**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

# Study in the Effect of Compatibilizer on the Properties of Oil Palm Shell Powder Filled Polypropylene

Thesis submitted in accordance with the partial requirements of the Universiti Teknikal Malaysia Melaka for the Degree of Bachelor of Engineering (Honours) Manufacturing (Materials Engineering)

By

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**BORANG PENGESAHAN STATUS TESIS***

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# DECLARATION

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## DEDICATION

*“Thanks to my parent, my family, my friends and all people that involve in this study for their support and guidance”*

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# ABSTRACT

The main goal of this research is to fabricate a lightweight composite material using environmentally friendly natural particulate reinforcement, to characterize the mechanical properties of oil palm shell powder filled polypropylene and to investigate the effect of AMPS on its mechanical properties. This research is conducted to recycle oil palm shell; oil palm shell powder will be used as a reinforcement of oil palm shell powder/polypropylene composite. The mechanical properties of this composite will be determined and compared with same composite but with existence of Aminopropyltriethoxysilane (AMPS). Processing involve to produce this composite is crushing, mixing, and hot pressing. The purpose of doing process above is to make sure oil palm shell powder mix well and homogenously with polypropylene, this is because bonding between oil palm shell powder and polypropylene still can be improved to upgrade it properties. Mechanical properties that will be determined are a flexural strength, tensile strength and impact strength, while physical properties determined is water absorption test. All tests for this material is referred and followed under American Standard Materials Testing (ASTM) for composite material. As the results, all mechanical properties and physical properties of oil palm shell filled polypropylene with compatibilizer is better than oil palm shell powder filled polypropylene without compatibilizer, that mean compatibilizer can improve properties of this material.

# ABSTRAK

Tujuan utama kajian ini adalah untuk menghasilkan komposit dari bahan terpakai dan mesra alam sekitar, serta mengenal pasti sifat-sifat serta kesan AMPS terhadap komposit ini.Kajian ini dilakukan untuk mengitar semula tempurung kelapa sawit di mana tempurung ini dijadikan bahan penguat dan diproses bersama polypropylene untuk dijadikan komposit. Sifat-sifat mekanikal komposit ini akan dihitung dan dibuat perbandingan dengan komposit dari bahan yang sama tetapi diproses dengan menggunakan bahan campuran Aminopropyltriethoxysilane (AMPS). Proses terlibat dalam menghasilkan komposit ini termasuklah proses menghancurkan tempurung kelapa sawit (crushing), menyebatikan tempurung kelapa sawit hancur dengan polypropylene (mixing) dan membentuk kepingan komposit pada suhu dan tekanan tinggi (hot pressing). Tujuan kesemua proses tadi dibuat adalah untuk memastikan serbuk tempurung kelapa sawit ini dicampur dan diadun sebati dengan polypropylene, ini kerana ikatan antara serbu tempurung kelapa sawit dengan polypropylene dapat diperbaiki dan sifat-sifat fizikal dan mekanikalnya dapat ditingkatkan. Ujian kelenturan, ujian terikan, ujian impak and kadar serapan air akan dilakukan mengikut American Standard Materials Testing (ASTM) untuk bahan komposit. Dan keputusan ujian-ujian ini menunjukkan komposit serbuk kelapa sawit dan polypropylene yang dicampur AMPS mempunyai sifat-sifat fizikal dan mekanikal yang lebih baik berbanding komposit yang tidak dicampur AMPS. Ini menunjukkan bahan AMPS ini dapat memperbaiki sifat-sifat bahan ini.

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| | |
|---|---|
| $\sigma$ | Tensile strength |
| $\sigma_f$ | Stress in outer fibers at midpoint, [MPa] |
| $\varepsilon_f$ | Strain in the outer surface, [%] |
| $E_b$ | Modulus of elasticity in bending,[MPa] |
| AMPS | Aminopropyltriethoxysilane |
| ASTM | American standard testing material |
| $b$ | Width of test beam, [mm] |
| C | Carbon |
| CMC | Ceramic matrix composite |
| CPO | Crude palm oil |
| $d$ | Depth of tested beam, [mm] |
| $D$ | maximum deflection of the center of the beam, [mm] |
| E | Flexural Modulus PP Polypropylene |
| $L$ | Support span, [mm] |
| $m$ | Slope of the tangent to the initial straight-line portion of the load deflection curve, [N/mm] |
| MAPP | Maleic Anhydride Polypropylene |
| MMC | Metal matrix composite |
| $P$ | load at a given point on the load deflection curve, [N] |
| PE | Polyethylene |
| PMC | Polymer matrix composite |
| R&D | Reasearch and development |
| Rp | Radius the plastic zone |
| Si | Silicon |
| UTeM | Universiti Teknikal Malaysia Melaka |
| UTHM | Universiti Teknologi Tun Hussein Malaysia |
| UTM | Universal Testing Machine |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Natural fiber composites have attracted the attention of scientists and engineers due to their low cost, low density an environmentally harmless properties. Many attempts have been made to prepare and evaluate natural fiber composites for various applications.

Polypropylene (PP) and oil palm shell powder are used to produce polymer composite in this project. The processes involved in producing this composite are a crushing of oil palm shell, extrusion moulding process, hot pressing and some cutting process. The purpose of crushing is to produce particulate form of oil palm shell, while the using of extrusion moulding machine is to produce a compound of oil palm shell powder and PP with a good blend. The extruded oil palm shell powder/PP composite will then crushed into crusher into small granules.

After the panel of oil palm shell/PP composite is prepared, it will be cut into specific dimension that required by its testing, in this research, 4 type of testing i.e. flexural strength, tensile strength, impact strength and water absorption will be conducted. All testings follow the American Standard Testing Material (ASTM) and the details about these testing will be elaborated in Chapter 2.

As a method to improve the compatibility between particulate reinforcement and the matrix, compatibilizer will be used in this project. By improving the compatibility between oil palm shell and PP, the mechanical properties also will be improved. The mechanical properties of the composite will be characterized by studying the flexural strength, impact strength, Young modulus, water absorption and effect of the compatibilizer on the properties of the composites itself.

## 1.2 Problem statement

The main bottlenecks in the broad use of natural particulate reinforcement in various polymer matrixes are poor compatibility between the particulate and the matrix, and the inherent high moisture absorption, which brings in involvement of compatibilizer in the composite. The efficiency of a particulate reinforce composite depends on the reinforcement/matrix interface and the ability to transfer stress from the matrix to reinforcement. In this project, in order to improve the compatibility between oil palm shell powder and PP granule, Aminopropyltriethoxysilane compatibilizer is used. Effect of compatibilizer on the properties of oil palm shell powder filled polypropylene will be studied (Callister Jr., 2003).

## 1.3 Objective of the project

- To fabricate a lightweight composite material using environmentally friendly natural particulate reinforcement
- To characterize the mechanical properties of oil palm shell powder filled polypropylene
- To investigate the effect of Aminopropyltriethoxysilane compatibilizer on the bonding properties between oil palm shell powder filled polypropylene

## 1.4 Scope of the project

In this project, the effect of Aminopropyltriethoxysilane compatibilizer on the mechanical properties of oil palm shell powder/ polypropylene composite will be discussed. The mechanical properties studied in this project are flexural strength, impact strength, tensile strength and water absorption. However this report will not cover on effect of other compatibilizer on this composite.

## 1.5 Hypothesis

In this research, it is expected that the use of the compatibilizer will improve the mechanical properties of oil palm shell powder/PP composites such as its tensile strength, flexural strength, impact strength, and water absorption.

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Composite

Composite is a multiphase material and the constituent phase must be chemically dissimilar and separate by a distinct interface. It can be divided into 3 groups that is Fiber reinforced composite, particulate reinforce composite and structural composite.

#### 2.1.1 Matrix

The phase in composite that continuous and surround the other phases that is reinforcement. Matrix is being melted and that mean some of their properties are changed. The problem of brittleness in reinforcement can be solved by using matrix. The reinforcement is bonded to matrix means any loads applied to a composite are carried by both constituents. Usually the reinforcement is the stiffer and stronger constituent while the matrix is supposed to transfer the load to the reinforcement.

### 2.1.2 Reinforcement

Reinforcement is discontinuous phase that surrounded by matrix phase. It is often a strong, stiff material the problem of this material is brittleness; although able to sustain a high stress. It's not melted and in solid and monolithic form, mechanical properties and chemical properties not change.

Many composites used today are applied especially in aircraft and spacecraft, with very good performance appropriate costs. But the idea of using composite to produce better properties actually has been used by nature for millions of years. Ancient society, imitating nature, used this approach as well, for example using straw to reinforce mud in brick making, without which the bricks would have almost no strength. Fibers used in modern composites have strengths and stiffnesses far above those of traditional bulk materials. The high strengths of the glass fibers are due to dispensation that circumvents the internal or surface flaws which normally weaken glass and the strength and stiffness of the polymeric aramid fiber is a significance of the nearly perfect alignment of the molecular chains with the fiber axis.

These materials are not generally functional as fibers alone, and naturally they are infusing by a matrix material that acts to transfer loads to the fibers, and also to defend the fibers from abrasion and environmental attack. The matrix dilutes the properties to some degree, but even so very high specific (weight-adjusted) properties are available from these materials. Metal and glass are offered as matrix materials, but these are now very expensive and largely limited to R&D laboratories. Polymers are much more commonly used, with unsaturated styrene-hardened polyesters having the majority of low-to-medium performance applications and epoxy or more sophisticated thermosets having the higher end of the market. Thermoplastic matrix composites are increasingly eye-catching materials, with processing difficulties being perhaps their principal drawback (Matthews and Rawlings, 1999).

## 2.2 Particulate reinforced composite

To produce particulate reinforcement is much simpler an easier than fiber and because of that, many material can be produce into particulate form. Roughly all material can be produced into powder, there have many method can be used to produce this powder for example bulk processing, precipitation from solution, gas atomization and sol-gel processing. Particulate reinforcements have dimensions that are approximately equal in all directions. The shape of the reinforcing particles may be spherical cubic, platelet or any irregular shape. The arrangement of particulate reinforcement may be random or with a preferable orientation, however for practical purpose it is made in random orientation.

## 2.3 Polymer matrix composite

Polymeric material is the most common composite material; firstly it is because the strength and stiffness are low compared to metals and ceramics. So, its mechanical properties are not adequate for many purpose of application, and this can be compensated by the use of reinforcement. Secondly the processing of PMC (polymer matrix composite) is easier than CMC (ceramic matrix composite) or MMC (metal matrix composite) because high temperature and pressure are not required. Equipment for this processing also simpler and less cost. For this reason, PMC is being used widely in structural application. PMC can be classified into three categories that are thermosetting, thermoplastics and rubber.

Over three quarters of all matrices of PMC's are thermosetting polymers, thermosets have cross-linking bonding that stronger than bonding in thermoplastic, but the limitation of cross-linking bonding is it cannot be melted because it can cause it lost it properties; compare than thermoplastic, it can be melted and after solidification it gain it properties. That why thermosetting process not applied high temperature (not reach melting point) and pressure. On the other hand, thermosets have their own advantages; it can be used at high temperatures and better creep properties than thermoplastics. They are also more resistance to chemical attack than most thermoplastics.

While thermoplastic should be melted during processing to allow them to fabricate into required shape after it solidified. This type of polymer can be melted repeatedly after fabricated and solidified; however it may degrade if it was melted too many times or heated too much temperature above melting point. As mentioned before, thermosets is a cross linking polymer and regain its properties through that type of bonding, while thermoplastic has linear or branches structure because they not cross linking to network. Even though it can be branches, it is still different with network in thermosets. The bonding between chains in thermoplastic is weak van der Waals forces that not strong against combined action of thermal activation and applied stress. This is why the thermoplastic flow at elevated temperatures.

Rubbers composite include in group of PMC, natural rubber is latex from Havea Brasiliensis and contain more than 98% polyisoprene. Polyisoprene can be cis and trans but the cis form is the main constituent of natural rubber. To gain suitable properties of rubber for structural purpose, it has to be vulcanized or in the more clear word it is a process to make the long molecule of rubber to become cross linking. The agent in vulcanized is usually sulphur and the stiffness and the strength increase is depending on the amount of cross linking.

There are many type of PMC processing such as hand lay-up, spray up (almost same with hand lay-up but use spray method), Match die moulding, forming methods employing gas pressure, Low pressure closed mould system, Pultrusion, Filament winding and many more. We use hands method in this experiment because it is easier, low cost and knowingly as effective method to introduce students in producing PMC.