# Characterization And Mechanical Properties Of Coconut Shell Filled Acrylonitrile Butadiene Styrene / Ethylene Propylene Diene Monomer Composites

by

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**APPROVAL AND DECLARATION SHEET**

**This project report titled Characterization And Mechanical Properties Of Coconut Shell Filled Acrylonitrile Butadiene Styrene / Ethylene Propylene Diene Monomer Composites was prepared and submitted by Siti Noorkhartina Bt Ishak (Matrix Number: 0831620289) and has been found satisfactory in terms of scope , quality and presentation as partial fulfillment of the requirement for the Master of Science(Polymer Engineering) in Universiti Malaysia Perlis (UniMAP).**

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**LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE**

| | |
|---|---|
| ABS | Acrylonitrile-butadiene-styrene |
| ASTM | American Society for Testing and Materials |
| DCPD | Dicyclopentadiene |
| EPDM | Ethylene-propylene-diene terpolymer |
| HDPE | High density polyethylene |
| MA | Maleic acid |
| MAPP | Maleic anhydride grafted polypropylene |
| NR | Natural Rubber |
| OMMT | Organic Montmorillonite |
| PC | Polycarbonate |
| PE | Polyethylene |
| PP | Polypropylene |
| PP-g-MA | Maleated polypropylene |
| PVC | Polyvinyl chloride |
| SEBS-g-MA | Maleic anhydride-grafted styrene-ethylene-butylene-styrene |
| SEM | Scanning Electron Microscope |
| TPE | Thermoplastic elastomer |
| WF | Wood flour |
| WRHA | White rice husk ash |

***PENCIRIAN DAN SIFAT MEKANIKAL KE ATAS GENTIAN TEMPURUNG KELAPA TERISI KOMPOSIT AKRILONITRIL BUTADIENA STIRENA/ ETILENA PROPILENA DIENA MONOMER***


***ABSTRAK***

*Gentian tempurung kelapa terisi komposit ABS/EPDM disediakan dengan menggunakan mesin percampuran bilah Z pada suhu pemprosesan 200$^{0}$C dan kelajuan rotor 50 rpm.Kesan rawatan kimia ke atas gentian tempurung kelapa ,perbezaan komposisi nisbah adunan ,perbezaan pembebanan pengisi dan kesan penuaan haba ke atas sifat mekanikal , haba, dan ujian morfologi terhadap gentian tempurung kelapa terisi komposit ABS/EPDM telah dikaji.Asid Maleik digunakan untuk merawat permukaan gentian.Peningkatan komposisi EPDM akan mengurangkan kekuatan tensil dan modulus Young's tetapi pemanjangan pada takat putus meningkat.Dengan peningkatan pembebanan pengisi dan kehadiran asid maleik menunjukkan peningkatan pada kekuatan tensil dan modulus Young's tetapi pemanjangan pada takat putus berkurang.Keputusan selepas penuaan haba menunjukkan polar yang sama tetapi lebih rendah dari sebelum.Penyiasatan morfologi menggunakan mikroskop penskanan elektron (SEM) memperlihatkan peningkatan kekuatan tensil dan modulus Young's disebabkan peningkatan pelekatan antaramuka antara matrik dan pengisi tempurung kelapa.Kestabilan haba antara matrik dan pengisi tempurung kelapa juga meningkat dengan kehadiran maleic asid.*

***CHARACTERIZATION AND MECHANICAL PROPERTIES OF COCONUT SHELL FILLED ACRYLONITRILE BUTADIENE STYRENE / ETHYLENE PROPYLENE DIENE MONOMER COMPOSITES***

***ABSTRACT***

*Coconut shell filled ABS/EPDM composites were prepared using a Z-blade mixer at processing temperature 200$^0$C and rotor speed 50rpm.Effect of chemical treatment,different composition of blend ratio , different filler loading and effect of thermal aging on mechanical, thermal, and morphological properties of coconut shell filled ABS/EPDM composites was investigated.Maleic acid (MA) were used to treat the fiber surface.The increasing composition of EPDM will decrease the tensile strength and Young's modulus but increasing in elongation at break.The increasing in filler loading and the presence of maleic acid increase the tensile strength and Young's modulus but decrease the elongation at break is decreased.Result after thermal aging shows the same trend but lower than before aging.Morphological investigation using SEM revealed that the improvement in tensile strength and Young's modulus was due to enhancement of the interfacial adhesion between coconut shell and ABS/EPDM. The thermal stability of coconut shell filled ABS/EPDM blends improved with the presence of MA.*

# CHAPTER 1

# INTRODUCTION



## 1.1 Polymer Composites

Polymer composites may be understood as the combination of two or more materials, for example, reinforcement elements or filler involved by a polymeric matrix (Luz, 2007). The introduction of fibers (treated or untreated) into a polymer is known to cause substantial changes in the resulting composite (Khalil H., Rozman, Ismail H., 2001) which may result, differently from the original materials, in good mechanical properties and rigidity (Xue, Rowell,2007). In recent years, studies about the utilization of lignocellulosic materials as reinforcement in polymeric composites are increasing due to the improvements that natural fibers can provide to the product, such as low density and biodegradability, besides the fact that these materials are from renewable and less expensive sources (Alcock, Barkoula, 2006).

Modification of organic polymers through the incorporation of additives yields, with few exceptions, multiphase systems containing the additives embedded in a continuous polymeric matrix. The resulting mixtures are characterized by unique microstructures or macrostructures that are responsible for their properties. The primary reasons for using additives are property modification or enhancement, overall cost reduction and improving and controlling of processing characteristics (Askeland,2006)

ABS was selected as the matrix because it's being copolymerized from three different monomers, has high impact strength and competes well with polypropylene, although it is more expensive. Its dimensional stability is good; it replaces die-cast metal components and can be electroplated. ABS is excellent for vacuum-forming and blow-moulding for the production of articles such as fire extinguishers, bus wheel arches, industrial containers, refrigerator shells and protective helmets. Basically, ABS is preferred for its favorable balance of strength, toughness, high gloss, colorability, processability and price. The balances of properties which are exhibited by ABS are not found in any other plastics material. Specialist applications can be tailor-made by adjustment of the proportions and arrangement of the three parts of the copolymer, thus emphasizing the character of the components. The characteristics of EPDM rubber, low glass transition temperature, excellent thermal oxidative and UV stability, make it an ideal candidate for impact modification of plastics.

Polymer composites featuring both stiffness and strength have been of great commercial interest for a century now. Although inorganic filler such as calcium carbonate, mica, fiberglass, talc and clay have been widely used, composites containing organic filler derived from renewable resources have aroused broad interest because of growing environmental concerns and the increasing costs of inorganic fillers. Using natural fillers to reinforce the composite materials offers the following benefits in comparison with mineral fillers:

- strong and rigid
- light weight
- environmental friendly
- conomical
- renewable and abundant resource

On the other hand, the disadvantages of the materials are summarized below:

- degradation by moisture
- poor surface adhesion to hydrophobic polymers
- non-uniform filler sizes
- not suitable for high temperature application
- susceptibility to fungal and insect attack

Coconut shell is one of the most important natural fillers produced in tropical countries like Malaysia, Indonesia, Thailand, and Sri Lanka. Coconut is a tropical fruit largely consumed in many countries. In some areas of the Brazilian coast, coconut shell represents more than 60% of the domestic waste volume. The coconut shell is composed mainly of lignin and cellulose, having a chemical composition very similar to wood. Many works have been devoted to use of other natural fillers in composites in the recent past and coconut shell filler is a potential candidate for the development of new composites because of their high strength and modulus properties. Composites of high strength coconut filler can be used in the broad range of applications as, building materials, marine cordage, fishnets, furniture, and other household appliances.

### 1.2 Research Objective

This study is concerned with coconut shell filled ABS/EPDM composite. The primary objective of these studies is divided into the following categories:

a) To study the mechanical properties and of different filler loading on coconut shell filled ABS/EPDM composites before and after aging
b) To study the effect of surface treatment using Maleic acid on tensile behaviour of coconut shell filled ABS/EPDM composite.
c) To characterize the composite sample by using SEM ,TGA and FTIR

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Thermoplastic Elastomers

Thermoplastic elastomers (TPE) are relatively new polymers which, in the ideal case, combine the service properties of elastomers with the processing properties of thermoplastics. This combination of properties can be obtained through the simultaneous presence of soft, elastic segments that have a high extensibility and a low glass transition temperature (Tg value) and hard, crystallizable segments which have a lower extensibility, a high Tg value and are susceptible to association (cross-linking). The hard and soft segments must be thermodynamically incompatible with each other so that they do not penetrate each other but act as individual phases.

These different segments may be present either in the same molecule,as macromolecule segments, or in the form of a micro-heterogeneous phase distribution of thermoplastics in plasticizer. This means that TPE properties are characterized more by their morphological behavior that by their chemical composition.

The ratio of soft and hard segments determines the hardness and the modulus of elasticity and also comparable properties of TPE. The chemical nature of the soft segments has an influence on elastic behavior and the low temperature flexibility, whilst the hard segments, which act as cross-link points, determine the heat resistance, the strength and the swelling behavior.

By their hardness, the TPEs can be classified as follows:

- Blends of rubbers with thermoplastics, blended TPEs ( e.g. EPDM/PP)
- Soft block copolymers as “multi-purpose” TPEs” (e.g. SBS)
- Hard block copolymers as “engineering TPEs” (e.g. thermoplastic polyurethanes,copolyesters, polyetheramides and hard elastomeric alloys)

Generally, the DSC (Differential Scanning Calorimetry) curve of a TPE shows two clear phase transition, i.e. the glass transition Tg of the elastic phase and the melting range Tm of the crystalline phase. The various TPE types, however, differ considerably from each other in terms of the temperatures at which the transitions occur and the intensity of the transitions. One of the advantages of thermoplastic elastomers is that they can be recycled-indicating that inter-chain bonding in TPE consist of thermo-reversible cross-links arising out of physical interactions like hydrogen bonding, charge transfer complexes, ion-dipole interactions and ionion interactions.

Thermoplastic vulcanizates are alloys of polyolefin thermoplastics and fully vulcanized rubber. The cross-linked rubber phase in TPVs gives them a good compression set and excellent dynamic properties. They have good chemical resistance against water, acids and bases and the main advantage which they present is that the rubber used as basis for their preparation can be recycled rubber.

## 2.2 Composites

A composite material is a materials system composed of a suitably arranged mixture or combination of two or more micro- or macroconstituents with an interface separating them that differ in form and chemical composition and are essentially insoluble in each other. The engineering importance of a composite material is that two or more distinctly different materials combine to form a composite material that possesses properties that are superior, or important in some other manner, to the properties of the individual components.

Thus composites are those materials formed by aligning extremely strong and stiff constituents such as fibers and particulates in a binder called matrix. The materials in this class have exceptional mechanical properties. One of the components is that accommodate stress to incorporate component called reinforcing phase and provide a strong bond called matrix. Polymers, ceramic and metals have found application as matrix materials. The reinforcing phase is other component and is called reinforcement and can be fiber, particulate or laminar. The composite properties depend on those of the individual components and on their interface compatibility. Many research works has been carried out to identify the parameters that govern mechanical behavior of particulate composites. Generally, it has been found that the reinforcement effect increases with decreasing particle size and with increasing adhesion to the matrix.

Modification of properties can be done by the physical combination of two polymers or by the physical combination of a polymer with a non-polymeric component. One type of the methods is through forming composite material. Composites are formed by combination of a polymer of some type non-polymeric solid or by combination of some types of engineering materials. Commonly, composites tend to have characteristics such as high strength; high modulus; low density; and excellent resistance to fatigue, creep, creep rupture, corrosion and wear.

**Table 2.1 Lists some advantages and disadvantages of composites (Peter 2002)**

| Advantages | Disadvantages |
|---|---|
| - weight reduction | - cost of raw materials and fabrication |
| - high strength-or-stiffness-to-weight ratio | -tranverse 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 | -analysis for physical properties and mechanical properties difficult, analysis for damping efficiency has not reached consensus |
| -inherent damping | -non destructive testing tedious |
| -increased (or decreased) thermal or electrical conductivity | |

From Table 2.1, application of typical or commercial composites still limited due to the economic factor. Since these composites used fibre glass or other engineering material as the reinforcement, the cost of raw materials and fabrication will be high. This is very obvious in industrial field that required advance composite material, for instance aeronautic and marine engineering. In general, polymeric composites are formed by combining fibres and polymer resin which also known as fibre reinforced plastic (FRP).

### 2.2.1 Current Trend of Composite

In this new era of technology, availability of bio-based composites offer the opportunity for environmental gains, reduced energy consumption, light weight, insulation and sound absorption properties, reduction in volatile organic emissions, and reduction in the dependence on petroleum based and forest product based materials. The development of sustainable materials as an alternative for petroleum based materials is being studied to decrease the dependence on oil or petroleum. This also can reduce carbon dioxide emissions and to generate a more economic opportunity for the agricultural sector globally. Figure 2.1 shows the outlook of application of bio-based composites in United State of America. It is forecasted that the introduction of bio-based composites will soon alter the global trend of composite and serves as a better choice when selecting the appropriate construction materials.

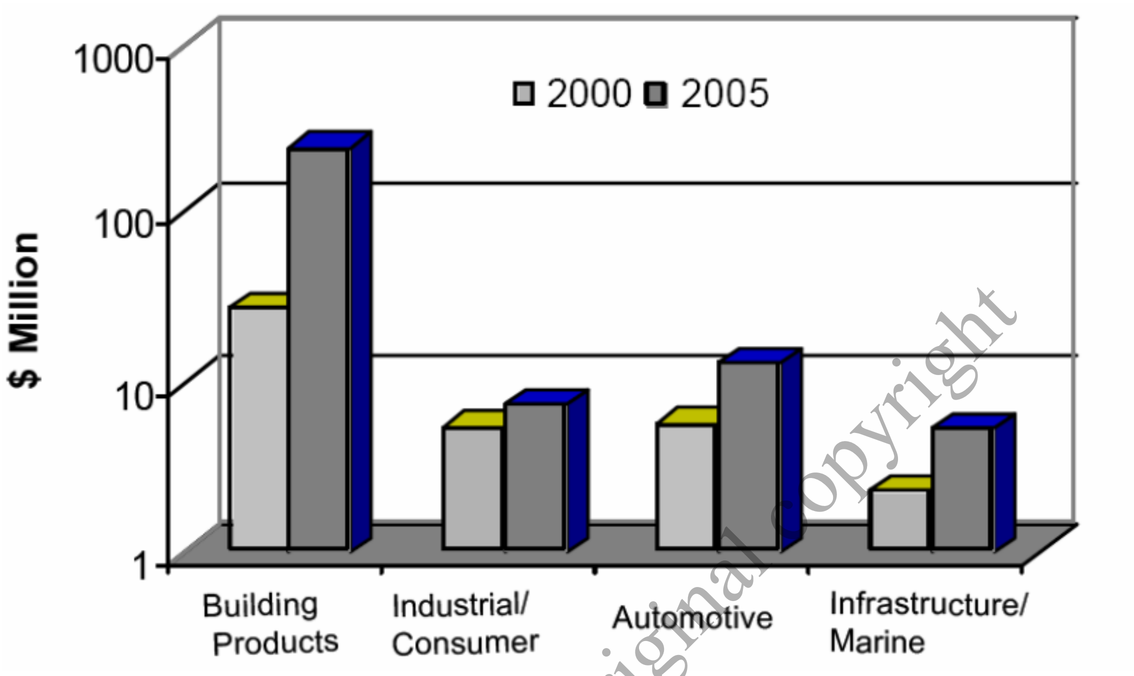


Figure 2.1: Growth Outlook for Bio-based Composites by Application in United State, 2000-2005 (Drzal *et al.*, 2003)



### 2.2.2 Matrix

In choosing to reinforce an engineering material the matrix are effectively selecting for a composite. This matrix is required to perform several functions, most of which are vital to the satisfactory performance of the composite. The matrix binds the fibers together, holding them aligned in the important stress direction. Loads are applied to the composite, are then transferred into the fibers, which constitute the principal load bearing component, through the matrix, enabling the matrix to withstand compression, flexural and shear force as well as tensile loads. The ability of composites reinforced with short or chopped fibers to support load of any kind is exclusively dependent on the presence of matrix as the load transfer medium and the efficiency of this transfer depends on the quality of the fiber-matrix bond.