A STUDY OF PROPERTIES OF LOW DENSITY POLYETHYLENE / PALM PRESSED FIBRE BIOCOMPOSITE FILM

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To my beloved mother, Pua Siew Mooi, father, Tan Huat @ Tan Loo Lian,

my dearest husband, Koay Yee Farn, and son Koay Ding Yu,

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ABSTRACT

The aim of this study is to develop low density polyethylene (LDPE) / Palm Pressed Fibre (PPF) biocomposite film which is used as semi-degradable black polyethylene bag for nursery planting application. Few formulations with fixed PPF dosage were designed in this study. Silane was used as coupling agent at same loading for all formulations while glycerol was used as plasticizer at different dosage. Effects of glycerol and alkali treatment on LDPE/PPF biocomposite film were analyzed. All blends were compounded with twin screw extruder and were extrusion blown into film sample. Samples properties including melt flow index (MFI), Fourier Transform Infrared (FTIR), mechanical, water absorption and biodegradability test were conducted. MFI of LDPE/PPF was found not far different than pure LDPE. Both glycerol and alkali treatment has affected the MFI where glycerol helped to increase the MFI but the treatment has declining the MFI. Tensile property was drastically reduced with incorporation of PPF prove that PPF failed to reinforce the LDPE/PPF biocomposite film but the property was improved with treated PPF (TPPF) while glycerol do not showed significant impact. Alkali treatment on PPF had improved the resistance of LDPE/PPF biocomposite film to water uptake but shown lower weight loss in biodegradability test.

ABSTRAK

Kajian ini adalah untuk menghasilkan beg plastik separa urai yang dibuat daripada polietilena rendah ketumpatan (LDPE) dan fiber pengukuh sabut kelapa sawit atau lebih dikenali sebagai fiber tekanan kelapa sawit (PPF) bertujuan untuk kegunaan nurseri penanaman pokok kelapa sawit. PPF ditetapkan pada kandungan yang sama dalam semua formulasi kajian ini. Silane digunakan sebagai ejen serasi pada kandungan yang tetap sementara gliserol dipakai sebagai pemplastik pada kandungan berbeza. Kesan glycerol dan rawatan alkali pada PPF ke atas filem biokomposit LDPE/PPF telah dianalisa dalam kajian ini. Semua formulasi diadun dengan menggunakan penyemperitan skru berkembar dan ditiup dalam bentuk filem. Sifat-sifat sampel termasuk indeks leburan aliran (MFI), pencirian, mekanikal, penyerapan air dan ujian biodegradabiliti telah dijalankan dalam kajian ini. MFI LDPE / PPF didapati tidak jauh berbeza daripada nilai MFI LDPE tulen. Gliserol dan rawatan alkali telah memberi kesan kepada MFI di mana MFI meningkat dengan tambahan gliserol dan menurun selepas rawatan alkali. Pengisian PPF ke dalam filem LDPE menunjukkan penurunan yang drastik dalam sifat-sifat regangan, membuktikan PPF gagal untuk bertindak sebagai pengisi pengukuh. Namun, sifat-sifat itu telah bertambah baik dengan TPPF. Sementara itu, kenaikan kuantiti gliserol tidak memberikan kesan yang ketara terhadap sifat-sifat regangan filem biokomposit LDPE/PPF ini. Rawatan alkali pada PPF telah meningkatkan pertahanan filem LDPE/PPF terhadap penyerapan air tetapi peratusan kehilangan berat filem dalam ujian keuraian telah menurun.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Material
C	-	Compatibilizer
DOE	-	U.S. Department of Energy
DSC	-	Differential Scanning Calorimetry
FDA	-	Food and Drug Administration
FRC	-	Fibre Reinforced Composite
FTIR	-	Fourier Transform Infra Red
HDPE	-	High Density Polyethylene
ISO	-	International Standards Organization
KBR	-	Potassium Bromide
LDPE	-	Low Density Polyethylene
LLDPE	-	Linear Low Density Polyethylene
Ma-g-PE	-	Maleic Anhydride Grafted Polyethylene
Ma-g-PP	-	Maleic Anhydride Grafted Polypropylene
MAH	-	Maleic Anhydride
MD	-	Machine Direction
MFI	-	Melt Flow Index
MINT	-	Malaysian Institute Nuclear Technology
MPOB	-	Malaysia Palm Oil Board
MWD	-	Molecular Weight Distribution
NaOH	-	Sodium Hydroxide
NSF	-	National Science Foundation

OPEFB	-	Oil Palm Empty Fruit Bunch
PALF	-	Pineapple Leaf Fibre
PE	-	Polyethylene
PP	-	Polypropylene
PPF	-	Palm Pressed Fibre (Oil Palm Mesocarp Fibre)
PS	-	Polystyrene
PVC	-	Polyvinyl Chloride
SEM	-	Scanning Electron Microscopy
TD	-	Transverse Direction
TPPF	-	Treated Palm Pressed Fibre
UHMWPE	-	Ultra High Molecular Weight Polyethylene
USDA	-	US Department of Agriculture
UTPPF	-	Untreated Palm Pressed Fibre
VLDPE	-	Very Low Density Polyethylene

LIST OF SYMBOLS

%	-	Percentage
^{0}C	-	Degree Celsius
cm^{-1}	-	Wavelength
ΔHm	-	Enthalpy of melting (biocomposite)
ΔH^{*}	-	Enthalpy of melting (100% crystalline LDPE)
J/g	-	Joule / gram
MPa	-	Mega pascal
Mt	-	Percentage of weight gain
ppm	-	Part per million
Tc	-	Crystallization peak
Tm	-	Melting peak
w	-	Weight fraction
Xc	-	Degree of crystallization

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CHAPTER 1

INTRODUCTION

1.1 Background

Industries have been always searching for new materialswith high performance at affordable costs. Lately, with growing of environmental consciousness and awareness as well as high demands from legislative authorities, this search has particularly focused on eco-friendly materials, with terms such as “renewable”, “recyclable”, “sustainable”and “triggered biodegradable”. This underscores the emergence of a new type of materials – a change from non-renewable, but difficult to degrade or non-degradable, to renewable and easily degradable materials (Satyanarayana *et al*., 2009).

Synthetic polymers have displaced metals, glasses, ceramics and wood in many products, especially in the area of packaging. The commodity plastics: polyethylene (PE), poly(propylene) (PP), polystyrene (PS) and poly(vinyl chloride) (PVC) ina variety of forms such as films, flexible bags and rigidcontainers have revolutionized the packaging industry. However, once these materials are discarded, they persist in the environment without being degraded thus givingrise to a multitude of ecological and environmental concerns (Mohanty *et al*., 2000).

With stringent environmental requirement and petroleum crisis, the concept of using natural fibre reinforced petroleum-derived non-biodegradable polymers such as PE and PP biocomposite is gaining more and more approval day by day. The most important disadvantage of conventional fibre such as glass, carbon or aramid composite materials is the difficulty of removal after the end of life time, as the components are closely interconnected, relatively stable and therefore difficult to separate and recycle (Mohanty *et al*., 2000).

The growing trend of using natural fibers as fillers and/or reinforcers in plastics composites are due to their renewability, less health risk, comparable specific tensile properties, low density and low cost (Ku *et al*., 2011). The main drawback of natural fibres is their hydrophilic nature which lowers the compatibilitywith hydrophobic polymeric matrix during composite fabrications. (Mohanty *et al*., 2000). Therefore, various treatments such as alkaline, silane, acetylation and etc are being used to improve fibers/matrix compatibility (Torres and Cubillas, 2005; Corrales *et al*., 2007; Liu *et al*., 2008).

The other disadvantage of natural fibres is the relatively low processing temperature required due to the possibility of fibre degradation and/or the possibility of volatile emissions that could affect composite properties. The processing temperatures for most of the biofibres are thus limited to about 200^0C (Mohanty *et al*., 2000).

The plants, which produce natural fibers, are classified as primary and secondary depending on their utilization. Primary plants are those grown for their fiber content while secondary plants are plants in which the fibers are produced as a by-product. Jute, hemp, kenaf, and sisal are examples of primary plants. Pineapple, oil palm and coir are examples of secondary plants. Oil palm mesocarp fiber, also called as palm pressed fiber (PPF), is the other important fibrous material left in the palm oil mill besides oil palm empty fruit bunch (OPEFB). PPF are left as a waste material after the oil extraction, when left on the plantation floor; these waste materials create great environmental problems. This study has chosen PPF as the natural reinforced fibre due to its low cost, availability in Malaysia as well as for the sake of environmental issue to turn waste material into other useful area.

PE, one of the mass products of petroleum derived polymers which categorized based on its different density range such as high density polyethylene (HDPE), low density polyethylene (LDPE) and liner low density polyethylene (LLDPE) are used extensivelyin many fields especially as film packaging product. LDPE has been widely used in several industrial applications especially in flexible film due to its good blown extrusion characteristic (Handbook of Plastic Films, 2003) and desired mechanical properties such as relatively good impact strength (Rahman *et al*., 2007). LDPE will be used as the polymer matrix in this study as it is commodity plastic, widely used and accepted in current industry.

Addition of coupling agent has improved the incorporation of natural fibre in PE matrix and enhances the biodegradability of the fibre reinforced composite (FRC). The degradation of the bio-film under fungi environment and natural ambience (soil burial) were increased with the incorporation of natural fibre (Rahman *et al*., 2009). It is also showed that using vegetable oil as additive has a dual function; as plasticizer which improves the film quality; as pro-oxidant, it accelerates degradation process of the film.

1.2 Problem Statement

The purposes of this study are as the followings:

1. To find out if PPF can be successfully serve as reinforcing filler for LDPE.
2. To study 10wt% of PPF used coupled with minimum 15wt% glycerol and fixed 5wt% of silane will be successfully processed in extrusion blown film aim for flexible packaging application.
3. To find ou tif LPDE/PPF biocomposite film is biodegradable.

1.3 Objectives of Study

This study was carried out with the following aims:

1. To investigate the effects of glycerol loadings on the properties of LDPE/PPF biocomposite film.
2. To investigate the effects of alkali treatment on the properties of LDPE/PPF biocomposite.
3. To study the biodegradability of LDPE/PPF biocomposite film.

1.4 Scopes of Study

In order to achieve the objectives of the study, the following activities wascarried out.

1. PPF was treated with sodium hydroxide, cleaned, grinded and sieved to desired dimension.
2. Mixing process by high speed mixer and compounding process by twin screw extruder.
3. Extrusionblown filmthe compounded LDPE/PPF resin.
4. Preparing sample specimens for testing and characterization.
5. Melt index test at 2.16kg, 190^{0}C on LDPE/PPF resin pellet as per ASTM D1238.
6. Sample characterization with Fourier Transform Infrared Spectrometry (FTIR).
7. Mechanical properties studies

   a) Tensile strength and elongation at break as per ASTM D882.

b) Water absorption analysis through weight gain after water immersion.

8. Biodegradation studies (weight loss) of LDPE/PPF biocomposite film by soil burial test.

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