Mechanical Properties of "Mengkuang" Fibre Reinforced Composite

by

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
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Approved by,

....
(DR. MOHAMAD ZAKI BIN ABDULLAH)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
January 2016

CERTIFICATION OF ORIGINALITY

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

....

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ABSTRACT

A natural fibre reinforced polymer is a composite material consists of a polymer matrix with natural fibre reinforcement. Due to its low cost, eco-friendly, light weight and high strength characteristics, natural fibre can replace the synthetic fibre. Traditionally, mengkuang leaves are used for making ropes and woven hand-crafts. Mengkuang leaves which are abundant in Malaysia have not been process as reinforcement for composite. The study of mechanical properties of mengkuang leaves reinforced composite is almost non-existence. Hence, the objective of this project was to evaluate the mechanical properties of polypropylene (PP)/mengkuang leave composite which include tensile, flexural and impact properties. PP was used as matrix while mengkuang leave was used as natural fibre reinforcement. To fabricate the specimens, extrusion and injection moulding techniques were employed. Tensile, flexural and impact tests were done according to their respective ASTM standards. Compositions of 80/20, 70/30 and 60/40 wt.% (PP/mengkuang fibre) were compared with neat PP. Mengkuang leave was cut into an average dimension of 7.5 mm X 1 mm before processing. Both tensile and flexural properties showed some improvements in the composite compared to neat PP. An improvement of 9.3% was achieved in tensile strength of 60/40 wt.% while the rest of the compositions recorded lower strength compared to neat PP. For flexural strength, all compositions showed some improvements where 70/30 wt.% recorded the highest improvement of 43.3%. Tensile and flexural moduli were improved in all compositions with the highest improvement achieved in 60/40 wt.%. Impact strength was lower than neat PP even though the trend showed the higher the fibre content, the higher the impact strength.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Composite material can be categorised as one or more discontinuous phases embedded in a continuous phases. The discontinuous phase in term of reinforcement or reinforcing material which is usually stronger than the other one which is termed as matrix. Technically, thermoplastics or thermosets are used as matrix, while natural or synthetic fibre as reinforcement.

Fibre type is commonly categorised as natural or synthetic fibre. Synthetic fibres which are more durable than most natural fibres have been used widely for various applications. For instance, carbon fibre reinforced polymer has been employed to manufacture rudder of aircraft. However, the energy consumption to produce synthetic fibre is much higher than natural fibre. Hence, the application of natural fibre as reinforcement is preferred especially in manufacturing sector such as aircraft interior [1]-[3] and sport industries [4]-[5]. Textile waste, which originated from natural fibre, has been used to reinforce plastics used in vehicles for automotive industry [6]-[9]. Natural fibres like kenaf, sisal, jute, henequen, and oil palm fibre have been proven to be good reinforcement with thermoset and thermoplastic matrices. They provide several advantages in term of low density and renewability over synthetic fibre.

Mengkuang leave are abundant in Malaysia. Mengkuang leave is a type of natural fibre that are traditionally used in making ropes, hats and mats due to its strong yield strength [10]. Figures 1.1 and 1.2 show mengkuang plant and typical mengkuang mat, respectively. Mengkuang leaves or its scientific name *Pandanus Tectorius* have a great potential to be used as reinforcement in polymer composite industry. Major components of mengkuang leaves are cellulose, hemicellulose and lignin structures. All of these structures are amorphous polymers that will yield strong fibre that were previously used for weaving and making ropes. Yet, mengkuang leave is another possibility that can be used as natural fibre reinforced composite.

Figure 1.1: Mengkuang plant [10].

Figure 1.2: Typical mengkuang mat.

1.2 Problem Statement

Traditionally, mengkuang leaves are used for making ropes and woven hand-crafts. Due to low cost, environmental friendly and renewable resource, mengkuang leaves have a great potential to be a natural fibre for polymer composite. Mengkuang leaves, which are abundant in Malaysia, have not been process as reinforcement in composite and the study of mechanical properties of mengkuang leaves reinforced composite is almost non-existence. Hence, this project is proposed.

1.3 Objective

The objective of this project is to evaluate the mechanical properties of polypropylene (PP)/mengkuang leave composite which include tensile, flexural and impact properties.

1.4 Scope of Study

This project focused on mechanical properties of natural fibre reinforced composite where PP was used as matrix while mengkuang leaves was employed as natural fibre reinforcement. Mengkuang mat was obtained from Kuala Kangsar, Perak. After disassembled the mat, the mengkuang strip was cut into small pieces with an average dimension of 7.5 mm X 1 mm. The fibre in this project was treated as short fibre. Compositions of 80/20, 70/30 and 60/40 wt. % (PP/mengkuang fibre) were selected for this project. Extrusion process was applied for compounding and mixing of the matrix and reinforcement. Injection moulding method was used to fabricate the specimens where tensile, flexural and impact tests were done according to their respective ASTM standards.

CHAPTER 2

LITERATURE REVIEW

2.1 Composite Material

A composite material can be defined as a combination of a matrix and a reinforcement. The combined material gives superior properties compared to the individual components. Normally, the reinforcement is in fibre form and is used to fortify the matrix in term of strength, toughness and stiffness. The matrix, normally in a form of chemical and environmental attack, and it bonds the reinforcement so that applied loads can be effectively transferred.

The main advantage of composite materials is they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made exactly meets the requirements of a particular application.

2.2 Natural Fibres

Natural fibre as an alternative reinforcement to synthetic fibres in polymer composite has been under study recently due to its suitability to reinforce polymers especially thermosets and thermoplastics. This reinforcement is well known in technical application due to its relative high strength and stiffness, environmental-friendly and low density properties [9]. Compared to synthetic fibre, natural fibre can be manufactured in lower cost and less hazardous process. Natural fibre has its own disadvantages such as low durability and less strength compared to synthetic fibre [11]. However, this does not mean that natural fibre cannot be employed as reinforcement.

2.3 Mechanical Properties of Natural Fibre Reinforced Composite

Studies were done over the past few years on natural fibre reinforced composite. These composites were fabricated to withstand a long life application. Selecting a proper matrix and reinforcement materials is an important factor in determining their mechanical properties.

A number of studies were done to investigate the mechanical properties of natural fibre reinforced composite. Sakthivel et al. [12] studied the mechanical properties of coir fibre reinforced by polypropylene and luffa fibre reinforced polypropylene where 80% of matrix and 20% of reinforcement were used. The composites were fabricated by adding the melting polypropylene pellets and dried coir and luffa fibre bundle and they were processed together in an injection moulding machine. Then, the samples produced were tested for mechanical properties including tensile and flexural properties. Sakthivel et al. [12] reported that coir reinforced polypropylene produced higher tensile strength compared to neat polypropylene and luffa fibre reinforced polypropylene composites as illustrated in Figure 2.1.

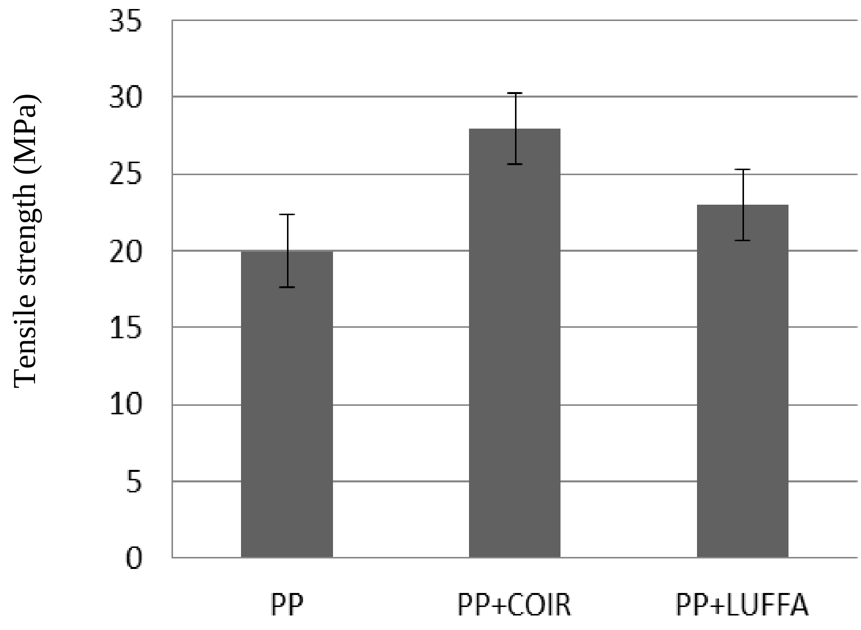

Figure 2.1: Tensile strength of coir and luffa fibre reinforced polypropylene composite [12].

Unlike flexural strength, flexural rigidity recorded much better result compared to neat PP and coir fibre reinforced PP as shown in Figure 2.2. Hence, the finding clearly indicated that mechanical properties of composites improved significantly compared to pure polymer.

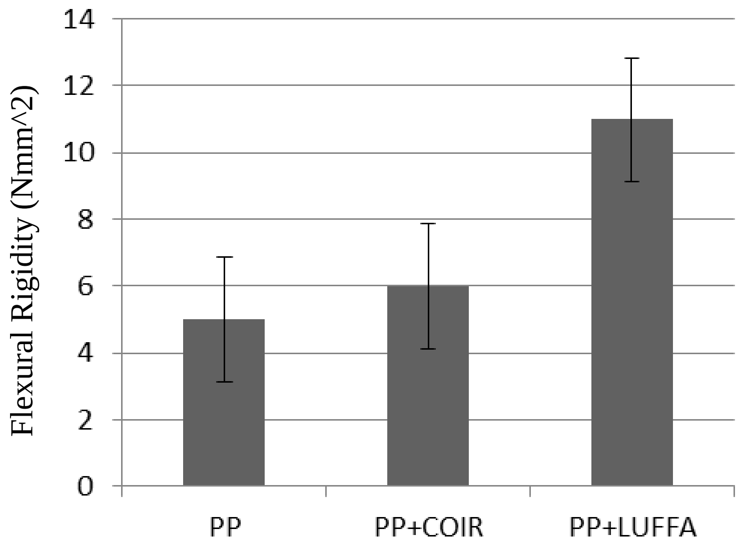

Figure 2.2: Flexural rigidity of coir and luffa fibre reinforced polypropylene composite [12].

For impact properties, there was an enhancement on the amount of the energy absorbed by the composites during fracture. The studies revealed that luffa reinforced polypropylene produced highest value of energy absorbed. Figure 2.3 presents the results obtained from Charpy impact test.

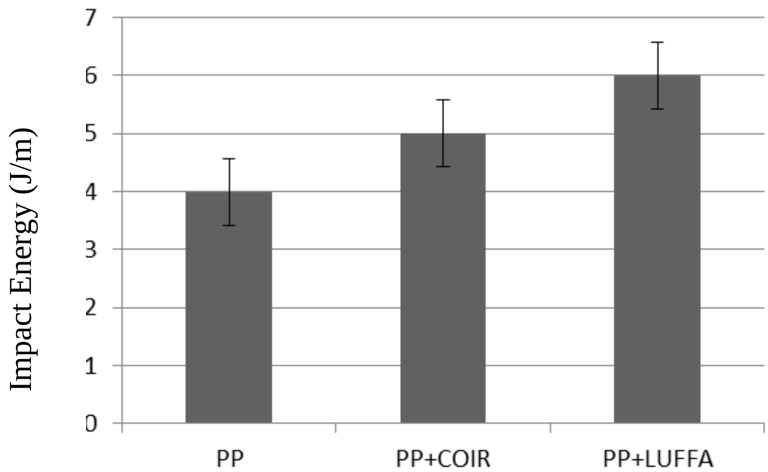

Figure 2.3: Impact energy of coir and luffa fibre reinforced polypropylene composite [12].

In a study of abaca, jute and kenaf fibre reinforced polypropylene by Bledzki et al. [13], the specimens were fabricated with fibre 2 mm length and compounded with polypropylene granules. To complete the fabrication, they were processed in injection moulding machine at temperature of 165°C to 220°C and injection pressure of 800 bars. Then, the composites underwent by 60/40 wt.% (matrix/fibre). Figure 2.4 shows the result of flexural strength in their studies.

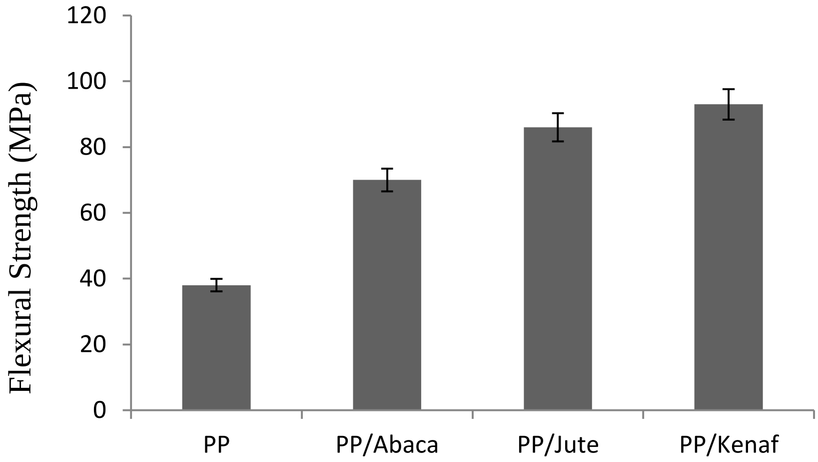

Figure 2.4: Flexural strength of abaca,jute, kenaf fibre reinforced polypropylene composite [13].

It can be concluded that when polypropylene were reinforced with abaca,jute and kenaf, they produced higher flexural strength compared to neat polypropylene. The highest value of flexural strength went to kenaf fibre reinforced polypropylene which was approximately 91 MPa. The authors indicated that the high performance of kenaf was due to high content of crystalline cellulose. Polypropylene reinforced abaca exhibited lowest value of flexural strength. This was probably due to fibre shear and damage during samples processing [13]. Figure 2.5 shows the Charpy impact strength of their research.

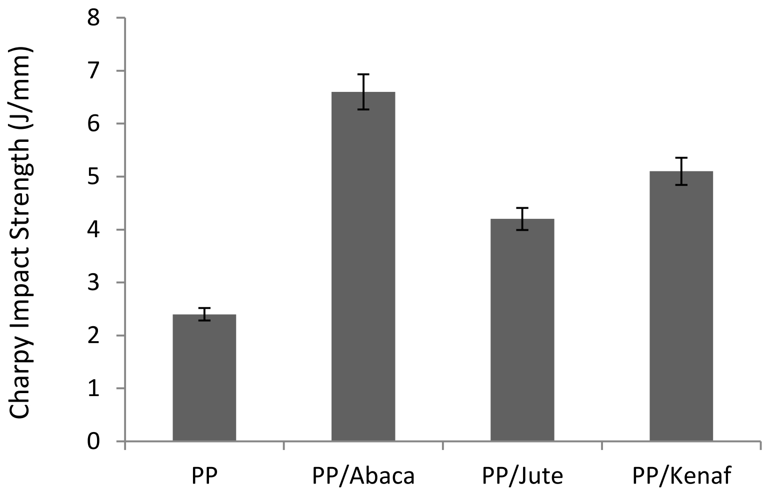

Figure 2.5: Charpy impact strength of abaca, jute, kenaf fibre reinforced polypropylene composite [13].

Polypropylene reinforced jute possessed the lowest impact strength compared to other reinforcements. The authors suggested that jute fibres and particles were too short to obstruct crack propagation [13]. In the meanwhile, for polypropylene reinforced abaca, the fracture of whole fibre bundles of the composite led to higher absorption of fracture energy thus produced enhancement in absorption of impact energy.

In fabrication of long and continuous natural fibre reinforced polypropylene, Lee et al. [14] studied the polypropylene was reinforced by kenaf and jute fibre. The composite produced higher tensile and modulus strength. The composites were fabricated by carding, punching and hot press compression moulding process. The tests results explained that when fibre volume fraction in the composite increased, the tensile modulus increased as well. In term of flexural strength, the results showed that as the fibre volume fraction of the composite increased, the flexural strength decreased.

2.3.1 Influence of Fibre Loading on Composite Strength

Bledzki et al. [15] studied on mechanical properties of abaca fibre reinforced polypropylene with different fibre loading. The weight percentages of fibre were varied with 20%, 30%, 40% and 50%. The fibres were chopped into 25mm fibre length and being processed together with polypropylene granules in mixer-injection moulding. The moulding process was run under temperature of 150-180°C and injection pressure of $20\ \mathrm{kN/mm^2}$. Then, the composites performed tensile, flexural and notched Charpy test according to their respective ISO standards. Figur 2.6 showed the tensile and flexural strength of abaca fibre reinforced polypropylene

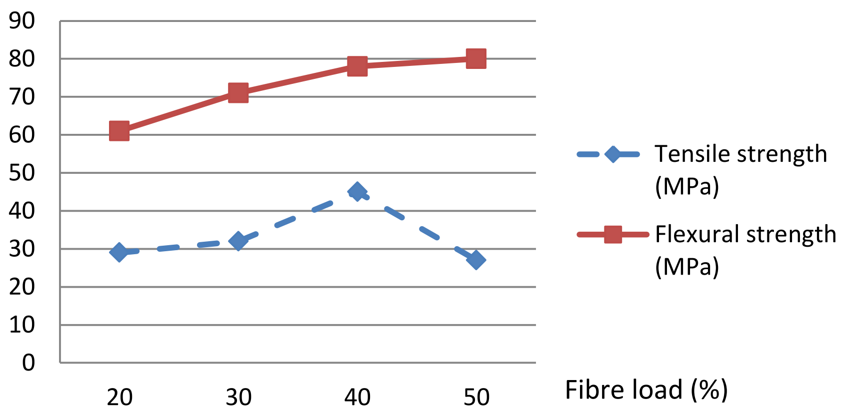

Figure 2.6 Tensile and flexural strength of abaca fibre reinforced polypropylene [15].

The tensile and flexural strengths showed that there were improvement of the strength up to 40 wt% fibre loading and then both strength decreased with increasing fibre load. The maximum strength properties observed at 40 wt% can be due to better fibre distribution in matrix material and less fibre fracture occurred during fabrication process. As result, the bond between fibre and matrix improved the properties by a good transferring load between them. It also can be said that there were less fibre fracture in the composites and more homogenous mixing that caused the improvement. For both properties, 40 wt% was the optimum fibre loading of abaca reinforced polypropylene composites [15].

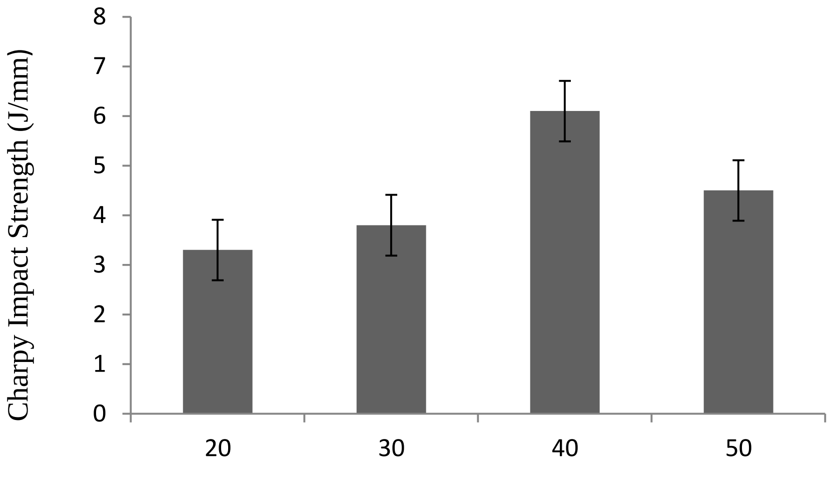

Figure 2.7: Impact strength of abaca fibre reinforced polypropylene [15].

In a meanwhile, results for notched Charpy impact strength of abaca reinforced polypropylene recorded a similar trend as tensile properties. The maximum property could be found at 40 wt% of fibre loading. However, the impact properties were found to be decreased a bit at 50 wt%. This could be due to increase in brittleness of matrix material. There were internal deformation in the composite material during the fabrication process as reported by Bledzki et al. [15].

2.3.2 Fibre Orientation

Fibre orientation in composite plays an important role in determining the strength properties of the composite. Joseph et al. [16] studied the mechanical properties of sisal fibre reinforced by polypropylene in unidirectional direction. The matrix and reinforcement were tested in longitudinal and transverse fibre oriented composite. Methods applied in this composite study were melt-mixing and solution-mixing technique. For melt-mixing method, compression moulding process at pressure of 8 MPa and temperature of 170°C were applied to fabricate the specimens. In a meanwhile, for solution-mixing process, the sisal fibre was mixed with slurry of polypropylene. The mixture was dried and subjected to extrusion through an injection molding machine. Then, the composite sheets were prepared by compression molding process and undergo mechanical testings to test for their strengths. The results of the testings are shown in Tables 2.1, 2.2 and 2.3.

Table 2.1: Tensile properties of unidirectional sisal/PP in transverse orientation.

Fibre length(mm)	**Tensile strength (MPa)**	**Tensile Modulus (GPa)**
0	35.0	0.498
2	28.3	0.678
6	31.1	0.798
10	35.1	1.078

Table 2.2: Tensile properties of unidirectional sisal /PP in longitudinal orientation.

Fibre length(mm)	**Tensile strength (MPa)**	**Tensile Modulus (MPa)**
0	35.0	498.0
2	33.3	798.6
6	39.1	971.0
10	48.2	1541.7

Table 2.3: Tensile properties of unidirectional sisal/PP composites in transverse orientation.

Fibre length(mm)	**Tensile strength (MPa)**	**Tensile Modulus (MPa)**
0	35.0	498.0
1	36.0	718.2
2	38.2	526.0
6	36.5	1630.8

From results obtained, Joseph et al. [16] revealed in case of solution-mixed composites, the tensile strength increased as fibre length increased. This was due to increased in fibre stress. The strength of fibre-reinforced composites depends on the degree to which an applied load is transmitted to fibres. The extent of load transmittance is a function of fber length and magnitude of fibre/matrix interfacial bond. In short-fibre-reinforced composites there was a critical fibre length which required for the fibre to develop its fully stressed condition in the matrix. If the fibre is shorter than this critical length, the fibre stress will debond from the matrix and composite will fail at a low load. In fact, when the length is greater than the critical length, the stressed composite will lead to breaking of fibres and a high composite strength. In the meanwhile, the tensile properties of melt mixed composites show an improvement in their values by increasing the average fibre length from 1 to 2 mm.

2.3.3 Effect of Fibre Length on Mechanical Properties

Subasinghe et al. [17] studied the mechanical properties of polypropylene reinforced kenaf composites with weight percentage of kenaf fibre was 30% and weight percentage of polypropylene was 70% reported that there were increase of tensile and flexural properties of the composites compared to neat polypropylene. The composites were fabricated by varying the kenaf fibre length which were 2.5 mm and 7.5 mm with two processes applied to produce the composites. Methods applied to process the composites were extrusion and injection moulding methods.

Table 2.4: Polymer and fibre blends [17].

Designation	Method	Fibre length (mm)
KeLC	Compounded	7.5
KeHLC	Compounded	7.5
KeLE	Extruded	7.5
KeHLE	Extruded	7.5
KeSC	Compounded	2.5
KeHSC	Compounded	2.5
KeSE	Extruded	2.5
KeHSE	Extruded	2.5

Ke-Kenaf, C-compound, E-extrude, L-long, S-short.

The test samples were fabricated according to designation presented in Table 2.4. Tensile, flexural and impact strength according to ASTM Standards D638, D790 and D6110, respectively. Figure 2.8 shows the results of tensile and flexural properties of the composites. There were significant improvement in tensile and flexural strength obtained compared to neat polypropylene. This improvement was due to the improved of interfacial bonding between fibre and matrix during the extrusion method [17].

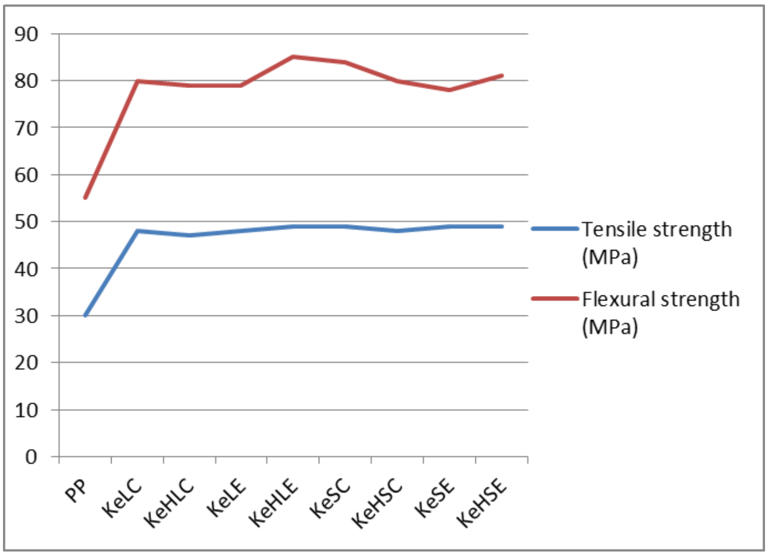

Figure 2.8: Tensile and flexural properties of polypropylene reinforced kenaf composites [17].

Bisaria et al. [18] studied on randomly oriented short jute fibre reinforced epoxy where the composites were prepared using hand lay-up method with 30 wt. % of jute fibre and 70 wt. % of epoxy in various jut fibre lengths i.e. 5, 10, 15 and 20 mm. The composites were tested in tensile, flexural and impact tests accordance to ASTM standard D638, D790, and D256, respectively. Tensile strength of 15mm (J15) was improved by 28.1%, 1% and 8.3% as compared to composites jute fibre length of 5 mm (J5), 10 mm (J10) and 20mm (J20), respectively.

As for tensile modulus, J15 was more than 9.26%, 3.51% and 3.51% compared to the composites J5, J10 and J20, respectively. For flexural strength, the results revealed that the flexural strength of J15 composite was improved by 63.84%, 91.07%, 80.39%, and 50.76% as compared to neat epoxy, J5, J10 and J20 composite, respectively. Flexural modulus of J15 composite was 221%, 87.40%, 45.41% and 6.72% more than neat epoxy, J5, J10 and J20 composite, respectively. The impact strength and impact energy of J20 composite were found improved by 16.50%, 73.40%, 57.02% and 35.61% compared to neat epoxy, J5, J10 and J15 composite, respectively.

Studies by Senthikumar et al. [19] on effect of fibre length and weight percentage on mechanical properties of polyester reinforced short sisal composite where the composites were fabricated using compression moulding method with varying fibre length 3 mm, 4 mm, 5 mm and varying weight percentages of 20%, 30%, 40%, 50% of fibre in room temperature. Then, the composites were tested for tensile, flexural and impact strength.

The results of the investigations revealed that mechanical properties of short-fibre sisal polyester composites changed with respect to their weight percentage and its fibre length. The increased in the fibre weight percentage increased the tensile, flexural and impact strength of the composites. It was found that the optimum mechanical properties were achieved at 3 mm fibre length with 50wt.% of fibre.

CHAPTER 3

METHODOLOGY

The preparation of PP/mengkuang composite specimens for tensile, flexural and impact test are discussed in this chapter. The methods used are explained in detail.

3.1 Process Flow

Figure 3.1 shows the process flow diagram of main activities planned for this project.

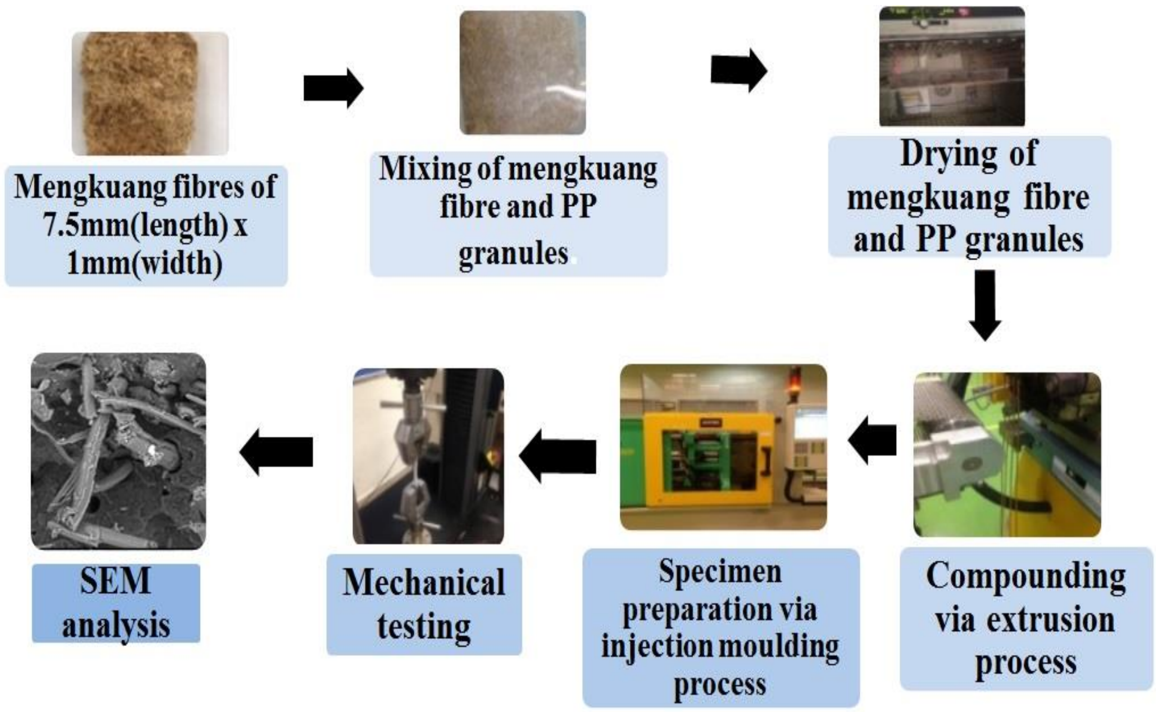

Figure 3.1: Process flow diagram of main activities.

3.2 Preparation of Materials

Detail procedures to produce the specimens are illustrated in this section.. The main materials used were mengkuang mat and polypropylene granules. The specimens prepared were neat polypropylene and mengkuang fibre reinforced polypropylene composites with fibre content of 20, 30 and 40 wt%. The mengkuang mats were chopped into fibre dimension of 7.5 mm length and 1 mm width. Figure 3.2 shows the sequence of mengkuang preparation from mat to fibre.

Figure 3.2: Sequence of mengkuang fibre preparation.

Once the fibres were prepared, they were mixed with PP granules according to the respective weight compositions and dried in the oven under temperature of 85°C for 24 hours. Figure 3.2 shows an example of PP/mengkuang fibre mixture. To ensure enough specimens were fabricated for testing, neat PP and PP/mengkuang fibre composite were prepared according to the amount shown in Table 3.1

Table 3.1: Preparation of composites.

Specimens Testing	Neat PP	80/20	70/30	60/40
Tensile	500g	400g	400g	400g
Flexural and Impact	500g	500g	500g	500g

Figure 3.3 shows an example of PP/mengkuang fibre mixture.

Figure 3.3: Sample mixture of mengkuang fibre and PP granules.

3.3 Compounding via Twin Screw Extruder

Twin screw extruder compounding is a high volume manufacturing process in which mengkuang fibres were forced to disperse homogenously throughout the melted PP. Mixing of material was properly done due to displacement of particles and shear deformation. When the counter rotated screw moved at 25 rpm, the screws forced the mixture to advance through the extruder cavity and then pushed through the die. The diameter of the die used in this process was 4 mm and the process was done under temperature of 166°C and pressure of 39 bars. Figure 3.4 shows the etrudate PP/mengkuang fibre. The mixture was cooled by forced air. The extrudate material was cut into cut into pellets as shown in Figure 3.5. The compounding process was done in ADTEC, Taiping.

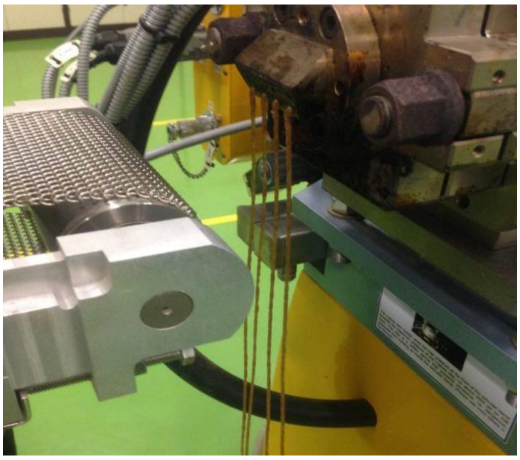

Figure 3.4: Extrudate PP/mengkuang fibre composite.

Figure 3.5: Pellets of PP/mengkuang fibre composite.

3.4 Injection moulding method

Injection moulding process was done in ADTEC, Taiping using 100 tons injection moulding machine shown in Figure 3.6. The process was done under pressure at 66.9 bars, temperature at 185°C and screw velocity of 95 mm/s. Both cross and axial mixing in injection moulding ensure homogenous distribution of fibres [17]. The fibres become entangled and tend to rotate themselves during mixing due to shear force generated within the barrel of the machine. The specimens were fabricated according to ASTM D638, D790 and D256 ,respectively, as shown in Figure 3.7.

Figure 3.6: Injection molding machine used in this project.

Figure 3.7 : Specimens produced by injection moulding.

3.5 Mechanical Testing

Tensile, flexural and impact test were carried out according to ASTM D638, D790, and D256 standards, respectively. Specimens width and thickness were measured using micrometer at 3 points per specimen. Then, the average value were calculated. These values were keyed-in to the respective testing machines.

3.6 Project Timeline

To ensure completion of this project, key milestones and Gantt chart were prepared. Table 3.2 shows the key milestones of the project while Table 3.3 shows the Gantt chart of the project.

Table 3.2: Key milestone of the project.

Key Milestone	**Date**
Completion of materials and tools procurement	28^{th} December 2015
Completion of sample preparation.	2^{nd} March 2016
Completion of specimen testing	20^{th} March2016
Completion of data analysis and report writing	18^{th} April 2016

Table 3.2: Gantt chart of key milestones and project activities for this project.

Key Milestones and Project Activities	Duration (Week)																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Completion of Materials and Tools Procurement															28/12 ▲														
• Selection of matrix and reinforcement																													
• Matrix and reinforcement procurement																													
Completion of Sample Preparation .																							2/03 ▲						
• PP granules preparation																													
• Cutting of mengkuang fibre																													
• Extrusion and Injection Moulding Process																													
Completion of Mechanical Testing.																										20/03 ▲			
• Tensile test																													
• Flexural test																													
• Izod Impact test																													
Completion of Data Analysis and Report Writing																													18/04 ▲
• Data analysis																													
• Report writing and submission																													

Key milestone

• Project activities

CHAPTER 4

RESULTS AND DISCUSSION

Chapter 4 describes the experimental results obtained from this study. Experimental results for tensile test are tabulated and discussed further. The results shon in this chapter are the average value of five specimens tested. At the end, the experimental results are analysed and the mechanical properties of the composite are compared according to neat PP.

4.1 Tensile Properties

Tensile strengths of neat PP, PP/mengkuang fibre composite with 80/20, 70/30 and 60/40 wt.% are tabulated in Table A1 (Appendix). The results are summarized in Figure 4.1.

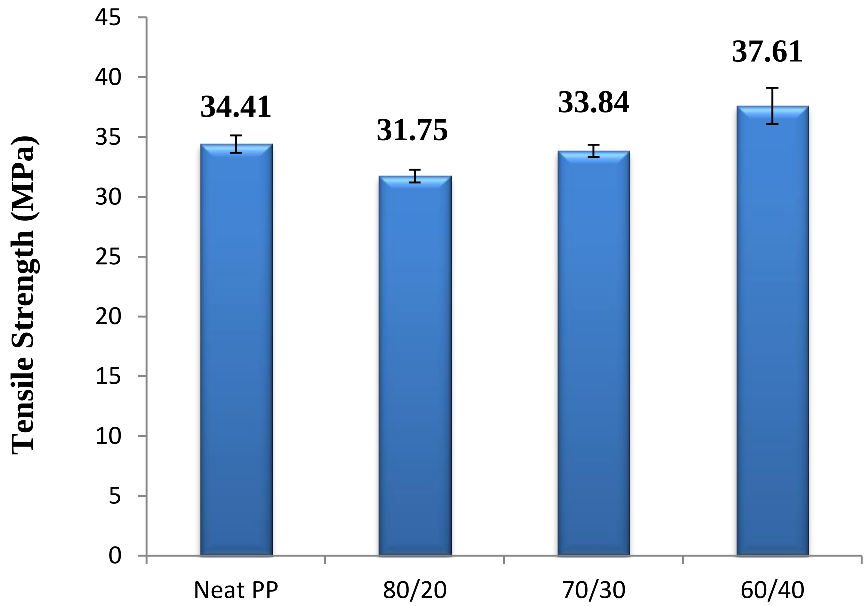

Figure 4.1: Tensile strengths of neat PP and mengkuang fibre reinforced PP composite.

The results showed no improvement in tensile strength for 80/20 and 70/30 wt.% compared to neat PP. However, an improvement of 9.3% in tensile strength was achieved in 60/40 wt.% composite compared to neat PP. To understand the structure of the composite, morphological studies on fractured samples were carried out using Scanning Microscope (SEM). Figure 4.2 shows SEM micrographs of PP/mengkuang composites according to their compositions.

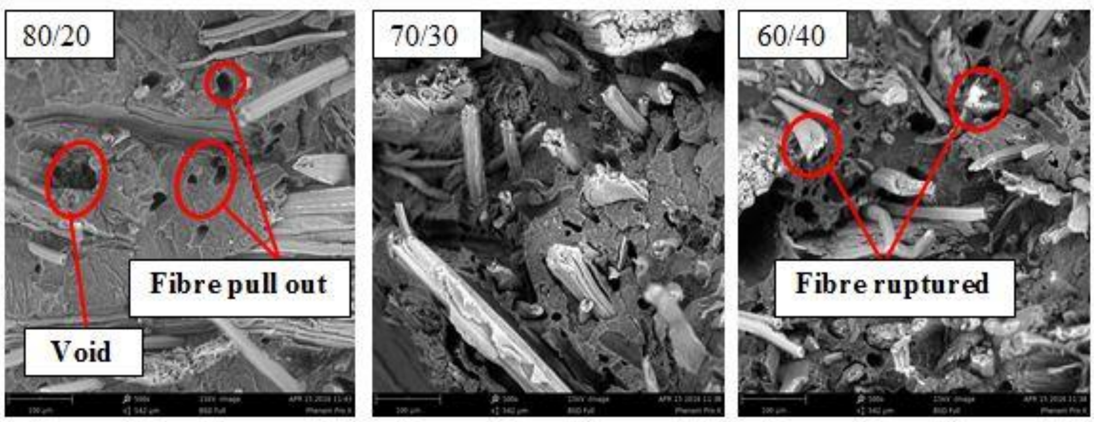

Figure 4.2: SEM micrographs of PP/mengkuang fibre composite with different compositions

SEM micrographs for 80/20 composition indicated fibre pull out and voids, suggesting poor adhesion between fibre and matrix as well as poor matrix filling due to void. As a result, the tensile strength was lower than neat PP. The failure can be explained in term of lack of load transfer from matrix to fibre due to poor adhesion between them as reported elsewhere [18].

For 70/30 composition, fibre pull out can still be clearly observed in the fractured sample. Although the fibre content is higher, it is not enough to support the load since the adhesion between fibre and matrix still lacking. However, fibre ruptured can be observed in SEM micrograph of 60/40 composition, indicating better adhesion between fibre and matrix. As a result, better tebsile strength was recorded for 60/40 composition compared to neat PP.

In tensile testing, another tensile property that can be obtained is tensile modulus. The tensile modulus of neat PP and tensile modulus of mengkuang fibre and PP composite are shown in Table A2 (Appendix) and its corresponding data were plotted in Figure 4.3.

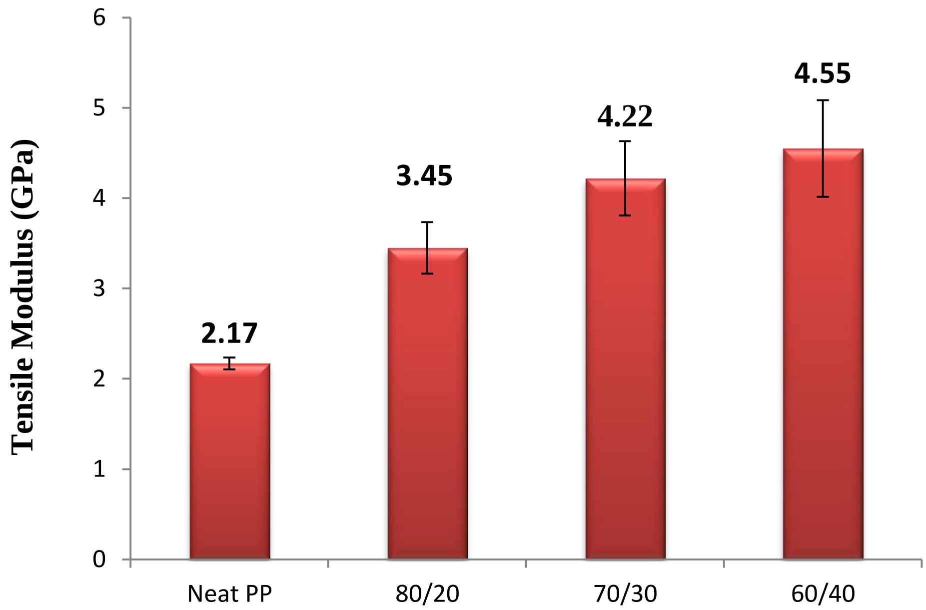

Figure 4.3: Tensile modulus of neat PP and mengkuang fibre reinforced PP composite.

Figure 4.3 shows a trend of higher tensile modulus with higher fibre content. The highest improvement achieved was 107.4% compared to neat PP. It was achieved by 60/40 wt.% with tensile modulus of 4.55 GPa. The higher tensile modulus indicates the better stiffness of the composite. Similar to tensile strength, better adhesion between fibre and matrix as suggested by SEM micrographs may be used to explain better tensile modulus with higher fibre content.

4.2 Flexural Properties

Flexural properties data are tabulated in Tables A3 and A4 (Appendix) and the data are summarized in Figure 4.4 nd 4.5 for flexural strength and modulus, respectively.

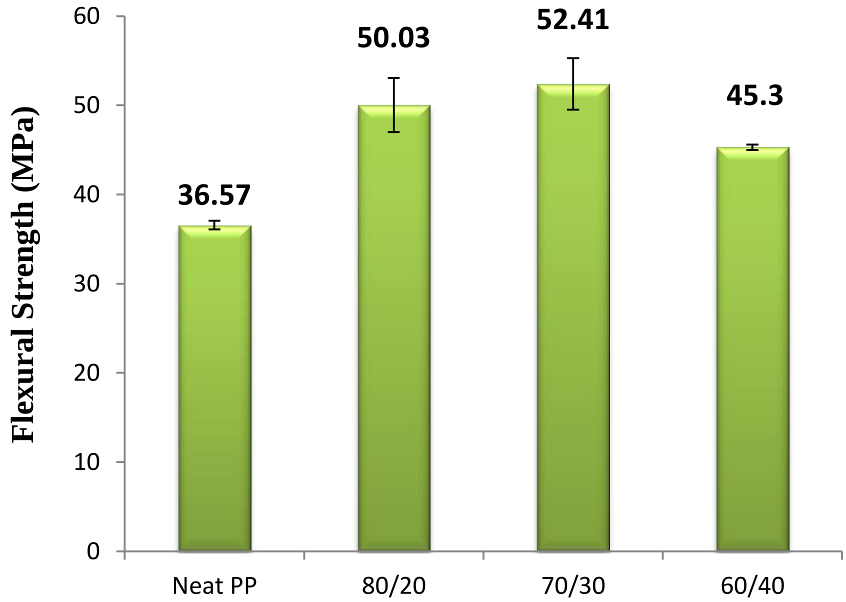

Figure 4.4: Flexural strength of neat PP and impact energy of mengkuang fibre and PP composites.

Flexural strength is a mechanical property that determines the ability of the material to resist bending. In this case, the materials deform and do not break during testing. They were measured at 5% deformation/strain of the outer surface to identify their strength. From results obtained, all composites showed a great improvement of flexural strength compared to neat PP. The results showed the highest flexural strength was achieved by 70/30 composition. The results suggests that fibre content of 30% should be enough to resist bending. Higher fibre content does not necessarily assist the flexural strength.

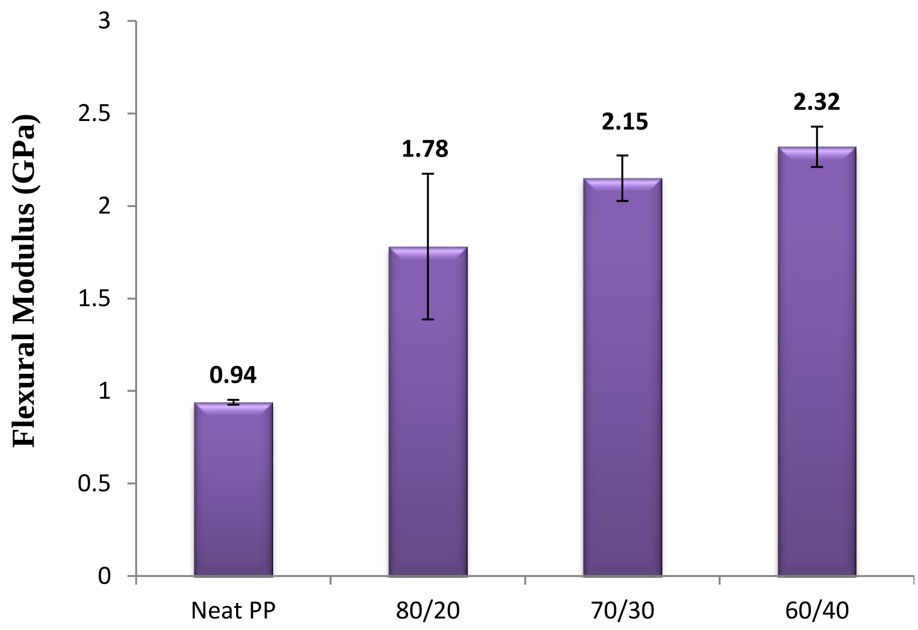

Figure 4.5: Flexural modulus of neat PP and impact energy of mengkuang fibre and PP composites.

Flexural modulus is a measure of stiffness and the extent of deformation of the composites when a bending stress is applied to the material. This property also indicates the measure of ductility of the material. For a composite of lower flexural modulus, the higher the ductility of the composite.

The trend showed the higher the fibre content, the higher the flexural modulus. The highest enhancement can be observed at 60/40 wt.% composites with a value of 2.32 GPa. This indicates that the higher the fibre content, the more brittle the material becomes.

4.3 Impact Properties

Izod impact testing according to ASTM D256 standard was done to determine the impact resistance of the composites. The amounts of energy absorbed by the composites were identified when the arm was released from a specific height to hit the composites. The absorbed energy acts as a mechanism to analyse the brittle-ductile transition of the material.

As results, the impact energy of neat PP and impact energy of mengkuang fibre and PP composite are tabulated in Table A5 and its corresponding data were plotted in Figure 4.6.

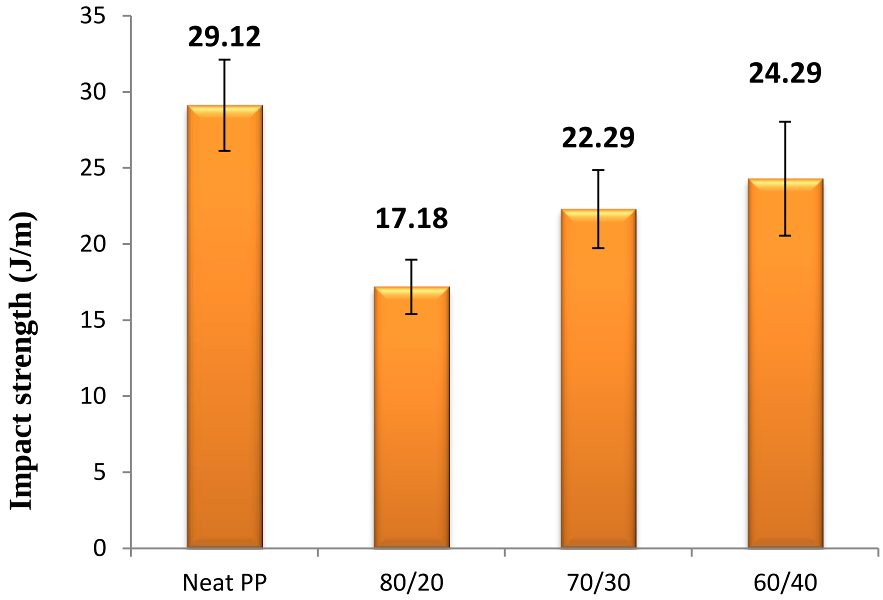

Figure 4.6: Impact energy of neat PP and PP/mengkuang composites.

Impact strengths of the composite were lower than neat PP, even though the trend showed higher impact strength with higher fibre content. Similar results were observed by Subasinghe et al. [17]. This failure can be related to the short fibre which were employed in this study, resulting in a decrease of impact strength. The results showed the 60/40 wt.% composite decreased a little bit compared to neat PP. This could be due to increase of brittleness and local internal deformation in composite materials [22].This could be due to increase of brittleness and local internal deformation in the composite materials [22].

CHAPTER 5

CONCLUSIONS AN RECOMMENDATIONS

5.1 Conclusions

In summary, objective of this project was achieved where all tensile, flexural and impact specimens were fabricated and tested. Tensile strengths of PP/mengkuang fibre composites were lower than neat PP except for 60/40 wt.%. An improvement in tensile strength of 9.3% was observed for 60/40 wt.% compared to neat PP. SEM micrographs of the composite indicated that a lot of fibre pull out for 80/20 wt.%, suggesting poor interfacial bonding between fibre and matrix. Although the pull out phenomena for 70/30 wt.% were less than 80/20 wt.%, the fibre content was not enough to support the load. The 60/40 wt.% specimens showed fibre ruptured indicating the load was successfully transferred from matrix to fibre. This results in better tensile strength.

Tensile modulus had shown a trend of higher values with higher fibre content. The highest tensile modulus improvement achieved was 107.4% compared to neat PP. For flexural properties, improvements were observed for all PP/mengkuang fibre composite compared to neat PP. However, the highest value of flexural strength was recorded at 70/30 wt.% while flexural modulus was observed highest at 60/40 wt.% composition. Impact strengths of the composite were lower than neat PP, even though the trend showed higher impact strength with higher fibre content. The results indicated a realistic potential of mengkuang leave to be used as reinforcement in polymer composite.

5.2 Recommendations

Several recommendations are proposed here to fully understand the potential of mengkuang leave as natural fibre reinforcement. The current study employed an existing mengkuang mat to be processed as mengkuang fibre. Virgin mengkuang leave should provide better potential than current ones. Therefore, study on mechanical properties of virgin mengkuang leave should be carried out.

Surface modification of natural fibre has shown some mechanical properties in polymer composite. For example, alkali bleach treatment can be applied onto the mengkuang leave to produce a better adhesion between fibre and matrix, resulting in higher mechanical properties.

Additive such as coupling agent and compatibilizer may be employed to enhance interfacial bonding between matrix and fibre. For instance, MAPP may be added into the composite to increase the mechanical properties.

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APPENDICES

Table A1: Tensile properties of neat PP and mengkuang reinforced PP composites.

Sample	Tensile Strength (MPa)	Average Tensile Strength (MPa)	Standard Deviation
Neat PP	34.55	**34.41**	0.71
	33.21		
	34.62		
	35.12		
	35.32		
80/20	32.03	**31.75**	0.54
	31.11		
	31.92		
	32.40		
	31.32		
70/30	34.10	**33.84**	0.53
	33.92		
	33.10		
	34.52		
	33.60		
60/40	38.37	**37.62**	1.51
	34.97		
	37.67		
	38.55		
	38.45		

Table A2: Tensile modulus of neat PP and mengkuang reinforced PP composites.

Sample	Tensile Modulus (GPa)	Average Tensile Modulus (GPa)	Standard Deviation
Neat PP	2.11	**2.17**	0.07
	2.27		
	2.20		
	2.12		
	2.22		
80/20	3.66	**3.45**	0.28
	3.86		
	3.26		
	3.22		
	3.30		
70/30	4.18	**4.22**	0.41
	3.53		
	4.45		
	4.41		
	4.55		
60/40	4.02	**4.55**	0.53
	4.21		
	4.21		
	5.02		
	5.23		

Table A3: The flexural strength of neat PP and mengkuang fibre reinforced PP composite.

Sample	**Flexural Strength (MPa)**	**Average Flexural Strength (MPa)**	**Standard Deviation**
Neat PP	36.80	**36.57**	0.47
	37.29		
	36.20		
	36.73		
	37.35		
80/20	47.49	**50.03**	3.02
	49.93		
	46.62		
	52.97		
	53.15		
70/30	51.32	**52.41**	2.89
	53.63		
	48.61		
	56.43		
	52.06		
60/40	45.28	**45.30**	0.31
	45.57		
	44.84		
	44.90		
	44.92		

Table A4: The flexural modulus of neat PP and mengkuang fibre reinforced PP composite.

Sample	Flexural Modulus (GPa)	Average Flexural Modulus (GPa)	Standard Deviation
Neat PP	0.95	**0.94**	0.01
	0.95		
	0.92		
	0.95		
	0.95		
80/20	1.50	**1.78**	0.39
	1.60		
	1.41		
	2.24		
	2.18		
70/30	2.12	**2.15**	0.12
	2.22		
	2.00		
	2.32		
	2.08		
60/40	2.30	**2.32**	0.11
	2.55		
	2.24		
	2.29		
	2.97		

Table A5: Impact strength of neat PP and impact strength of mengkuang fibre and PP composites.

Sample	Impact strength (J/m)	Average Impact Strength (J/m)	Standard Deviation
Neat PP	27.06	**29.12**	2.99
	27.35		
	29.71		
	34.12		
	27.35		
80/20	16.76	**17.18**	1.78
	19.70		
	17.35		
	14.70		
	17.35		
70/30	19.12	**22.29**	2.56
	20.29		
	24.46		
	25.00		
	22.65		
60/40	28.24	**24.29**	3.74
	20.56		
	28.24		
	21.18		
	23.24		