TENSILE AND DAMPING PROPERTIES OF GRAPHENE NANOPLATELETS/CARBON BLACKS FILLED CHLOROPRENE RUBBER NANOCOMPOSITE FOR ENGINE MOUNTING

Submitted in accordance with the requirement of the Universiti Teknikal

Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Hons.)

by

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2019

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Tajuk: **TENSILE AND DAMPING PROPERTIES OF GRAPHENE NANOPLATELETS/CARBON BLACKS FILLED CHLOROPRENE RUBBER NANOCOMPOSITE FOR ENGINE MOUNTING**

Sesi Pengajian: **2018/2019 Semester 1**

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DECLARATION

I hereby, declared this report entitled "Tensile and Damping Properties of Graphene Nanoplatelets/Carbon Blacks Filled Chloroprene Rubber Nanocomposite for Engine Mounting" is the result of my own research except as cited in references.

Signature : ……

Author's Name : CHENG LIN YI

Date : 9th January 2019

APPROVAL

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

……

Profesor Madya Dr. Noraiham Binti Mohamad

ABSTRAK

Penyelidikan ini menumpu terhadap kekuatan tegangan dan ciri-ciri redaman getaran bagi getah Chloroprene (CR) yang diisi dengan grafin nano platelets (GNPs) dan bahan pengisi carbon blacks (CBs). Penyelidikan ini merupakan satu kajian yang dilakukan di bawah kerjasama Kilang Saiko Rubber (M) Sdn Bhd yang merupakan pengeluar adunan getah yang berlokasi di Senawang, Negeri Sembilam. Penyelidikan ini bermatlamat untuk mengenal pasti kekuatan tegangan dan ciri-ciri redaman getaran bagi getah Chloroprene (CR) yang diisi dengan grafin nano platelet dan bahan pengisi carbon black. Penyelidikan ini juga menganalisasi sifat morfologi dan terma untuk menyokong hasil ujian kekuatan tengangan dan ciri-ciri redaman getaran adunan tersebut. Penyelidikan ini bermula dengan penyediaan adunan CR dengan menggunakan pencampur mixer pada suhu 95°C dan kelajuan pemutar 800 rpm. Parameter pemprosesan yang digunakan adalah berdasarkan cadangan kilang. Nanokomposit polimer diuji terhadap ciri matang melalui analisis meter alir Monsanto berdasarkan ASTM D 2084, kekuatan tegangan melalui ujian tegangan (U-CAN). Sifat terma dan morfologi juga dikaji. Nanokomposit polimer juga diuji terhadap ciri-ciri redaman getaran. Seterusnya, pendapat kajian tersebut disokong dengan ciri morfologi dan terma melalui penjelmaan Fourier infra-merah (FTIR), sinar-X (XRD), kemikroskopan elektron imbasan (SEM) dan pengimbasan calorimetri (DSC). Pencampuran GNPs ke dalam matrik CR menunjukkan keserasian yang baik dengan peningkatan pada sifat tegangan dan redaman getaran. Hasil ujian XRD dan FTIR juga menunjuk keadaan serakan GNPs dalam matrik CR. Secara kesimpulannya, pengisian GNPs ke dalam matrik CR telah menunjukkan peningkatan sifat mekanikal dan redaman getaran yang mana ia berfaedah dalam aplikasi getah pencagak engin.

ABSTRACT

This research focuses on tensile and damping properties of Graphene Nanoplatelets (GNPs)/Carbon blacks (CBs) filled Chloroprene (CR) nanocomposite. The research is an industrial cooperated project in which it is supported by Saiko Rubber (M) Sdn Bhd, a rubber compounding manufacture industry located at Senawang, Negeri Sembilan. The study aims to determine the tensile and damping properties of the GNPs/CBs filled CR nanocomposite as well as to analyze the morphological of the GNPs/CBs filled CR nanocomposite to further clarify the tensile and damping properties of the nanocomposites. The incorporation of the GNPs/CBs hybrid system is to enhance the tensile and damping properties of the CR nanocomposites on the existing CR nanocomposite formulation. In the beginning of the research, CR compound was produced by using Intensive Mixer at temperature 95°C and motor speed at 800rpm. The processing parameter was based on the suggestion from industry. Then, the compound was filled with nanofillers (GNPs/CBs). The CR nanocomposites were then vulcanized using hot press at 160°C after being tested for cure characteristics using Monsanto moving die rheometer (MDR 2000) accordance to ASTM D 2084, tensile properties was conducted by using universal testing machine (U-CAN) accordance to JIS K 6251 and damping properties by using accelerometer (Free Vibration Test). Morphological characteristics were also studied. Next, the findings were further supported by morphological and thermal evaluation by using Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM) analysis and Differential Scanning Calorimetry (DSC) respectively. The introduction of GNPs into the CR matrix showed good compatibility with respect to the observed enhancement on the tensile and damping properties. XRD and FTIR pattern had provided adequate explanation as well on the dispersion of GNPs in the CR matrix. In overall, the introduction of GNPs into the CR matrix is able to provide improved mechanical and damping properties which is beneficial for the engine mounting application.

DEDICATION

For my father, who taught me that the best kind of knowledge to have is that which is learned for its own sake.

For my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

For my university, who taught me that the greatest achievement to have is that which is never give up along the progress.

For my supervisor, who taught me that even the biggest challenge can be overcome if initiative action is taken.

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LIST OF ABBREVIATIONS

ASTM	-	American standard testing method
BNC	-	Bayonet Neill Concelman connector
BS	-	British standard
C	-	Carbon
CBs	-	Carbon Black
CH	-	Hydrocarbon
CNTs	-	Carbon nanotubes
CR	-	Chloroprene Rubber
CS	-	Control sample
DSC	-	Differential scanning calorimetry
EB	-	Elongation at break
EPDM	-	Ethylene propylene diene monomer
DAQ	-	Data acquisition
DMA	-	Dynamic mechanical analysis
e.g	-	Example
et. al.	-	and others
etc	-	Et cetera
FTIR	-	Fourier transform infrared spectroscopy
GNPs	-	Graphene nanoplatelets
i.e	-	In example
JIS	-	Japanese Industrial Standards
LGM	-	Lembaga Getah Malaysia
MgO	-	Magnesium Oxide
M_H	-	Maximum torque
M_L	-	Minimum torque
M_H-M_L	-	Torque difference
M100	-	Modulus at 100% elongation
M300	-	Modulus at 300% elongation
MWNT	-	Multi-walled carbon nanotube

NR	-	Natural rubber
NVH	-	Noise, vibration and harshness
Phr	-	Parts per hundred rubber
RMS	-	Root Mean Square
SEM	-	Scanning electron microscopy
Si	-	Silica
Tg	-	Glass transition temperature
TS	-	Tensile strength
Ts_2	-	Scorch time
T_{90}	-	Cure time
Tm	-	Melting temperature
UTM	-	Universal testing machine
XRD	-	X-ray diffraction
Wt%	-	Weight percent
W_0	-	Initial mass of samples before the immersion in toluene
W_1	-	Mass of samples after the swelling

LIST OF UNITS

^{o}C	-	Degree Celsius
$^{o}C/min$	-	Degree celsius per minute
m/s	-	Meter per second
mm/s	-	Milli meter per second
%	-	Percentage
min	-	Minute
kg	-	Kilogram
mm	-	Millimeter
µm	-	Micrometer
s	-	Second
nm	-	Nanometer
g	-	Gram
Hz	-	Hertz
dNm	-	Decinewton metre

CHAPTER 1
INTRODUCTION

1.1 Research Background

Engine mount is also known as motor mount and it is an essential component to a properly functioning car. The running engine has a tendency to torque or twist to one side and to rock especially during accelerating or having load on it. The engine mount will dampen that movement to protect components from damage. Besides, it is also designed to provide a comfortable environment to the passenger by reducing the noise and vibration from reaching to the passenger compartment (Darsivan and Martono, 2006).

Vibration is produced as a result of the transfer of energy commonly generated by the rotating machinery. This vibration may bring the effect on the overall performance of the equipment and thus affect its longevity. Therefore, a well vibration isolating system can enhance a vehicle's NVH (noise, vibration, and harshness) (Kowalczyk *et al*., 2004). The role of the engine mount is not only to secure the engine in place, but also to reduce the engine vibration experienced inside the vehicle.

Engine mounts are commonly produced by using rubber material. The rubber material in engine mounts is to ensure no direct metal to metal contact of the engine to the car body. Engine mounts rubbers are used then to provide vibration attenuation in isolating the vibration source (Ripin and Ooi, 2010). Hence, a study of damping measurement of the engine mount rubber is needed to obtain the information of damping characteristics in real operation condition as it roles as damper to damp the vibration and noise created by the engine.

In current engine mounting application, the mounting rubber used is commonly utilizing a single polymer matrix composite namely natural rubber (NR). Although natural rubber has very good shock absorbing characteristics, it has limitations. NR has a poor resistance to heat and ozone (Boonsong *et al*., 2008). This limitation is significant because rubber mounting is subjected to ozone deterioration. Synthetic rubber such as Chloroprene Rubber (CR) is also used in engine mounting due to its good rubber to metal attachments. These rubbers alone do not possess excellent damping, heat and dynamic fatigue resistance well to the engine mount system. Hence, polymer nanocomposites can be implemented, where the incorporation of dispersed nanofillers into a polymer matrix will provide materials with tailored and controlled properties. Mechanical strength and stiffness which are not inherent in pure polymers or conventional composites is improved dramatically with a very low level of nanofiller loading. Therefore, it is necessary to study the vibration damping characteristics with a determination to develop polymer nanocomposites that not only show excellent mechanical properties but also good in vibration damping capability.

1.2 Problem Statement

Motor mount is the component of a vehicle that is commonly made of solid rubber or polyurethane that is bonded to metal brackets. They are significant to perform their role in the efficient functioning of automobile systems. Generally, these engine mounts play the important roles in automotive especially to the effects on the noise and vibration harshness (NVH) characteristics. A bad engine mount would lead to more noticeable vibration inside the vehicle as well as the raise of engine noise, or excessive engine movement (Kowalczyk *et al*., 2004). Therefore, too much engine movement impose the strain on the driveline and even interrupt normal clutch and transmission operation. Hence, a study of dynamic damping measurement of the engine mount rubber is important in order to provide the information of damping characteristic.

The mounted rubber used in engine mount is mainly focus in the utilizing of a single polymer composite. However, the poor ability of these rubber alone in posing excellent damping, heat and dynamic fatigue resistance well to the engine mount system is not adequate to damper the vibration generated from engine. This limitation of the mounts

rubber lead researchers to investigate on possible advanced materials to fulfil the aspect of NVH characteristics thus reducing the costs and in the same time prolonging the service life.

CR is moderately resistant to both petroleum oil and weather. Graphene has been widely used in rubber composition with its extraordinary mechanical, thermal and electrical properties (Kuila *et al*., 2012). The incorporation of graphene brings its unique graphene function into the compound materials. Aside from this, the nanofillers dispersion acts as connector of interfacial interaction become an important parameter for the enhancement of mechanical properties.

The approach of incorporating GNPs and CBs with CR rubber could possibly improve the limitation of properties of both single rubber components. Therefore, the goal of this study is to compare the tensile and damping properties of the GNPs/CBs filled CR nanocomposites for engine mounting. It is a wise step to fill up the gap in the literature.

1.3 Objectives

The objectives are as follows:

(a) To prepare Graphene Nanoplatelets (GNPs)/Carbon blacks (CBs) filled Chloroprene (CR) nanocomposite by using melt compounding.

(b) To determine the tensile and damping properties of the GNPs/CBs filled CR nanocomposite.

(c) To analyse the morphological properties of the GNPs/CBs filled CR nanocomposite to further clarify the tensile and damping properties of the nanocomposites.

1.4 Scopes of the Research

The scopes of research are as follows:

(a) Preparation of GNPs/CBs filled CR compounds through melt compounding by using Intensive Mixer at temperature 95°C, 800rpm rotor speed. Then, the GNPs/CBs filled CR compounds were vulcanized by using a hot press at 160°C and the time T_{90} determined from cure characteristics by using Monsanto moving die rheometer (UR-2010) following ASTM D 2084.

(b) The vulcanized CR nanocomposites were tested for tensile properties by using universal testing machine (U-CAN) following JIS K 6251 and damping properties by using accelerometer.

(c) The findings were further supported by morphological and structural properties by using Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and X-ray Diffraction (XRD) respectively and thermal evaluation by Differential Scanning Calorimetry (DSC).

1.5 Rationale of Research

The rational of research as follows:

(a) There is less study to investigate the properties of GNPs/CBs filled CR nanocomposites in the market.

(b) The researchers did the study emphasize more in the mechanical properties of graphene-based polymer nanocomposites meanwhile the investigation in vibration damping behaviour of nanoparticle reinforced rubber is relatively low.

(c) To gain more knowledge behind the experimental research by improve the engine mounting quality. Develop a better material used in engine mounting by studying tensile and damping properties of GNPs/CBs filled CR nanocomposites.