CHARACTERIZATION AND PROPERTIES OF POLYPROPYLENE / RECYCLED ACRYLONITRILE BUTADIENE RUBBER / PALM KERNEL SHELL COMPOSITES

by

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A thesis submitted in fulfillment of the requirements for the degree of Master of Science in Environmental Engineering

School of Environmental Engineering
UNIVERSITI MALAYSIA PERLIS
2018

UNIVERSITI MALAYSIA PERLIS

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Title	CHARACTERIZATION AND PROPERTIES OF POLYPROPYLENE / RECYCLED ACRYLONITRILE BUTADIENE RUBBER / PALM KERNEL SHELL COMPOSITES
Date of Birth	28 JUNE 1991
Academic Session	2017/2018

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ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah SWT. for giving me blessing, strength, chance and the time to complete my research and theses successfully. I would also like to express my gratitude for people who had helped and supported me in completing my research successfully.

First, I would like to express my heartfelt thanks to my loving parents, my father Marwan Affandi and my mother Sri Wahyuni. Without your pray and love, i would not be able to finish my research and theses and this definitely would have been a lot harder to achieve. For my lovely husband, Abdi Suheri. Thank you for your understanding through good and bad times, always listening and giving good suggestion for me. And for my brother Rangga Pratama Affandi, my sister Indri Dwi Wardhani and also my nephew Radim Kaisan Affandi. Thank you for always cheering me up.

Special thanks to my main supervisor, Dr. Ragunathan A/L Santiagoo for his generous guidance, kindness and patience with me throughout the project. I would also like to convey my sincere appreciation to my supervisor for willing to share his knowledge and experience as well as giving constructive advices.

I would also like to thank my co-supervisor, Dr. Mohamad Kahar bin Ab Wahab for his constructive and helpful advices throughout the research. And not forgotten to thank all of the technicians and PLVs from School of Environmental Engineering, School of Bioprocess Engineering, School of Material Engineering and School of Manufacturing Engineering Universiti Malaysia Perlis for their continuous guidance and assistance during the preparation of my samples as well as their technical assistance during my laboratory work.

My special appreciation goes to my colleagues, Ms. Nurul Syazwani Othman, Mr. Mustaffa Zainal, Mrs. Nabila, Ms. Izzah, Mrs. Nurliyana, Mrs. Nasuha, Ms. Mira and other students who are not name here for being my friends and give big support for me through the research work and compelete my theses. Furthermore, a big thank to School of Environmental Engineering for giving me a valuable chance to complete my master degree.

Last but not least, my special thanks to Universiti Malaysia Perlis for giving me new experience and opportunity to continue my master degree. Thank you!

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LIST OF ABBREVIATIONS

γ-MPS	γ-methacryloxypropyltrimethoxysilane
ASTM	American Standard for Testing and Materials
CMC	Ceramic Matrix Composites
DSC	Differential Scanning Calorimetry
DTG	Derivative Thermogravimetric Analysis
FTIR	Fourier Transfrom Infrared
MMC	Metal Matrix Composites
NaOH	Sodium Hydroxide
NBR	Acrylonitrile Butadiene Rubber
NBRr	Recycled Acrylonitrile Butadiene Rubber
PKS	Palm Kernel Shell
PMC	Polymer Matrix Composites
PP	Polypropylene
PPMAH	Polypropylene Maleic Anhydride
PVC	Polyvinyl Chloride
SEM	Scanning Electron Microscopy
TGA	Thermogravimetric Analysis
TPE	Thermoplastic Elastomer
TOR	Trans-Polyoctylene Rubber

LIST OF SYMBOLS

μm	Micrometer
E_b	Elongation at Break
M_n	Number average molecular weight
M_w	Weight average molecular weight
Phr	Part per hundred resin
W_d	Original dry weight of the samples
W_m	Weight of the samples after water and oil exposure
M_t	Moisture rate of the samples at the time (t)
M_∞	Moisture rate of the samples at the equilibrium
D	Diffusion coefficient
S	Sorption coefficient
P	Permeability coefficient
T_{onset}	Initial degradation temperature
T_{70}	Temperature at 70% weight
T_{maxdeg}	Final degradation temperature
T_g	Glass transition temperature
T_c	Crystallization temperature
T_m	Melting temperature
X_{com}	Degree of crystallinity of composite
X_{pp}	Degree of crystallinity of PP fraction
ΔH_f	Heat of fusion of composites
ΔH^o_f	Heat of fusion of neat PP
W_f	Weight fraction

Pencirian Dan Sifat Sifat Komposit Polipropilena / Getah Akrilonitril Butadiena Kitar Semula / Tempurung Kelapa Sawit

ABSTRAK

Termoplastik elastomer yang berasaskan polipropilena / getah akrilonitril butadiena kitar semula yang diisi oleh tempurung kelapa sawit telah dihasilkan. Semua sampel ujian disediakan dengan menggunakan mesin pencampur dua kisar giling yang dipanaskan pada suhu 180 ^{o}C dengan kelajuan 15 putaran setiap minit dengan jumlah masa pencampuran selama 9 minit. Semua sampel yang telah dicampurkan itu kemudian dibentuk menggunakan acuan mampatan pada suhu 180 ^{o}C dan diikuti dengan penekanan sejuk dengan jumlah masa selama 12 minit. Saiz partikel bagi PKS dan NBRr yang digunakan di dalam kajian ini adalah 100-200 µm. Kesan daripada pemuatan NBRr dan PKS sebagai siri kawalan telah disediakan dan diselidik. Kajian untuk sifat-sifat komposit tertumpu kepada penyelidikan kesan agen penserasi seperti maleik anhidrida tercantum polipropilena (PPMAH) dan getah trans-polioktilena (TOR) dan juga ɤ-MPS sebagai agen pengkupel. Sifat-sifat mekanikal, pencirian morfologi, analisis FTIR, sifat-sifat terma, penyerapan air dan tingkah laku pembengkakan telah dikaji. Sifat-sifat mekanikal dan terma bagi semua komposit yang dirawat telah meningkat. Sifat-sifat yang lebih baik seperti tensil, kestabilan terma, penghabluran, penyerapan air dan tingkah laku pembengkakan komposit telah ditunjukkan oleh PPMAH dibandingkan dengan penserasian TOR. Pengubahsuaian rawatan dari pengisi PKS dengan menggunakan ɤ-MPS telah meningkatkan keserasian kimia, perlekatan antara muka dan pengagihan tekanan diantara pengisi PKS dan matrik PP/NBR yang menghasilkan sifat yang lebih baik.

Characterization And Properties Of Polypropylene / Recycled Acrylonitrile Butadiene Rubber / Palm Kernel Shell Composites

ABSTRACT

Thermoplastic elastomer composites was developed by using polypropylene (PP) / recycled acrylonitrile butadiene rubber (NBRr) filled by palm kernel shell (PKS). All test samples were prepared by using heated two roll mill machine at temperature of 180 °C at a speed of 15 rpm with the total mixing time of 9 minutes. All the compound samples were shaped using compression moulding at temperature of 180 °C and followed by cool pressing for total time of 12 minutes. The particle sizes of the PKS and NBRr used in this study were 100-200 µm. The effect of NBRr loading and PKS loading were prepared and investigated as control series. The studies of composites properties were aimed to investigations of the effects of compatibilizer such as polypropylene maleic anhydride (PPMAH) and trans-polyoctylene rubber (TOR) and also ɤ-MPS as a coupling agent. The mechanical properties, morphological characterization, FTIR analysis, thermal properties, water absorption and swelling behaviour were investigated. Better properties such as tensile, thermal stability, crystallinity, water absorption and swelling behaviour of composites showed by PPMAH compared with TOR compatibilization. The treatment modification of PKS filler by using ɤ-MPS have improved the chemical compatibility, interfacial adhesion and stress distribution between PKS filler and PP/NBRr matrix which results in better properties.

CHAPTER 1 : INTRODUCTION

1.1 Research Background

Recently thermoplastic elastomer composites (TPE) have gained much attention from researchers to produce a new polymer composites materials. Basically, thermoplastic elastomer composites can be made by combining a thermoplastic polymer with a suitable elastomer material. It produces typical properties of elastomer materials but it can still be processed like thermoplastics. The main advantages of the TPE are simple compounding, easy recycling, reprocessable and low cost (Kmetty, Bárány, & Karger-kocsis, 2012; Sae-oui et al., 2010).

Thermoplastic matrix materials can be classified as polyolefins (polyethylene, polypropylene), vinylic polymers (polyvinyl chloride (PVC), polyamides, polyacetals, polyphenylenes, polysulphone and polyetheretherketone (PEEK), polystyrene, polycarbonate, polyether imide and so on (Akovali, 2001; Jose et al., 2012). One of the most commonly used thermoplastic is polypropylene. Polypropylene (PP) is synthesized by the polymerization of propylene, a monomer derived from petroleum products (Anne-Marrie & Joey, 2004). PP provides some advantages such as good resistance of moisture uptake, good chemical resistance and high thermal stability. However, the usage of polypropylene has been reduced due to the expensive cost of the petroleum derived products and also environmental hazard.

Addition of elastomer materials into the thermoplastic composites may improve the properties of the resulting composites. Acrylonitrile butadiene rubber (NBR) is one of the elastomeric materials used in the thermoplastic elastomer composites. NBR is commonly used in a wide variety of application areas requiring oil, fuel and chemical resistance. NBR has an excellent capability to resist in oil, water, alcohols and chemical. NBR is used in many aplications such as belt conveyor, hydraulis hose, roll covers, oil field packers, and seals for all kinds of plumbing and appliance application (Santiagoo, Ismail, & Hussin, 2011).

Nowadays, the recycling of waste materials has become very important due to the environmental reasons. Consumption of recycled acrylonitrile butadiene rubber (NBRr) or known as nitrile rubber gloves has increased rapidly in Malaysia. Since this country is one of the world's largest of exporter and producer of nitrile rubber gloves. There is high demand of the nitrile rubber gloves (NBRr) particularly due to health awareness of the world population and consumption from industries. Unfortunately, NBRr is one of the non degradable waste materials. Discarding the NBRr and burning it into the landfill space are not recommended because they may cause environmental problems. Research on recycling of nitrile rubber gloves has been conducted in order to solve the environmental issue and also to create a value added of the waste materials (Ahmad, Ismail, & Rashid, 2016).

Recycled nitrile rubber gloves made of synthetic rubber that contain no latex proteins, have excellent resistance to wear and tears, resistance to many types of chemicals. The nitrile rubber gloves are commonly used because of their high degree of flexibility and excellent solvent resistance. Furthermore, nitrile rubber gloves have a good resistance to many oils and some acids, making them a good choice for many manufacturing environments (Ridhwan et al., 2014).

Properties of thermoplastic elastomer composites can be improved by the addition of natural filler into the composites. Nowadays, natural filler composites have received increasing attention compared to synthetic fiber composites which may be caused of the advantages of natural filler such as biodegradability, renewability, low price, low density, problem free disposal and less abrasiveness to equipment. Addition of natural filler such as palm kernel shell, kenaf core, empty fruit bunch, sagoo, sisal, coir, and hemp into composites can improve the properties of the composites. However, there is a main disadvantage of the natural filler composites that is the incompatibility between the hydrophilic natural fillers and hydrophobic polymer matrix. The incompatibility leads to poor adhesion between the fillers and polymer matrix, poor wettability, the difficulties of homogeneous mixing and easy to be agglomerate during processing (Anuar & Zuraida, 2011; El-shekeil et al., 2014; Yeh et al., 2015).

However, there is limited research on using palm kernel shell as a natural filler to develop a new composite based on the polypropylene (PP) and recycled acrylonitrile butadiene rubber (NBRr) as the thermoplastic elastomer natural filler composites. Hence, this study is carried out to evaluate the mechanical, thermal and morphological properties of PP/ NBRr/ PKS composites.

1.2 Problem Statement

Combinations of PP/NBRr polymer matrix using PKS natural filler looks to be an attractive way to obtain a thermoplastic elastomer with good oil resistance, good mechanical properties and easy processability. However, this combinations are found to be highly incompatible. The hydrophobicity of polymer matrix and hydrophilicity of natural filler are the major reasons of incompatibility between them. The incompatibility leads to poor adhesion between the fillers and polymer matrix, poor wettability, the difficulties of homogeneous mixing and easy to be agglomerate during processing (El-shekeil et al., 2014).

Another problem using natural filler in composites is the higher moisture uptake which affects the durability of the composites. As the natural filler absorbs moisture, the composites swell and affect the surrounding matrix, which start to crack and weaken filler matrix interface interactions. It is therefore necessary to do the treatment in order to improve the water resistance of fillers and promote interfacial adhesion. The performance of fillers is critical to obtain the improved physical and mechanical properties of the resulting composites. Many researchers have developed various methods in thermoplastic elastomer composites such as compatibilizing agent using polypropylene maleic anhydride (PPMAH), trans-polyoctylene rubber (TOR) and coupling agents using silane to improve the filler/matrix adhesion.

Many researchers were investigated polypropylene maleic anhydride (PPMAH) and trans-polyoctylene rubber (TOR) as compatibilizer in the TPE composites. It was found that better tensile properties, thermal and swelling properties of the resulting composites. The compatibilizing agent can promote better matrix/filler interaction due to the anhydride groups of PPMAH may react with the surface hydroxyl groups on natural fillers. The chemical modification using silane coupling agent have functions to create a chemical bridge between filler and matrix at the interface.

1.3 Objectives of Study

The main focus of this study is to develop a thermoplastic elastomer (TPEs) filled natural filler composites using polypropylene, recycled acrylonitrile butadiene rubber and palm kernel shell. It is also to find a solution to the existing problem of abundant nitrile rubber gloves and palm kernel shell as biomass waste. The main objectives of the study are:

1. To study the effects of recycled acrylonitrile butadiene rubber (NBRr) loading using polypropylene maleic anhydride (PPMAH) and trans-polyoctylene rubber (TOR) as compatibilizer on mechanical, morphological, thermal, water absorption and swelling behaviour properties of PP/NBRr/ PKS composites.
2. To study the effects of palm kernel shell (PKS) loading using γ-methacryloxypropyltrimethoxysilane (γ-MPS) as coupling agent on mechanical, morphological, thermal, water absorption and swelling behaviour properties of PP/NBRr/PKS composites.
3. To study the effects of thermal aging on mechanical properties of PP/NBRr/PKS composites using polypropylene maleic anhydride (PPMAH) and trans-polyoctylene rubber (TOR) as compatibilizer and using γ-methacryloxypropyltrimethoxysilane (γ-MPS) as coupling agent .