UNIVERSITI TEKNOLOGI PETRONAS

FINAL YEAR PROJECT II

DISSERTATION

MECHANICAL PROPERTIES OF PP/PET (POLYPROPYLENE AND POLY (ETHYLENE TEREPHTHALATE)) MICROFIBRILLAR COMPOSITE WITH AND WITHOUT COUPLING AGENT

Submitted by:

MUHAMMAD SOLIHIN BIN MOHAMED AMIR

10861

Submitted to:

DR. MOHAMAD ZAKI BIN ABDULLAH

MECHANICAL PROPERTIES OF PP/PET (POLYPROPYLENE AND POLY (ETHYLENE TEREPHTHALATE)) MICROFIBRILLAR COMPOSITE WITH AND WITHOUT COUPLING AGENT

By

Muhammad Solihin bin Mohamed Amir

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Mechanical Engineering)

SEPTEMBER 2011

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

Mechanical properties of PP/PET (Polypropylene and Poly (ethylene terephtalate)) microfibrillar composite with and without coupling agent.

By

Muhammad Solihin bin Mohamed Amir (10861)

A project dissertation submitted to the
Mechanical Engineering Programme
Universiti Teknologi PETRONAS
In partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(MECHANICAL ENGINEERING)

Approved by,

______________________.

(Dr. Mohamad Zaki bin Abdullah)

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
September 2011

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 acknowledgement, and the original work contained herein have not been undertaken or done by unspecified sources of persons.

____.

MUHAMMAD SOLIHIN BIN MOHAMED AMIR

ABSTRACT

Among thermoplastic polymer blends, combination of polypropylene, (PP) with poly (ethylene terephthalate), (PET) offer great advantages over the pure components. PET enhanced the stiffness of PP at higher temperature while PET low permeability towards water vapor and oxygen helps in packaging materials where it can prevent moisture from damaging the product inside the packaging. Tensile strength of PP can be increased with addition of PET element in it which helps the product produced have higher strength to withstand the force applied. This project will present the feasibility study of processing and characterization of PP/PET microfibrillar composites. MFCs are created by mixing two polymers with melting temperature different about 40 to 45°C. In this project, the matrix is PP and PET acting as the reinforcement. The two polymers then melt and blend together using twin-screw extruder at temperature above the melting point T_m to ensure that the polymers melt completely during the extrusion process. Then the polymer blends was drawn carefully under the glass transition temperature, T_g of PET and then the blends was cut using granulator. Compression moulding machine was used to compress the polymer blends in the shape of granule into a plate of polymer blends. Dog bone shape of the polymer blends then were cut to test the sample's mechanical properties using Universal testing machine. ASTM D638, D790 and D256 standards were used in the mechanical properties test to study the tensile, flexural and impact strength of the polymer blends. The processing of PP/PET MFCs was successfully done with 70/30/5 wt% ratio. MFCs show improvement in tensile strength of 5% for the drawn and undrawn comparison and 3% for coupling agent comparison. Flexural strength shows 1.3% for the drawn and undrawn comparison and 24% for coupling agent comparison. Impact strength shows 5.3% for the drawn and undrawn comparison and 110% for coupling agent comparison.

ACKNOWLEDGEMENT

Alhamdulillah, first and foremost the author would like to express his gratitude to those who have helped him to complete the Final Year Project which focuses on the microfibrillar and coupling agent effects on polymer blend's mechanical properties.

For the past 14 weeks of this semester, the author had received countless assist, guidance and moral support from his supervisor, Dr. Mohamad Zaki bin Abdullah, and the help from PETRONAS Research Sdn Bhd which represented by Mr Yusoff Said and Mr Rossi. The author would like to thank all the people involved in making this project possible.

Last but not least, the author would like to thank the UTP students who had helped him, directly or indirectly to make this study a success.

Thank you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 Project background

Polymers and structural composites are used in a variety of applications include transport vehicles, sporting goods, civil engineering and electronics. Thermosetting and thermoplastic polymers are two general classes of polymers based on their behavior when exposed to heat. There are well over 50 types of thermoplastics based on chemical structure and more than 10,000 specific grades of thermoplastics available commercially. In addition to chemical structures, these grades are distinguished based on molecular weight distribution, fillers, additives and reinforcements [1].

A new composite called Microfibrillar Composites (MFCs) has been proven to improve the mechanical properties of polymers in MFCs. The reinforced polymer will be blend into matrix polymer to create a new blend polymer. This process will mixed the polymers together which the minority amount of polymers (reinforced) will dispersed into the majority amount of polymers (matrix) that will form the homogenous body [2]. It means that PP will act as a matrix and PET as the reinforced polymer. In this study, the ratio of 70/30 was used in order to get a good partnership to the polymer chain microstructure and the coupling agent were added by 5% to increase the chemical bending between the polymers.

Both polymers were prepared and blended with melting temperatures difference from 40°C to 45°C [2]. There are 3 basic steps for the MFCs manufacturing process:

1. Blending of two homopolymer using extruder (mixing process).
2. Drawing of the composites with good and constant orientation (fibrillation).
3. Thermal treatment at a temperature between the melting temperatures of the polymers (isotropization process).

The first process was carried out above the melting temperature of both polymers to ensure that the polymers melt completely during the extrusion process. The second step was done carefully to allow the formation of reinforcing fibrils in the polymers blend. The third step was during the compression molding process to form the MFCs [1].

The polymer blend samples were tested using tensile, flexural and impact tester after the compression molding process to observe the changes in the mechanical properties. The morphology and molecular orientation of the MFC samples then were checked under scanning electron microscope (SEM).

1.2 Problem statement

PP may be used for certain applications useful for human needs daily, but because of its limited mechanical properties, there is certain barrier that the manufacturers need to comply in making the products. The mechanical properties of PP can be improved by applying reinforcement to it. By applying this MFCs concept, where the matrix (PP) blends with reinforcement (PET) with addition of coupling agent (PP-MA), then the cold drawing process and lastly the compression molding, the mechanical properties can be improved significantly.

1.3 Objectives and scope of study

- To study the effect of microfibrillar on the mechanical properties of PP/PET composites.
- To study the effect of coupling agent on the mechanical properties PP/PET composites.

The scope of study for this project would involving the processing of the polymer blends composite (PP/PET) and the characterization of it. The mechanical properties tests were done on the PP/PET samples to check the difference. The tests are:

1. Tensile Strength (ASTM D638)
2. Flexural strength (ASTM D790)
3. Impact test, Izod (ASTM D256)

Characterization of the samples were done under the scanning electron microscopic (SEM).

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

The first literature relating to polymers were done in 1865, where the first polymer blend was created [3]. Nowadays, the materials with unique combination of good friction and wear properties along with easy process ability are in need. This can be realized by blending polymers. It is necessary to understand the tribological properties of these blends. The friction and wear behaviour of polymer blend is fairly complex because the individual components have their unique response towards the friction and wear. Further, the extension and distribution of individual polymer and its interphase, are also important in determining the performance of the whole system [4].

Polyethylene terephthalate (PET) is a semi crystalline polymer widely used for packaging, electronic parts, and is especially suitable for making gears and bearings, because of high wear resistance, general toughness, fatigue resistance and availability of high purity recycled resin. The sensitivity to brittle fracture due to notch and stress concentration restricts its applicability. The considerable distortion, shrinkage and clouding of PET make its moulding difficult. On the other hand polypropylene (PP) can be processed very easily however, the sliding wear properties are inferior [5].

2.2 Journal 1: Comparison of compatibilizer effectiveness for PET/PP blends [11].

The compatibilizing efficiency for PET/PP blends was examined using tensile testing, Dynamic mechanical analysis (DMA), and differential scanning calorimetry (DSC) and scanning electron microscopy of crycrofractured surfaces before and after etching. Compatibilizers used were maleic anhydride modified, PP (PP-*g*-MA), LLDPE (LLDPE-*g*-MA) and hydrogenated SBS block copolymer (SEBS-*g*-MA). Large deformation behavior of aged blends indicated that SEBS-*g*-MA performed best by far. However, addition of a thermoplastic polyolefin alloy (TPO), PP/ethylene–propylene copolymer, increased the compatibilizing efficiency of PP-*g*-MA to a level comparable to that of SEBS-*g*MA. Improved efficiency of SEBS-*g*-MA and PP-*g*-MA with TPO compared to PP-*g*-MA or LLDPE-*g*-MA is attributed to better emulsification of the former at the interface, reduced migration of PP-*g*-MA into the PP phase and retardation of PET crystallization in the presence of the elastomeric additive. In addition, the elastomeric compatibilizers absorb more efficiently, the stresses developed at the PET/PP interface

2.3 Journal 2: PET/PP Blending by Using PP- g-MA with different weight percentage [12].

In attempts to improve the compatibility of polypropylene (PP) with polyethylene terephthalate (PET), a maleic anhydride grafted PP (PP- g-MA) was evaluated as a compatibilizer in a blend of 30/70 wt % PP/PET. PP- g-MA was produced from isotactic homopolymer PP utilizing the technique of solid phase graft copolymerization. Qualitative confirmations of the grafting were made by Fourier transform infrared spectroscopy (FTIR). Three different weight percent of compatibilizer, PP- g-MA, i.e., 5, 10, and 15 wt % have been used in PP/PET blends.

The compatibilizing efficiency for PP/PET blend was examined using differential scanning calorimetry (DSC), optical microscopy (OM), scanning electron microscopy (SEM) of crycrofractured surfaces, and energy dispersive X-ray spectrum (EDAX). The results show that the grafted PP promotes a fine dispersed phase morphology, improves processability, and modifies the crystallization behavior of the polyester component. These effects are attributed to enhance phase interaction resulting in reduced interfacial tension. Also, the results show that the compatibilizing effects of the three amounts of grafted PP in blend are different and dependent on the amount used. Adding 10 wt % o f compatibilizer into blend produced the finest dispersed morphology. Elemental analysis results show that PP is matrix. DSC determination revealed that the melting temperature (T) of the PET component declined to some extent by comparison with neat PET.

2.4 Journal 3: Role of PET in improving wears properties of PP in dry sliding condition [13].

Efforts have been intensified to develop PP/PET blends due to their potential for various engineering applications (Danaklon 1989; Hayes 1989; Xanthos *et al* 1990). Addition of PET in PP resulted in modulus increase that was independent of type of PP and presence of additives (Xanthos *et al* 1990). Improvement in mechanical properties was observed when acrylic acid functionalized PP was blended with PET. The PET has been blended with other polyolefins such as the high density polyethylene (HDPE) and the oriented blends of PET/HDPE were investigated. Simultaneously stretched blends show better physical properties than the sequentially oriented blends. The blends with compatibilizers show strain hardening effect whereas without compatibilizer does not show strain hardening upon orientation (Sambaru and Jabarin 1993). PP/PET blends have been studied for observing the effect of blend composition on permeability (Bataille *et al* 1987). In the present study, by using the melt blending technique, the blends of PP and PET of various compositions have been developed. The morphology and worn surfaces of PP/PET blends were studied using scanning electron microscopy. Sliding wear properties of these blends have been determined and studied for various blend compositions.

2.5 Journal 4: Extrusion Foaming of PP/PET Blends [14].

In order to develop new applications for recyclable commingled resin streams, blends containing PET and PP resins with different rheological characteristics were dry blended or compounded at different ratios and subsequently foamed by using PBAs and CBAs. Properties of the foamed blends were compared with those of similar products obtained by foaming the individual PET and PP components in the absence of compatibilizers/rheology modifiers. Foamed polymer blends with fine cell size and low density could be produced in the presence of suitable compatibilizer systems consisting of functionalized polyolefins or their combinations with reactive coagents. In this research, an attempt is made to produce extrusion foamed PET/PP blends at different resin weight ratios with either PBAs or CBAs. Virgin resins were used to prepare compositions mimicking mixtures of postindustrial, post-consumer materials. The ultimate objective is to assess the possibility of using recyclable mixed waste streams containing resins with different rheological characteristics in order to produce novel lowdensity items. The inherent lack of miscibility of the PET/PP pair that would lead to technologically incompatible systems is addressed through the use of reactive additives that are expected to affect, not only morphology but, also rheology of these complex, multiphase, multicomponent systems [6].

2.6 Journal 5: Phase Morphology of PolypropylenePolyethylene Terephthalate Blend Fibres [15].

The research deals with the phase morphology of polypropylene-polyethylene terephthalate (PP/PET) blend. The development of the morphology of the blend PP/PET fibres in the spinning and drawing processes, in dependence on molecular weight and the rheological properties of PET in the dispersed phase has been investigated. In experimental work both the length and diameter of PET deformed particles in PP matrix have been evaluated. In general, it was found that the length of the PET microfibrils in PP fibres after spinning and drawing is indirectly proportional to the molecular weight of the PET. However, in the drawing process the increment of the microfibril length of the dispersal phase is higher for PET with a higher molecular weight in comparison to the length after spinning. This means that the length of PET particles in the PP matrix is strongly influenced by spinning conditions for a lower molecular weight of PET and by the drawing conditions for a higher molecular weight of PET.

CHAPTER 3
METHODOLOGY

This chapter will discuss the methodology to form and test the MFCs. This chapter consists of 4 main components which are material used, tool and equipment, experimental process, and gaunt chart. The tools and equipment used will be explaining about mainly about the tools function in the progress of the project. Experimental processes will describe the process that has been done to complete the project.

3.1 Material

The material used in this study.

1. Polyethylene (PP), TITANPRO 6331.
    - Melting Temperature, T_m (160-165°C)
    - Tensile strength (Yield) 35.3 MPa
    - Tensile Elongation (10%)
    - Melt flow rate (MFR), 230°C/2.16 kg
2. Poly (ethylene terephthalate), PET.
    - Melting Temperature, T_m (254-256°C)
    - Tensile strength, 55-57 MPa
    - Tensile modulus, 2.7-4.0 GPa
    - Density, 1.38-1.4 g/mm^3
3. Coupling Agent/Compatibilizer, (PP-Ma, (Fusabond P 613)).
    - Melting Temperature, T_m (162°C)
    - Melt flow rate (MFR), 190°C/1.0 kg
    - Density, 0.903 g/mm^3

3.2 Tools and Equipment

Table 3.1: Tools and equipment

Tools	Function
Speed Granulator (model SG21-P)	Grinder the PET to smaller pieces for extrusion process.
Leistriz twin screw extruder (model Mi027/G6-32D)	Mix and blend PP/PET/PP-MA.
Palletiser machine (model C.F.SCHEER)	Grind the PP/PET/PP-MA from the extruder to get pallet size composites.
Compression molding (model ME 20ii)	Compress the polymer composites blend into samples that need during tests.
Scanning electron microscope (model LEO VP1430)	Checking the morphology characteristic of the polymer composites.
Universal testing Machine (model LLOYD LR54)	Tensile and Flexural tests on the polymer composites.
Impact testing machine (model LLOYD IZ78)	Impact test on the polymer composites.

3.3 Experiment

3.3.1 Preparation of Material

PP was raw material supplied by Titan Chemical as shown in Figure 3.1 while PET was processed form derbies of bottle by grinder using granulator until it becomes plastic flakes like in Figure 3.2.

Figure 3.1: PP raw material.

A)  B) 

Figure 3.2: Raw materials (A) PET before grinder; (B) PET after grinder.

3.3.2 Mixing and Extrusion

The material was mixed together with the ratio of 70/30/5 wt% (Figure 3.3) which consist of PP/PET/PP-MA. The weight ratio is PP (700g) and PET (300g) and PP/MA (50g).

Figure 1.3: Mixture of PP/PET/PP-MA with ratio 70/30/5 wt%.

The PP, PET, and coupling agent was mixed, compounded and extruded using Leistriz twin screw extruder (Figure 3.4(a)) with increasing temperature profiles of T_1, T_2, T_3, T_4, T_5, T_6, and T_{die} was 200, 220, 250, 260, 270 and 250°C and the speed was set to 30 rpm for the whole process. The temperature profiles were set based on the highest melting temperature, Tm of the materials which is PET, 270°C. The materials that undergoing this process will form an isotropic and continues blend composites and later will be cold drawn and going through straight to a palletiser to get a pallet size of PP/PET/PP-MA (Figure3.4(b)) for compression molding process.

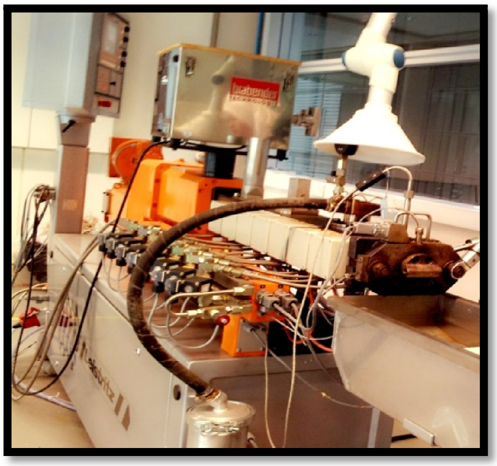
A)  B) 

Figure 3.2 : (A) Leistriz twin screw extruder; (B) The pallet size of PP/PET/PP-MA.

3.3.3 Drawing

The PP/PET/PP-MA blend composites were drawn to create the microfibrillar morphology essentials to MFCs. The drawing process was done right after the material come out from the extruder machine (Figure 3.5(a)), straight into water to decrease the temperature and stretched until it indicates the point of necking at the blend composites and then it goes into the palletiser machine to get pallet size of PP/PET/PP-MA blend (Figure 3.5(b)).

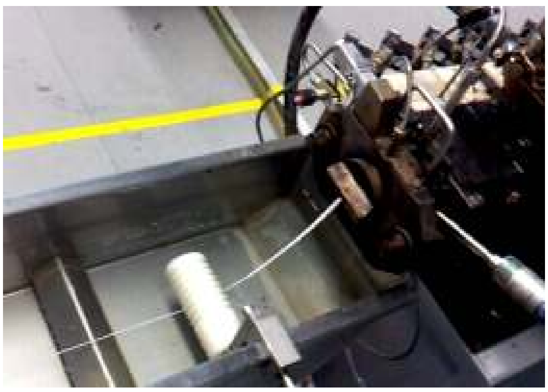
A)  B) 

Figure 3.5: (A) Drawing process; (B) Pallet size of PP/PET/PP-MA after going through the palletiser.

3.3.4 Compression Molding

All the materials blends which were drawn PP/PET, drawn PP/PET/PP-MA, undrawn PP/PET, and undrawn PP/PET/PP-MA pallets were compressed via compression molding machine (Figure 3.6(a)) with temperature 190°C, 50 bar compress pressure to make plate samples of the blends (Figure 3.6(b)). The temperature was set to the matrix polymer (PP) melting temperature to ensure that the reinforcing fibril shape of the drawn PET was not affected by the compression molding process. Then from the plates, dumbbell and bar samples for the tensile, flexural and impact test were cut during air compressed cutter.

A)

B)

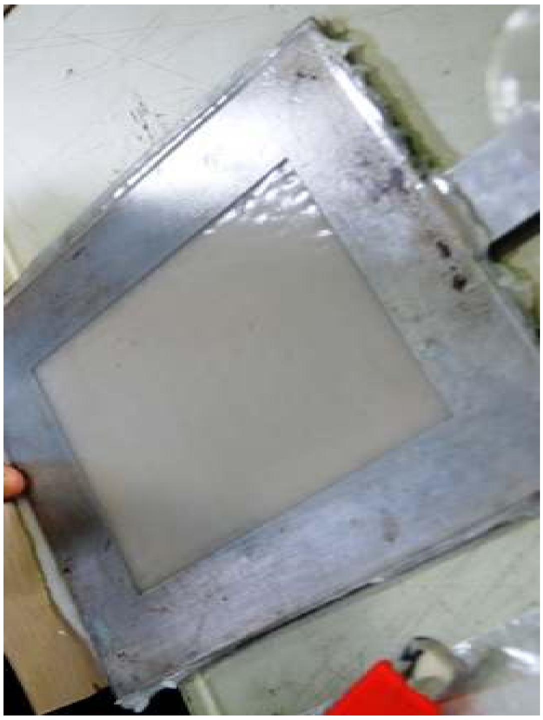


Figure 3.6: (A) Compression Molding Machine; (B) Plate sample of the polymer blend.

The dumbbell (Figure 3.8) and bar (Figure 3.8) samples were processed using the standard ASTM mold where 7 good samples for drawn PP/PET (A), drawn PP/PET/PP-MA (B), undrawn PP/PET (C) and undrawn PP/PET/PP-MA (D), have been made for the test and analysis. The bar samples (Figure 3.8) were used for flexural test and later on will be notched by a notched cutter for the impact test (izod).

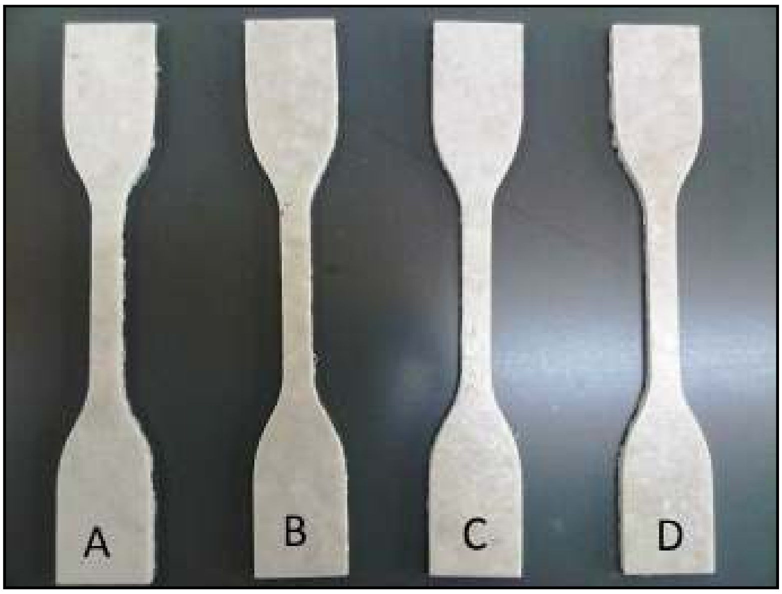


Figure 3.7: (A) drawn PP/PET; (B) drawn PP/PET/PP-MA; (C) undrawn PP/PET; (D) undrawn PP/PET/PP-MA.

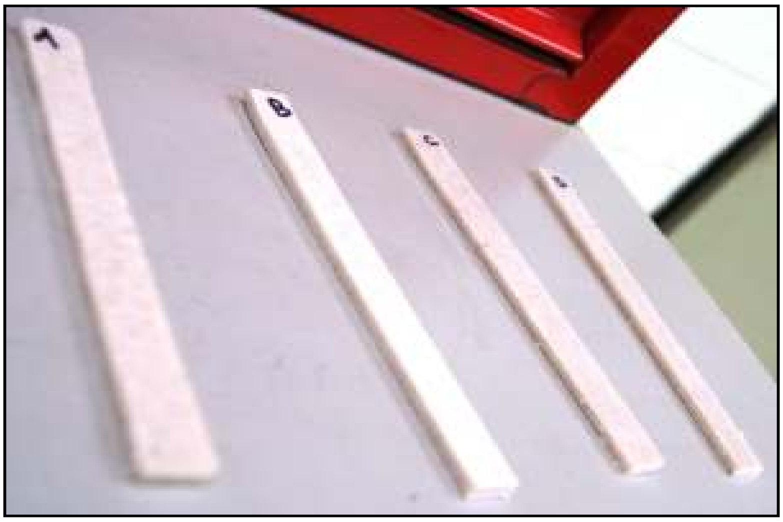


Figure 3.8: (A) drawn PP/PET; (B) drawn PP/PET/PP-MA; (C) undrawn PP/PET; (D) undrawn PP/PET/PP-MA.

3.3.5 Characteristics

Scanning electron microscope (SEM) was used to study the morphological structure before and after drawing with 1000X magnification, (Figure 3.9). The samples were prepared by immersed in the liquid nitrogen for at least 10 minutes and fracture which allowed performing extraction. Samples later on coated with a fine layer of gold to aid in electron conductance for the SEM analysis.

Figure 3.9: Scanning Electron Microscope.

3.4 Mechanical Testing

Mechanical testing includes tensile, flexural and impact test. Tensile and flexural tests were done using 5 kN universal testing machine (Figure 3.10(a)). The impact test was done using impact tester machine (Figure 3.11) after the notch has been cut using notch cutter (Figure 3.12) at the samples. All the tests were done based on the ASTM standards. For tensile (ASTM D638), flexural (ASTM D790), and impact test (ASTM D265). Test samples underwent conditioning and testing at 23 ± 2°C temperature and 50 ± 5% relative humidity. All the tests performed were using 5 good samples to get better and accurate results.

A) B)

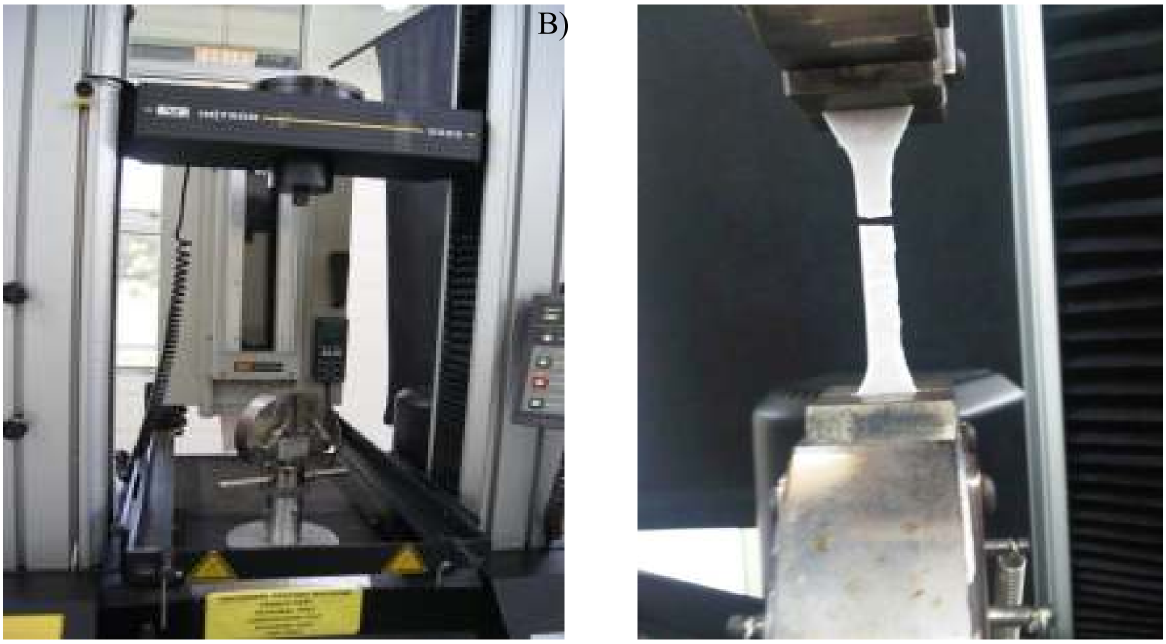


Figure 3.10: (A) Universal testing machine; (B) Tensile test for the samples.

Figure 3.11: Impact tester.

Figure 3.12: Notch cutter.

3.5 Gantt chart and Key Milestone

	2011								2012
Activities	M	J	J	A	S	O	N	D	J
• Study on the methods and proper procedure for the process. • Process: Compression molding. • Study on the standards for the process and the machine procedure.									
• Purchasing of material needed.									
• Pre-fabrication of the material. • Prepare the mold for the dog bone shape. • Cutting the PP into dogbone shape using CNC machine.									
• Tensile and flexural strength tested. • Machine: Universal Testing machine.									
• Results and observation documentation. • Report compilation.									

Figure 3.13: Gantt chart

	2011								2012
Milestone	M	J	J	A	S	O	N	D	J
1) Completion of all documents and calculations needed: • Temperature profile and pressure required for the compression molding process. • Standards that will be used throughout the entire project.									
2) Completion of sample preparation: • Pre-fabrication of the sample shape (dog bone) using PP • Completion of at least 8 specimens.									
3) Completion of all testings needed: • Tensile and flexural testing using universal testing machine • Collection of data and results from the testing. • Comparison between 3 conditions of specimen. • Data analysis									
4) Report documentation: • Compilation of photos from experiment. • Report completion.									

Figure 3.14: Key Milestone

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Mechanical Properties

Mechanical tests were done on the samples to inspect difference on the mechanical properties. Tensile, flexural and impact tests were done according to specific standards of ASTM. Five samples were going through the test and the neat PP was compared with undrawn and drawn samples. The tensile properties were shown in Table 4.1.

4.1.1 Tensile Strength

Table 4.1 shows the tensile strength for the samples.

Table 4.1: Tensile strength

Samples	**Tensile Strength (Mpa)**				
	Pure PP	Undrawn PP+PET	Undrawn PP+PET+F	Drawn PP+PET	Drawn PP+PET+F
1	20.01	17.18	19.11	19.88	19.16
2	19.58	18.76	19.46	19.89	20.17
3	21.98	17.99	19.37	18.90	19.67
4	15.34	18.20	19.60	18.76	19.39
5	15.37	18.38	17.68	17.52	19.36
Average	18.46	18.10	19.04	18.99	19.55
Standard Deviation	2.97	0.59	0.78	0.98	0.39

From the Figure 4.1, the graph shows the tensile strength of 1) pure PP, 2) undrawn PP+PET, 3) undrawn PP+PET+Fusabond (coupling agent), 4) drawn PP+PET, 5) drawn PP+PET+F. From the comparison of undrawn and drawn samples without coupling agent, the average tensile strength is 18.10 and 18.99 respectively. It shows 5% improvement. As for the drawn samples with and without coupling agent, the average tensile strength is 18.99 and 19.55 respectively. This samples show 3% improvement. From the comparison of samples above, it shows that the microstructure changed from sphere to fibril which improved the tensile strength of the polymer mixture. The coupling agent also proved that there are bonding reaction between the matrix and the reinforcement. If the pure PP was compared with undrawn PP+PET, there is slight decreased in the tensile strength and this is maybe due to the effect of moisture that brings water vapors because we are in atmosphere with high relative humidity value.

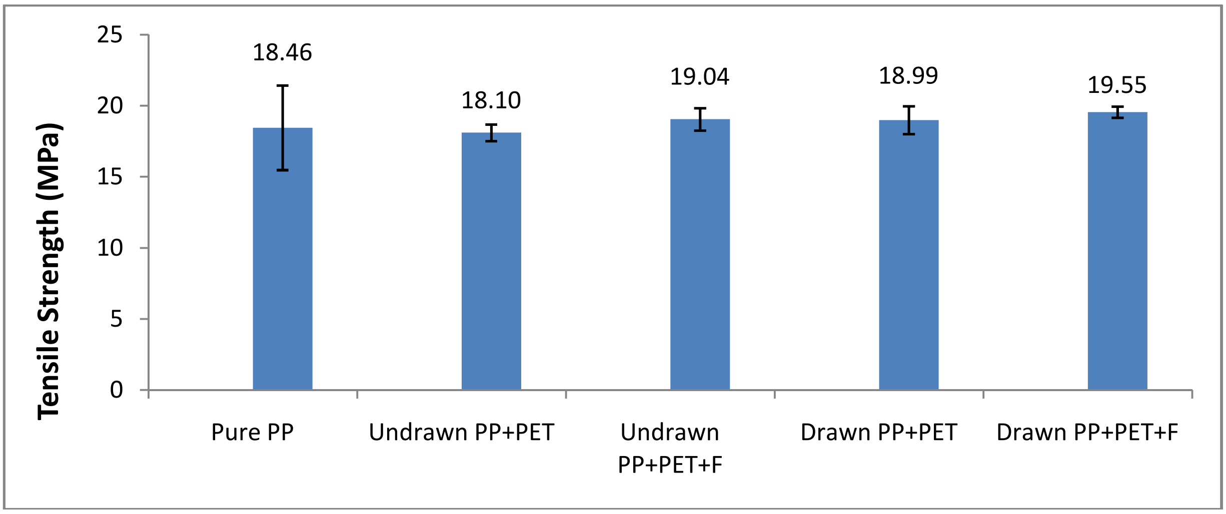


Figure 4.1: Tensile strength of (1) pure PP; (2) undrawn PP+PET; (3) undrawn PP+PET+F; (4) drawn PP+PET; (5) drawn PP+PET+F

4.1.2 Flexural Strength

From Figure 4.3, the graph shows the flexural strength of 1) neat PP, 2) undrawn PP+PET, 3) undrawn PP+PET+Fusabond (coupling agent), 4) drawn PP+PET, 5) drawn PP+PET+F. The comparison between undrawn and drawn samples without coupling agent shows slight improvement where the average strength is 37.24 and 37.74 respectively. This means 1.3% improvement. If the drawn samples with and without coupling agent were compared, it also shows improvement of 24% with the average strength were 37.74 and 46.93 respectively. Table below shows the flexural strength for all the samples.

Table 4.2: Flexural strength

Sample	Flexural Strength				
	Pure PP	Undrawn PP+PET	Drawn PP+PET	Undrawn PP+PET+F	Drawn PP+PET+F
1	35.11	36.33	36.44	41.26	43.03
2	35.31	37.21	37.41	38.55	46.32
3	36.05	36.53	38.36	40.05	50.43
4	36.01	36.87	37.65	40.14	52.51
5	35.66	39.25	38.86	39.56	42.35
Average	35.63	37.24	37.74	39.91	46.93
Satndard Deviation	0.42	1.17	0.93	0.98	4.47

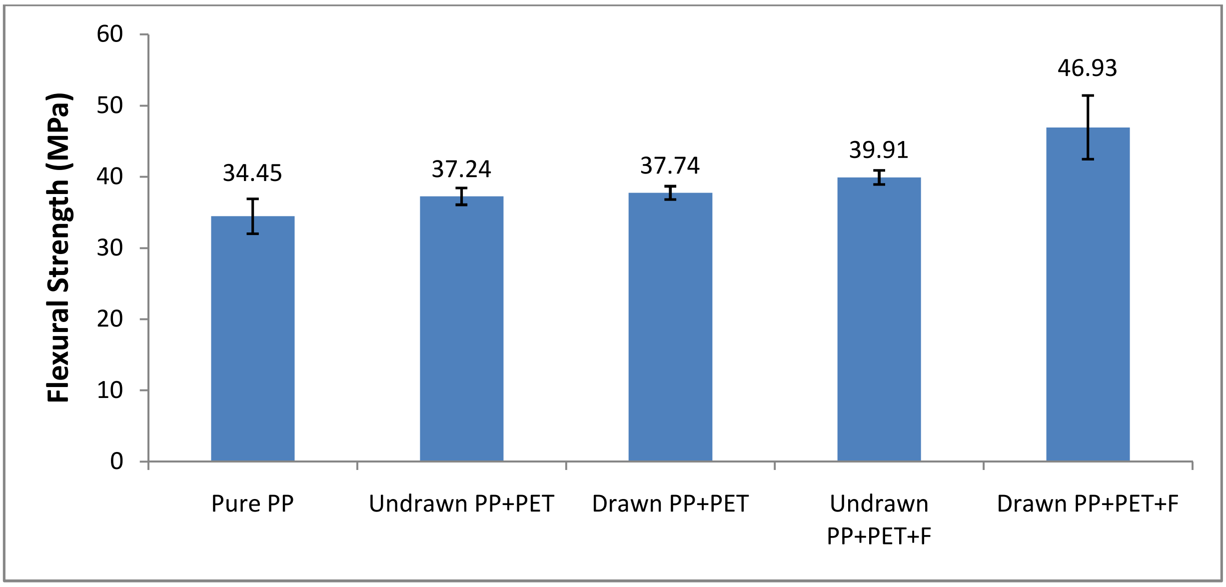


Figure 4.2: Flexural strength of (1) pure PP; (2) undrawn PP+PET; (3) undrawn PP+PET+F; (4) drawn PP+PET; (5) drawn PP+PET+F

4.1.3 Impact Strength

From Figure 4.3, the graph shows the impact strength of 1) neat PP, 2) undrawn PP+PET, 3) undrawn PP+PET+Fusabond (coupling agent), 4) drawn PP+PET, 5) drawn PP+PET+F. The comparison between undrawn and drawn mixture without coupling agent shows improvement where the average impact strengths are 1.69 and 1.78 respectively. This shows 5.3% improvement. As for the drawn mixture with and without coupling agent, the improvement was better with the impact strengths are 1.78 and 3.79 respectively. This samples comparison shows 110% improvement. Table below shows the impact strength of all the samples.

Table 4.3: Impact Strength

Sample	**Impact Properties**				
	Pure PP	Undrawn PP+PET	Drawn PP+PET	Undrawn PP+PET+F	Drawn PP+PET+F
1	6.67	1.67	2.14	2.46	2.88
2	5.85	1.58	1.87	2.46	3.44
3	7.35	2.03	1.76	1.41	4.15
4	6.54	1.57	1.58	2.39	4.38
5	6.56	1.58	1.55	2.44	4.12
Average	6.59	1.69	1.78	2.23	3.79
Standard Deviation	0.53	0.20	0.24	0.46	0.62

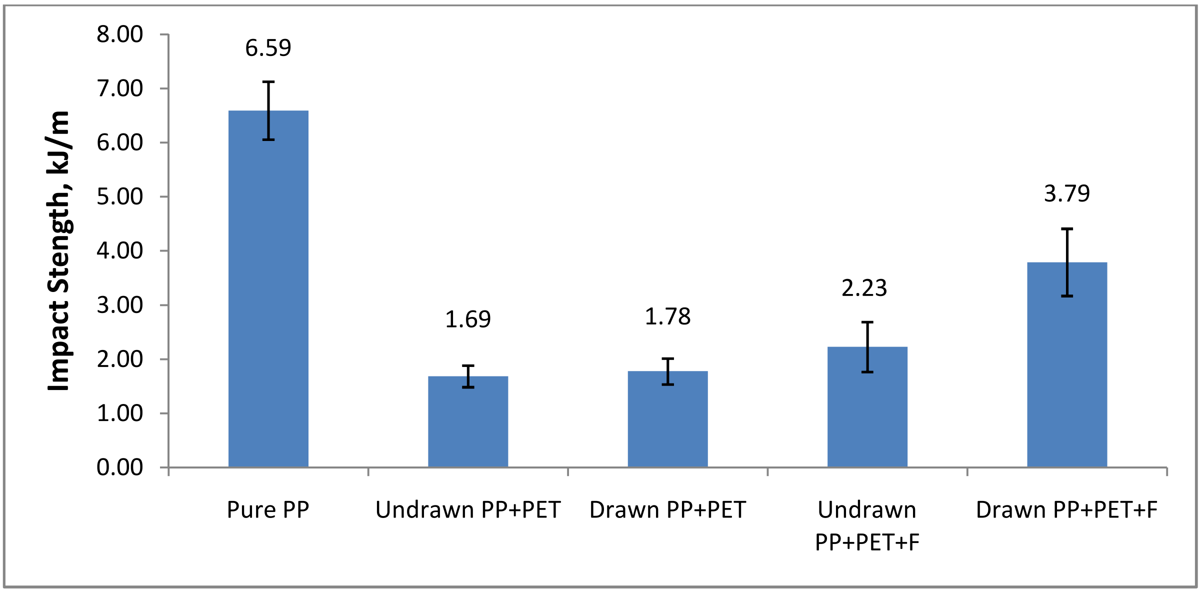


Figure 4.3: Impact strength of (1) pure PP; (2) undrawn PP+PET; (3) undrawn PP+PET+F; (4) drawn PP+PET; (5) drawn PP+PET+F

CHAPTER 5
CONCLUSIONS AND RECOMMENDETIONS

5.1 Conclusion

The main objective of this project is to process and characterize PP/PET MFCs. The conclusion that can be drawn from this study:

- The processing of PP/PET MFCs was successfully done with 70/30/5 wt% ratio
- MFCs show improvement in tensile strength of 5% for the drawn and undrawn comparison and 3% for coupling agent comparison.
- Flexural strength shows 1.3% for the drawn and undrawn comparison and 24% for coupling agent comparison.
- Impact strength shows 5.3% for the drawn and undrawn comparison and 110% for coupling agent comparison.

5.2 Recommendation

The process of drawing can be improved by drawing machine that can control the specific diameter of the blend composites that coming out right after extrusion process. This machine is important to control the formation of fibrils in the polymer blends. The drawing should be done in constant speed to ensure all the fibrils forms in the polymer blend are in constant diameter.

REFERENCES

1. FRIEDRICH, K., Evstatiev, M., Fakirov, S., Estatiev , O., Ishii, M., Harrass, M., 2004, "Microfibrillar reinforced composites from PET/PP blends: processing, morphology and mechanical properties," *Composites Sciences and Technology* **65**: 107-116.
2. Shields, R.J., Bhattacharyya, D., Fakirov, S., 2008, "Fibrillar polymer-polymer composites: morphology, properties and applications," *Journal Master Science* **43**: 6758-6670.
3. Shields. R.J., 2008, Characterisatio of the mechanical and oxygen barrier properties of microfibril reinforced composites, PhD Thesis, Auckland University, New Zealand.
4. Somit Neogi, S., A., R., Hashimi, Navin Chand, 2003, "Role of PET in improving wear properties of PP in dry sliding condition," *Journal Master Science* **26**: 579-583.
5. Chand N., Fahim M., 2000, "An introduction to tribology of FRP materials," *Jounal Master Science* **3**: 926-932.
6. A.L. Bisio., M., Xanthos, Eds.,1994, "How to Manage Plastics Waste: Technology and Market Opportunities," Munich, New York.
7. Eva Körmendy., Anton Marcincin., Marcela Hricová., Vladimír Kovacic., 2003, "Phase morphology of polypropylene polyethylene terephthalate blend fibres," Russia.
8. Product Data Sheet, 2007. TITANPRO 6331, report number D01, Titan Petchem (M) Sdn Bhd.
9. Standard Test Method, 2004. *Tensile properties of Plastics*, D638-03: 50-63, ASTM International.
10. Standard Test Method, 1999. *Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials*, D790-98: 148-155, ASTM International.
11. C.P. Papadopoulou, N.K. Kalfoglou, 2003. Comparison of compatibilizer effectiveness for PET/PP blends: their mechanical, thermal and morphology characterization.
12. M. Akbari, A. Zadhoush, M. Haghighat, 2006. PET/PP Blending by Using PP- g-MA Synthesized by Solid Phase.

13. Somit Neogi, S A R Hhashmi and Navin Chand, 2003. Role of PET in improving wears properties of PP in dry sliding condition

14. C. Wan, M. Xanthos, S. Dey and Q. Zhang**.** Extrusion Foaming of PP/PET Blends.

15. Eva Körmendy, Anton Marcinčin, Marcela Hricová, Vladimír Kovačic. Phase Morphology of PolypropylenePolyethylene Terephthalate Blend Fibres.