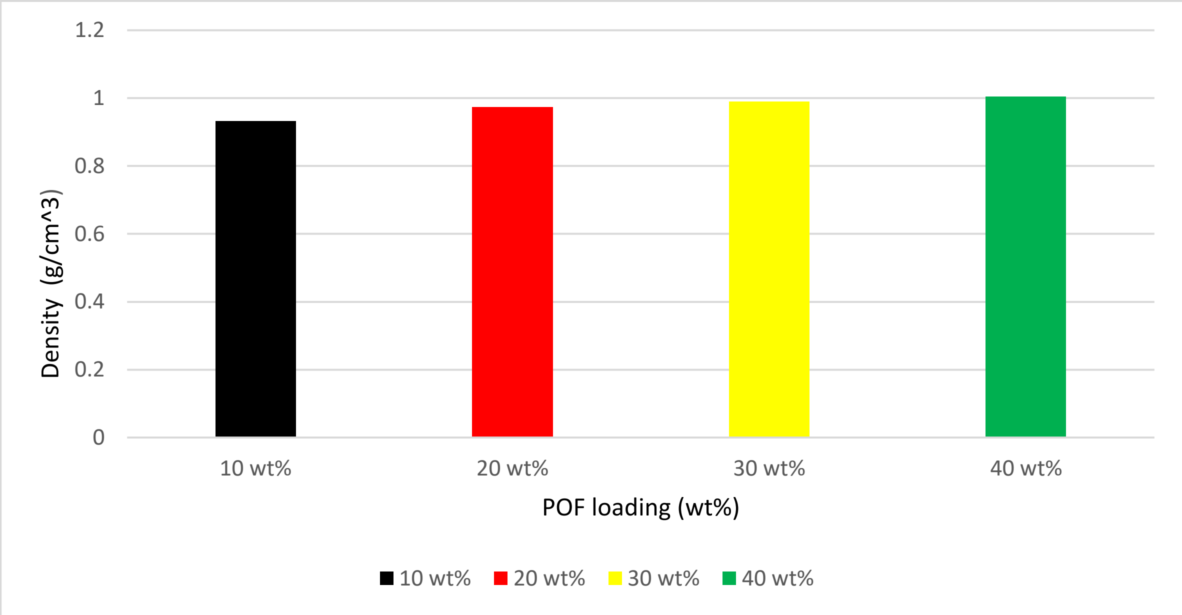


Figure 4.5: The graph of density (g/cm^3) against POF loading (wt%).

Table 4.3 and Figure 4.6 show hardness results (Shore-D) and POF load percentage (wt %). Based on the table shows that the graph pattern is decreasing because of the increase in fiber content. The 40 wt % of POF loading has the highest fiber content having the lowest hardness value that is 52.67 (Shore-D) while the highest hardness value is 10 wt % of POF loading, 66.00 (Shore-D). This pattern was obtained because the fiber content increased. The 20 wt second highest percentage of hardness (Shore-D) that is 57.30 and the third highest 30 wt % hardness (Shore-D) that is 54.60. The high palm oil fiber (POF) content makes the composite stronger but the composite hardness decreases. Perhaps the decrease in hardness due to matrix and fiber composition.

Table 4.3: Hardness properties of the POF/PP.

P0F loading (wt%)	Hardness (Shore-D)
10	66.00
20	57.30
30	54.60
40	52.67

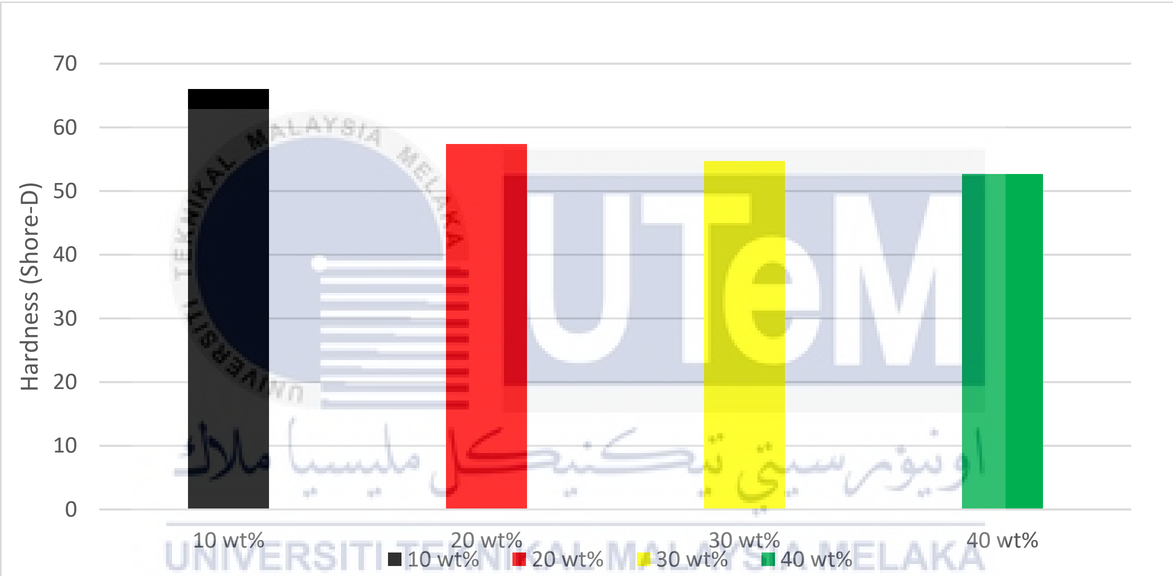
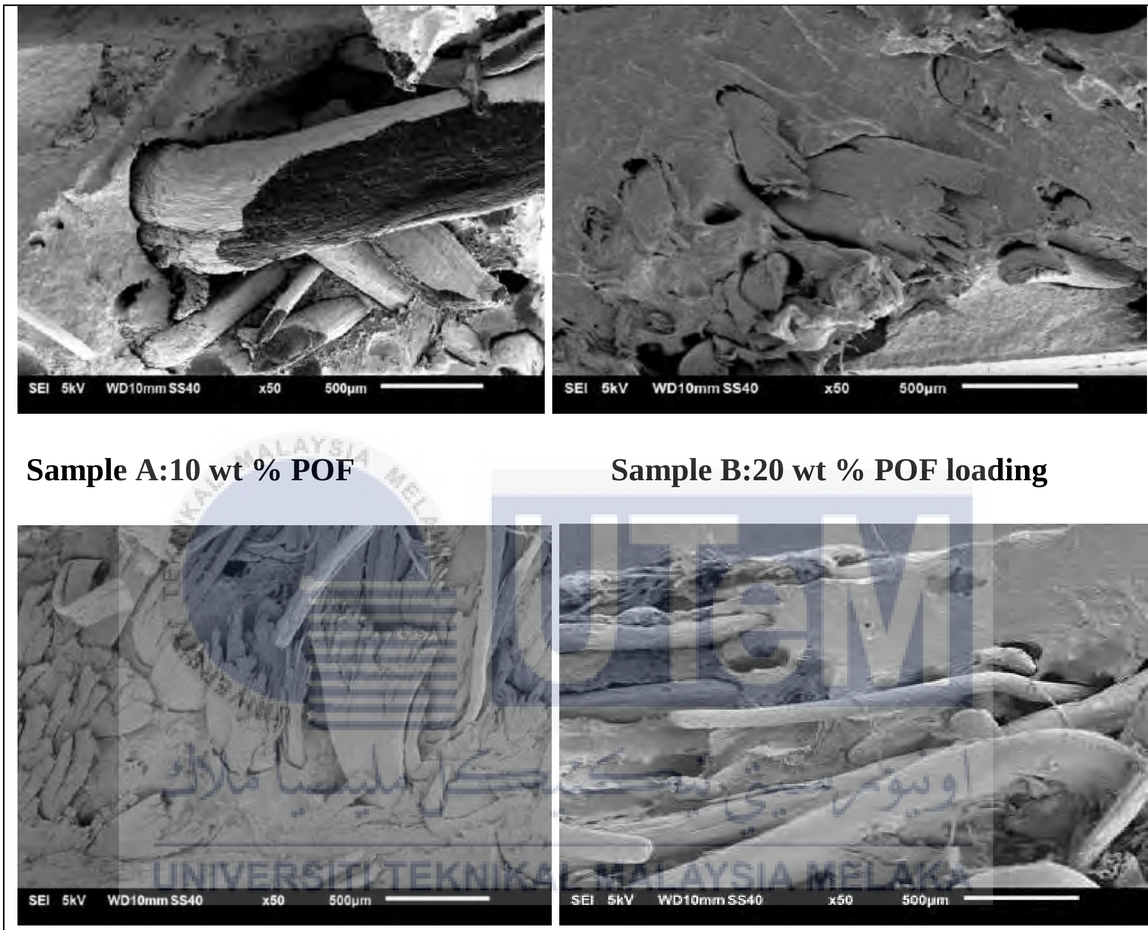


Figure 4.6: The graph of hardness (Shore-D) against POF loading (wt%)

4.4 Microstructure Analysis (SEM)

4.4.1 **Magnification x 50**



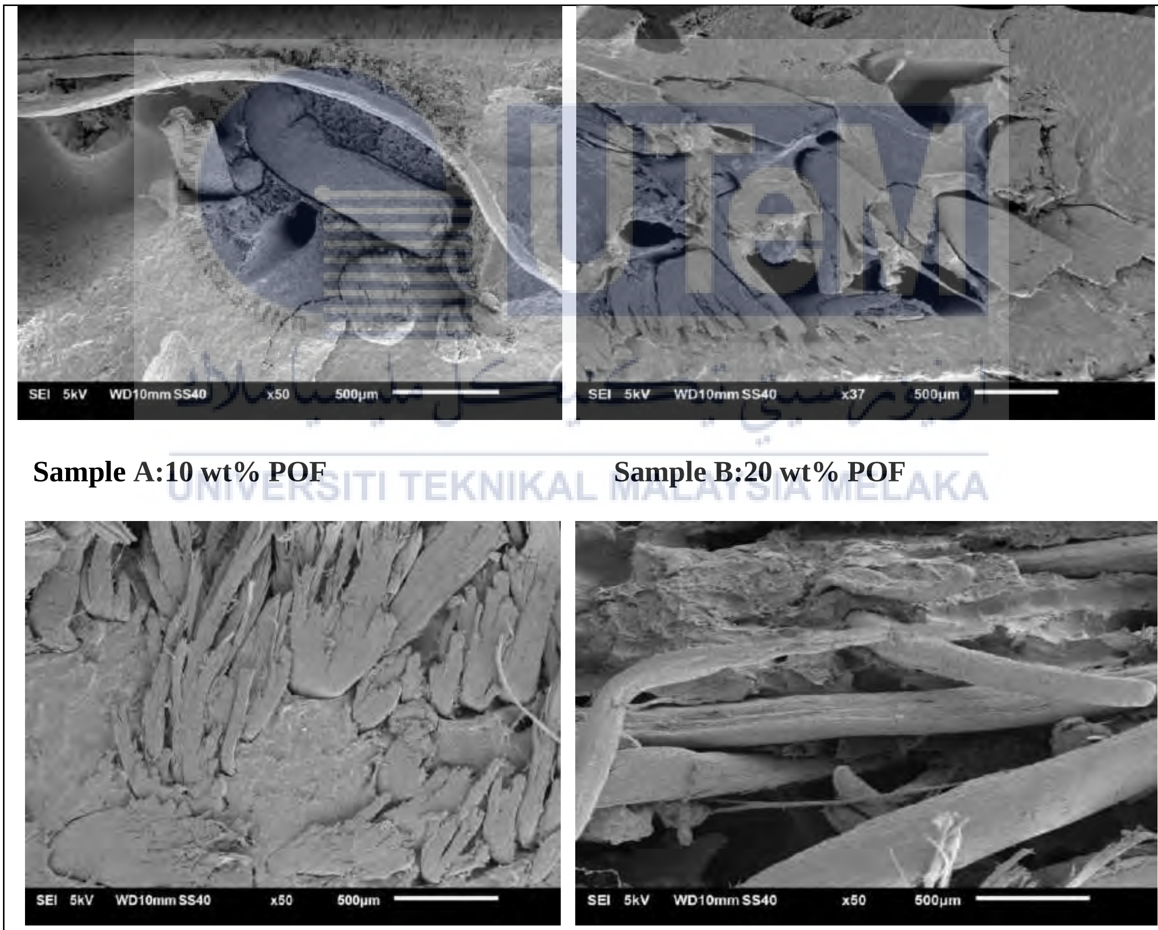
Sample A:10 wt % POF **Sample B:20 wt % POF loading**

Sample C: 30 wt % POF **Sample D:40 wt % POF**

Figure 4.7: The microstructure analysis for interfacial bonding between POF/PP

Based on figure 4.7 show the image about scanning electron microscope towards the PP/POF composite with magnification of 50 µm. Figure above can be analysed that 10 wt% has highest strength adhesion bonding between fibre and matrix because the fibre is not pull out but it breaks down the fibre when undergoes tensile test.The 10 wt % have strong adhesion because it less competition for the space and can mixture together well to become stronger bonding. Next, figure above show the 20 wt % the image has a few holes where the fibre had pull out and some fibre broke up while doing tensile test.This show the mixture between PP and POF not good enough compare with 10 wt% .Based on image 30 wt% can be analysed the mixture between the PP and POF has good adhesion bonding because not has fibre pull out and the fibre broke up when the tensile test implemented. Lastly, based image 40 wt% can analysed the high fibre content, the less the strength adhesion bonding.

4.4.2 Magnification x 50



Sample A:10 wt% POF **Sample B:20 wt% POF**

Sample C:30 wt % POF **Sample D:40 wt% POF**

Figure 4.8: The microstructure analysis for interfacial bonding between POF/PP

Based on figure 4.8 show the image about scanning electron microscope towards the PP/POF composite with magnification of 50 um. Based image 10 wt % can be analyzed the distribution of mixture PP and POF not distribute uniformly. Based on image 10 wt% can analysis the sample A have half region only PP and another half region PP with POF. The image 20 wt % show the image have wide holes which group of palm oil fiber pull out together when undergoes tensile test. This show composite not have strong adhesion bonding between PP and POF. Based on image 30 wt% can analysis the PP and POF have small region PP in the image. Lastly, based image 40 wt% can analyzed the high fibre content make the PP hard to mixture together.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This project will study how a natural compound is produced from natural fiber to thermoplastic compounding. Palm Oil Fiber (POF) and Polypropylene (PP) are the materials used for this project. POF was used as a strengthening when PP was being used as a matrix. The composite POF / PP is also available for manufacturing applications in the automotive industry. The main purpose is thus to detect the mechanical and physical characteristics of the POF and PP microstructures and analyze them.

The mechanical characteristics tested in these studies show that the pattern is decreasing linearly with increasing percentage fiber loads. The highest tensile resistance of 894.859 MPa and the highest strength is 66.0 D for 10 wt % of the fiber charging. In addition, the highest result, which is 1.0040 g/cm^3, is the result, at 40 wt. %. Based on the results, mechanical and physical proprieties of natural composites have affected the percentage of fiber load.

Finally, the deduction of the fiber load percentage is beneficial for correctly mixing it with the fiber. It can therefore be classified as a good potential for the manufacture of the superior composite materials by a lower percentage of the fibre load.

5.2 Recommendation

Few recommendations for further research on the mechanical properties of POF / PP are available to improve the results. The key points in this recommendation are essentially materials preparation, treatment process and manufacturing processes that must be improved step by step to ensure the better results of this process in the future. The following are the recommendations:

5.2.1 Preparation to obtain raw materials

The first step towards improving the preparation of raw materials is to produce fresh fiber to produce quality fiber to improve mechanical properties of composites. Secondly, to prevent impurity materials from PP, the pulverizing machine should also be purified with acetone. After a two times operation, the pulverization machine needs to rest ten minutes to avoid bowl overheating. The overheating can cause for PP damage. Next, PP should sieve less 500µm to measure the composite can mixture together to get strong adhesive bonding between PP and fiber. Increase the time for rotate mixture fiber with PP using ball mill machine to measure the mixture between PP and fiber distribute uniformly. Lastly, The PP and POF must pour in the bottle together uniformly to make the raw material easier to mixture

5.2.2 Fabrication process of the sample

With the preheat, the manufacturing process can improve with the specific temperature in order to smoothly measure the heat compress process. Next, the temperature and time should follow the procedure instructions to prevent bad impact on the composite structure. In addition, the mixture compound should fully in mould before to hot compress proceed to more get the accurate result. The researcher should also do nothing more than prolong the cooling process because excess heat on the molds can damage composite structure. The compounded material should pour to mould slowly to prevent it from spilled out.

5.2.3 Treatment process towards POF

The POF should be processed to prevent loss of properties as soon as possible. Next, after alkaline treatment, the POF should dry quickly to maintain its quality. Small POF should be dried quickly and dry under the sun. The drying procedure should not be too long under the sun as the structure of the POF can be damaged and the effect can be poor. The POF should also not store POF for too long, as it can rust and lose properties.

5.2.4 Testing

In order to improve this research, the researcher needs more information on other mechanical and physical properties. For future researchers, numerous mechanical and physical tests can be studied. For future research, bending test and porosity are the most recommended mechanical and physical test.

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