



**CHARACTERIZATION MECHANICAL AND THERMAL  
PROPERTIES OF MODIFIED MONTMORILLOINTE CLAY  
FILLED POLYPROPYLENE COMPOSITES**

**By**

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## ACKNOWLEDGMENT

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

*In the name of Allah the Beneficent, the Merciful*

*With blessings and peace be upon the most honorable Prophets and Messengers,*

*Muhammad and his Folk, Companions and those who follow noble way.*

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**THANKS TO ALMIGHTY ALLAH**

**ADEL MOHAMAD MASOD SHTAWA**

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# ***SIFAT-SIFAT MEKANIKAL DAN TERMAL KOMPOSIT POLIPROPILENA TANAH LIAT TERUBAH USAI PADA***

## ***ABSTRAK***

Dalam penyelidikan ini, sifat-sifat mekanikal dan haba PP yg diisi dengan tanah liat telah dikaji. Komposit tersebut telah disediakan dengan menggunakan Z- blade mixer pada suhu pemprosesan 170 °C dan kelajuan rotor 50 rpm. Sampel yang diadun telah dimampatkan menggunakan mesin hidraulik pada suhu yang sama untuk menghasilkan sampel komposit dalam bentuk helaian. Penekanan telah diberikan terhadap penyifatan PP yang diisi dengan tanah liat. Kekuatan tensil dan juga ketegaran meningkat dengan penambahan tanah liat. Ini menjurus kepada sifat mekanikal yang lebih baik. Secara umumnya, keputusan menunjukkan bahawa komposit yang menggunakan tanah liat yang dirawat mempunyai sifat mekanik serta ketahanan yang lebih baik berbanding dengan komposit yang menggunakan tanah liat tanpa dirawat. Mikrograf permukaan retakan menunjukkan bahawa tanah liat yang dirawat mempunyai interfasa yang lebih baik berbanding tanah liat yang tidak dirawat. Selain itu, adalah ditemui bahawa tanah liat yang dirawat mempunyai kestabilan terma yang lebih baik dalam komposit PP/ tanah liat berbanding tanah liat yang tidak dirawat.

**CHARACTERIZATION MECHANICAL AND THERMAL PROPERTIES  
OF MODIFIED MONTMORILLOINTE CLAY FILLED  
POLYPROPYLENE COMPOSITES**

**ABSTRACT**

In this research, we investigated the mechanical and thermal properties of MMTC filled polypropylene composites. The composites were prepared by using Z-blade mixer at processing temperature (170°C) and rotor speed (50 rpm) and mixed samples were then compressed by using a hydraulic hot press at the same temperature to form sheet samples composites. Emphasis was placed on the fracture characterization of the MMTC -filled polypropylene. Tensile strength and stiffness increased steadily with an increased in the clay loading. This led to improve in mechanical properties of the composites. Generally, the results indicated that with modified Montmorillointe clay MMTC showed better mechanical properties and resistance than unmodified MMTC filled polypropylene composites. The micrograph of tensile fractured surface showed that the properties of modified filler polypropylene composites have better inter phase in matrix compared to unmodified filler composites. It was also found that the modified montmorillointe clay offers better thermal stability in the polypropylene/ montmorillointe clay composites than unmodified polypropylene/montmorillointe clay composites.

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## LIST OF SYMBOLS AND ABBREVIATION

ABS	Acrylonitrile-Butadiene-Styrene
ASTM	American System Test Mechanical
CEC	Cation Exchange Capacity
CMC	Ceramic Matrix Composite
DSC	Differential Scanning Calorimeter
DMA	Dynamic Mechanical Analysis
EDX	Energy Dispersive X-ray
FTIR	Fourier Transform-Infrared Spectroscopy
HIPS	High-Impact Polystyrene
MMC	Metal Matrix Composite
MMTC	Montmorillonite Clay
PE	Polyethylene
PMC	Polymer Matrix Composite
PP	Polypropylene
PS	Polystyrene
RPM	Rotations Per Minute
SEM	Scanning Electron Microscopy
TGA	Thermo Gravimetric Analysis
T <sub>g</sub>	Glass Transition Temperature
T <sub>m</sub>	Melting Temperature

# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Polymer composites have been subjected to increasing interest, study, and utilization for some decades. Polypropylene (PP) is one of the fastest growing commercial thermoplastics due to its attractive combination of low density and high heat distortion temperature. There are some limitations in physico-chemical properties that restrict PP applications. (La Mantia& Morreale, 2006). The polymers component leads to enhance the various physical and mechanical properties. These enhancements are considered as a result of complex interplay between the characteristics of the phases of the individual component: the interfacial region, filler, and polymer. Filler morphology like the structure, element size, and aspect ratio (diameter/length) has a great influence on the polymer compounds physical performance (Joly et al., 2002).

Polymers have substituted many of conventional materials, especially metals, in various applications due to the advantages of polymers over conventional materials. They are used in many applications because they are easy to process, high productivity low cost and versatility. However, for some specific uses, some mechanical properties, such as strength and toughness of polymer materials are inadequate. Various approaches have been developed to improve such properties. In most of these applications, the properties of polymers are modified using fillers and fibers to suit the high strength/high modulus

requirements. Fibre-reinforced polymers have better specific properties compared to the conventional materials and find applications in diverse field, ranging from appliances to spacecraft (Wirawan et al., 2009)

Polypropylene (PP) is a commodity polymer used in a wide range from automotive applications such as automotive bumpers and interior parts to packaging applications such as pouches for ready-to-eat meals and others food containers. Enhancement of mechanical and thermal properties of PP can be obtained through PP composites, by adding micro-fillers (conventional fillers) or nano-fillers into PP matrix. Montmorillonite or clay (silicate nanolayers) is a nano-filler which has a large aspect ratio and surface area and can enhance stiffness, thermal properties and scratch resistance significantly at a much lower loading when well dispersed and oriented. However, the mechanical properties related to toughness or impact strength of PP composites are usually reduced which compromises impact-stiffness balance of PP composites. (Michler, 2005 and Zhang, 2006). Polypropylene (PP) is a material of the thermoplastic with some desirable properties that can makes it a flexible material and became most important in the thermoplastics business field. Currently, the consumption of Polypropylene is rapidly increasing more than the sum of all thermoplastics. This case is expected to be sustainable into the future owing to the reasons are listed bellows (Brydson, 1989 and Lynch, 2000):

- i. The relatively low of the product cost is owing to the low monomer cost and established polymerization technology, compared to other thermoplastics.
- ii. The polymer can be modified for a variety of applications.

iii. The ease in processing these polymers allows their use in most commercial fabrication techniques.

Polypropylene is one of the most widely used thermoplastic polymers in the industrial and applications because of its low cost, high strength, toughness, low processing temperature, good chemical and fatigue resistance. Polypropylene is used for wide range of applications, including food packaging, ropes, textiles, stationery and plastic parts because polypropylene doesn't soak up water (Mezghani et al., 1997).

Clay mineral filled plastic composites have received a lot of attentions. The addition of clay mineral to polymer can be changed in properties of the natural materials and those of the polymer. For example, the development of clay composites (Lee et al., 2004). Organically modified clays are currently used as fillers to ease dispersion in polymer/clay composite. Though, some bentonite clay of origin effective without any modification, as filler element in polypropylene composite. The results show that the optimum filler loading which gives enhanced tensile strength but no significant change in tensile modulus values was observed (Maduchhanda et al., 2008).

Clays and clay minerals like the montmorillonite, saponite, hectorite, etc, are cheap natural raw materials that have been commonly used for several years as filler for polypropylene and plastic to decrease polymer utilization and cost. Clay is included of silicate layers having a 1 nm thick planar structure and 200-300 nm in the lateral dimension. Because of the agglomeration of these particles, their low surface activity and these mineral fillers are not suitable with the polymer matrix, their reinforcing effect is weak (Arroyo et al., 2003).

## 1.2 Problem Statement

The application of fillers in thermoplastics or thermoset generated a special interest in the world of polymer engineering nowadays. Many kinds of filler have been introduced so far in order to increase the number of filler selections in the market. Fillers could be conveniently classified into two groups, natural or synthetic. Natural fillers are categorised as agriculture, clay and industrial waste which contribute much attention on cost saving. Mineral fillers also considered as natural as well since they come from deposit of the earth, for example talc, clay, calcium carbonate, kaolin and silica. On the other hand, synthetic fillers are much more expensive. The usage of common mineral fillers, as mentioned earlier, has been established in the research world. Perhaps combination of two of them, in research and development stage.

The used of clay could be a valuable material in the formation of a composite material that can be used:

- 1) Development and usages of MMTC modified filler in our life nowadays.
- 2) The challenge to obtain more advantages of MMTC modified and unmodified as filler.
- 3) Development of the composites with clay filler in industrial can be found largely as invaluable material.

This material just threw away and left as waste without any significant used the conventional filler need to be used in large quantity to achieve the desired properties enhancement to is depends on the other material the use of fillers like MMT clay have attracted the attention of scientists and technologists for application in consumer goods, low-cost and housing and other civil structures because it has been found that these filler composites possess better electrical resistance good thermal and insulation properties and higher resistance to fracture so there is need of study by using this waste material to produce composites.

### **1.3 Objectives of the Research**

This study aim to:

1. To compare the mechanical properties between modified and unmodified montmorillonite clay reinforced polypropylene composites.
2. To investigate the effect of filler contents on the mechanical and thermal properties of montmorillonite clay filled polypropylene.
3. To study the effects of thermal properties of modified and unmodified montmorillonite clay filled polypropylene composites.

#### **1.4 Scope of the Research**

The scope of this project is to prepare modified and unmodified montmorillonite clay filled polypropylene composites with different filler loading. The compounding have been fabricated using Z-blade mixer. In this project the testing of mechanical and thermal properties (tensile, flexural, thermogravimetric Analysis (TGA), Scanning Electron Microscopy (SEM), Differential Scanning Calorimetry Analysis (DSC), Fourier Transform-Infrared Spectroscopy (FTIR) and Charpy Impact Test) will be investigated.

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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter will cover the fundamental on the definition and classification of composites followed by a brief overview of composite materials explaining their increasing use in a wide range of engineering structures. The role of polymer matrix, fillers and extenders with particular interest focused on filler-matrix interaction will be described in this chapter. Subsequently, a literature survey was done on various published works on polymer composites, particularly those related to this work. Works on other polymer composites were also extensively reviewed.

#### 2.2 Composite Materials

The composite materials are those constituted through the gathering of more than two materials in order to achieve the superior properties to those of their constituents (Supri, 2009). Polymer composites comprise a polymer resin as the matrix, with fibers as the reinforcement medium (William and Callister, 2005). Composite materials are combinations of mechanical properties, lightness, and ease of processing that cannot be met by the conventional metals alloy, ceramics, and polymeric materials. Composite materials that have strength and toughness are strongly influenced by factor of particle size

(Shao et al., 2008). Composites materials have received significant attention to the scientific community and it is used in a wide variety of application. Composite materials date from the dawn of earliest recorded history. The first known application of composite materials occurred several thousand years ago when the Egyptians started using clay in construction. Since that time great strides have been made in the development of composite materials. They now offer the promise of new products with extraordinary strength, stiffness, chemical and temperature resistance.

Composite materials are materials that made from two or more constituent materials with significantly different physical or chemical properties, to give a combination of properties that cannot be in the original materials (Gupta & A.P. Gupta, 2005). The development of these new materials will enable the circumvention of classic performance trade-off by accessing new properties and exploiting unique synergies between materials (Chung, 2001) said that composite materials are multiphase materials obtained by artificial combination different materials to attain properties. Tuttle, (2004) described composites materials as combination of materials that is not in which two or more materials are bonded together to form a third material.

Strong, (2000) derived the composites materials as those solid materials composed of binder or matrix that surrounding and binds together fibrous reinforcement. Hull & Clyne, (1996) derived composites as a material that comprise of hard and discontinuous reinforcement that embedded in matrix (Alger, 1989) has defined a composite material as a combination of two or more materials in which the individual components retain their separate identities while it exhibits different properties from those of its components. The