EFFECT OF KAPOK HUSK CONTENT AND CHEMICAL TREATMENT ON PROPERTIES OF LINEAR LOW DENSITY POLYETHYLENE ECO-COMPOSITES

by

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LIST OF SYMBOL

°C	Degree Celcius
ΔH°_{f}	Heat of fushion for 100% crystalline LLDPE
ΔH_{f}	Heat of fushion for LLDPE
%	Percentage
μm	Micrometer
cm^{-1}	Reciprocal Wavelength (wavenumber)
cm^{3}	Centimetre cubic
X_{c}	Degree of crystallinity
wt%	Weight percentage
lb	pound
MPa	Mega pascal
rpm	Revolutions per minute
M_{t}	Percentage of water absorption
W_{o}	Original dry weight
W_{f}	After immersed weight
T_{dmax}	Decomposition temperature at maximum rate
T_{m}	Melting Temperature

LIST OF ABREVIATIONS

LLDPE	Linear Low Density Polyethylene
KH	Kapok Husk
SEM	Scanning Electron Microscope
FTIR	Fourier Transform Infrared
TGA	Thermogravimetric Analysis
DSC	Differential Scanning Calorimetric
DTG	Derivative Thermogravimetric
PP	Polypropylene
PE	Polyethylene
LDPE	Low Density Polyethylene
PLA	Poly Lactic Acid
PHA	Polyhydroxyalkanoate
PVS	Poly (vinyl sulfate)
ABS	Acrylonitrile butadiene styrene
PKS	Palm Kernel Shell
php	Part per hundred polymer
TPCS	Thermoplastic cassava starch composites
HDPE	High density polyethylene
RPF	Rambutan Peel Flour
ASTM	American Society for Testing Materials
rPP	Recycle Polypropylene
SA	Stearic Acid
UP	Unsaturated Polyester

NF	Nypa Fruticans
MMA	Methyl Metacrylate Acid
rLDPE	Recycle Low Density Polyetyhylene
PEAA	Polyethylene Acrylic Acid
RH	Rice Husk
UCS	Ultimate compressive strentgh
WF	Wood Flour
VTMOS	Vinyltrimethoxysilane
DCP	Dicumyl Peroxide
CA	Citric Acid
CAPS	Citric Acid Modified Pea Starch
CARS	Citric acid Modified Rice Starch
MAA	Methacrylic Acid
PMMA	Poly (Methyl Methacrylate)
CPH	Cocoa Pod Husk
OPEFB	Oil Palm Empty Fruit Bunch
RC	Regenerated Cellulose
SDS	Sodium Dodecyl Sulfate
CSP	Coconut Shell Powder
LA	Lactic Acid
AHA	Alpha Hydroxy Acid
ETSS	Elasteriospermum tapos seed shell

LIST OF NOMENCLATURES

C	Carbon
C=O	Carbonyl
C=C	Ethylene (IUPAC name: Ethene)
C-O-C	Ether
OH	Hydroxyl
CH_2	Methylene
CH_3	Methyl Group

Kesan Sekam Kekabu dan Rawatan Kimia Terhadap Sifat-sifat Eko-Komposit Linear Polietilina Berketumpatan Rendah

ABSTRAK

Penggunaan sekam kekabu (SK) sebagai isian di dalam linear polietilina berketumpatan rendah (LPEKR) telah dikaji. Kesan kandungan SK dan rawatan kimia terhadap sifat-sifat tensil, morfologi, terma, dan serapan air eko-komposit LPEKR/SK telah dikaji. Eko-komposit LPEKR/SK telah disediakan dengan menggunakan Brabender Plasticoder EC-Plus pada suhu 160°C dengan kelajuan rotor 50 rpm. Empat jenis rawatan kimia telah digunakan iaitu asid metakrilik (AMA), asid sitrik (AS), asid laktik (AL), dan sodium dodecyl sulfat (SDS). Keputusan menunjukkan penambahan SK ke dalam eko-komposit LPEKR telah mengurangkan kekuatan tensil, pemanjangan pada takat putus dan penghabluran. Walau bagaimanapun, modulus elastisiti dan serapan air dalam eko-komposit telah meningkat dengan peningkatan kandungan SK. Kehadiran SK telah menurunkan kestabilan terma LPEKR/SK eko-komposites berbanding LPEKR sendiri. Walau bagaimanapun, peningkatan SK meningkatkan kestabilan terma. Kajian morfologi terhadap eko-komposit telah menunjukkan interaksi yang lemah di antara pengisi SK dan matrik LPEKR. Kesan rawatan kimia terhadap SK telah meningkatkan sifat-sifat tensil dan terma dalam eko-komposit. Kekuatan tensil dan elastisiti modulus LPEKR/SK eko-komposit yang telah dirawat dengan AMA, AS, AL, dan SDS adalah lebih tinggi berbanding dengan eko-komposit yang tidak dirawat. Penghabluran dan kestabilan terma dalam eko-komposit LPEKR/SK yang telah dirawat juga adalah lebih baik berbanding eko-komposit yang tidak dirawat. Eko-komposit yang telah dirawat menunjukkan rintangan air yang lebih baik dari eko-komposit yang tidak dirawat. Interaksi yang lebih baik antara pengisi-matrik telah dibuktikan melalui kajian imbasan mikroskop elektron (IME). Analisa FTIR spektra menunjukkan perubahan kepada kumpulan berfungsi di dalam SK yang telah dirawat. Daripada keseluruhan jenis rawatan kimia, eko-komposit yang dirawat oleh AMA menunjukkan kekuatan tensil, modulus elastisiti, kestabilan terma, dan penghabluran yang paling tinggi berbanding dengan jenis rawatan yang lain.

Effect of Kapok Husk content and Chemical Treatment on Properties of Linear Low Density Polyethylene Eco-Composites

ABSTRACT

The utilization of kapok husk (KH) as filler in linear low density polyethylene (LLDPE) was studied. The effect of KH content and chemical treatments on tensile properties, morphology, thermal properties and water absorption of LLDPE/KH eco-composites were investigated. The LLDPE/KH eco-composites were prepared by using Brabender Plasticorder EC-Plus at temperature 160 °C and rotor speed 50 rpm. The four types of chemical treatments used were methacrylic acid (MAA), citric acid (CA), lactic acid (LA) and sodium dodecyl sulfate (SDS). The results indicated that the addition of KH in LLDPE eco-composites had decreased the tensile strength, elongation at break and crystallinity of the eco-composites. However, the modulus of elasticity and water absorption of eco-composites increased with increasing of KH content. Presence of KH has lowered the thermal stability of LLDPE/KH eco-composites compare to neat LLDPE. However, the increment of KH content improved the thermal stability. The morphological studies of eco-composites exhibited poor interfacial interaction between KH filler and LLDPE matrix. The effect chemical treatment of KH had increased the tensile and thermal properties of eco-composites. The tensile strength and modulus of elasticity of treated LLDPE/KH eco-composites with MAA, CA, LA, and SDS were higher than untreated eco-composites. The crystallinity and thermal stability of treated LLDPE/KH eco-composites were also improved compared to untreated eco-composites. The treated eco-composites had better water resistance than untreated eco-composites. The better filler-matrix interaction has been proven by scanning electron microscope (SEM).Spectra FTIR analysis showed the changes of functional group of treated KH. From various chemical treatments, the treated eco-composites with MAA showed the highest tensile strength, modulus of elasticity, thermal stability, and degree of crystallinity compared to others treated eco-composites.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Polymer eco-composites have been concerned an expanding studied in the course of recent decades for both industrial applications and fundamental research (Thomas et al., 2014; Petchwattana et al., 2013). Recently, a remarkable interest towards eco-composites has been attracted due to increasing environmental consciousness and demands of governmental authorities. The terms "eco-composites" are subjects to eco-friendly natural filler filled polymer matrix (Gaceva et al., 2007). The complex combination between polymer matrices and eco-friendly natural filler is usually made up for enhancement of properties of the products. Moreover, polymer eco-composites are more economic and environmentally friendly compare to a raw polymer matrix. Expanding in environmental awareness all throughout the globe has constrained the researchers to create new green materials that enhance the environmental quality of products (Gupta & Gupta, 2007; Chun et al., 2015b). In addition, several commercial programs towards momentum of eco-composites have been done such as the expanding worldwide natural and social worry, consumption of petroleum assets, and new ecological controls (Bagoeva et al., 2007).

Polymer matrix is basically inert to microorganisms or the chemicals in an environment (Kahar et al., 2012; Prachayawarakorn et al., 2010). Due to this, to eliminate a high volume of polymer waste may take a long time to degrade which prompted to natural issues. A developing effort has merged the polymer researchers to expand ecological materials lately by the addition of natural filler (Luo et al., 2014) instead of synthetic fillers (Hamid et al., 2015; Chun et al., 2014; Sébastien et al., 2015). Towards the unstable economic worldwide nowadays, customers definitely preferred a high quality product beneficial with a low cost. Finding addition materials for plastic could involve lower cost by using natural filler as reinforcement to the polymer eco-composites (Nitayaphat et al., 2009). They have been consolidated in polymer matrices with the major objective of giving improvement in properties and a decrease in cost of the final products (Leaversuch., 2002). These also prevent the waste of potentially useful materials and reduced the consumption of raw polymer matrix with addition of natural filler (Choi et al., 2006; Ashori et al., 2009; Ashori et al., 2010).

The plastic industries are a key enables of innovation of many products and technologies in other sectors of the economy such as engineering, medicine, automobile, sports, domestic, packaging, etc (Nwanonenyi et al., 2013). This is because of their simplicity of handling and low energy consumption during fabrication and their inertness, which makes them appropriate to be utilized as a part of all fields (De Carvalho et al., 2002). Moreover, the unique characteristics of plastics also allowed them to make a strong contribution to a more environmentally sustainable and resources efficient in worldwide (Qaiss et al., 2014; Malha et al., 2013). The increasing demand for plastics industries is expected to be one of the key factors driving the expansion of plastics market (Petchwattana & Covavisaruch., 2014; Manikantan et al., 2012). Linear low density polyethylene (LLDPE) matrix is one of a polymer with numerous applications, for example, film applications (e.g. stretch cling film, silage film), plastic bags, liquid paper board coatings, wire and cable, injection moulding parts and pipes (Geng et al., 2006). Generally, linear low density polyethylene is versatile polymer among polyethylene. It is a vital commercial polymer which is generally utilized for various applications as a part of current innovation. LLDPE has greater mechanical properties which have higher tensile strength, impact and puncture resistance (Hemati et al., 2011; Nestore et al., 2012; Kontou & Niaounakis., 2006). Meanwhile, Nwanonenyi et al., (2013) has reported that LLDPE has very flexible, elongates under stress, and has better environmental stress cracking resistance properties.

Some researchers have been reported that the addition of hemp as natural filler in LLDPE eco-composites (Nestore et al., 2013) improved the tensile strength and flexural strength of the eco-composites. This is expected since natural fillers are one of the most prospective materials which have been used to improve the properties of the polymer eco-composites (Pérez et al., 2012; Wang et al., 2008; Fauzani et al., 2014; Moayad & Khalaf., 2015) instead of biodegradable (Kaith & Kaur, 2011), low toxicity, low manufacture costs, low disposal costs and renewability (Puppi et al., 2010). Natural filler proposed a number of advantages over synthetic fillers in various technical applications (Nacher et al., 2007; Yarysheva et al., 2007). It is mainly due to their renewable origin, lightweight, moderately high specific strength, no health hazards, and more economic (Pervaiz et al., 2003). Probably, the most attractive properties the utilization of natural filler filled polymer matrix is the ecological effect, arising out from the fact that these natural fillers can be effortlessly degrade toward the end of their life cycle (Kahar et al., 2012; Prachayawarakorn et al., 2010).

Natural fillers, depending upon the source, are classified into three types which are animal, plant and mineral. Many natural plant types of filler found in Malaysia are obtained from crop residues and by products of the agricultural industry such as empty fruit bunch (Rozman et al., 2003), coconut shell powder (Chun et al., 2013a) and cocoa pod husk (Chun et al., 2014). Kapok is one of the abundance natural filler in Malaysia which has heavily cultivated to obtain kapok cotton for pillow and mattress productions. In the meantime, a numerous of kapok husk has disposed as a by-products. Contribution to a waste management and to overcome the environmental problem, kapok husk has been utilized as new natural fillers in polymer eco-composites field. Kapok husk has been reported contain high number of cellulose compositions which expected to improve the eco-composites properties (Kobayashi et al., 1977).

Along with these properties, lignocellulosic fillers also have a few drawbacks. Lignocellulosic of natural fillers are prone to absorb moisture in the environment, which affects the properties of eco-composites. The main disadvantage of natural fillers is their hydrophilic natures, which lower the compatibility with hydrophobic polymeric matrices during eco-composites fabrication (Boujmal et al., 2014; Salleh et al., 2014). However, there is an effort to develop the nature properties of these natural fillers which is chemical treatment. A number of chemical treatments can be done to obtain good properties by improving the compatibility between the polymer matrices and natural filler such as silane treatment (Singha and Takur, 2009), alkaline treatment (Farahani et al., 2012) and esterification (Salmah et al., 2011). Filler treatment is important in natural filler based eco-composites as well as to improve the wetability, dispersion, and filler-matrix interaction. Chemical treatment is performed to overcome the incompatibility between hydrophilic lignocellulosic filler and hydrophobic polymer matrix. The strong interfacial bonding between polymer matrix and natural filler obtained by chemical treatment will improve the physical, mechanical, and thermal properties of the composites system (Essabir et al., 2013).

1.2 Problem Statement

Many previous researchers have reported on the development of linear low density polyethylene (LLDPE) with natural fillers eco-composites. However, the utilization of LLDPE with kapok husk filler eco-composites has not been reported. In this project, kapok husk (KH) has been used as filler in LLDPE matrix. In order to cut cost usage of neat LLDPE polymer matrix, using of local KH filler can enhance the value of agriculture waste materials which are abundant in Malaysia. The KH could have promising future as new filler in polymer eco-composites not because of their low cost, low density, environmental friendliness and good mechanical properties but also in a context of valorising abundant and unexploited in Malaysian resources.

However, the main problem of LLDPE/KH eco-composites is their incompatibility between hydrophobic LLDPE and hydrophilic KH. Thus, the chemical treatments were used to improve the interfacial interaction between both materials and also reduced the hydrophilicity of natural fillers itself. In this study the different types of organic compound were used such as citric acid, lactic acid, methacrylic acid, and sodium dodecyl sulfate.

1.3 Objectives of Study

The objectives of this study are:

1. To study the effect of kapok husk (KH) filler content on tensile properties, morphological study, water absorption test, and thermal properties of LLDPE/KH eco-composites.
2. To investigate the effect of organic acids chemical treatments such as citric acid, lactic acid and methacrylic acid on properties of LLDPE/KH eco-composites.
3. To study the effect of sodium dodecyl sulfate on properties of LLDPE/KH eco-composites.