PRODUCTION AND CHARACTERIZATION OF INSULATOR MATERIAL FROM OIL PALM EMPTY FRUIT BUNCH (EFB)

NORHANIZA BINTI MAT SAAD

BACHELOR OF CHEMICAL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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NORHANIZA BINTI MAT SAAD

Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Chemical Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Chemical Engineering.

SIGNATURE	:
NAME OF SUPERVISOR	: DR. MOHAMMAD DALOUR HOSSEN BEG
POSITION	:
DATE	:

STUDENT'S DECLARATION

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

SIGNATURE :

NAME : NORHANIZA BINTI MAT SAAD

ID NUMBER : KA08065

DATE :

Dedicated to my parents

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ABSTRACT

Malaysia is the largest producer and exporter of product based on palm oil. They are grown for the oil but only 10% will be extracted to the oil and the rest will become biomass. Based on this current situation it make oil palm empty fruit bunch (EFB) is readily available in Malaysia in large quantity. The used of landfill disposal or burning process that are become increasingly difficult due to environmental concern and legal requirement. Looking forward to a better method, an alternative approach for optimizing the usage of oil palm residues were obtained as it turn into value-added product. Focus for this study is to optimize bonding mechanism between fiber and filler and to study the effect of fiber treated on the mechanical properties and thermal decomposition. Two sets of experiment were performed, in the first set EFB fiber were blended in various ratios up to 30 wt% with the polypropylene (PP) using the twin screw extruder. For another set, 5 wt% Maleated polypropylene (MAPP) has been added to increase filler-matrix interactions and the filler dispersion in matrix. From this study, it has been proven that composite with MAPP shows the improvement on mechanical properties but as fiber loading increase the mechanical properties will be decrease due to the inefficient stress transfer. For the TGA characterization showed thermal stability for PP/EFB composite is higher with the presence of MAPP.

ABSTRAK

Malaysia adalah pengeluar terbesar dan pengeksport produk berasaskan minyak sawit. Mereka berkembang untuk minyak tetapi hanya 10% yang akan diekstrak kepada minyak dan selebihnya akan menjadi biomas. Berdasarkan keadaan semasa, tandan kelapa sawit kosong (EFB) adalah mudah didapati di Malaysia dalam kuantiti yang besar. Penggunaan pelupusan tanah atau proses pembakaran yang menjadi semakin rumit kerana kebimbangan alam sekitar dan keperluan undang-undang. Oleh kerana itu, satu pendekatan alternatif untuk mengoptimumkan penggunaan sisa kelapa sawit telah diperolehi kerana ia boleh menjadi produk nilai tambah. Fokus kajian ini adalah untuk mengoptimumkan mekanisme ikatan antara gentian dan pengisi dan untuk mengkaji kesan serat yang dirawat ke atas sifat mekanik dan penguraian terma. Dua set eksperimen telah dijalankan, gentian EFB di set pertama dicampur dalam nisbah yang pelbagai sehingga 30% dengan *polypropylene* (PP) menggunakan penyemperit skru kembar. Bagi set lain, 5% *Maleated polypropylene* (MAPP) telah ditambah untuk meningkatkan pengisi-matriks interaksi dan penyebaran pengisi dalam matriks. Daripada kajian ini, ia telah membuktikan bahawa komposit dengan MAPP menunjukkan peningkatan pada sifat-sifat mekanik tetapi pertambahan serat-serat di dalam akan mengurangkanan sifat-sifat mekanik disebabkan perpindahan tegasan tidak cekap. Bagi pencirian TGA menunjukkan kestabilan terma bagi komposit PP / EFB adalah lebih tinggi dengan kehadiran MAPP.

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LIST OF SYMBOLS

%	Percentage
wt%	Weight percentage
°C	Degree celcious
ε	Strain
Δε	Strain range
σ	Stress
Δσ	Stress range

LIST OF ABBREVIATIONS

ASTM	American Standard Testing Machine
CPO	Crude palm oil
DP	Degree of polymerization
DTA	Differential thermal analysis
EFB	Oil palm empty fruit bunch
FFB	Oil palm fresh fruit bunch
g/cm^3	Gram per $centimeter^3$
g/min	Gram per minute
l/d	Length to diameter ratio
MAPP	Maleated polypropylene
mm	Millimeter
MPa	Mega Pascal
NaOH	Sodium Hydroxide
OPT	Oil palm trunk
OPF	Oil palm frond
PP	Polypropylene
TGA	Thermo gravimetric analysis

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Highly developed in science and technology have requisite a selection of new polymers with a good performance and low cost. In industrial competition, the performance and cost are the main criteria that will consider in a production of new material that can make it compete with the glass fiber. The use of natural fiber can lead to superior materials based on their advantages. Therefore, studies on the use of natural fiber as a replacement to man-made fiber in fiber reinforced composites have increased and opened up further industrial possibilities.

Oil palm empty fruit bunch (EFB) is readily available in Malaysia in large quantity. According to Feng (2010) Malaysia will produced 46 million m^3/year residue from agricultural with more than 30 million metric tons of oil palm biomass are oil palm trunk (OPT), oil palm frond (OPF) and empty fruit bunch (EFB).

Table 1.1: Estimate raw natural fiber capacity available in Malaysia

RESOURCES	ESTIMATE CAPACITY/YEAR
Log production	~ 20.7 million m^3 / year
Forest and wood residue	~ 10 million m^3 / year
Rubber wood	2.1 million m^3 / year
Oil palm biomass (OPT,OPF,EFB)	30 million metric tons / year
Coconut stems	3200 metric tons/year
Rice husk / straw	500,000 metric tons / year
Bagasse	180,000 metric tons /year
Bamboo	10 million culms / year

Source: Feng (2010)

Oil palm fiber is one of the natural fibers that were extracted from EFB. In the manufacturing procedure of oil palm fiber, EFB are shredded, separated, refined and dried. In conventional method, burning process had been choosing for disposal purpose which is creating the environment problem especially in air pollution and the ash from burning process will be used as fertilizer for the oil palm mill.

The advantages of EFB fiber are biodegradability, can reduced greenhouse emissions, non-toxic, can change from low cost lignocellulosic fillers into relatively expensive thermoplastic, low energy consumption, low density, acceptable specific strength properties etc. (Feng, 2010; Rozman et. al, 2001a). Currently EFB are utilized with polypropylene (PP) to be used in automotive application, insulation and manufacture of mattress. However, EFB fiber has several disadvantages such as poor moisture resistance, low durability and poor fire resistance (Joseph et.al,2005).

In general, insulation is combination of mineral oil and cellulose in the form of paper, pressboard, and sometimes selected natural wood. New technologies have been proposed and tried including modern plastic foil and tapes instead of paper. Unfortunately, these combinations are failed to outperform the classic combination of natural mineral (mineral oil) and cellulose fibers (Särneroth, 2001) Therefore, more research on the EFB will give a better situation for environment.

1.2 PROBLEM STATEMENT

The demands of natural fiber composite in various applications is high based on the characteristics possessed by the fiber itself and due to its advantages such as biodegradability, low energy consumption, low density, and acceptable specific strength properties.

Based on the current situation in Malaysia, EFB is readily available in abundant quantity. The used of landfill disposal or burning process that are become increasingly difficult due to environmental concern and legal requirement. Looking forward to a better method, an alternative approach for optimizing the usage of oil palm residues were obtained as it turn into value-added product.

However, the combination of EFB fiber and PP will reduce the mechanical strength of the composite. Therefore, this research is attempt the improvement of mechanical properties of the composite after the addition of coupling agent.

1.3 OBJECTIVE

The main objectives of this study are:

1) To optimize the bonding mechanism between the fiber and filler.
2) To study the effect of fiber treated on the mechanical properties and thermal decomposition.

1.4 SCOPE OF STUDY

In order to achieve the objective, the following scopes of study are needed:

1) Production of composite with different percentage of EFB fiber and addition of coupling agent.
2) Analyze the mechanical and thermal properties of the composite by using the tensile test and Thermo gravimetric analysis (TGA)

1.5 RATIONALE AND SIGNIFICANCE

These researches are important to reduce the residue from the agricultural and the used of landfill disposal or burning process that are become increasingly difficult due to environmental concern and legal requirement. In addition, this research is also to produce the insulator material that environment friendly which is all the material that will be used in the research is non toxicity. Lastly, it can help to enhance the performance of composite in order to comply with the safety during used it as insulator and can be used in various application.

CHAPTER 2

LITERATURE REVIEW

2.1 OVERVIEW OF OIL PALM FIBER

Oil palm or *Elaeis guineensis* is originated from West Africa and the American oil palm *E. oleifera* is native to Central and South America. They are grown for their oil but only 10% will be extracted to the oil and the rest (90%) will be biomass. The biomass is consist of palm kernel cake (59%), shell (5.5%), empty fruit bunch (22%), and fiber (13.5%) are comes from the fresh fruit bunch. (Rowell, 2008).

Figure 2.1: EFB fiber

In 2009, the 421 of Malaysian palm oil mills was produced approximately:

a) 17.7 million tons of Crude Palm Oil (CPO) (20% of FFB).
b) 19.47 million tons of (wet) Empty Fruit Bunch (EFB) (22%of FFB).
c) 11.9 million tons of (wet) palm mesocorp fiber (13.5% of FFB).
d) 5.85 million tons (wet) palm kernel shells (5.5% of FFB) for turning into activated carbon.
e) There are also millions of tons of fiber from Palm Tree Trunks and fronds every year.

All above items are biomass raw material which can be turned into turn into value-added product. For example fertilizers, fuel pellets and briquettes, pallets, composite fiber boards, paper pulp, paper, paper products etc. (Hoong, 2011). In addition, EFB fibers are used in various applications such as furniture, infrastructures, mattress, erosion control, paper production and also landscaping. (Rowell, 2008).

2.2 PROPERTIES OF FIBER

Normally, all natural fibers, whether wood or non wood types are cellulosic in nature. The major components of natural fibers are cellulose and lignin. Basically the natural fiber physical properties are influenced by the chemical structure such as cellulose content, degree of polymerization, orientation, and crystalline, which are affected by conditions during growth of plants as well as extraction method used. (Franco & Valadez- González, 2005)

The approximate of chemical composition of EFB fiber is given in Table 2.1:

Table 2.1: Proximate chemical composition of EFB fiber

Chemical composition	**Weight (%)**
Ash	3.5
Extractive (hot water)	8.9
Extractive alcohol benzene	2.7
Lignin	20.4
Holocellulose	77.7
Alfa-cellulose	44.2
Hemicelluloses	33.5

Source: Khalid et al. (2008)

2.2.1 Cellulose

According to Bismarck, Mishra and Lampke (2005) “cellulose is a linear macromolecule consisting of D-anhydroglucose ($C_6H_{11}O_5$) repeating units joined by β-1,4-glycosidic lingkages with a degree polymerization (DP) of around 10,000. Each of the repeating unit contains three hydroxyl groups. These hydroxyl groups and their ability to hydrogen bond play a major role in directing the crystalline packing and also govern the physical properties of cellulose material”. In addition, all natural fibers are hydrophilic in nature and the mechanical properties of a fiber are significantly dependent on the DP. (Mohanty et al., 2005).

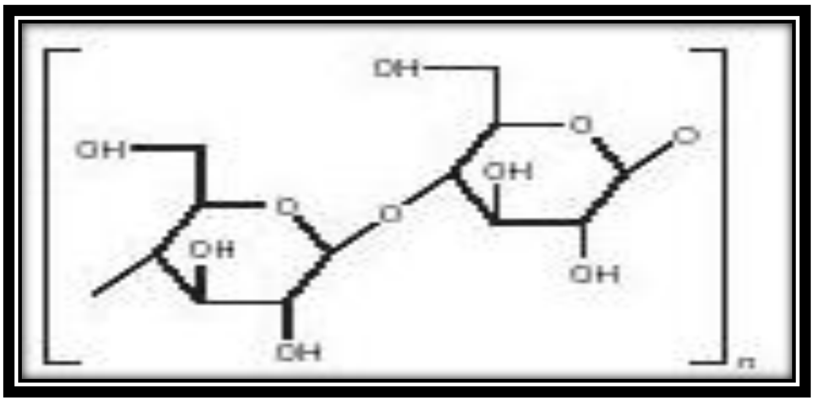


Figure 2.2: A portion of a cellulose fiber.

Source: Sulliva

2.2.2 Hemicellulose

As a matter of fact, hemicelluloses are polysaccharides composed by the combination of 5-and 6- ring carbon ring sugars and the polymer chains are much shorter (DP around 50 to 300) and branched, containing pendant side groups giving rise to its noncrystalline nature. Additionally, hemicelluloses are very hydrophilic and soluble in alkali and easily hydrolyzed in acids (Bismarck et al., 2005).

2.2.3 Lignin

Lignin is a high molecular-weight phenolic compound. Normally, it is resistant to microbial degradation and functions as structural support material in plants. In fact, the exact chemical structure of lignin still remains doubtful but most of the functional groups and units have been identified. Lignin has highly unsaturated or aromatic in nature because it has high carbon, low hydrogen content, amorphous and hydrophobic in nature. However, lignin is polyfunctional that exist in the combination with more than one neighboring chain molecule of cellulose and/or hemicelluloses. (Bismarck et al., 2005; Mohanty et al., 2005)

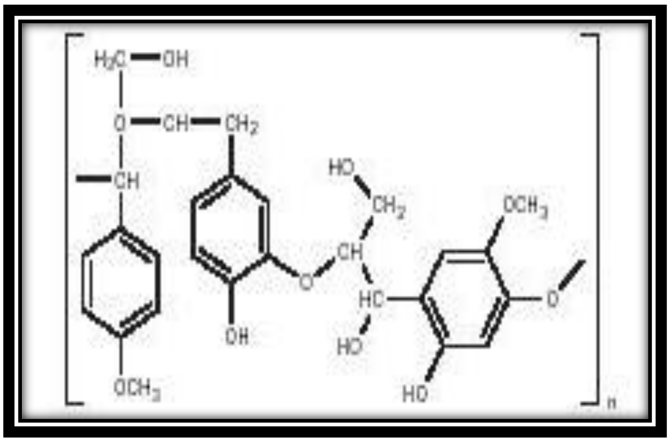


Figure 2.3: A portion of one of the many possible structures of lignin.

Source: Sulliva

2.3 OVERVIEW OF POLYPROPYLENE (PP)

Polypropylene, C_3H_6 (PP) is a plastic polymer that can be used in many different settings, both in industry and in consumer goods. It can be used as a structural plastic and as a fiber. (McGuigan, 2011). PP are widely used in the production of composite because it's low density, high water and chemical resistance, good process ability and high cost performance ratio. (Zhang & Horrocks, 2003). Normally, PP fibers have been used in apparel, upholstery, floor coverings, hygiene medical, geotextiles, car industry, automotive textiles, and so on. (Gleixner, 2001).

2.4 COUPLING AGENT

In order to enhance the mechanical properties of the composite, especially to overcome the problem between the hydrophilic nature of the fibers and hydrophobic matrix, the suitable chemical modification is needed. Therefore, coupling agent are normally added into the composite production because to improve the dispersion, adhesion and compatibility between fiber and polymer (Saad). Generally, chemical coupling agents are molecules possessing two functions which are to react with hydroxyl groups of cellulose and to react with the functional group of the matrix (Li, Tabil & Panigrahi, 2007). The bonds formed covalent and hydrogen improves the interfacial adhesion.

2.4.1 Maleated polypropylene (MAPP)

Basically, Maleated polypropylene (MAPP) is derived from the PP. Kazayawoko et al. (1997) believe that MAPP has been well thought-out as a coupling agent because of its efficiency in improving the mechanical properties of wood fiber-polypropylene composite. Jani et al. (2006) indicates that the composite with MAPP treated filler had higher flexural strength than the untreated filler due to its anhydride groups in the MAPP which increase the covalent and hydrogen bonding the OH groups and the oxygen from the carboxylic groups. In most cases, the flexural toughness increased with the MAPP loading (from 1%, 3% and 5%) are due to the anhydride groups which caused more ester bonds to found between the OH groups of the EFB filler, and/or hydrogen bonding between the OH groups and oxygen and oxygen of the carboxylic groups.

According to Khalid, Ali, Abdullah, Ratnam, and Choong, (2006), “the best result for the biocomposites is observed by using 2 wt% of MAPP. It will increase the tensile strength of PP-EFB composite nearly 58% compared to control sample. Unfortunately, further increase in the concentration of MAPP it will reduce the tensile properties. It is because of the MAPP has a lower molecular weight compared to the matrix PP.”

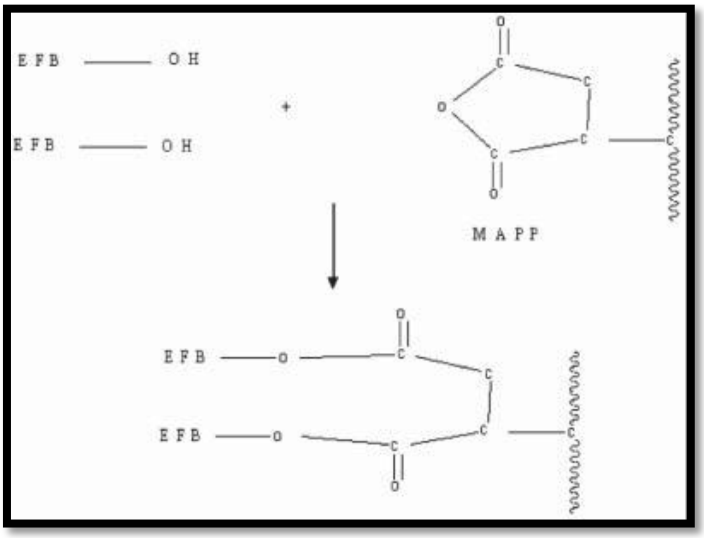


Figure 2.4: Reactions involved in producing the MAPP treated EFB-PP composite

Source: Jani et al. (2006)

2.5 ALKALINE TREATMENT

In point of fact, EFB fiber has a polar in nature while PP is characterized by non polar groups. This factor will tend to the poor adhesion between these two materials (Khalid et al., 2008). Therefore, alkali treatment is one of the methods to improve the adhesion between the fiber and polymer. This method is one of the most chemical treatments of the natural fibers when used to reinforce thermoplastics and thermosets. (Li, Tabil & Panigrahi, 2007).

$$\text{Fiber} - \text{OH} + \text{NaOH} \longrightarrow \text{Fiber} - \text{O} - \text{Na} + H_2O$$

Alkali treatment will increase the surface roughness to give a good mechanical interlocking and increase the amount of cellulose exposed on the surface of fiber, thus will increase the possible reactions site (Franco & Valadez- González, 2005; Li, Tabil & Panigrahi, 2007). Bachtiar et al. (2008) indicates that when the alkali concentration increase the tensile strength will be decrease for soaking in 1hour and when time and alkali concentration are increased, the strength also will be increased. Shinoj et al. (2010) agrees to this notion and adds that, after the alkali treatment have been done the density of composite is slightly increase as a result of low void content indicating better interfacial adhesion between polymer and fiber.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Summary of experiment flow process in producing insulator material:

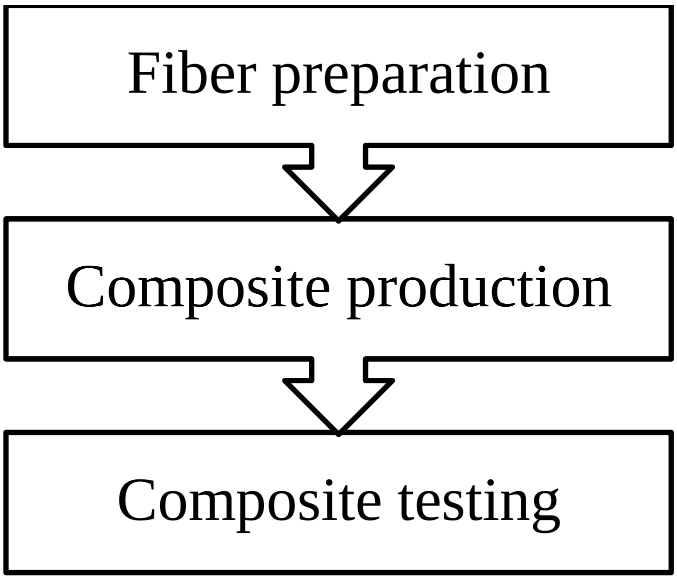


Figure 3.1: Overview of the process

3.2 MATERIAL

The polypropylene used was Propelinas 600G (homopolymer), purchased from Polypropylene (M) Sdn Bhd, Kuantan, Pahang with density and melt index specified as 0.9 g/cm^3 and 12g 10min^{-1}, respectively.

3.3 FIBER PREPARATION

EFB fiber was fully immersed in 5% NaOH solution for 1 hour. Then the fiber is rinsed with distilled water to remove the excess of NaOH until the rinse solution become colorless. Finally, fibers are dry under the sunlight for several days.

3.4 COMPOSITE PRODUCTION

Two steps procedures are needed in sequence to produce the insulator material from EFB fiber which is extrusion and hot press molding.

3.4.1 Extrusion

Compounding of the materials and filler was carried out by using the extrusion machine, Thermo Scientific Prism Eurolab 16 Model Twin Screw Extruder (figure 3.2). The screw speed was fixed at 85rpm, with temperature zones of 188°C (zone 1), 185°C (zone 2 until zone 4) and 184°C (zone 5). The compositions of composite are given in Table 3.1. The composite will be cooled at room temperature and cut into the pellets using a rotating cutter (Figure 3.3).

Figure 3.2: Twin screw extruder machine

Figure 3.3: Rotating cutter

Table 3.1: Composition of EFB fiber/PP/ and MAPP composite

EFB fiber (wt %)	PP (wt %)	MAPP (wt%)
10	90	-
20	80	-
30	70	-
10	85	5
20	75	5
30	65	5

3.4.2 Hot Molding Press

By using the Lotus Scientific LS-22025 Hot & Cold Molding Press, a mould with 5 cavities with dimensions 97mm (gauge length) × 15mm (width) × 3mm (thickness) was used to prepare the test specimens for tensile test. The temperature for compression molding was set at 190°C and the pressure applied was 16MPa, and followed by cooling for 10 minutes. All the specimens were than conditioned at room temperature before being tested.

Figure 3.4: Hot & Cold Molding Press

3.5 COMPOSITE TESTING

3.5.1 Tensile testing

Figure 3.5: Dumbbell shape specimen

Filler dispersion, degree filler adhesion and degree of degradation of polymer are the main factors which determine the tensile properties of composites during the processing period. All samples are mold into the dumbbell shape with the same length; width and thickness (Figure 3.5) were tested for their tensile strength according to ASTM D638 using a Shimadzu Universal Testing Machine at a crosshead speed of 5mm/min. Tensile toughness was computed from the area under the stress-strain curve. The tensile strength and tensile modulus were calculated by:

$$\text{Tensile strength} = \text{maximum stress}$$

$$\text{Tensile modulus} = \text{slope} = \frac{\Delta\sigma}{\Delta\epsilon} = \frac{\sigma_2 - \sigma_1}{\epsilon_2 - \epsilon_1}$$

3.5.2 Thermo Gravimetric Analysis (TGA)

TGA is one of the techniques that have been used to study the primary decomposition reaction involving solid and to study the thermal decomposition of polymer. TGA measurement is performing by using thermogravimetric analyzer (TA instrument, TGA Q500). Each specimen weighed about 10mg (±5mg) at scanning temperature range of 25°C to 700°C in nitrogen gas and heating rate of 20°C/min.

Figure 3.6: Thermo gravimetric analysis

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this chapter, mechanical and thermal properties of insulator material with and without MAPP with various wt% of EFB fiber were studied.

4.2 MECHANICAL PROPERTIES

4.2.1 Stress-Strain Behavior

Stress is a measure of an applied mechanical load or force while strain is represents the amount of deformation induced by a stress. In general, stress-strain behavior of polymer will fall within three general classifications which are brittle, plastic and highly plastic. (Callister & Rethiwisch, 2008, p.233). Appendix A shows the stress-strain behavior of the composite produced was initially elastic, followed by yielding and a region of deformation.

4.2.2 Tensile Properties

From the tensile test, there are three properties that can be observed which are Tensile Strength, Young's Modulus and Tensile Toughness. Table 4.1 shows the summary of tensile properties from the production of insulator material.

Table 4.1: Summary of tensile properties

Sample	Fiber content (wt %)	Tensile Strength (MPa)	Tensile Modulus (MPa)	Tensile Toughness (MPa)
without	10	3.65	218.48	2.50
	20	7.89	253.33	14.00
	30	3.48	173.33	4.00
with	10	3.99	250.00	3.50
	20	6.72	271.43	11.50
	30	3.70	175.00	4.25

The effects of 5% MAPP on the tensile strength of the composites are shown in Figure 4.1. The composite at 10 wt% and 30 wt% of fiber content had higher tensile strength than composite without the MAPP. This is due to the better compatibility between fiber and filler. In spite of this, at 20 wt% of EFB fiber the tensile strength without MAPP had the higher value (7.89MPa) compared to composite with MAPP (6.72MPa). Some error may be occurring during the hot press molding that can be effect the structure of composite.

From Figure 4.1, it can be seen that the strength is reduced since the amount of EFB fiber content are increased. This is might be due to the incompatibility of hydrophilic lignin in the EFB fiber with matrix. Generally, composites with higher fiber content has greater tendency for filler-to-filler interaction takes place, as a result more voids are formed, initiating the crack formation and propagation compared to low fiber loadings. (Siyamak et al, 2012)

According to Jani, Rozman , Ishak, Abusamah and Rahim (2007, p.340), a good filler matrix interaction can be derive from the formation of ester bonds between the anhydride groups of MAPP and the hydroxyl groups at the surface of the EFB filler. In other words, the more anhydride groups, the more of ester bonds are formed. As highlighted by several workers (Rozman et al., 2001, p. 1285 and Jani et al., 2007. p. 341), different fiber which have a uniform cross-section and relatively high aspect ratio (length to diameter ratio, l/d) the ability of irregularly-shaped filler such as EFB, to support stress transmitted from the thermoplastic matrix is rather poor.

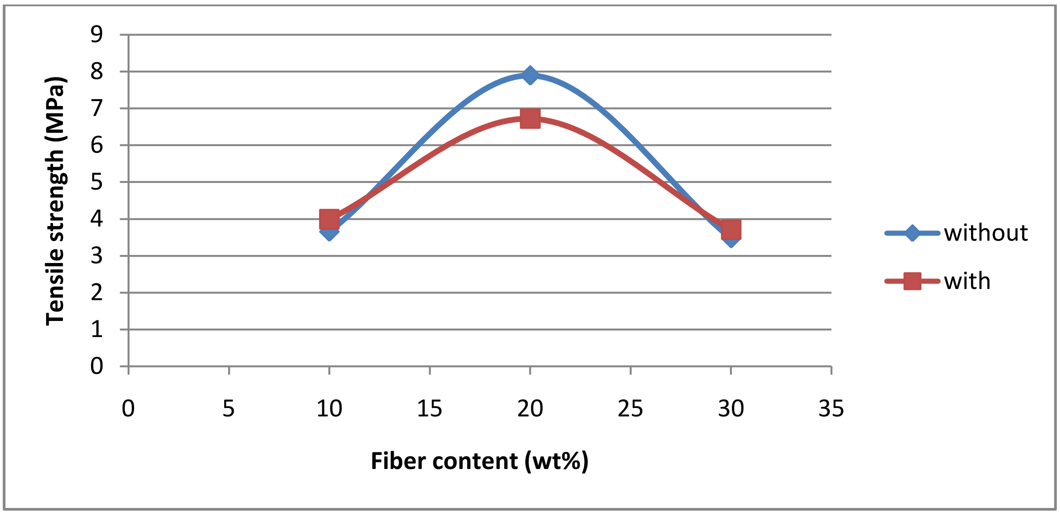


Figure 4.1: Effect of fiber content on the tensile strength

The tensile modulus with the MAPP was higher than the composite without the MAPP as shown in Figure 4.2. Tensile modulus is the ratio of stress to strain when the deformation is totally elastic and it is also a measure of a stiffness of a material. Therefore, the addition of MAPP were enhanced the stiffness of the composite. In most cases, major improvement in tensile modulus was observed with the MAPP as a coupling agent. Figure 4.2 show that an increasing the fiber content will increase the Young's modulus value. However, at 30 wt% of EFB fiber the tensile modulus was started to decreased because of the EFB fiber are incorporate in the composites. Composite with MAPP at 20 (wt%) of fiber content showed the highest tensile modulus of 271.43 MPa. There are many factors that affecting the modulus of composite such as filler content, modulus and aspect ratio (Khalid et al, 2008, p. 176).

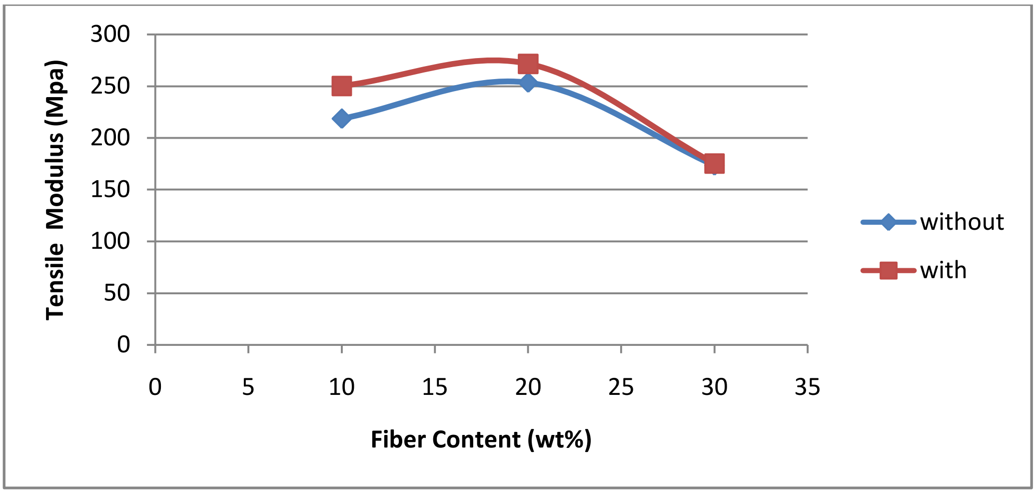


Figure 4.2: Effect of fiber content on tensile modulus

Basically, toughness is a measure of the amount of energy absorbed by a material as it fractures. From the tensile test, toughness are indicates by the total area under the stress-strain curve. Figure 4.3 shows that at 20 wt% of the fiber content without MAPP have higher tensile toughness of 14 MPa. As a result, more energy is needed to break the composite without MAPP. Usually, the tensile toughness decreased as the filler loading increased because of the lack of compatibility between the polar functional groups of EFB and the non-polar PP giving rise to weak interfacial regions. (Jani et al., 2007. p. 343).

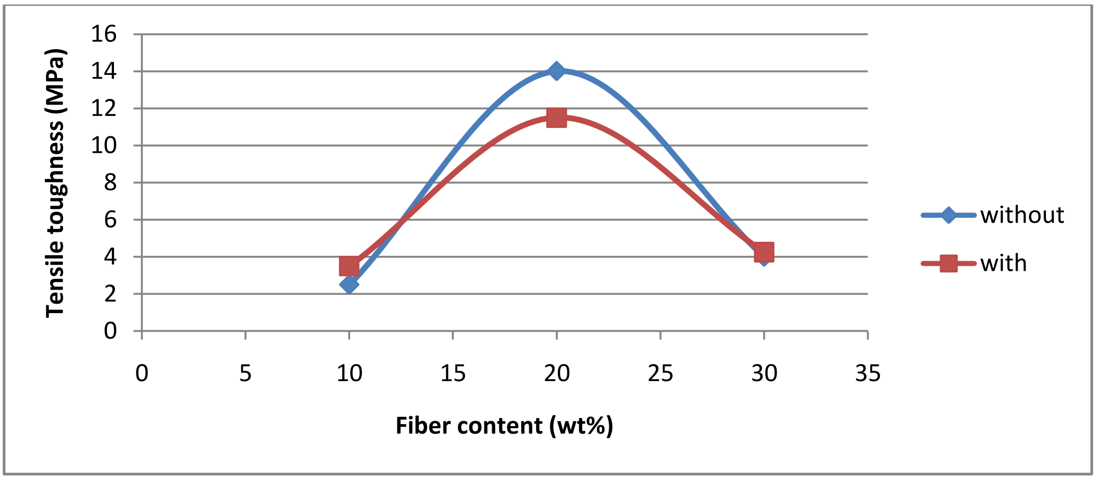


Figure 4.3: Effect of fiber content on tensile toughness.

4.3 THERMO GRAVIMETRIC ANALYSIS (TGA)

Thermo gravimetric analysis was held on PP/EFB fiber composite to investigate the thermal decomposition and weight loss between the composite at 10 and 30% of EFB fiber with and without MAPP. The thermo gravimetric analysis (TGA) and the differential thermal analysis (DTA) of PP/EFB fiber with and without MAPP are presented in Figure 4.4 and Figure 4.5 respectively with the TGA result demonstrated in Table 4.2.

Main factor which can affects the experimental results are furnace heating, composition of sample, amount of sample and the particle size. These four factors will effects on the decomposition temperature and the residue

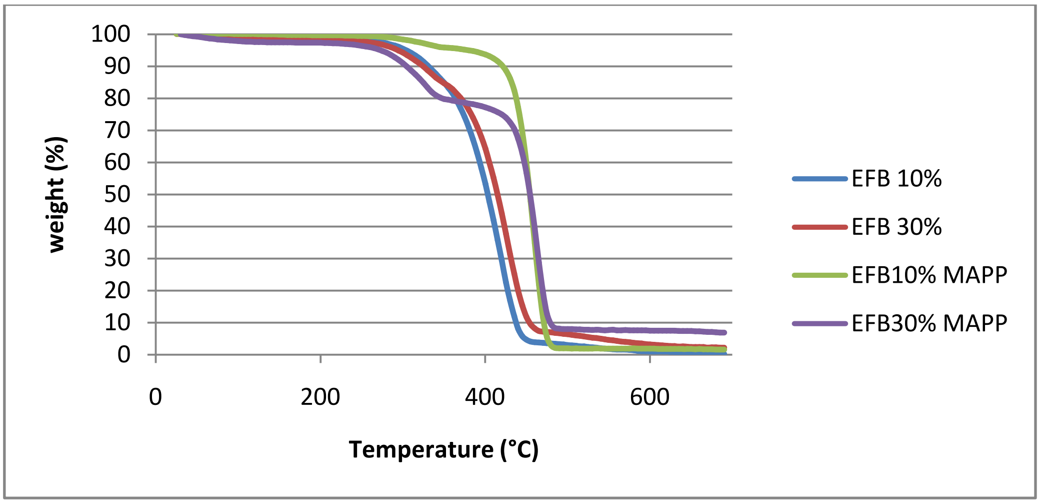


Figure 4.4: Effect of fiber content on thermal degradation of PP/EFB composites with and without MAPP (TG thermograms)

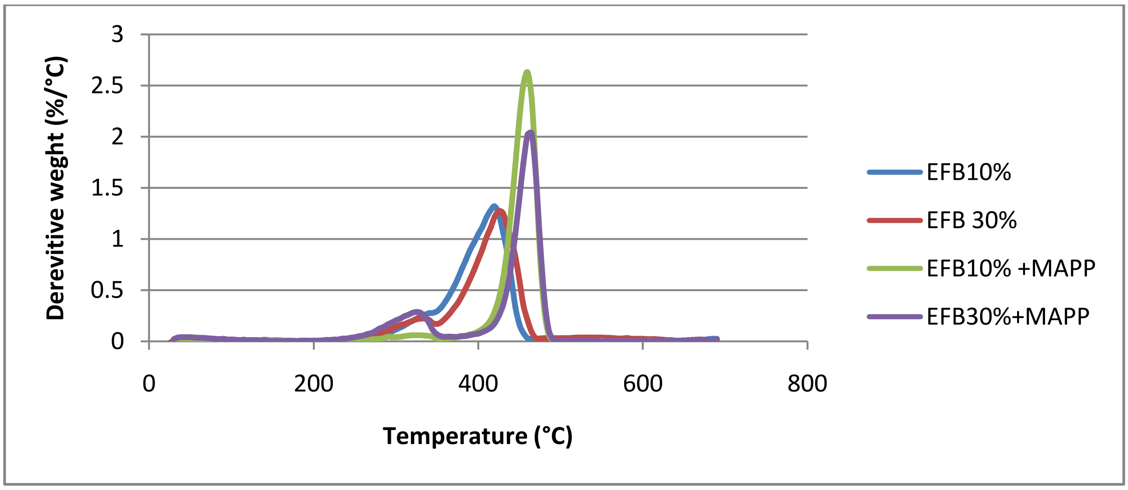


Figure 4.5: DTA thermograms of PP/EFB composites with and without MAPP

According to Siyamak et al. (2012), the thermal degradation of EFB fiber was due to decomposition of cellulose, lignin and hemicelluloses to give of volatiles. 10(wt %) with MAPP showed highest decomposition temperature, followed by 10(wt %) without MAPP, 30 (wt %) with MAPP and 30(wt %) without MAPP. Tan et al. (2011), indicates that the increasing of decomposition temperature of composite because of the interaction between fiber and matrix was increased because of EFB fiber had good compatibility with the matrix, created strong interface and made the composite harder to decompose. On top of that, the addition of coupling agent also will improved fiber/matrix adhesion of the formation of bonds existing between fiber and matrix.

Table 4.2: Weight loss percentage of PP/EFB fiber composite with and without MAPP

Sample	Fiber content (wt %)	Decomposition temperature (°C)	Percentage weight loss (%)	Residue (%)
Without	10	215	94.83	0.2987
	30	210	91.28	2.23
With	10	350	93.85	1.536
	30	200	88.77	6.892

TGA result also gave weight loss information for the PP/EFB composites with and without MAPP respectively as demonstrated in Table 4.2. The residue of the decomposition for the fiber composite with MAPP was much higher compared to the fiber composite without MAPP. This is may be due to the presence of more carbon in the fiber compared to the matrix (Tan et al., 2011).

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

As a conclusion, based on the objective for this study to optimized the bonding mechanism between oil palm empty fruit bunch (EFB) fiber with filler were observed from the tensile properties and to study the effect of fiber treated on the mechanical and thermal decomposition . Composite with the MAPP shows the improvement on the tensile strength, tensile modulus and tensile toughness. The highest tensile strength, tensile toughness, and tensile modulus were found to be increased at 20 (wt%) and starting to decreased at 30 (wt%). Composite with MAPP shows the improvement on mechanical properties but as fiber loading increase the mechanical properties will be decrease due to the inefficient stress transfer.

The thermo gravimetric analysis (TGA) characterization showed thermal stability for PP/EFB composite is higher with the presence of MAPP. The residues of the composite with MAPP were higher than the composite without the MAPP.

5.2 RECOMMENDATIONS

Some recommendations are made for enhanced the future study on the production of insulator material from EFB fiber. First of all, need to standardized length and the orientation of fiber because length and orientation of fiber are the factors that can be affect the performance of composite. Another recommendation is using the different concentration of NaOH and different percentage of MAPP or used the different type of coupling agent to get the optimized bonding mechanism. In addition, this study is also need to compare with the 100(wt %) of PP. In order to obtain the optimum mechanical properties and thermal stability performance, it is advisable to change the method of production from hot press molding to injection molding.

REFERENCESS

Bachtiar, D., Sapuan, S.M., & Hamdan, H.H. (2008). The effect of alkaline treatment on tensile properties of sugar palm fiber reinforce epoxy composite. *Materials and Design. 29,* 1285-1290

Bismark, A., Mishra, S., & Lampke, T. (2005). Plant fibers as reinforcement for green composites. In Mohanty A. K., Misra, M., & Drzal L. T. (Eds.), *Natural Fibers, Biopolymers and Biocomposites. (pp. 37-109). London: Taylor & Francis.*

Callister, W. D., & Rethiwish, D. G. (2008). *Fundamental of materials science and engineering: An integrated approach*. (3^{rd} ed.). Asia: John Willey & Sons.

Feng, L. Y., (2010). The biomaterial for green composite. *JEC CompositeMagazine. 55*, 29-30.

Franco, P. J.H., & Valadez-González, A. (2005) Fiber matrix adhesion in natural fiber composites. . In Mohanty A. K., Misra, M., & Drzal L. T. (Eds.), *Natural Fibers, Biopolymers and Biocomposites. (pp. 177-230). London: Taylor & Francis.*

Hoong, S. S. (2011). *Palm oil and related products: 1 of 12 National Key Economics Areas under Economic Transformation Programme.* 11-15.

Jani, M et al. (2006). Oil palm empty fruit bunch-polypropylene composites: the effect maleated polypropylene on the mechanical properties. *Journal of Oil Palm Research. 18,* 260-271.

Jani, M et al. (2007). The effect of PP/MAPP blends on EFB fibres for improving tensile and dimensional stability properties. *Journal of Oil Palm Research.* 17, 338-349

Kazayawoko, M., Baltinecz, J.J., Woodhams, R.T & Law, S., (1997). Effect of ester lingkages on the mechanical properties of wood fibres- PP composites. *Journal of Reinforced Plast and Comp. 16,* 1383-1406

Khalid, M., Ali, S. Abdullah, L. C., Ratnam, C. T. & Choong, S.Y. T. (2006). Effect of MAPP as coupling agent on the mechanical properties of palm fiber empty fruit bunch and cellulose polypropylene biocomposites. *Journal of Engineering and Technology. 3(1),* 78-84.

Khalid, M., Ratnam, C. T., Chuah, T.G., Ali, S., & Choong, T. S. Y. (2008). Comparative study of polypropylene composites reinforced with oil palm empty fruit bunch fiber and oil palm derived cellulose. Material *& Design, 29,* 173-178.

Li, X., Tabil, L. G. & Panigrahi, S. (2007). Chemical treatments of natural fiber for use in natural fiber-reinforced composites: A Review. *J Polym Environ. 15,* 25-33.

McGuigan, B. (2011). *What is Polypropylene?* Retrieved December 25, 2011, from http://www.wisegeek.com/what-is-polypropylene.htm.

Mohanty, A. K. et al. (2005). Natural fibers, biopolymers, and biocomposites: An introduction. In Mohanty A. K., Misra, M., & Drzal L. T. (Eds.), *Natural Fibers, Biopolymers and Biocomposites. (pp. 1-36). London: Taylor & Francis.*

Rozman , H. D., Tay, G. S., Kumar, R. N., Abusamah, A., Ismail, H., & Mohd. Ishak, Z. A. (2001a). Polypropylene-oil palm empty fruit bunch-glass fibre hybrid composites: a preliminary study on the flexural and tensile properties. *European Polymer Journal, 37,* 1283-1291.

Rozman , H. D., Tay, G. S., & Kumar, R. N. (2001b). Tensile properties of oil palm empty fruit bunch-polyurethane composites. *European Polymer Journal, 37*, 1759-1765.

Rowell, R. M. (2008) Natural fibers: types and properties. In K.L.Pickering (Eds.), *Properties and performance of natural-fibre composites (pp.3-64). Cambridge England: Woodhead Publishing Limited*

Särneroth, O.,(2001). Insulation material. Retrieved March 17, 2011, from *http://materias.fi.uba.ar/6209/download/insulate.pdf*

Siyamak, S., et al. (2012). Enhancement of mechanical and thermal properties of oil palm empty fruit bunch fiber Poly(butylene adipate-co-terepthalete) biocomposites by matrix esterification using succinic anhydride. *Molecules, 17*, 1969-1991

Tan, C., Ahmad, I., & Heng, M. (2011). Characterization of polyester composites from recycled polyethylene terephthalate reinforced with empty fruit bunch fibers. *Material and Design, 32*, 4493-4501

Zhang, S., & Horrocks, A. R. (2003). A review of flame retardant polypropylene fibers. *Progress in Polymer Science. 28,* 1517-1538.

APPENDIX A

STRESS AND STRAIN BEHAVIOR

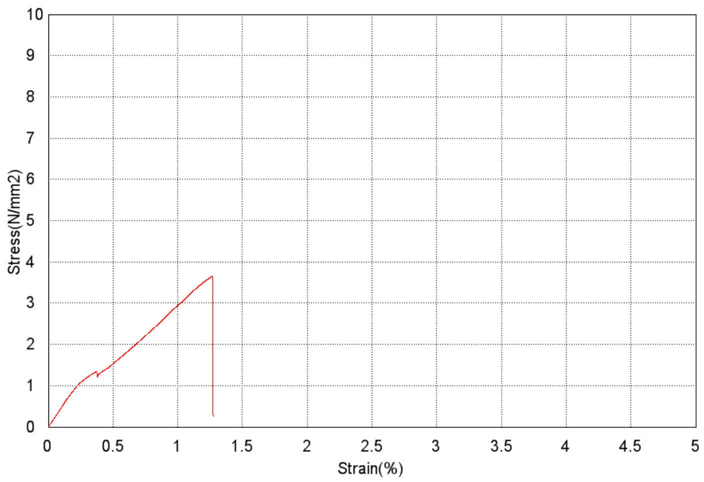
Title

Key Word		**Product Name**	
Test File Name	10%EFB+PP	**Method File Name**	Astm D638-03 NIZA.xm
Operator	NORHANIZA	**Report Date**	2012/01/12
Test Date	2012/01/12	**Test Mode**	Single
Test Type	Tensile	**Speed**	5mm/min
Shape	Plate	**No of Batches:**	1
Qty/Batch:	1		

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	164.246	3.64991	1.26957	13.7822
Average	164.246	3.64991	1.26957	13.7822
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	164.246	3.64991	1.26957	13.7822
Minimum	164.246	3.64991	1.26957	13.7822

Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	0.30627	1.23475	1.27294	1.23148
Average	0.30627	1.23475	1.27294	1.23148
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	0.30627	1.23475	1.27294	1.23148
Minimum	0.30627	1.23475	1.27294	1.23148

Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00555	473.830
Average	0.00555	473.830
Standard Deviation	-.-	-.-
Maximum	0.00555	473.830
Minimum	0.00555	473.830



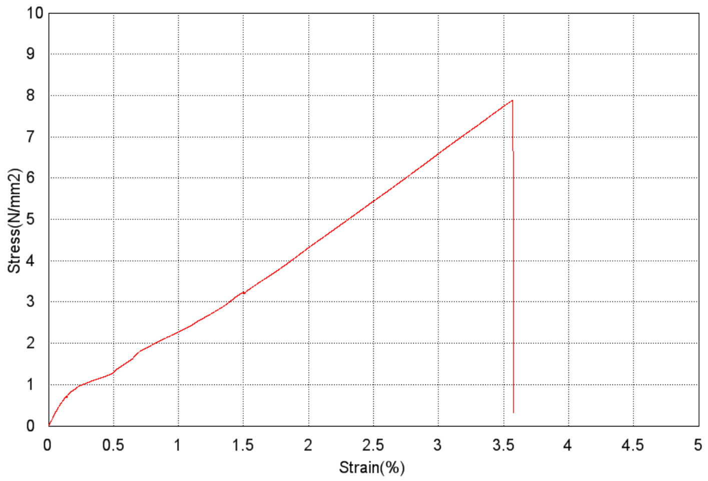
Title

Key Word **Product Name**
Test File Name 20%EFB+PP **Method File Name** Astm
D638-03-NIZA.xm
Operator NORHANIZA **Report Date**
2012/01/12
Test Date 2012/01/12 **Test Mode** Single
Test Type Tensile **Speed**
5mm/min
Shape Plate **No of Batches:** 1
Qty/Batch: 1

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	354.831	7.88514	3.57191	32.0276
Average	354.831	7.88514	3.57191	32.0276
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	354.831	7.88514	3.57191	32.0276
Minimum	354.831	7.88514	3.57191	32.0276

Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	0.71172	3.46731	3.57455	3.46475
Average	0.71172	3.46731	3.57455	3.46475
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	0.71172	3.46731	3.57455	3.46475
Minimum	0.71172	3.46731	3.57455	3.46475

Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00516	552.879
Average	0.00516	552.879
Standard Deviation	-.-	-.-
Maximum	0.00516	552.879
Minimum	0.00516	552.879



Title

Key Word		**Product Name**	
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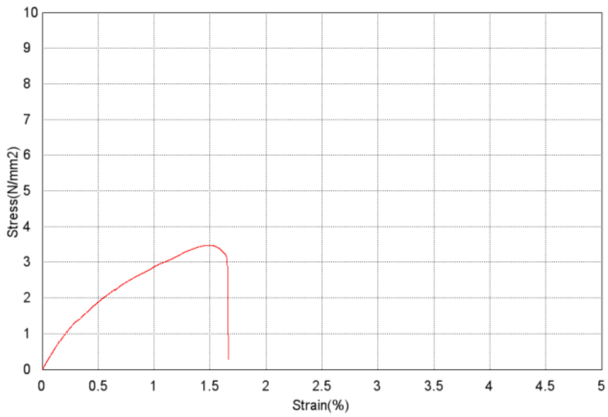
Operator	NORHANIZA	**Report Date**	2012/01/12
Test Date	2012/01/12	**Test Mode**	Single
Test Type	Tensile	**Speed**	5mm/min
Shape	Plate	**No of Batches:**	1
Qty/Batch:	1		

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	156.427	3.47616	1.48780	16.2896
Average	156.427	3.47616	1.48780	16.2896
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	156.427	3.47616	1.48780	16.2896
Minimum	156.427	3.47616	1.48780	16.2896

Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	0.36199	1.61231	1.66218	1.44317
Average	0.36199	1.61231	1.66218	1.44317
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	0.36199	1.61231	1.66218	1.44317
Minimum	0.36199	1.61231	1.66218	1.44317

Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00701	505.142
Average	0.00701	505.142
Standard Deviation	-.-	-.-
Maximum	0.00701	505.142
Minimum	0.00701	505.142



Title

Key Word		**Product Name**	
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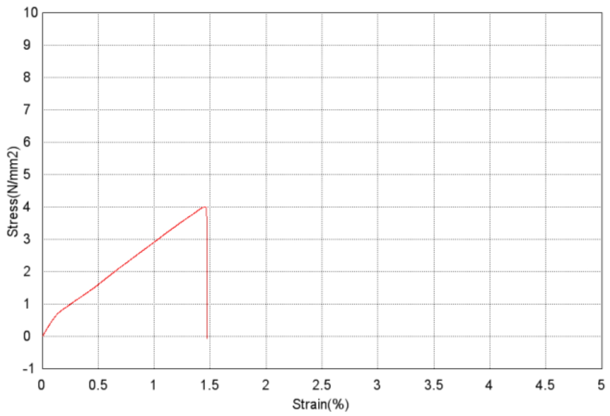
Operator	NORHANIZA	**Report Date**	2012/01/12
Test Date	2012/01/12	**Test Mode**	Single
Test Type	Tensile	**Speed**	5mm/min
Shape	Plate	**No of Batches:**	1
Qty/Batch:	1		

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	179.512	3.98915	1.45148	-0.3425
Average	179.512	3.98915	1.45148	-0.3425
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	179.512	3.98915	1.45148	-0.3425
Minimum	179.512	3.98915	1.45148	-0.3425

Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	-0.0076	1.42800	1.47217	1.40794
Average	-0.0076	1.42800	1.47217	1.40794
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	-0.0076	1.42800	1.47217	1.40794
Minimum	-0.0076	1.42800	1.47217	1.40794

Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00722	544.384
Average	0.00722	544.384
Standard Deviation	-.-	-.-
Maximum	0.00722	544.384
Minimum	0.00722	544.384



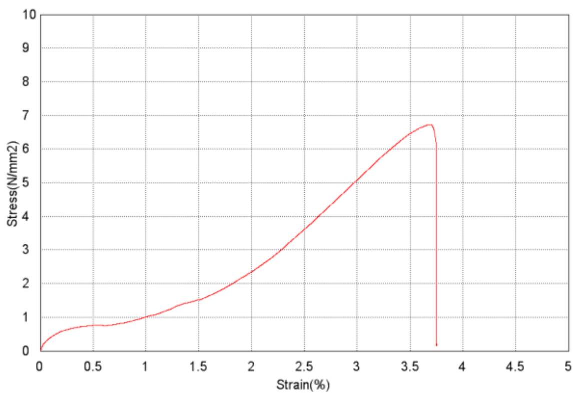
Title

Key Word **Product Name**
Test File Name 20%EFB+PP+MAPP **Method File Name** Astm
D638-03-NIZA.xm
Operator NORHANIZA **Report Date**
2012/01/12
Test Date 2012/01/12 **Test Mode** Single
Test Type Tensile **Speed**
5mm/min
Shape Plate **No of Batches:** 1
Qty/Batch: 1

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	302.594	6.72431	3.68531	6.59943
Average	302.594	6.72431	3.68531	6.59943
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	302.594	6.72431	3.68531	6.59943
Minimum	302.594	6.72431	3.68531	6.59943

Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	0.14665	3.63894	3.75148	3.57475
Average	0.14665	3.63894	3.75148	3.57475
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	0.14665	3.63894	3.75148	3.57475
Minimum	0.14665	3.63894	3.75148	3.57475

Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00535	256.788
Average	0.00535	256.788
Standard Deviation	-.-	-.-
Maximum	0.00535	256.788
Minimum	0.00535	256.788



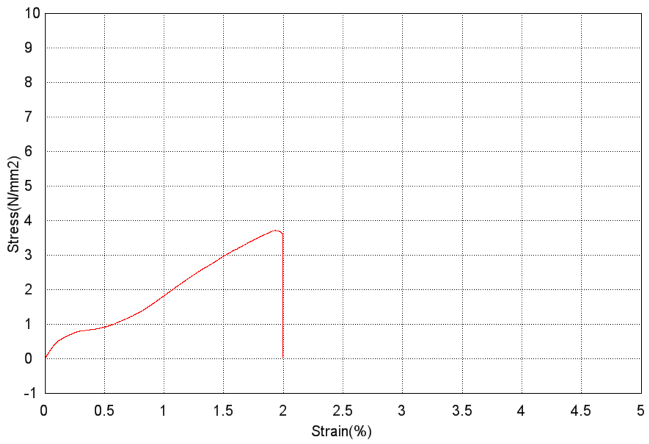
Title

Key Word | **Product Name**
Test File Name 30%EFB+PP+MAPP **Method File Name** Astm D638-03-NIZA.xm
Operator NORHANIZA **Report Date** 2012/01/12
Test Date 2012/01/12 **Test Mode** Single
Test Type Tensile **Speed** 5mm/min
Shape Plate **No of Batches:** 1
Qty/Batch: 1

Name	Max_Force	Max_Stress	Max_Strain	Break_Force
Parameters	Calc. at Entire Are	Calc. at Entire Are	Calc. at Entire Are	Level(%/Max) 15
Unit	N	N/mm2	%	N
PP	166.730	3.70511	1.93093	3.58741
Average	166.730	3.70511	1.93093	3.58741
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	166.730	3.70511	1.93093	3.58741
Minimum	166.730	3.70511	1.93093	3.58741

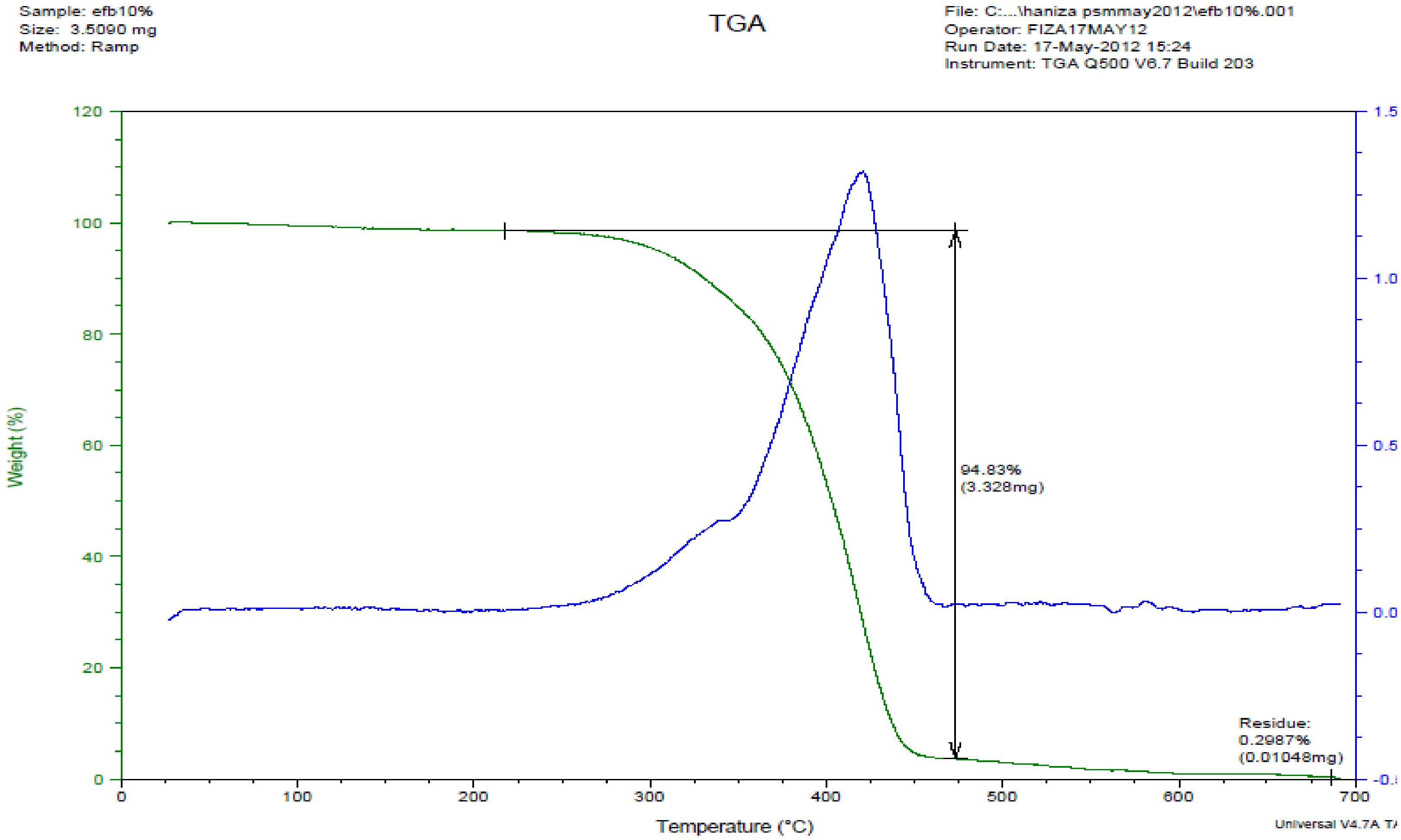
Name	Break_Stress	Break_Disp.	Break_Strain	Max_Disp.
Parameters	Level(%/Max) 15	Level(%/Max) 15	Level(%/Max) 15	Calc. at Entire Are
Unit	N/mm2	mm	%	mm
PP	0.07972	1.93723	1.99714	1.87300
Average	0.07972	1.93723	1.99714	1.87300
Standard Deviation	-.-	-.-	-.-	-.-
Maximum	0.07972	1.93723	1.99714	1.87300
Minimum	0.07972	1.93723	1.99714	1.87300

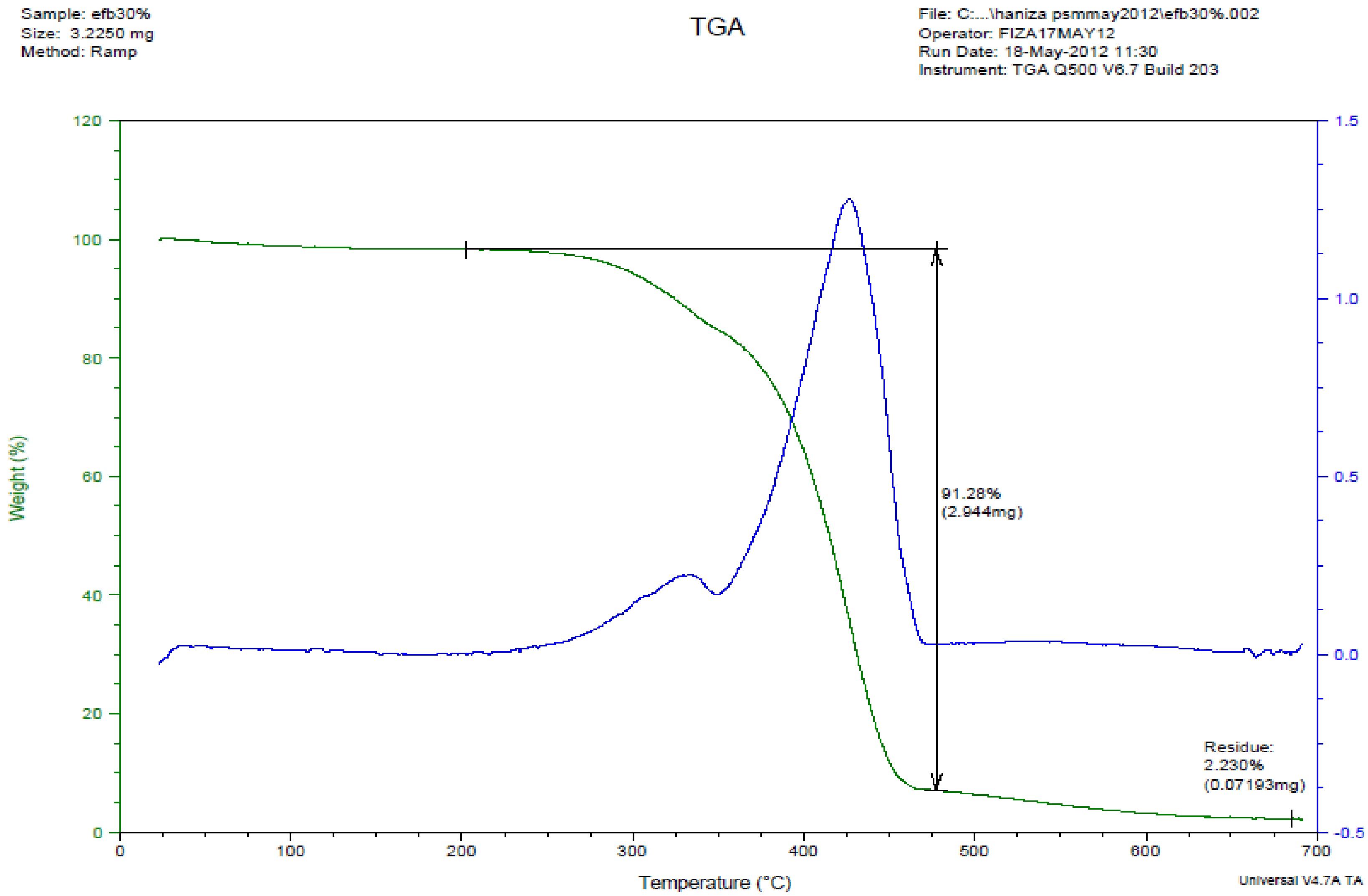
Name	EASL1_Stroke	Elastic
Parameters	Force 1 N	Force 10 - 20 N
Unit	mm	N/mm2
PP	0.00711	452.266
Average	0.00711	452.266
Standard Deviation	-.-	-.-
Maximum	0.00711	452.266
Minimum	0.00711	452.266

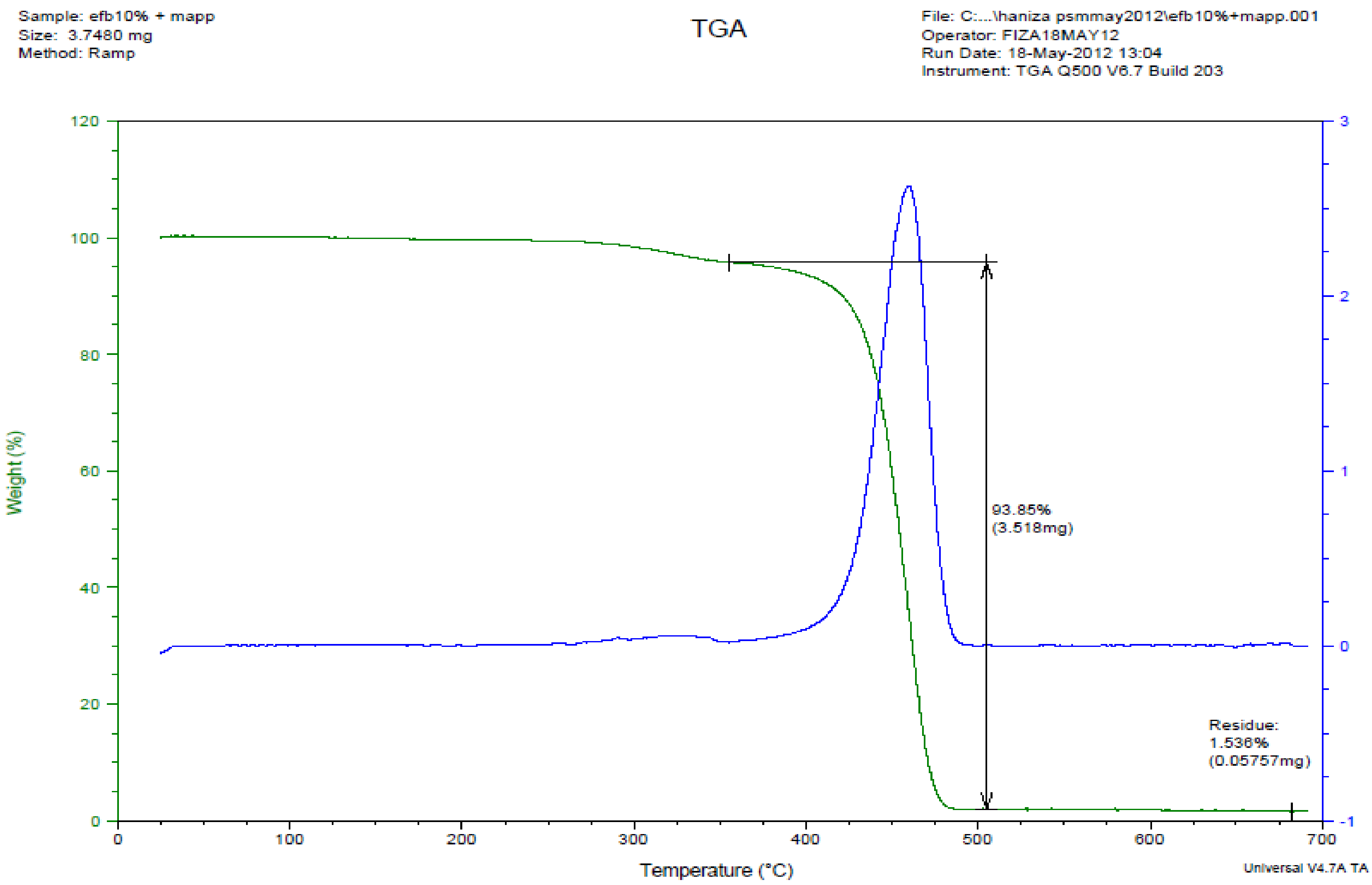


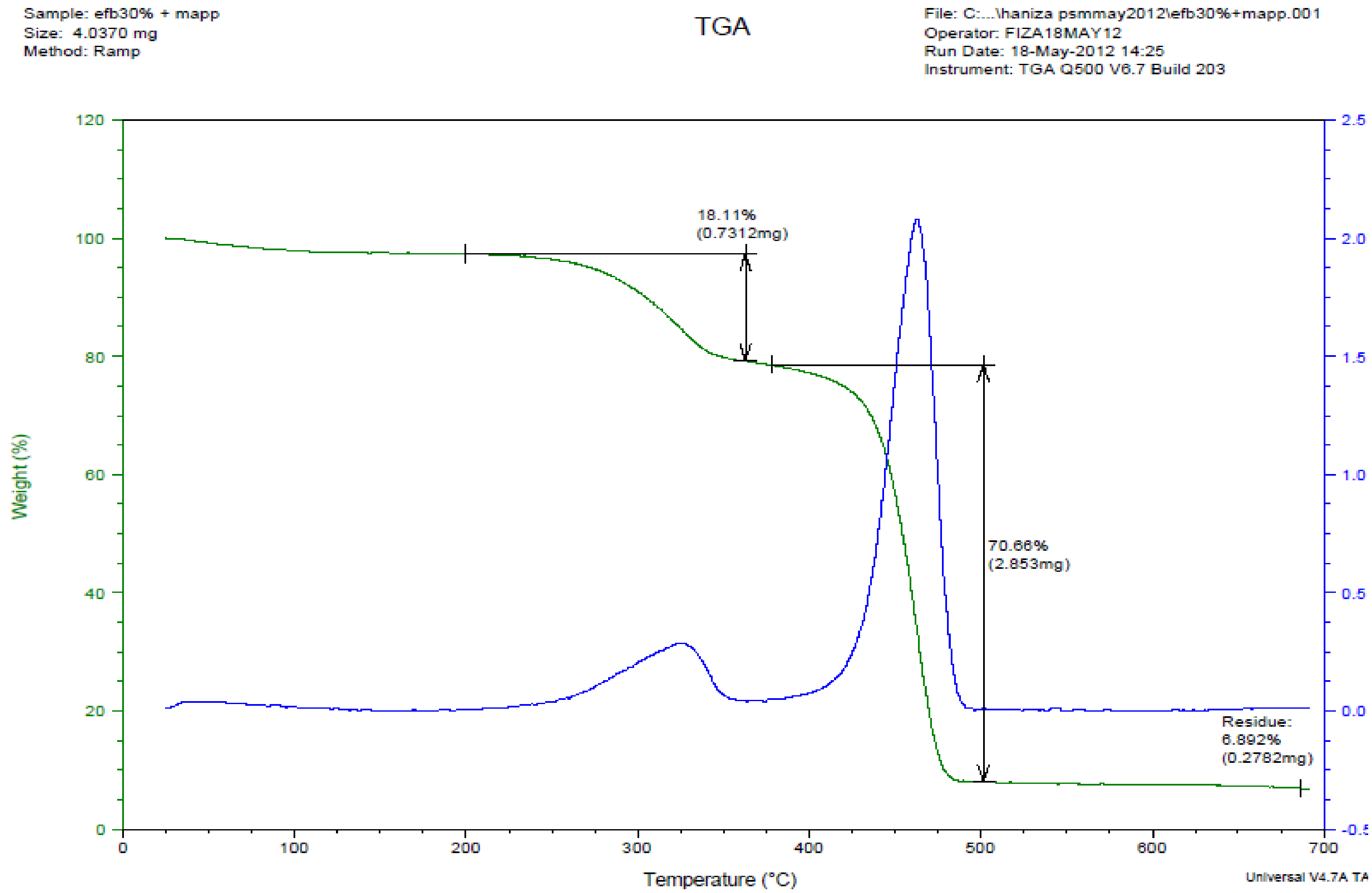
APPENDIX B

THERMO GRAVIMETRIC ANALYSIS (TGA


Sample: efb10%
Size: 3.5090 mg
Method: Ramp
TGA
File: C:...\haniza psmmay2012\efb10%.001
Operator: FIZA17MAY12
Run Date: 17-May-2012 15:24
Instrument: TGA Q500 V6.7 Build 203
Weight (%)
94.83%
(3.328mg)
Residue:
0.2987%
(0.01048mg)
Temperature (°C)
Universal V4.7A TA


Sample: efb30%
Size: 3.2250 mg
Method: Ramp
TGA
File: C:...\haniza psmmay2012\efb30%.002
Operator: FIZA17MAY12
Run Date: 18-May-2012 11:30
Instrument: TGA Q500 V6.7 Build 203
Weight (%)
91.28%
(2.944mg)
Residue:
2.230%
(0.07193mg)
Temperature (°C)
Universal V4.7A TA


Sample: efb10% + mapp
Size: 3.7480 mg
Method: Ramp
TGA
File: C:...\haniza psmmay2012\efb10%+mapp.001
Operator: FIZA18MAY12
Run Date: 18-May-2012 13:04
Instrument: TGA Q500 V6.7 Build 203
Weight (%)
120
100
80
60
40
20
0
3
2
1
0
-1
93.85%
(3.518mg)
Residue:
1.536%
(0.05757mg)
0
100
200
300
400
500
600
700
Temperature (°C)
Universal V4.7A TA


Sample: efb30% + mapp
Size: 4.0370 mg
Method: Ramp
TGA
File: C:...\haniza psmmay2012\efb30%+mapp.001
Operator: FIZA18MAY12
Run Date: 18-May-2012 14:25
Instrument: TGA Q500 V6.7 Build 203
18.11%
(0.7312mg)
70.66%
(2.853mg)
Residue:
6.892%
(0.2782mg)
Weight (%)
Temperature (°C)
Universal V4.7A TA