FABRICATION, CHARACTERISATION AND PROPERTIES OF POLYSILOXANE RICE HUSK SILICA COMPOSITES

MOHD AZHAM BIN AZMI

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To my precious Allah S.W.T,
who gave me new life, hope and purpose of life.

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ABSTRACT

The polysiloxane silica composites were fabricated and characterised as to elucidate the feasibility of casting (CA) and compression (CO) method. Besides, the contribution of rice husk silica (RHA SiO_2) and crystalline silica (CS) in enhancing the composites properties were also investigated. Moreover, fabricated composites were applied in hand grinder as a vibration damper and the performance had been analysed. The important issues covered in this study were the contribution of RHA SiO_2 instead of using CS as a filler and the investigation of most ideal parameter in improving thermal, physical, mechanical and vibration properties of composites. The polysiloxane composites were analysed and compared with various parameters i.e; composition of fillers (2wt% to 12wt%) and curing temperatures (room temperature (RT), 65 and 100˚C). Addition of 10wt% RHA SiO_2 had found to contribute better performance compared to CS addition, accredited to RHA SiO_2 density and surface morphology. As for the fabrication effects, CO method was found to offer composites with better tensile and vibration properties. However, as for the thermal behavior, CA method yielded composites with better thermal stability due to better filler distribution on surface of the composites. On the other hand, the increment of curing temperature does not show significant effect in improving thermal properties as the thermal stability were decreased due to interferences of curing network stability. However, the polysiloxane composites cured at 65˚C and 100˚C were found to offer better tensile and vibration properties. Throughout the observations, the maximum perfomance of thermal, tensile and vibration behavior for polysiloxane composites were achieved by addition of 10wt% RHA SiO_2, fabricated using CO method and cured at 100˚C.

ABSTRAK

Komposit polysiloxane silika dihasilkan dan diperincikan bertujuan mengenal pasti sumbangan kaedah tuangan (CA) dan mampatan (CO) terhadap sifat bahan komposit. Selain itu sumbangan silika sekam padi (RHA SiO_2) dan silika terhablur (CS) dalam meningkatkan sifat bahan komposit turut dikenal pasti. Komposit polysiloxane silika turut diaplikasikan pada mesin canai tangan sebagai peredam getaran dan prestasinya dianalisa. Antara isu penting yang diketengahkan di dalam kajian ini adalah sumbangan RHA SiO_2 berbanding CS sebagai pengisi dan pencarian parameter yang paling ideal untuk meningkatkan sifat terma, fizikal, mekanikal dan getaran. Komposit polysiloxane silika juga turut dianalisa dan dibandingkan dengan pelbagai parameter seperti suhu terawat (RT, 65˚C and 100˚C) dan peratusan berat (wt%) pengisi, iaitu antara 2wt% ke 12wt%. Penambahan 10wt% RHA SiO_2 didapati telah menyumbang prestasi lebih baik berbanding penambahan CS, kesan daripada ketumpatan dan morfologi permukaan RHA SiO_2. Dari sudut kesan fabrikasi, kaedah CO menawarkan sifat tegangan dan getaran yang lebih baik. Walau bagaimanapun, kaedah CA telah menawarkan sifat terma yang lebih baik berikutan susunan pengisi pada permukaan komposit. Melalui pemantauan ke atas suhu terawat komposit, peningkatan suhu terawat tidak memberi kesan dalam menambah baik sifat terma berikutan terdapat penurunan di dalam kestabilan terma disebabkan oleh gangguan terhadap kestabilan jaringan terawat. Walau bagaimanapun, komposit polysiloxane terawat pada suhu 65˚C and 100˚C menawarkan peningkatan sifat tegangan dan getaran. Secara keseluruhan, sifat maksima bahan komposit polysiloxane boleh dicapai melalui penambahan 10wt% RHA SiO_2 sebagai pengisi, difabrikasi melalui kaedah mampatan dan terawat pada suhu 100˚C.

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LIST OF SYMBOLS AND ABBREVIATIONS

CA	-	Casting
CO	-	Compression
CS	-	Crystalline Silica (Current Study)
M_c	-	Mass of Composite, g
M_f	-	Mass of Filler, m
M_m	-	Mass of Matrix, g
ρ_c	-	Density of Composites, g/cm^3
ρ_f	-	Density of Filler, g/cm^3
ρ_m	-	Density of Matrix, g/cm^3
RHA SiO_2	-	Rice Husk Silica (Current Study)
RT	-	Room Temperature
RTV	-	Room Temperature Vulcanised
V_c	-	Volume of Composites, g
wt%	-	Weight Percentage

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CHAPTER 1

INTRODUCTION

1.1. Introduction

Particulate polymer composites are also known as filled polymers due to the incorporation of filler material in form of particle. Particulate composites consist of heterogeneous systems which imply that, the filler and polymers flow and disperse together during processing (Leblanc, 2009).

Particulate polymer composites offer interesting mechanical, physical and rheological properties resulting from polymer matrix and filler dispersed phase interaction. Polymer matrix and filler would have to be prepared through mixing process which is requires specific equipment in order to achieve uniform dispersion of fillers in the polymer matrix (Pal, 2010)

The importance of filler addition on polymer is to modify properties, either mechanical properties in example stiffness, modulus, or physical properties for conductivity or density or rheological properties such as viscoelasticity or viscosity (Leblanc, 2009).

This study focuses on improving polysiloxane properties by incorparation of silica filler. Polysiloxane or so called as silicone rubber were filled with naturally derived silica produced *via* rice husk burning designated as RHA SiO_2 and Crystalline Silica (CS). Several previous studies have shown that filling polysiloxane with reinforced filler enhanced polysiloxane in terms of its physical, mechanical and chemical properties (Ahmed, Nizami, & Riza, 2014).

Polysiloxane is categorised as an elastomer which is in the polymeric material family. Generally, polysiloxane are known for their biocompatibility, high thermal stability, hydrophobic nature, electrical and release properties (Jerschow, 2001). Polysiloxane also offer rubber-like properties due to the outstanding elasticity properties. Elasticity of rubber like material is definitely the most important parameter in reducing vibration source of machine to avoid hand arm vibration syndrome that may affect neurological and vascular disorders (Chaturvedi, Kumar, & Singh, 2012; J. Singh & Khan, 2014).

1.2. Problem Statement

The usage of engineering works and processes which involved the application of powered tool leads to exposure of hand arm vibration among operators. The vibration source may arise from rotating and percussive hand held power tool. Hand transmitted vibration also may occur from vibrating workpieces. Extreme hand arm vibration would affect hand arm neurological and motor functions and induce disturbances in finger blood flow (BS EN ISO, 2001). Curent practice, the most used material as a vibration damper were polymer and elastomer material including polysiloxane. High elasticity of polysiloxane is the most suitable candidate in reducing vibration source. Thus, in order to elucidate the performance of polysiloxane and filled polysiloxane composites as a vibration damper, the contribution of silica as a filler in reducing the hand arm vibration of portable hand grinder were revealed.

Thermal degradation is a common problem of polymer material which leads to material properties decreased. Heat, lights and chemicals are the main cause of

polymer degradation (Moeller, 2007). In order to reduce the tendency of polymer to degrade, the role of silica as thermal stability agent were analysed. Silica offers high thermal properties with thermal coeffiecient at 0.55 10^{-6}/°C, and thus by combining with polysiloxane, it had offered thermal stability.

Since silica acts as a reinforcing filler in polysiloxane matrix, it can also improve the mechanical properties of the composites. However the suitable filler-matrix ratio have to be identified, since the contribution of filler addition in enhanced material properties are limited. Once filler composition exceeds the filler maximum ratio, agglomeration or weak filler-matrix bonding of the composites will occur and lead to decrement of mechanical properties (G V Kozlov, IAnovskii, & Zaikov, 2010; Georgii V Kozlov, 2015). Thus, various parameter such weight percentage (wt%) of filler, curing parameter and characteristics of filler during mixing could be considered in order to improve the thermal, tensile and vibration behavior.

Rice husk as one of the agricultural waste is indeed one of many efforts in controlling our environment sustainability. The usage of manufactured resources compared to natural resources may produce pollution and waste that may affect our environment. Thus, the current study explored and compared the contribution two types of silica namely RHA SiO_2 and CS. The ability of RHA SiO_2 properties in replacing CS were revealed. Besides the mass production method in producing RHA SiO_2 were also revealed by controlling the incineration holding hours and temperature.

1.3. Objectives

In accomplishing successful fabrication and characterization of Polysiloxane Silica Composites, the following objectives had been fulfilled:

(i) To investigate the suitability of naturally derived amorphous rice husk silica (RHA SiO_2) and manufactured crystalline silica (CS) as filler in polysiloxane : silica composites.

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