TENSILE, THERMAL AND FLAMMABILITY PROPERTIES OF DATE PALM FIBER FILLED RECYCLED TERNARY BLENDS AND COMPOSITES

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TENSILE, THERMAL AND FLAMMABILITY PROPERTIES OF DATE PALM FIBER FILLED RECYCLED TERNARY BLENDS AND Composites

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To my beloved husband Nassir Hamid

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ABSTRACT

High density polyethylene (HDPE), low density polyethylene (LDPE) and polypropylene (PP) are olefinic thermoplastics polymers that are most commonly found as municipal solid waste in many countries. Their accumulation has become a major concern to world agencies and environmental conservationists due to their harmful effect on environment. The objective of this study is to develop a mechanically strong, and thermally insulating, flame retardant, date palm leaf fibre (DPLE) filled composites based on recycled HDPE, LDPE and PP. Maleated polypropylene (MAPP) and maleated polyethylene (MAPE) were compared as coupling agents for the HDPE/LDPE/PP system. The effects of addition of MAPE and MAPP at 1, 3 and 5 wt% content were investigated. The addition 1 wt% MAPE acted as nucleating agent by increasing the crystallinity of the blends, resulting in improvement of the tensile strength from 20 to 22.7 MPa of the blend. On the other hand addition of 1 wt% MAPP marginally increased the tensile strength of the blend to 21 MPa from 20 MPa. The addition of 5, 10, 20 and 30 wt% DPLF fibre to the 1 wt% MAPE compatibilized ternary blend yielded composites with improved tensile properties. The composites with 10 wt% DPLF content showed the highest tensile strength of 25 MPa. Above 10 wt% DPLF content, agglomeration of the fibre in the matrix was noticed resulting in a decrease in the tensile strength. No improvement in the tensile strength was achieved with addition of 5 wt% DPLF loading in the composite. Additionally, 11% reductions in the effective thermal conductivity of the composites with 10 wt% DPLF was observed. This was attributed to low thermal conductivity of the DPLF compared to the matrix. The flame retardancy of the developed composites was significantly improved with the addition of magnesium hydroxide (Mg $(OH)_2$). However, the tensile strength of the composites was reduced. It was observed that addition of 10 wt% of Mg $(OH)_2$ led to improvement in the limiting oxygen index (LOI) by 22% compared with the composite without Mg $(OH)_2$. The developed composites have potential applications in low heat conducting roofing materials for the building construction industry.

ABSTRAK

Polietilena berketumpatan tinggi (HDPE), polietilena berketumpatan rendah (LDPE) dan polipropilena (PP) adalah polimer olefin yang paling banyak ditemui sebagai sisa pepejal perbandaran di kebanyakan negara. Pengumpulan mereka telah menjadi perhatian utama kepada agensi-agensi dunia dan pemuliharaan alam sekitar disebabkan oleh kesan berbahaya terhadap alam sekitar. Objektif kajian ini adalah untuk menghasilkan komposit HDPE, LDPE dan PP kitar semula berpengisi gentian daun pokok tamar (DPLF), bersifat mekanikal yang kuat dan berpenebat haba serta mempunyai sifat rencatan nyalaan. Polipropilena maleat (MAPP) dan polietilena maleat (MAPE) telah dibandingkan sebagai ejen pengserasi untuk sistem HDPE/LDPE/PP. Kesan penambahan MAPE dan MAPP pada kepekatan 1, 3 dan 5 wt% telah dikaji. Penambahan 1 wt% MAPE bertindak sebagai ejen penukleusan dengan meningkatkan penghabluran adunan. Hasilnya, peningkatan dalam kekuatan regangan daripada 20 kepada 22.7 MPa terhadap adunan itu telah dicapai. Bagi penambahan 1 wt% MAPP, hanya sedikit peningkatan dalam kekuatan regangan adunan, iaitu kepada 21 MPa daripada 20 MPa. Penambahan 5, 10, 20 dan 30 wt% gentian DPLF ke dalam adunan pertigaan yang diserasikan oleh 1 wt% MAPE menghasilkan komposit dengan peningkatan sifat-sifat regangan. Komposit dengan 10 wt% kandungan DPLF menunjukkan kekuatan regangan yang tertinggi, iaitu pada 25 MPa. Apabila kandungan DPLF adalah melebihi 10 wt%, aglomerasi gentian dalam matrik telah berlaku dan menyebabkan pengurangan dalam kekuatan regangan. Tiada peningkatan dalam kekuatan regangan yang dapat dicapai dengan penambahan 5 wt% kandungan DPLF dalam komposit. Pengurangan 11% dalam kekonduksian haba komposit telah diperhatikan dengan 10 wt% kandungan DPLF. Ini disebabkan oleh kekonduksian haba DPLF yang rendah berbanding dengan matrik. Rencatan nyalaan bagi komposit yang dihasilkan bertambah baik dengan penambahan magnesium hidroksida ($Mg(OH)_2$), namun kekuatan regangan komposit menurun. Penambahan 10 wt% $Mg(OH)_2$ membawa kepada peningkatan dalam LOI sebanyak 22% berbanding dengan komposit tanpa $Mg(OH)_2$. Komposit yang dihasilkan berpotensi sebagai bahan untuk membuat bumbung berkonduktif haba yang rendah dalam industri pembinaan.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

ΔG_m	-	Gibbs free energy change in mixture
ΔH	-	Enthalpy
T_c	-	Crystallization temperature
χ_c	-	Degree of Crystallinity
κ	-	Thermal conductivity
Q	-	Quantity of heat passing through a base area of the sample
E%	-	Percent elongation at break

LIST OF ABBREVIATION

LDPE	-	Low Density Polyethylene
HDPE	-	High Density Polyethylene
PP	-	Polypropylene
DSC	-	Different scanning calorimetry
TGA	-	Thermogravimetric analysis
SEM	-	Scanning Electron Microscopy
AFM	-	Atomic force microscopy
HFM	-	Heat Flow Meter
FTIR	-	Fourier Transform Infrared spectroscopy

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Polyolefin such as polyethylene (PE) and polypropylene (PP) have been used extensively for making composite materials due to their interesting physical and mechanical properties. PE is one of the most versatile and widely used thermoplastics in the world because of its near zero moisture absorption, excellent chemical inertness, low coefficient of friction and ease of processing. Polyethylene is classified into different categories based on itsdensity, such as low-density polyethylene (LDPE) and high-density polyethylene (HDPE) [1, 2]. PP is another type of polyolefin with excellent properties such as low cost, light weight, process ability higher modulus than PE and tough [1, 2].

These polyolefin represent the majority of commodity thermoplastics that are currently used in several applications. Since the production and consumption of these polymers is persistently increasing, the environmental impacts of polymer wastes have become an important problem for the society, governmental and non-governmental agencies [2].

Recycling of polymer waste has recently attracted attention mainly due to environmental concerns and the depletion of petroleum resources. According to the data obtained from General cleaning Project of Qatar GCP of waste production2011 [3], the municipal plastics waste consist of HDPE, LDPE and PP with 50%, 25% and 25% by weight respectively. Usually, the plastics waste end up in landfill which accumulates annually and an effective recycling program is necessary to address this issue [4].

Polymer blending has become an important field in polymer research and especially in the area of recycling. Therefore, blending of recycled polymers is considered as useful route for the development of new polymeric materials with wide range of properties [5].

The improvement in mechanical and physical properties of recycled materials depends on the adhesion of one phase into another. From the economic point of view, blending process is far less costly and less time consuming than producing new materials through synthesis procedures. Therefore adding compatibilizer is essential to improve the adhesion between the matrices. Some compatibilizers act as bonding agents or coupling agents such as maleic anhydride grafted polyethylene and maleic anhydride grafted polypropylene, they improve the adhesion between matrices as well as improve the bonding between filler and matrix [6, 7].

Natural fibers have attracted the attention of researchers as biodegradable reinforcing materials for composites fabrication as an alternative to the synthetic fibers. These natural fibers have several advantages including low cost, low density, biodegradable nature, abundantly available, absence of associated health hazards, easy fiber surface modification, and relatively nonabrasive. A lot of work has been done on the natural fiber reinforced thermoplastic composites which have various applications [8, 9,10].

The date palm trees are important crops in the Middle East generally and Qatar in particular. It plays an important part in the economic and social life of the people and their products are extensively used in daily life. Each year the date palm trees are pruned to remove old dead or broken leaves which are considered as an agricultural waste. The use of date palm fiber from agro waste can reduce waste disposal problems, the addition of date palm fiber to polymer waste with specific limit have improved the mechanical and physical properties of thermoplastic composites. Pre-treatment of hydrophilic DPLF is essential to be more compatible with hydrophobic polymer. Alkali treatment is a common method use to remove hemicellulose which is more susceptible to thermal degradation. It was reported that treatment with 1% NaOH could achieve the maximum tensile strength of single fiber [9, 11].

The weak point of recycle polyolefin composite reinforced by alkali treatment of DPLF is the high flammability of the composite. Enhancing their flame retardancy enlarge the range of their applications. Halogenated flame retardants, such as organic brominated compounds are often used to improve the flame-retarding properties of polymers; but these also increase both the smoke and carbon monoxide yield rates due to their inefficient combustion. The use of halogenated flame retardant has reduced due to their high toxicity. An alternative halogen free flame retardant such as magnesium hydroxide which is highly used in industries as filler due to its adequate endothermic decomposition with polymer composite [8] has been investigated.

1.2 Problem Statement

Commodity thermoplastics such as polyolefin which include all the different types of polyethylene and polypropylene are the most versatile and widely used thermoplastics due to their excellent properties, low cost and ease of production. These thermoplastics find a range of applications in everyday life from simple bread wraps to medical replacements. Due to their versatility of applications, enormous amount of plastic waste is generated daily. This plastics waste is not biodegradable and hence caused environmental problems. World conservationists and governmental agencies are becoming increasingly alerted on the menace of municipal plastics waste. Blending of recycled plastics waste such as HDPE, LDPE and PP could offer a solution to the problems of environmental degradation and to reduce the waste problem by producing material with newly acquired properties at a reasonable cost. However, these plastics limited miscibility and therefore, the use of a suitable compatibilizers required to improve interface adhesion. MAPP and MAPE are the two polymers that have been used as a compatibilizer for the PP and PE blends systems and were proved to be effective as compatibilizers. The mechanical properties of the synthesized blend can be further improved by the incorporation of reinforcing fillers such as date palm fiber. The addition of date palm fiber as a reinforcing filler can improve the mechanical and physical properties of the composites, reduce waste disposal problems and reduce production cost due its availability and low cost. The use of date palm fiber is also expected to reduce the effective thermal conductivity of the composites which may benefit some specific applications such as roofing materials.

Since polymers and natural fiber filled polymer composites have high flammability their applications are limited in some special fields such as oil fields and chemical explosive factories. The use of a flame retardant may improve the flame retardancy properties of the composites and widen their scope of applications. Halogenated flame retardants, such as organic brominated compounds increase both the smoke and carbon monoxide yield rates due to their inefficient combustion and hence their use as flame retardants have been reduced due to toxicity. Halogen free flame retardant such as magnesium hydroxide which release inert gas during thermal decomposition has been used by industries for many years as a filler. Therefore, magnesium hydroxide was used in this work as flame retardant enhances the flame retardancy of the date palm fiber reinforced HDPE/ LDPE/PP composites. To the best of our knowledge no similar study was reported in the open literature.

1.3 Objectives of Study

The overall objective is to develop a green composite based on halogen free flame retarded date palm filled recycled HDPE/LDPE/PP composites. The specific objectives are:

1) To determine the effect of DPLF content on thermal and tensile properties of recycled HDPE/LDPE/PP composites.
2) To investigate the effect of MAPE as coupling agent on DPLF filled recycled HDPE/LDPE/PP composites.
3) To study the effect of magnesium hydroxide on flammability on DPLF filled recycled HDPE/LDPE/PP composites.

1.4 Scope of Research

In order to achieve the objectives of this research the following activities were carried out:

(a) Sample preparation

In this research the blending of the recycled polymers was performed via melt intercalation method which includes optimization of blend ratio using twin screw extruder and the addition of the compatibilizer in the second stage.

The third stage involved the treatment of the fibers with 1% NaOH to remove the amorphous sections. The compounding of the fiber and blend matrix was achieved via melt intercalation using twin screw extruder and test samples were produced by injection molding process.

(b) Testing and Characterizations

Functional groups analysis of the untreated ar was achieved by Fourier Transform Infrared spectroscopy (FTIR**).** Tensile properties of blends and composites was conducted using an instron tensile tester. Measurement of thermal properties was achieved by differential scanning calorimeter (DSC), thermogravimetric analysis (TGA) andThermal conductivity test. The morphological analysis of specimens was done by Scanning Electron microscope type (SEM). The flammability tests was carried out via a limiting oxygen index (LOI)

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