



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**The Mechanical Properties and Morphology Study of the Silica-PE
Composite Using Modified Silica**

This submitted in accordance with requirements of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Engineering Material) with Honours.

By:

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Using Modified Silica**

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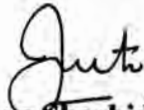
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I hereby declare that this report entitled **“THE MECHANICAL PROPERTIES AND MORPHOLOGY STUDY OF THE SILICA-PE COMPOSITE USING MODIFIED SILICA”** is the result of my own research except as cited in the references.

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (*Material Engineering*). The members of the supervisory committee are as follow:



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ABSTRACT

The purpose of this project is to study the mechanical properties and morphology study of polyethylene (PE) composite reinforced with modified silica. Modification of silica is obtained by the stirring and ball milling process which is performed using stirrer and ball milling machine. PE is mixed with the modification of silica using extrusion machine and hot pressing machine to fabricate the mixture into composite with 25 wt%, 32.5 wt%, 50 wt% and 75 wt% of modified silica. Plates thickness and width of 3mm and 2mm respectively were prepared for mechanical testing samples. Silica is fabricated with PE in purpose of comparing the mechanical properties between several types of silica size. In terms of tensile properties, Young's modulus shows an increase at modification of silica, whereas tensile strength decreased with the increase in modified silica weight fraction. Flexural strength and flexural modulus increase with the increasing in modified silica weight fraction. Impact strength of composite with modification of silica exhibits higher value compared to the other weight fraction. Furthermore, increasing of modified silica percentage results in increase of water absorption. Scanning electron microscopy (SEM)

ABSTRAK

Tujuan utama melakukan projek ini adalah untuk mengkaji ciri-ciri mekanikal dan kajian morfologi silika polietilena (PE) komposit menggunakan silika yang telah diubahsuai. Pengubahsuaian silika adalah dilakukan dengan cara proses pengacauan dan bebola mengilang. PE telah dicampur dan digaul dengan silika yang telah diubahsuai dengan menggunakan mesin extrusion dan menggunakan mesin hot press untuk menyatukan campuran tersebut menjadi komposit dengan 25 wt%, 32.5 wt%, 50 wt% and 75 wt% silika yang telah diubahsuai. Plat dengan ketebalan dan lebar 3mm dan 2mm masing-masing telah disediakan sebagai contoh ujian. Pembentukan PE yang tulen adalah bertujuan untuk membandingkan ciri-ciri mekanikal antara polimer yang tulen dan polimer yang berisi. Dalam ciri-ciri ketegangan, modulus Young menunjukkan satu penambahan pada pengubahsuaian silika, manakala kekuatan tegangan berkurangan dengan peningkatan pada pemberat geseran silika yang telah diubahsuai. Lenturan kekuatan dan lenturan modulus meningkat dengan peningkatan dalam pecahan berat silika yang telah diubahsuai. Kekuatan hentaman rencam meningkat dengan penambahan silika yang telah diubahsuai pada komposit berbanding dengan pecahan berat lain. Sebagai tambahan, bertambahnya peratusan silika yang telah diubahsuai mengakibatkan meningkatnya penyerapan air. Mikroskop pengimbasan elektron (SEM) adalah digunakan bagi mengkaji ketegangan mikrostruktur yang retak.

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LIST OF ABBREVIATIONS, SYMBOLS, NOMENCLATURES

ABS	-	Acrylonitrile Butadiene Styrene
ASTM	-	American Society for Testing and Material
ASW	-	Anti-submarine Warfare
CMC		Ceramic Matrix Composite
FVF		Fiber Volume Fraction
GPa		Giga Pascal
HDT		Heat Deflection Temperature
MMC		Metal Matrix Composite
MPa		Mega Pascal
MPOB		Malaysia Palm Oil Board
OER		Oil Extraction Rate
OPS		Oil Palm Shell
OPSP		Oil Palm Shell Powder
PE		Polyethylene
PMC		Polymer Matrix Composite
PORIM		Palm Oil Research Institute Malaysia
PP		Polypropylene
PVC		Polyvinylchloride
R&D		Research and Development
SEM		Scanning Electron Microscopy
UTeM		Universiti Teknikal Malaysia Melaka
UTHM		Universiti Tun Hussein Onn Malaysia
UTM		Universal Testing Machine
°C		Degree Celcius
°F		Degree Fahreheit
Tg		Glass Transition Temperature
Wt %		Percent Weight of Fraction

CHAPTER 1

INTRODUCTION

1.1 Project Background

Silica is used as filler in polymer. Silica is a polar while polyolefin are non polar. Therefore, coupling agents which are expensive should be used to improve the interaction between the two. If the particle size of silica can be significantly reduced, interaction between two could also be improved without using the coupling agents. From this study, the particle size of silica is reduced by using ball milling process and can improve the mechanical properties. This study also focuses on the polymer matrix composite. The some of the application of polymer matrix composite is in automotive industry. Due to their strength, weight, quality and cost advantages. Many automotive components are already produced in natural composites, mainly based on polyester or polypropylene or polyethylene and fibers like flax, hemp or sisal. The adoption of combination silica with polyethylene and become composites in this industry is lead by motives of price, weight reduction and marketing processing renewable resources rather than technical demands. In other hands, another application of this polymer matrix composite is in medical (M.W. Lee, 2003).

1.2 Problem Statement

This project is about combination of silica and polyethylene to be a composite by using modified silica which it prove that reduce the particle size of silica can improve the mechanical properties of the composite. This research is important to make a new implementation by using the modified silica. Nowadays, the silica is widely used. Silica is often a principle component of concrete. This is because the properties of silica is hard and strength. In the other hands, this project is to identify the mechanical properties and morphology study of silica. This project also must be understand about polymer matrix composite (PMC), composite fabrication process, mechanical testing and, morphology study.

1.3 Hypothesis

The hypothesis of this project is successfully reducing the size of silica by 7 and 14 hours by using ball milling process. Then, the size of modification of silica will be compare to the size of silica before the milling process is carried out. Make the composite using polyethylene and modified silica is stronger and high melting point when compare with another composite that used another reinforcement like plastic.

1.4 Objectives

The purposes of this study are:

- i. To study on the size modification of silica using ball milling process.
- ii. To study the effect of various sizes of modified silica particles on the mechanical properties of polyethylene composite
- iii. To investigate the effect of reinforce to the mechanical properties of polyethylene composite
- iv. To study the morphology of modified silica particles reinforced polyethylene composite at different filler loading

1.5 Scope Of The Project

The scope of this project is to modify the size of silica. This modification is by ball milling process. So, the best method process is by using ball milling. The ball is made from alumina. This process takes time in seven and fourteen hours. Next, is to find the optimum filler loading. The amount of filler loading is used in this project are 25%, 37.5%, 50%, and 75% of silica. Then, to study the mechanical and morphological studies of silica-PE composite.

CHAPTER 2

LITERATURE REVIEW

2.1 Composite

2.1.1 Introduction

A composite material is a macroscopic combination of two or more distinct materials, having a recognizable interface between them. Composites are used not only for their structural properties, but also for electrical, thermal, tribological, and environmental applications. Modern composite materials are usually optimized to achieve a particular balance of properties for a given range of applications. Given the vast range of materials that may be considered as composites and the broad range of uses for which composite materials may be designed, it is difficult to agree upon a single, simple, and useful definition. However, as a common practical definition, composite materials may be restricted to emphasize those materials that contain a continuous matrix constituent that binds together and provides form to an array of a stronger, stiffer reinforcement constituent.

The resulting composite material has a balance of structural properties that is superior to either constituent material alone. The improved structural properties generally result from a load-sharing mechanism. Although composites optimized for other functional properties (besides high structural efficiency) could be produced from completely different constituent combinations than fit this structural definition, it has been found that composites developed for structural applications also provide attractive performance

in these other functional areas as well. As a result, this simple definition for structural composites provides a useful definition for most current functional composites. Thus, composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase. Many types of reinforcements also often have good thermal and electrical conductivity, a coefficient of thermal expansion (CTE) that is less than the matrix, and good wear resistance. There are, however, exceptions that may still be considered composites, such as rubber-modified polymers, where the discontinuous phase is more compliant and more ductile than the polymer, resulting in improved toughness. Similarly, steel wires have been used to reinforce gray cast iron in truck and trailer brake drums.

Composites are commonly classified at two distinct levels. The first level of classification is usually made with respect to the matrix constituent. The major composite classes include organic-matrix composites (OMCs), metal-matrix composites (MMCs), and ceramic-matrix composites (CMCs). The term “organic-matrix composite” is generally assumed to include two classes of composites: polymer-matrix composites (PMCs) and carbon-matrix composites (commonly referred to as carbon-carbon composites). Carbon-matrix composites are typically formed from PMCs by including the extra steps of carbonizing and densifying the original polymer matrix.

In the research and development community, intermetallic-matrix composites (IMCs) are sometimes listed as a classification that is distinct from MMCs. However, significant commercial applications of IMCs do not yet exist, and in a practical sense these materials do not provide a radically different set of properties relative to MMCs. In each of these systems, the matrix is typically a continuous phase throughout the component. The second level of classification refers to the reinforcement form—particulate reinforcements, whisker reinforcements, continuous fiber laminated composites, and woven composites braided and knitted fiber architectures are included in this category. In order to provide a useful increase in properties, there generally must be a substantial volume fraction (10% or more) of the reinforcement. Reinforcement is considered to be a “particle” if all of its dimensions are roughly equal. Thus, particulate-reinforced composites include those reinforced by spheres, rods, flakes, and many other shapes of

roughly equal axes. Whisker reinforcements, with an aspect ratio typically between approximately 20 to 100, are often considered together with particulates in PMCs. Together, these are classified as “discontinuous” reinforcements, because the reinforcing phase is discontinuous for the lower volume fractions typically used in PMCs. There are also materials, usually polymers, which contain particles that extend rather than reinforce the material (Aso, O. 2007).

These are generally referred to as filled systems. Because filler particles are included for the purpose of cost reduction rather than reinforcement, these composites are not generally considered to be particulate composites. Nonetheless, in some cases the filler will also reinforce the matrix material. The same may be true for particles added for nonstructural purposes, such as fire resistance, control of shrinkage, and increased thermal or electrical conductivity.

Continuous fiber-reinforced composites contain reinforcements having lengths much greater than their cross-sectional dimensions. Such a composite is considered to be a discontinuous fiber or short fiber composite if its properties vary with fiber length. On the other hand, when the length of the fiber is such that any further increase in length does not, for example, further increase the elastic modulus or strength of the composite, the composite is considered to be continuous fiber reinforced. Most continuous fiber or continuous filament composites, in fact, contain fibers that are comparable in length to the overall dimensions of the composite part. Each layer or ply of a continuous fiber composite typically has a specific fiber orientation direction. These layers can be stacked such that each layer has a specified fiber orientation, thereby giving the entire laminated stack laminate highly tailor able overall properties.

Complicating the definition of a composite as having both continuous and discontinuous phases is the fact that in a laminated composite, neither of these phases may be regarded as truly continuous in three dimensions. Many applications require isotropy in a plane, and this is achieved by controlling the fiber orientation within a laminated composite. Hybrid organic metal laminates are also used, where, for example layers of glass or epoxy are combined with aluminum alloy sheets. These laminates provide improved wear, impact and blast resistance, and fire resistance. The final category of fiber

architecture is that formed by weaving, braiding, or knitting the fiber bundles or tows to create interlocking fibers that often have orientations slightly or fully in an orientation orthogonal to the primary structural plane. This approach is taken for a variety of reasons, including the ability to have structural, thermal, or electrical properties in the third or out-of-plane dimension. Another often cited reason for using these architectures is that the dry fiber performs (fibers before any matrix is added) are easier to handle, lower in cost, and conform to highly curved shapes more readily than the highly aligned, continuous fiber form (Wen, H.R. 2007).

In addition to these general categories, it is possible to create fiber architectures that are combinations of two or more of these categories. For example, it is possible to create laminated structures of both knitted fabric and continuous fiber layers. The design flexibility offered by composites is truly infinite.

2.1.2 Matrix

2.1.2.1 Introduction

The matrix material binds the fiber together and transfers the load to the fibers. It provides rigidity and shape to the structure. The matrix isolates the fibers so that individual fibers can act separately. This stops or slows the propagation of crack. The matrix provides a good surface finish quality and aids in the production of net-shape or near net-shape parts. The matrix provides the protection to reinforcing fiber against chemical attack and mechanical damage. Depending on the matrix material selected, performance characteristic such as ductility, impact strength, etc are also influenced. A ductile matrix will increase the toughness of the structure. For higher toughness requirements, thermoplastic-based composite are selected. The failure mode is strongly affected by the type of matrix used in the composite as well as its capability with the fiber (Wen, H.R. 2007).

2.1.2.2 Thermoset

Thermosets are polymer materials that irreversibly cure to a stronger form. The cure may be done through heat generally above 200 degrees Celsius, through a chemical reaction for example two-part epoxy, or irradiation such as electron beam processing.

Thermoset materials are usually liquid or malleable prior to curing and designed to be molded into their final form, or used as adhesives. Others are solids like that of the molding compound used in semiconductors, and Integrated Circuits (IC's).

The curing process transforms the resin into a plastic or rubber by a cross-linking process. Energy and/or catalysts are added that cause the molecular chains to react at chemically active sites (unsaturated or epoxy sites, for example), linking into a rigid, 3-D structure. The cross-linking process forms a molecule with a larger molecular weight, resulting in a material with a higher melting point. During the reaction, when the molecular weight has increased to a point so that the melting point is higher than the surrounding ambient temperature, the material forms into a solid material.

Uncontrolled reheating of the material results in reaching the decomposition temperature before the melting point is obtained. Therefore, a thermoset material cannot be melted and re-shaped after it is cured. This implies that thermosets cannot be recycled, except as filler material (Keynes, M. 2000).

Thermoset materials are generally stronger than thermoplastic materials due to this 3-D network of bonds, and are also better suited to high-temperature applications up to the decomposition temperature of the material.

Some examples of thermosets are vulcanized rubber, bakelite, a phenol-formaldehyde resin (used in electrical insulators and plastic ware), urea-formaldehyde foam (used in plywood, particleboard and medium-density fiberboard), melamine resin (used on

worktop surfaces), epoxy resin (used as an adhesive and in fiber reinforced plastics such as glass reinforced plastic and graphite-reinforced plastic), polyamides (used in printed circuit boards and in body parts of modern airplanes), and mold or Mold Runners (the black plastic part in Integrated Circuits (IC) or semiconductors)

Some methods of molding thermosets are reactive injection molding (used for objects like milk bottle crates), extrusion molding (used for making pipes, threads of fabric and insulation for electrical cables), compression molding (used to shape most thermosetting plastics), and spin casting (used for producing fishing lures and jigs, gaming miniatures, figurines, emblems as well as production and replacement parts) (Keynes, M. 2000).

2.1.2.3 Thermoplastic

A thermoplastic is a plastic that melts to a liquid when heated and freezes to a brittle, very glassy state when cooled sufficiently. Most thermoplastics are high-molecular-weight polymers whose chains associate through weak Van der Waals forces (polyethylene); stronger dipole-dipole interactions and hydrogen bonding (nylon); or even stacking of aromatic rings (polystyrene). Thermoplastic polymers differ from thermosetting polymers (Bakelite; vulcanized rubber) as they can, unlike thermosetting polymers, be remelted and remoulded. Many thermoplastic materials are addition polymers; examples vinyl chain-growth polymers such as polyethylene and polypropylene.

The difference between thermoplastics and thermosetting plastics is that thermoplastics become soft, remold able and weld able when heat is added. Thermosetting plastics however can not be welded or remolded when heated, simply burning instead. On the other hand, once a thermosetting is cured it tends to be stronger than a thermoplastic.

Testing of thermoplastics can take various forms.

(a) Tensile tests — ISO 527 -1/-2 and ASTM D 638 set out the standardized test methods. These standards are technically equivalent. However they are not fully