EVALUATION OF MECHANICAL PROPERTIES IN THERMOPLASTIC POLYMER NATURAL RUBBER FILLED WITH HYBRID FILLERS

This report is submitted in accordance with requirement of the University Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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Sesi Pengajian: **2020/2021 Semester 2**

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I hereby, declared this report entitled “Evaluation of Mechanical Properties in Thermoplastic Polymer Natural Rubber Filled With Hybrid Fillers” is the result of my own research except as cited in references.

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Date : 15th September 2021

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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ABSTRAK

Penggunaan barangan elektronik yang meningkat masa kini telah menyebabkan berlakunya satu pencemaran baru iaitu gangguan frekuensi radio atau gangguan elektromagnetik yang boleh menyebabkan gangguan pada alatan elektronik dan juga komponen dalamannya. Perkara ini berlaku dalam semua sektor termasuk industri, tentera, komersial dan sektor pengguna. Oleh itu, penggunaan pelindung elektromagnetik diperlukan bagi mencegah pencemaran ini daripada berlaku. Pengisi tambahan nano yang akan digunakan dalam kajian ini adalah nanotiub karbon (CNT) dan nanoplatelet grafen (GNP). Bahan-bahan ini akan dicampur ke dalam gabungan karbon hitam (CB) bagi mengkaji bagaimana kesan hidbridisasi ke atas tingkah laku polipropelina (PP) dan getah asli (NR) termoplastik elastomer. PP/NR pada 75/25 dijangka mempunyai kekuatan impak yang lebih tinggi tetapi mempunyai kekuatan tegangan, modulus keanjalan dan kekerasan yang lebih rendah berbanding PP asli sahaja. PP/NR pada 75/25 bersama 30 phr karbon hitam dan 1 phr CNT dan GNP. Berdasarkan tinjauan kritikal, fokus utama adalah pada sifat mekanikal dan fizikal sesebuah komposit. Terdapat dua jenis gabungan hibrid pengisi nano yang digunakan iaitu CB/CNT dan CB/GNP. Berdasarkan keputusan yang beralasan, PP/NR yang berhibrid pengisi nano CB/CNT mempunyai kekuatan tegangan yang sama seperti CB/GNP, modulus kenjalan yang lebih baik dan kekuatan impak yang lebih baik berbanding CB/GNP. Sementara itu, CB/GNP mempunyai kekerasan yang lebih baik. Konklusi ini disokong oleh analisis mikroskop electron pengimbas (SEM) dan difraksi sinar-x (XRD)

ABSTRACT

Growth in electronic devices nowadays has created a new form of pollution which is radio frequency interference (RFI) or electromagnetic interference (EMI) that can cause equipment to malfunction and cause interference towards the components. This is applicable in all sectors such as industrial, military, commercial and consumer sectors. Therefore, the usage of EMI shielding is needed to prevent this pollution from occurring is needed. The nanofillers that is used in this study are graphene nanoplatelet (GNP) and carbon nanotube (CNT). They will be employed in combination with carbon black to evaluate how the hybridization affects the properties of PP/NR thermoplastic elastomers. PP/NR of 75/25 is predicted to have better impact strength but have lower tensile, Young's modulus and hardness compared to pure PP. PP/NR composition is at 75/25 with 30 phr of carbon black and 1 phr of CNT and GNP. In the evaluation based on critical review, the main focus is the mechanical and physical properties of the composites. There are two different pair of hybrid fillers which is CB/CNT and CB/GNP. In the postulated result, PP/NR with hybrid fillers of CB/CNT has the same tensile strength as CB/GNP blend, better Young's modulus, and better impact strength compared to CB/GNP. Meanwhile CB/GNP has better hardness. The conclusion is supported by the scanning electron microscopy and X-Ray Diffraction analysis.

DEDICATION

Only

my beloved father, Ahmad bin Daud

my appreciated mother, Afizah binti Ahmad

my adored brothers, Muhammad Haziq and Izzat Harith

my dearest best friends

for giving me moral support, financial support, cooperation, encouragement and also understanding

Thank You So Much & Love You All Forever

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EMI	-	Electromagnetic Interference
RFI	-	Radio Frequency Interference
ESD	-	Electrostatic Discharge
NR	-	Natural Rubber
CB	-	Carbon Black
CNT	-	Carbon Nanotube
GNP	-	Graphene Nanoplatelet
PP	-	Polypropylene
XRD	-	X-Ray Diffraction
SEM	-	Scanning Electron Microscopy
SE	-	Shielding Effectiveness
PEDGE	-	Polyethylene Glycol Diglycidyl Ether
PVC	-	Polyvinyl Chloride
EVA	-	Ethylene-Vinyl Acetate
SCF	-	Short Carbon Fiber
CVD	-	Chemical Vapor Deposition
SWCNT	-	Single-Walled Carbon Nanotube
MWCNT	-	Multi-Walled Carbon Nanotube
PSA	-	Particle Size Analyzer

LIST OF SYMBOLS

℃	-	Degree Celsius
cm	-	Centimeter
mm	-	Millimeter
%	-	Percent
H	-	Magnetic Field
E	-	Electric Field
V	-	Volt
Amp	-	Ampere
λ	-	Lambda
π	-	Pi
TPa	-	Tera Pascal
MPa	-	Mega Pascal
GPa	-	Giga Pascal
n	-	Nano
g	-	Gram
W	-	Watt
K	-	Kelvin
Ω	-	Ohm
T_g	-	Transition Temperature
kg	-	Kilo Gram

µ	-	Micro
ASTM	-	American Society for Testing and Materials
min	-	Minute
Q	-	Mass of Toluene Absorbed in each Rubber Compound
phr	-	Parts Per Hundred Rubber

CHAPTER 1

INTRODUCTION

This chapter contains the background, problem statements, objectives and scope of the study, as well as the organization of the report.

1.1. Background of Study

Electromagnetic interference is the unwanted noise that occurs when a supersensitive electronic device receives an electromagnetic radiation emitted from the usage of electronic devices such as laptop, microwaves, speaker and phones too. This noise is undesirable as it will affect the overall performance of the electronic devices. A striking example of that is the dysfunction of pacemakers when in the vicinity of certain electronic device. The unnecessary EMI is an electromagnetic disturbance that affects the unit, transmission channel, or system performance. It is also called as radio frequency interference (RFI) when the interference is in the radio frequency spectrum. This problem occurs in operation of any electrical devices when the proximity of the electromagnetic field to the spectrum of radio frequencies derived from other electronic devices.

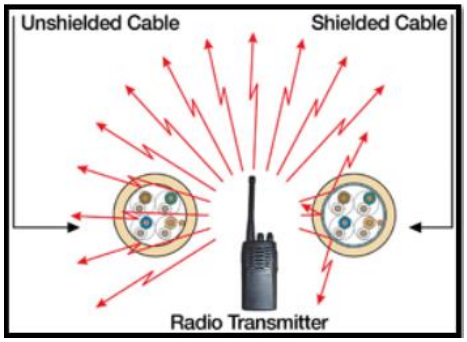

Figure 1.1: Shielded and non-shielded cable from EMI.

Furthermore, interference also frequently happened to mobile phone, aircraft and medication too. Electromagnetic interference (EMI) occurring to medical devices has been widely established (Klein AA, 2003), but its clinical consequences remain controversial (Myerson SG, 2003). The electromagnetic interference (EMI) also occurs when making a call when noise from the cellphone handshaking with the communication tower. In military sector, EMI can cause jamming of enemy radio tower network to disable their communication which is considered as a useful EMI. The EMI can cause disturbance of communication between control tower and their aircraft.

This will also increase the demand for injection moldable thermoplastic for the housing of the component. The features and specifications require improvement, making them lighter, smaller and better at preventing electromagnetic interference (EMI). The fact that plastic is not able to replace metal as a conductive material due to the electrical conductivity, one application where conductivity requirement is not as severe as in electromagnetic interference (EMI) shielding (Grady, 2011). To prevent system failure, most electronic gadgets need to be shielded from electromagnetic interference (EMI). Due to its lightweight, low cost and ease of process, the housing of the unit is typically made of plastic. However, most of the plastic cannot prevent electromagnetic interference (EMI) from occurring. As a result, plastic housing, especially in the electronics and communications industries, has posed some serious problems. Since communication devices have become increasingly sensitive, dense, and abundant, EMI shielding has become one of the most important concerns in optical-electronic packaging.

On top of that, the main solution to this particular problem is the electrical conductive properties in plastics are required to ensure adequate EMI shielding to enhance the EMI shielding for the electronic housing of a device. The current available techniques for EMI shielding are including conductive sprays, conductive fillers, electro-plating or electrolysis-plating on housing surface, modification of electrical properties during molding stage and other metallization process (M. Murt, 1990). Among these methods, the most popular for EMI shielding is compound plastics with discontinuous electronic conductive fillers, such as metal particles, metal flakes, stainless fiber, graphitized carbon particles, graphitized carbon fibers, and metal-coated glass and carbon fibers (J. Bell et al, 1992).

Conductive polymer is recommended which small volume fractions of electrically conductive filler are added into a non-conducting polymer matrix such as engineering polymers through melt blending process (Jou et al, 2001). Carbon black/fibres was one of the first materials used for the purpose of conductive filler. Since carbon black is a semiconductor, the typical resistivity of carbon black is in range of 20-0.5Ω cm and when used as a filler in polymer matrix composites it endowed the compound with conductive properties (Guo et. al.,2013). So, there is other material that can be used as conductive filler such as carbon nanotube and graphene nanoplatelets.

1.2. Problem Statement

In modern era nowadays, the market for electronic devices has been growing rapidly in various fields, such as military, entertainment, industrial and medical. Electromagnetic interference (EMI) or radio frequency interference (RFI) that is not really necessary can cause plenty of issues, such as system interference and failure, as a result of this situation. Since EMI usually occur in daily routine such as noise on microphones from the cell phones, distortion of television broadcast reception and interference of radio frequency. Most of electronic gadget must be protected against these EMI and electrostatic discharge (ESD) especially in sectors involved.

Thus, development of EMI shielding using thermoplastic elastomer with nanofillers as housing component is introduced in order to prevent EMI from occurring. Besides its lightweight and easy to shape characteristics, the usage of elastomers such as polypropylene integrated with nanofillers can reduce and eliminate seam and has better properties than normal metal EMI shielding material that is heavy and expose to corrosion. In order to become EMI shielding materials, thermoplastic elastomer added with various conductive filler such as carbon black, carbon nanotube and graphene nanoplatelets which allows current flow and can both absorb and reflect EMI.

Generally, thermoplastics elastomer is not a good electrically conductive material. Metal is the most common and suitable material for EMI shielding which metal has a very high electrical conductivity (106 Siemens/cm). However, the disadvantages of the usage of metal are the weight of the metal itself which is heavy will increase the weight of the whole product compared to plastics. Other than that, there is also a possibility of corrosion of metal could occur in a certain amount of time. This can be solved by providing metal coating but it will be costly. The electrical conductivity can be improved with additional carbon black, carbon nanotube and graphene nanoplatelets. Therefore, the main objective of the research is to study the impact of additional nanofillers on the thermoplastic elastomer to be used as EMI shielding.

1.3. Objectives

The overall objective of this study is to evaluate the mechanical properties in thermoplastic polymer natural rubber filled with nanofillers such as carbon black, carbon nanotubes and graphene nanoplatelets. There are several objectives listed below that need to be achieved in this study:

1. To postulate the effect of NR content to the physical and mechanical properties of PP/NR thermoplastic elastomer.
2. To predict the impact of filler hybridization on the physical and mechanical properties of the thermoplastic elastomer.
3. To correlate the morphological properties of the nanofiller filled PP/NR composites with their mechanical behavior.