Effects of Cobalt Stearate on the Properties of Compatibilized Low Density Polyethylene/ Jackfruit Seeds Flour Blends

by

Santhiya A/P Peremel
(1333511125)

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

School of Bioprocess Engineering
UNIVERSITI MALAYSIA PERLIS

2016

ACKNOWLEDGEMENTS

I am much gratitude to Universiti Malaysia Perlis (UniMAP) and School of Bioprocess Engineering for giving me a chance to complete my Master in Biosystem Engineering and my research project.

On the other hand, I would like to express my deepest sense of gratitude to my project supervisor, Dr. Sam Sung Ting, on the advices and guidance he's given me throughout the project. His wisdom and his constructive comments have has been of great value for me. His understanding and encouragement have provided a good basis for my thesis. I also thank him for his generosity to spend time and invaluable help in editing the wording and contents of the text.

Besides, I warmly thank Dr. Ragunathan a/l Santiago, my co-supervisor and Dr. Saleha Binti Samsuddin, my chairman for bioprocess postgraduate student for their assistance valuable advice based on the project submission and for project guidelines. I also wish to express my personal thanks to all the PLV's either from school of Bioprocess or School of Material Engineering, for their continuous guidance and valuable assistance during preparation of my samples, and safety precaution instructions and for their technical assistance in laboratory work.

Also my warmest thanks must go to my fellow mates, Ms. Nur Adibah, Ms. Nurul Hani, Ms. Nor Srikurniati and Ms. Aina Dira, family and friends for their understanding, moral support and patience during the long preparation of the project.

Santhiya A/P Peremel

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

LDPE	Low Density Polyethylene
JFS	Jackfruit Seed
SEM	Scanning electron microscope
ASTM	American Standard Testing and Material
MA	Maleic anhydride
MA-g-PLA	Meleic anhydride grafted polylactic acid
CO2	Carbon Dioxide
FTIR	Fourier transforms infrared spectroscopy
DSC	Differential Scanning Calorimetry
TGA	Thermogravimetric analysis
ENR	Epoxidised Natural Rubber
AA	Apidic Acid
CA	Citric Acid
NW	Natural Weathering
SB	Soil Burial

Kesan Kobalt Stearate Pada Agen Penserasi dalam Polietilena Berketumpatan Rendah/ Tepung Biji Nangka

ABSTRAK

Kesan asid adipic (AA) dan asid sitrik (CA) kepada sifat ketegangan, morfologi, dan sifat haba oleh polietilena berketumpatan rendah (LDPE)/ tepung biji nangka (JSF) telah dikaji. Pada mulanya, LDPE telah dicampurkan dengan pelbagai kandungan JSF selama 10 minit dengan menggunakan pengadun dalaman. Sifat tegangan telah diuji dengan menggunakan tensometer instron mengikut ASTM D638. Kekuatan tegangan dan pemanjangan pada takat putus (E_b) telah meningkat dengan penambahan AA dan CA sebagai agen penserasi, seperti yang dibuktikan oleh analisis morfologi dengan menggunakan imbasan elektron mikroskop. Modulus juga meningkat dengan kandungan JSF sehingga 3 wt% dan menurun dengan peningkatan berat kandungan JSF. Penghabluran dan penghabluran suhu campuran meningkat dengan penambahan AA dan CA, berbanding dengan campuran tanpa agen penserasi. Kestabilan haba pula mencatatkan penurunan nilai dengan peningkatan kandungan JSF. Walau bagaimanapun, AA dan CA menambah baik kestabilan terma LDPE /JSF. Penyerapan air juga telah meningkat dengan peningkatan kandungan JSF. Tahap degradasi sampel telah diuji dengan ujian penanaman tanah dan pencuacaan sampel dalam pelbagai cuaca selama 9 bulan. Melalui ujian tersebut, didapati bahawa untuk komposisi JSF yang lebih tinggi, kadar degradasi meningkat. Sampel dengan campuran agen penserasi mencatatkan kadar proses degradasi yang lebih rendah daripada sampel campuran tanpa agen penserasi. Akhir sekali, pro-oksidan kobalt stearat (CS) telah ditambah untuk mempercepatkan proses degradasi. Oleh itu, kekuatan tegangan dan E_b daripada campuran CS lebih mudah terdegradasi berbanding dengan campuran tanpa CS. Disamping itu, semasa ujian pencuacaan dan penanaman tanah, sampel menunjukkan peningkatan dalam kadar penghabluran dengan penambahan CS di dalam campuran, tetapi dengan penambahan agen penserasi, penghabluran telah meningkat.

Effect of Cobalt Stearate on the Properties of Compatibilized Low Density Polyethylene/ Jackfruit Seeds Flour Blends

ABSTRACT

The effect of adipic acid (AA) and citric acid (CA) on the tensile, morphological, and thermal properties of low-density polyethylene (LDPE)/ jackfruit seeds flour (JSF) was investigated. Initially, the LDPE was mixed with various JSF contents for 10 minutes by using internal mixer (Brabender). The tensile properties were evaluated by using Universal Testing Machine (UTM) according to ASTM D638. The tensile strength and elongation at the break (E_b) were significantly improved by the addition of AA and CA, as evidenced by morphological analysis using scanning electron microscopy (SEM). On the other hand, the Young's modulus increased with JSF content up to 3 wt% and decreased thereafter. The crystallinity and crystallization temperatures of the blends increase with the incorporation of AA and CA, compared with uncompatibilized blends. The thermal stability of the mixture was lower with increasing JSF content. However, AA and CA had improved the thermal stability of LDPE/JSF blends. The water absorption increased with increasing amount of JSF content. The degradability of the sample had been investigated for 9 months soil burial and natural weathering test. It was found that for higher JSF content resulted in higher degradation. In the presence of compatibilizer, the interfacial adhesion was significantly improved and lower the degradation duration. Lastly, cobalt stearate (CS) had been added as pro-oxidantin order to accelerate the degradation process. The tensile strength and E_b of the blends with CS were more susceptible to degradation compare to the blends without CS. Meanwhile, during weathering and soil burial test, the crystallinity increased with the addition of CS in the blends.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Polyethylene has achieved a dominant position as a packaging material because of its relatively low cost, versatile properties including high tensile strength, elongation at break, good barrier properties against water borne organisms, lower cost, higher energy, effectiveness, light weight and good water resistance. The products from polyethylene become famous in over the decade. So, during the past two decades the quantity of plastics material used in the packing application has increased annually at a phenomenal rate. However, polyethylene is an non-biodegredable plastic which has high life span. It has been a target of much criticism due to its lack of degradability especially the plastic bag and agriculture bag product (Sirocic et al., 2014). Figure 1.1 (Steven, 2002) illustarted the major usage of plastics in the industries.

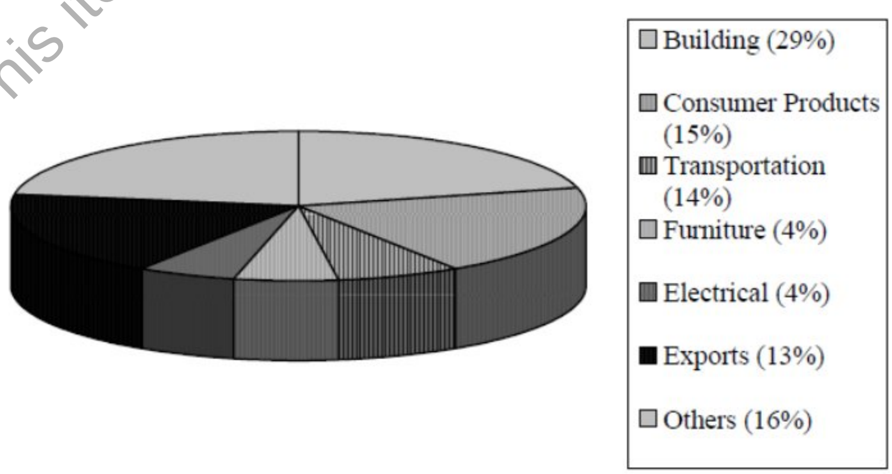

Figure 1.1: Major usage of plastics in industry

Besides that, the projected life-span of polymer products varies from several months for example packaging products, to over 50 years for construction components. In United States alone, about 50 millions tons of synthetic polymers were consumed every year (Charles, 2008). Around 64% accounts for the packaging products made of polyethylene. Linear low density polyethylene is the mostly used polymer in packaging industry due to its excellent properties (Santana and Manrich, 2003, Satapathy et al., 2006, Jose et al., 2007, Ojeda et al., 2009).

Since most of the packaging product are "throwaway" items, the amount of waste plastic generated is enormous. Statistically, the amount of packaging waste accumulates at the rate of 30 millions tons/year (Shah et al., 1995). Earlier most of waste plastics were buried in the landfill. These lead to serious environment effect as most of them are not biodegradable (Singh and Sharma, 2008). At the same time, the landfilling practice is going to be banned in the near future due to public health reasons. Therefore, waste managemant is a urgent problem that need environmental compatibility and eco-friendly solution. According to Guillet (2010), the most effective way to deal with this litter problem is to reduce the 'life time' of the littered objects. The meaning of 'life time' is to reduce for their chain ability of the polyethylene material to make it easier to decompose.

Thus, to minimize waste plastics, conventional techniqes like recycling and incineration were used. However, these techniques had serious limitation such as;

a. Recycling only practical for scrap plastics by manufacturing while collection of plastics are contaminated with soil, food, or other chemicals, their recycling is rather difficult. As such, only 7.1% of pastic waste is recycled in the North China in 2014 (Zhenwu et al., 2015)

b. Incineration of plastics waste is less attractive due to high capital cost and may produce carcinogens such as dioxin. This process also consumes a lot of energy and generates greenhouse gases such as carbon dioxide (Yuan et al., 2015).

A lot of effort has been focused in recent years to develop environmentally compatible plastic products that possess biodegradability characteristics. Several approaches had been considered in accelerate biodegradation process such as:

a. Synthetic polymer with additives

   Incorporation of photosensitive (Ratanakamnuan and Ong, 2006, Harada et al., 2007) and pro-oxidant (Larissa et al., 2015, Koutny et al., 2006, Roy et al., 2007, Fontanella et al., 2010) additives induce degradation process of polymer by photo-oxidation. Polymer incorparated with additives were classified as oxo-degradable polymer (Chiellini et al., 2006).

b. Synthetic polymer with hydrolysable backbones

   Polymers with hydrolysable backbones are fully biodegrable under suitable conditions. Examples of polymers with hydrolysable backbones are aliphatic polyesters such as polylactic acid (Drumright et al., 2000, Kumar et al., 2010), polycaprolactone (Teramoto et al., 2004, Vaskavo et al., 2008), polyhydroxybutyrate (Kim et al., 2000, Cetin, 2009, Volova et al., 2010) and so on. These polymer are often too expensive for nonmedical use (Chen et al., 2007, Vaskova et al., 2008, Cottam et al., 2009, Sambha'a et al., 2010).

c. Synthetic polymer with carbon backbones

   Polymer with carbon backbones, such as vinyl polymers is fully biodegradable (Katsura and Sasaki, 2001). However, photo-degradation is essential for biodegradation of vinyl polymers.

d. Biodegradable polymers of renewable resources

   Biodegradable polymers obtained from renewable resources such as polysaccharides (Glenn and Orts, 2001, Avella et al., 2005, Senna et al., 2007), proteins and bacterial polymers have attracted significant researches.

On the other hand, bio-plastics have identified as an effort to develop environmentally compatible plastic product. Bio-plastic are plastics which derived from renewable biomass sources, such as vegetable fats and oils, starch or microbiota. For these bio-plastics, prices are most important issues since able to compete with low cost synthetic commercial polymers. In this regard, blending biodegradable polymer either natural or synthetic with commercial plastics will enlarge the range of applicability of these materials in packaging applications.

Therefore, to replace bio-plastics, starch based product are used. Starch is a biocompatible polymer. It is useful in making hybrid organic-inorganic materials, hybrid composites, starch /clay- composite and Polymer/Clay nano-composites. Reduced defects, increased surface area, percolation, interphase volume, polymer morphology are the concepts of nanocomposites. As the size of a particle is reduced, the number of defects per particle is also reduced and mechanical properties rise proportionately (Theivasanthi and Alagar, 2011). A survey of literature indicates that not much work has been done on the jackfruit seed in blends with polymers.

Starch-based materials originally attracted a great deal of interest because of their low cost, real biodegradability, and renewable origins. Thermoplastic starch (TPS) is one of such materials obtained after disruption and plasticization of starch by heating in presence of water or other plasticizers such as glycerol (Senna et al., 2007, Song and Zheng, 2008 and Nakason et al., 2006). Thermoplastic starches have being also successfully blended with inorganic material like clay, other suitable polymers like natural rubber (Majdzadeh and Sadeghi, 2010).

In this research, jackfruit seeds flour (JSF) have been used as starch to add on the properties of degradation to the blends. The Artocarpus heterophyllus Lam is a species of tree of the mulberry family (Moraceae) is commonly known as jackfruit. It is native to Western Ghats of India and Malaysia. It's also produces heavier yield than any other tree and bear the largest known edible fruit (up to 35kg).The sweet yellow sheaths around the seeds are about 3-5 mm thick and have a milder and less juicy. Seeds are separated horny endocarpus enclosed by sub-gelatinous exocarpus (1mm thick) a thin whitish membrane. They are oval, oblong or oblong ellipsoid or rounded shape, light brown colour in nature, 2-3 cm (0.8-1.2 inch) in length and 1-1.5 cm (0.4-0.6 inch) in diameter (Prakash et al., 2009 and Theivasanthi and Alagar, 2011). Limited research was carried out by using JSF.

Furthermore, starch based product can accelerate the degradation process and degradability offers a complimentary strategy to deal with the litter problem. One of the simplest ways of modifying the existing polymer is to accelerate the rate of photo-degradation and thermal degradation process already taking place with using the additive such cobalt strearate. Degradability also offers a complimentary strategy to deal with this litter problem (Vaskova et al., 2008). One of the simplest ways of modifying the existing polymer is to accelerate the rate of thermal/photodegradation process already taking place by using the additive.

1.2 Problem Statements

The rapid increase in production and consumption of plastics has led to the serious plastic waste problems, so called 'White Pollution', and landfill depletion, due to their high volume to weight ratio and resistance to degradation. Accumulated plastic film residues in soil have caused significant decrease in yield. Plastic wastes floating on rivers and lakes are increasingly threatening fishery, navigation, operation of hydropower plants, irrigation and other public works. Moreover, as over 99% of plastics are of fossil fuel origin, their rapid increase will put further pressure on the already limited non-renewable resources on earth (Zhigui et al., 2015).

Solid waste disposal and litter like polyethylene among the many problems that arise from whereby the litter is related with human inventor. The present generation commodity plastics, especially the packaging materials, contribute significantly to resolve the solid waste disposal problem. The use of plastic materials that can re-enter the biological life cycle, appear to be one of the most promising solution to this problem after the first photodegradation process is