SUPERVISOR DECLARATION

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in term of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Structure & Material)."

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THE EFFECT OF COUPLING AGENT ON THE MECHANICAL PROPERTIES OF PLA-BASED POLYMER COMPOSITES

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This report is written as a partial fulfilment of terms in achieving the award for Bachelor of Mechanical Engineering (Structure & Material)(Hons.)

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JUNE 2015

DECLARATION

"I hereby declare that the work in this thesis is my own except for summaries quotation which have been duly acknowledged"

Signature :..

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Date :..

Thank you a lot to all of my family especially to my father and my mother for helping and support to finish this thesis.

Mahmood Bin Ibrahim

Laila Dahalan

ACKNOWLEDGEMENT

Praise to Allah the Almighty, with His will I had finally completed preparing for this FYP thesis. I would like to take this opportunities to thank to my supervisor Dr Siti Hajar Binti Sheikh Md Fadzullah for her never ending support, guidance, and advices during completion of this thesis.

My appreciation also goes to my parents for their support towards me to successfully done this project in order to graduate from UTeM. Last but not least, my appreciation goes to those who had involve directly or indirectly in helping me to complete this thesis.

ABTRACT

This research describes biodegradable polymers using composites PLA as a matrix and reinforced with pineapple leaf fibres (PALF) to produce environmentally friendly “green composites”. To-date, there has been numerous published papers, highlight the potential composite of such materials to replace the synthetic composites. However, these type of biocomposites is well-known to be brittle in nature as well as possess low tensile strength and impact properties in comparison to that of the synthetic polymer composites. Hence, this research aims to investigate the effect of coupling agent in promoting improved bond between the fibre reinforcement and the polymer matrix, which enhanced the mechanical properties of biocomposites. In this research, pineapple leaf are considered natural fibre reinforcement and polylactid acid (PLA) as a biodegradable polymer. Mechanical properties have been conducted and analysed by characterised under tensile, flexural and impact loading according to the American Society for Testing and Materials (ASTM). Findings show that PALF reinforced PLA composites possessed superior properties in comparison to that of the plain PLA. In addition, the effect of using alkaline pre treatment improved the bonding forms at the fibre/matrix interface.

ABSTRAK

Penyelidikan ini memfokuskan kepada bahan polimer terbiodegrasi menggunakan bahan PLA sebagai satu matrik dan diperkukuhkan dengan gentian daun nenas untuk menghasilkan bahan biokomposit yang bersifat mesra alam. Sehinnga kini, telah banyak kajian yang telah dijalankan yang menekankan bahawa komposit ini boleh menggantikan polimer sintetik. Walaubagaimanapun, biokomposit ini terkenal mempunyai sifat rapuh dan serta mempunyai tegangan yang rendah dan hentaman berbanding dengan sintetik polimer. Maka, penyelidikan ini bertujuan untuk menyiasat kesan agent pengupelan dalam mempromosikan ikatan yang lebih baik antara matrik polimer dan gentian nenas yang meningkatkan ciri-ciri mekanikal komposit. Dalam penyelidikan ini, PLA digunakan sebagai matrik dan daun nenas sebagai gentian untuk menghasilkan polimer terbiodegrasi. Sifat mekanik telah dijalankan dan dianalisa di bawah tegangan,, lenturan dan hentaman mengikut *American Society Testing Materials (ASTM).* Penemuan ini menunjukkan bahawa bahan komposit PLA diperkuat gentian nenas mempunyai ciri-ciri yang hebat berbanding dengan bahan polimer PLA yang tidak diperkuat pada antara muka di antara bahan matrik dan gentian nenas. Hal ini turut dipengaruhi oleh peningkatan yang ditingkatkan pada antara muka dia antara bahan matrik dan gentian dengan proses pra-rawatan alkali dengan menggunakan natrium hidroksida.

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CHAPTER I

INTRODUCTION

1.1 BACKGROUND

The growing environmental awareness, the concern for environmental sustainability and the growing wasted problem is increased year by year. The production of fuel-derived plastics is often harmful to the environment [1]. For example automotive applications based on natural fibres with polypropylene as matrix material are very common today [2]. Limited studies have been carried out on composites with matrices, which originate from renewable raw materials. There are many different polymers of renewable material. For example, polylactic acid, cellulose esters, poly hydroxyl butyrates, starch and lignin based plastics, are some of the renewable polymer materials or biopolymer [3].

The use of natural plant fibres as a reinforcement in fibre-reinforced plastics (FRP) to replace synthetic fibres such as glass is receiving attention, because of advantages such as low density, high specific strength and renewability. The development of biodegradable composite materials using natural fibres such as flax, bamboo, pineapple, jute, and kenaf as a reinforcement for biodegradable plastics have examined molding conditions, mechanical properties, and interfacial bonding.

However, the processes involved in using natural plant fibres as a reinforcement are different from those using industrial products such as glass and carbon fibres. The shape, size, and strength of the natural plant fibres may vary widely depending on cultivation environment, region of origin, and other characteristics. Besides, these features of the natural fibres are likely to influence the mechanical properties of the natural fibre-reinforced plastics [4].

Coupling agents are used to provide a stable bond between two otherwise non-bonding and incompatible surfaces. In reinforced and filled plastics, the improved bond between the fibrous or particulate inorganic component and the organic matrix polymer results in greater composite strength [5]. Coupling agent are commonly employed to treat fibre surfaces in order to improve interfacial adhesion within composites which can also in some cases improve their initial mechanical properties. Coupling agent investigated include, but are not limited to; conventional silanes, various phosphonic acids, poly-(HEMA), zirconate and titanate coupling agents [6].

1.2 OBJECTIVES

The objectives of this research are listed as below:

i. To develop PLA-based polymer composites using pineapple leaf fibre as reinforcement.
ii. To study the effect of using chemical coupling agent on the bonding mechanism present.
iii. To access the effect of using chemical coupling agent on the tensile and impact properties of the degradable polymer composites.

1.3 SCOPE OF RESEACRH

The scopes of this research are listed as below:

i. selection of materials and coupling agent for the composites.
ii. fabrication of biodegradable polymer composites test panels.
iii. mechanical testing.
iv. physical testing.
v. surface morphology.

1.4 PROBLEM STATEMENT

The developing environmental awareness and new rules and regulations are forcing the industries to seek more ecologically friendly materials for their products [3]. There are many different polymers are renewable materials for example polylactic acid, starch, cellulose esters and lignin based plastics. The problems with these polymers have been poor commercial availability, poor processability, low toughness, high price and low moisture stability.

Biodegradable polymers such as PLA, cellulose esters and starch can be reinforced with these bio-based fibres such as kenaf, flax, bamboo and sisal to produce environmentally friendly “green compo-sites” [7]. However, this type of biocomposites is well-known to be brittle in nature as well as possess low tensile strength and impact properties in comparison to that of the synthetic polymer composites [8]. Hence, this research aims to investigate the effect of coupling agent in promoting improved bond between the fibre reinforcement and the polymer matrix, which is expected to enhance the mechanical properties of biocomposites.

1.5 PLANNING AND EXECUTION

Table 1.1: Gantt chart PSM I

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of PSM title	■	■												
Literature Review		■	■	■	■	■	■	■	■	■	■	■	■	■
Design of Experiment				■	■	■								
Draft of PSM I Poster						■	■	■						
Submission of poster								■						
Characterisation of raw materials									■	■	■	■		
Preliminary data analysis											■	■		
PSM I report writing											■	■		
Submission of PSM I report												■		
PSM I seminar													■	■

The Gantt chart shows project the planning for Final Year Project (PSM I) which commences in September 2014. The research activities include selection of research title and approval by the respective lecturer, literature review that is continuous throughout the studies, design of experiment, as well as establishing the methodology. This is followed by poster preparation and submission. After that fabrication process. Once required results and analysis, report PSM I will be submitted and have PSM I seminar.

Table 1.2: Gantt chart PSM II

Week / **Task**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Material Review	■	■	■											
Design Test Model			■	■										
Experimental Work				■	■									
Fabrication					■	■	■	■						
Mechanical Test								■	■	■				
Analysis										■	■			
Result & Discussion											■	■	■	
Submission of PSM II report													■	
PSM II seminar														■

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION TO COMPOSITE MATERIAL

A composite material is made by combining two or more materials. The two materials work together to give the composite unique properties. However, within the composite it can easily tell the different materials apart as they do not dissolve or blend into each other [9]. Composites have become an integral part of our day-to-day life and can be discovered all over the place, for example rubber tire, spacecraft, asphalt, etc. Composites have been around for a long time with the classic example of bricks made from straw and mud. Another example is the Mongol bow which was constructed out of animal tendons, wood, and silk bonded together with an adhesive [10].

Nature also has its own composites in the form of wood, teeth, bones, muscle tissue, etc. In general the composite materials consist of a matrix reinforced with fibres. The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive [11].

High performance fibre reinforced composite materials are comprised of high strength and modulus fibres, embedded in, or bonded to, a matrix, with a distinct interface between them. In a composite, the fibre, as well as the matrix, retain their physical and chemical identities, but still provide a combination of properties that cannot be achieved with either of the constituents alone. In general the fibres play the role of load bearer. The matrix, while keeping the fibres in the desired location and orientation, act as a load transfer agent and protects the fibres from external conditions such as chemicals, heat and moisture [12].

Composites can be classified based on the type of fibres or matrix used. Based on the type of fibres, composites can be further classified as continuous fibre reinforced composite and short fibre reinforced composites. Based on the type of matrix, composites can be broadly classified into three categories, there are metal matrix composites, ceramic matrix composites and polymer matrix composites [11].

Table 2.1: Advantages and disadvantages of composites [11].

Advantages	Disadvantages
• Weight reduction	• Cost of raw materials and fabrication
• High strength or stiffness to weight ratio	• Transverse properties may be weak
• Tailorable properties: can tailor strength or stiffness to be in the load direction	• Matrix weakness, low toughness
• Redundant load paths (fibre to fibre)	• Matrix subject to environmental degradation
• Longer life (no corrosion), better fatigue life	• Difficult to attach
• Lower manufacturing costs	• Non-destructive testing tedious

2.2 POLYMER MATRIX COMPOSITES

Polymer matrix composites are widely used and sub-divided into two classes based on the type of matrix polymer are thermoplastic or thermoset. Thermoplastics consists of linear or branched chain molecules having strong intramolecular bonds but weak intermolecular bonds. They can be reshaped by application of heat and pressure and are either semicrystalline or amorphous in structure. Examples include polyethylene, polypropylene, polystyrene, nylons, polycarbonate, polyacetals, polyamide-imides, polyether ether ketone, polysulfone, polyphenylene sulfide, polyether imide, and so on. [8].

Thermoset have cross-linked or network structures with covalent bonds with all molecules. They do not soften but decompose on heating. Once solidified by cross-linking process they cannot be reshaped. Common examples are epoxies, polyesters, phenolics, ureas, melamine, silicone, and polyimides [14].

The difference between thermoplastics and thermosets plastics is that thermoplastics become soft, remoldable and weldable when heat is added. Thermoets plastics however cannot be welded or remolded when heated, simply burning instead. On the other hand, once a thermosets is cured it tends to be stronger than a thermoplastic [14].

Table 2.2: Advantages and disadvantage of thermosets and thermoplastics [14].

Property	Thermosets	Thermoplastics
Formulations	Complex	Simple
Melt viscosity	very low	High
Fiber Impregnation	Easy	Difficult
Prepeg tac	good	None
Prepag drape	good	none to fair
Prepag stability	good	Excellent
Processing cycle	Long	short to long
Processing temperature	low to moderate	High
Processing pressure	low to moderate	High
Fabrication cost	high	Low
Mechanical properties 54 to 93 °C.hot/wer	fair to good	fair to good
Environmental durability	good	Unknown
Solvent resistance	excellent	poor to good
Damage tolerance	poor to excellent	fair to good
Database	very large	Small