THE MECHANICAL PROPERTIES OF ACRYLONITRILE-BUTADIENE-STYRENE (ABS) / NYLON 6 / TALC COMPOSITES

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ABSTRACT

Blending is capable of providing materials which extend the useful properties beyond the range that can be obtained from single polymer equivalents. But on the other hand, reinforcement has received considerable attention for many years in polymer world to come up with new material with unique properties and low cost. In this study, Acrylonitrile-Butadiene-Styrene (ABS) and nylon 6 reinforced with talc were prepared in different ratios and it went through twin screw extruder, injection moulding and was tested with three different tests: tensile test, flexural test and Izod impact test. A super high impact ABS was used and different concentration of talc were incorporated into the blends to study the mechanical properties of the composites: tensile, flexural and impact properties. Accurately, this study is done to investigate the optimum blending ratio for ABS and nylon 6 and also to study the effect of talc concentration as filler on ABS/nylon 6 blends. From the research, it was found that tensile strength and Young Modulus increased with the increasing of talc content in ABS/ nylon 6 blends. Flexural modulus increased with increasing talc content but the flexural strength decreased with filler loading. However, with increasing talc composition the composites gave decreasing impact strength values.

ABSTRAK

Penyebatian berupaya menghasilkan bahan-bahan yang mempunyai sifat-sifat yang sangat berguna mengatasi sifat-sifat polimer tunggal. Namun begitu, peneguhan juga mendapat perhatian di dalam dunia polimer bagi menghasilkan bahan baru dengan sifat - sifat unik dan kos yang rendah. Dalam kajian ini, Acrylonitrile-Butadiena-Stirena (ABS) dan nilon 6 diteguhkan dengan talkum disediakan dengan nisbah berat yang berbeza, dan dilalukan kepada penyemperit dua skru, mesin pengacuan suntikan dan diuji dengan tiga ujian yang berbeza: ujian regangan, ujian lenturan dan ujian hentaman Izod. ABS hentaman tinggi digunakan dan talkum berlainan kepekatan digabungkan bersama sebatian untuk mengkaji sifat-sifat mekanikal komposit tersebut: sifat-sifat regangan, lenturan dan hentaman. Secara tepat, kaijan ini dilakukan untuk mengkaji nibah sebatian optimum bagi ABS dan nilon 6 dan juga mengkaji kesan kepekatan talkum sebagai pengisi terhadap sebatian ABS/ nilon 6. Daripada kajian, didapati kekuatan regangan dan Young Modulus meningkat dengan peningkatan kepekatan talkum di dalam sebatian ABS/ nilon 6. Modulus lenturan menaik dengan peningkatan kepekatan talkum tetapi kekuatan lenturan menurun dengan bebanan talkum. Namun begitu, dengan peningkatan komposisi talkum, sebatian ABS/ nilon 6 menghasilkan penurunan nilai kekuatan hentaman.

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LIST OF SYMBOLS AND ABBREVIATIONS

ABS	-	Acrylonitrile-Butadiene-Styrene
ABS-MA	-	Acrylonitrile-Butadiene-Styrene-Maleated –Acrylonitrile
AS	-	Acrylonitrile-co-Styrene
ASTM	-	American Society for Testing and Materials
cm/sec	-	centimeters per seconds
FE	-	Field Emission
HDT	-	Heat Distortion Temperature
IA	-	Imidized Acrylic
J/m	-	Joule per meter
kJ/m^2	-	kilojoule per meter square
LaB_6	-	Lanthanum Hexaboride
MPa	-	Mega Pascal (Pressure)
No.	-	Number
PA	-	Polyamide
PC	-	Personal Computer
rpm.	-	resolutions per minute
SAN	-	Styrene-Acrylonitrile
SAN-g-PB	-	Styrene-Acrylonitrile-grafted-Polypropylene
SANMA	-	Styrene/Acrylonitrile/Maleic Anhydride
SEM	-	Scanning Electron Microscope
UV	-	Ultraviolet
%wt	-	Weight percent

CHAPTER 1

INTRODUCTION

Acrylonitrile-butadiene-styrene (ABS) and nylon 6 are the two of the most widely used engineering thermoplastics, such as in automobile, electrical, laboratory equipment, office accessories, textiles, and consumer applications, because of their excellent mechanical properties. Acrylonitrile Butadiene Styrene (ABS) is produces by polymerization of Acrylonitrile, Butadiene, and Styrene monomers. Chemically, this thermoplastic family of plastics is called "terpolymers", in that they involve the combination of three different monomers to form a single material that draws from the properties of all three. The combination of the copolymers makes ABS possesses outstanding impact strength and high mechanical strength, which makes it so suitable for tough consumer products. Additionally, ABS has good dimensional stability and electrical insulating properties. However, there are disadvantages exist, which are, poor weathering resistance, poor flame and heat resistance and lack of transparency. These intricacies can be control with blending ABS with nylon. Nylon is one of many heterochain thermoplastics which have atoms other than C in the chain. Nylon is created when a condensation reaction occurs between amino acids, dibasic acids and diamines. Nylon also has its own drawbacks which are, it requires UV stabilization, easy to be attacked by oxidizing agents, and high shrinkage in molded sections.

Nowadays, we are seeing new and improved blending development that offers a much more diverse polymer product with less cost and shorter development period. The combination of two or more commercially available polymers through blending represents an inexpensive route in tailoring a polymer compound which fulfills the specific application requirements for the end user. PA/ABS is a nylon/ABS alloy with a viscosity suitable for processing by injection molding. It is formulated to offer excellent toughness, together with good strength and rigidity. Nylon/ABS alloys combine many of the best characteristics of nylons and ABS, and exhibit unusually low impact notch sensitivity. The presence of nylon provides properties typical of a semi-crystalline polymer, including good high temperature performance, resistance to a broad range of chemicals and solvents, and good abrasion resistance. The ABS contributes toughness, lower shrinkage, with consequent control of warp age and sink in larger area or complex shape parts, and exceptional surface appearance.

The blending enhancement produced are, improved chemical resistance over ABS, higher elongation at break and notched izod impact strength than unmodified ABS or unmodified nylon. ABS/nylon alloys are candidates for applications in a wide range of industries where their unique performance and processing characteristics offer a cost-effective material selection alternative. Many products are being generated from this type of blend. Some of them are housings for power tools, electro-technical components, lawn and garden equipment, sporting goods, gears and impellers. Unfortunately, the blend also constructs some disadvantages. The disadvantages turn out to be, moisture absorption higher than ABS, lower maximum operating temperature and dielectric strength than polyamide and lower flexural modulus, volume resistivity and dielectric strength than ABS.

Therefore, to solve the problems, industry had come out with an idea which called reinforcement. Particulate reinforced thermoplastics composites have received considerable attention for many years. Great efforts have been taken to design composites with unique properties and low cost. Particle-filled polymer composites have become attractive because of their wide application and low cost and widespread applications in household, automobile, and electrical industries. Incorporating inorganic mineral fillers and / or organic fibres into plastics resin improves various physical strength, modulus, and heat deflection temperature. Furthermore, replacing the volume of expensive resins with less costly filler results in lower costs. In general, the mechanical properties of particulate-filled polymer composites depend strongly on the size, shape, and distribution of filler particles in the matrix polymer and good adhesion at the interface surface. (Unal *et al*, 2002)

For this study, blend of ABS and nylon 6, are to be reinforced with talc. Talc is a versatile mineral, widely used in various industrial applications. Talc is a metamorphic mineral resulting from the alteration of silicates of magnesium such as pyroxenes, amphiboles, olivine and other similar minerals. This softest rock in the world is usually found in metamorphic rocks, often of a basic type due to the alteration of the minerals mentioned above.The nature of deposit, formation of talc is the index of its chemical purity, particle shape and other physical features. Talc possesses some unique and unusual properties, which makes it ideal for its multiple uses. The important properties of talc are its chemical inertness, high dielectric strength, high thermal conductivity, low electrical conductivity and oil & grease absorption.

1.0 Current Research

Overall improvement in tensile strength and Young's Modulus of the blend is observed. Both tensile strength and Young's Modulus increased with the increase of nylon 6 content in the ABS/nylon 6 blend. From Figure 4.1, it showed that the tensile strength increased almost linearly with the increase of nylon 6 ratio in the ABS/nylon 6 blend. Obviously, there was a mark increase of tensile strength value (22%) with the addition of 20 wt% of nylon 6 into the pure ABS. After that, the tensile strength increased linearly from 20 to 100 wt% nylon 6 content. Besides that, the Young's Modulus showed a significant improvement from 1500 to 1790 MPa between the 20 and 40 wt% nylon 6. Between this ranges, it was found that the increment was 19%. Therefore, the results showed positive blending effect on tensile property on the whole range composition (Ling, 2006).

Toughening mechanisms and mechanical properties of two high-crystallinity propylene (hcPP)-based composite systems, hcPP/talc and hcPP/CaCO3, are investigated. Significant improvement in tensile modulus is observed in the PP/talc composite, but only a moderate improvement is found for hcPP/CaCO3. A detailed investigation of fracture mechanisms suggests that well-dispersed, highly oriented talc particles cause embrittlement of hcPP (J.-I. Weon, and H.-J. Sue, 2006).

1.1 Problem Statement

i. Investigate the effect of ABS/nylon 6 blends on its mechanical properties to determine the optimum blending ratio between two incompatible homopolymers / copolymers.
ii. Find out the effect of talc as filler on mechanical properties of ABS/nylon 6/talc composites to achieve the optimum mechanical properties.

1.2 Objective

i. To investigate the effect of different weight ratio of ABS/nylon 6 blends on tensile, flexural and impact properties to obtain the optimum blending ratio for ABS and nylon 6.
ii. To study the effect of talc concentration as filler on mechanical properties of ABS/nylon 6/talc composites and determine the best formulation to produce new material with better properties.

1.3 Scopes of Research

The scope of this study includes the following criteria:

1. Literature review
   - Studies, the previous till the present of the development of researches and technologies about this topic.

2. Sample preparation
   - Sample will be prepared by using extrusion process using twin-screw extruder over the whole range of compositions. This is followed by the

injection moulding process to prepare samples specimen according to ASTM for testing.

3. Testing of the specimen will involve mechanical and flow properties which are:
   - tensile test (ASTM D638)
   - flexural test (ASTM D790)
   - impact test (ASTM D256)

4. Data analysis

5. Report writing

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction