

EFFECT OF PALM COOKING OIL AS PROCESSING AIDS IN LOW DENSITY POLYETHYLENE (LDPE)/TAPIOCA STARCH BLENDS

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Abstract

The aim of this work is to study the effect of palm cooking oil as processing aid in biodegradable/tapioca starch packaging film. A blends of low density polyethylene (LDPE)/tapioca starch were prepared by twin screw extrusion with the addition of glycerol and palm cooking oil as processing aids. Studies on their melt flow properties and thermal stability were carried out by melt flow index analysis and thermogravimetry analysis respectively. Melt flow index of LDPE/TS:90/10 with addition of glycerol and palm cooking oil are higher than MFI value of LDPE. This indicated that incorporation of glycerol and palm cooking oil as processing aids increase the melt flow index of the blends compared to neat LDPE. Addition of palm cooking oil as processing aid in the blend also increased thermal stability of the polymer.

Keywords: biodegradable polymer, palm cooking oil, tapioca starch, packaging film

1.0 Introduction

Worldwide production of plastics is more than 78 million tons per year and almost half of that is discarded within a short time, remaining in garbage deposits and landfills for decades (more than 30 years) [1]. Furthermore, major application of plastics is in packaging and this situation may contribute to serious environmental problems. Synthetic plastics accumulate in nature at a rate of 25 million tons per year and polyethylene represents 64% of the produced synthetic plastics. Petrochemical based plastics such as polyolefin, polyesters and polyamides have been increasingly used as packaging materials because of their availability in large quantities at low cost and favorable functionality characteristics such as good tensile and tear strength, good barrier properties to oxygen and aroma compounds and heat seal ability [2].

However, these plastics are made of petroleum-based materials that are not readily biodegradable. Synthetic plastics such as polyethylene and polypropylene have a very low water vapor transmission rate and most importantly, so that, they are totally non-biodegradable, and therefore lead to environmental pollution, which pose serious ecological problems. Polyolefin are not degraded by microorganisms in the environment, which contributes to their long lifetime of hundred of years. There has been an increased interest in enhancing the biodegradability of synthetic plastics by blending them with low cost natural biopolymers.

Biodegradable plastics are plastics that can undergo a degradation process known as biodegradation. They are defined as plastics with similar properties to conventional plastic but which can be decomposed after disposal to the environment by

the activity of microorganism [2,3]. It is also defined as plastics with similar properties to conventional plastics, but it can be decomposed after disposal to the environment by the activity of microorganisms to produce end products of CO_2 and H_2O [2]. Biodegradable polymers can be divided to two main categories, which are naturally occurring biodegradable polymers and synthetic biodegradable polymers [4]. Naturally occurring biodegradable polymers including polysaccharides such as starch, cellulose, chitin/chitosan, pullulan, levan, konjac and elsinan. In this compound, simple sugar such as glucose, fructose and maltose are the basic units [4]. Biodegradable plastics provide opportunities for reducing municipal solid waste through biological recycling to the ecosystem and can replace the conventional synthetic plastic products. In addition, it is desirable that these biodegradable polymers come primarily from agricultural or other renewable resources for a sustainable environment.

Biodegradation occurs when microorganism such as bacteria and fungi degrade a polymer in an aerobic and an anaerobic environment, carbon dioxide, methane and other natural products are derived from the degradation process. Hence, biodegradation can be stated as the conversion of the constituents of a polymer to carbon dioxide/methane, microbial cellular components and miscellaneous by-products, by microorganisms [3]. Microorganisms break down the polymer chains and consume the material through several methods. In this present study, low density polyethylene (LDPE)/tapioca starch biodegradable film were prepared by twin screw extrusion with the addition of glycerol and palm cooking oil as processing aids.

2.0 Methodology

2.1 Raw Materials

Low-density polyethylene (LDPE) resin grade (TITANLENE® LOW-DENSITY POLYETHYLENE, 71009A, LDF 260GG) supplied by Titan Polyethylene (M) Sdn. Bhd. were used in this research. The density of the polymer was 0.922 g/cm^3 according to ASTM D1505. It had a melt flow of 5 g/10 min according to ASTM D 1238 and a melting temperature (T_m) of 110°C . Tapioca starch, food grade was used as filler in this research. The particle size of those starches ranged from 9.73 μm to 83 μm with an average particle size of 32.97 μm . The moisture content of starch is average of 11.5%. Glycerol (glycerin, $\text{C}_3\text{H}_8\text{O}_3$) from Fisher Chemicals (Molecular weight = 92 g/mol^{-1}) and palm cooking oil (commercial grade) were used as processing aids to this blends.

2.2 Sample Preparation

Low-density polyethylene and starch was dried in an oven for 24 hours at 80°C before pre-mixing and compounding to dry the moisture especially for starch. The compounding of LDPE/starch was done using twin screw Brabender Plasticoder with the addition of glycerol (GLY) and palm cooking oil (PCO) (20 wt%) as processing aids. The compounding process was out at a speed of 80 rpm and temperatures were set at $150^\circ\text{C}/150^\circ\text{C}/140^\circ\text{C}/140^\circ\text{C}$. The extrudates were palletized using a palletizer machine for each formulation as indicated in Table 1.

Table 1: The abbreviations of blends

Samples	LDPE (wt %)	Tapioca starch (TS)(wt%)
LDPE	100	0
LDPE/TS:90/10-GLY	90	10
LDPE/TS:90/10-PCO	90	10

2.3 Melt Flow Index (MFI) Measurements

Melt flow index (MFI) of various sample formulations was measured using Extrusion Plastometer according to ASTM D1238-01. A load of 2.16 kg and temperature at 190°C was used in this measurement.

2.4 Thermogravimetry Analysis

Thermogravimetry analysis (TGA) was used to determine the degradation temperature of the samples. The LDPE/starch blends were scanned at a heating rate of 20°C/min from 30°C to 900°C and the analysis was carried out in the presence of nitrogen flowing of a rate of 20 ml/min.

3.0 Result and Discussion

3.1 Melt Flow Index

Figure 1 shows the melt flow index (MFI) values of LDPE and blends of LDPE and tapioca starch with the addition of glycerol and palm cooking oil as processing aids. Melt flow index of LDPE/TS:90/10 with addition of glycerol and palm cooking oil are 9.381 g/10 min and 17.144 g/10 min respectively, which are higher than MFI value of LDPE, 2.262 g/10 min. This indicated that incorporation of glycerol and palm cooking oil as processing aids increase the melt flow index of the blends compared to neat LDPE. Thakore et al. reported that the MFI of starch composite decreased as the filler loading increased [5]. However, the decline of MFI was being balance by incorporation of processing aids. Incorporation of glycerol and palm cooking oil as processing aids increase the melt flow index of the blends compared to neat LDPE. Glycerol and palm cooking oil as plasticizer decreased the intermolecular forces between polymer coils and increased the molecular spaces [6,7] and mobility of polymers resulted in the increase in MFI. The value of MFI of LDPE/TS:90/10 with addition palm cooking oil is higher than LDPE/TS:90/10 with addition of glycerol. This indicates that viscosity of the blend was decreased with the addition of palm cooking oil. As the viscosity of the LDPE/TS:90/10 blends decreases the process ability is expected to be improved.

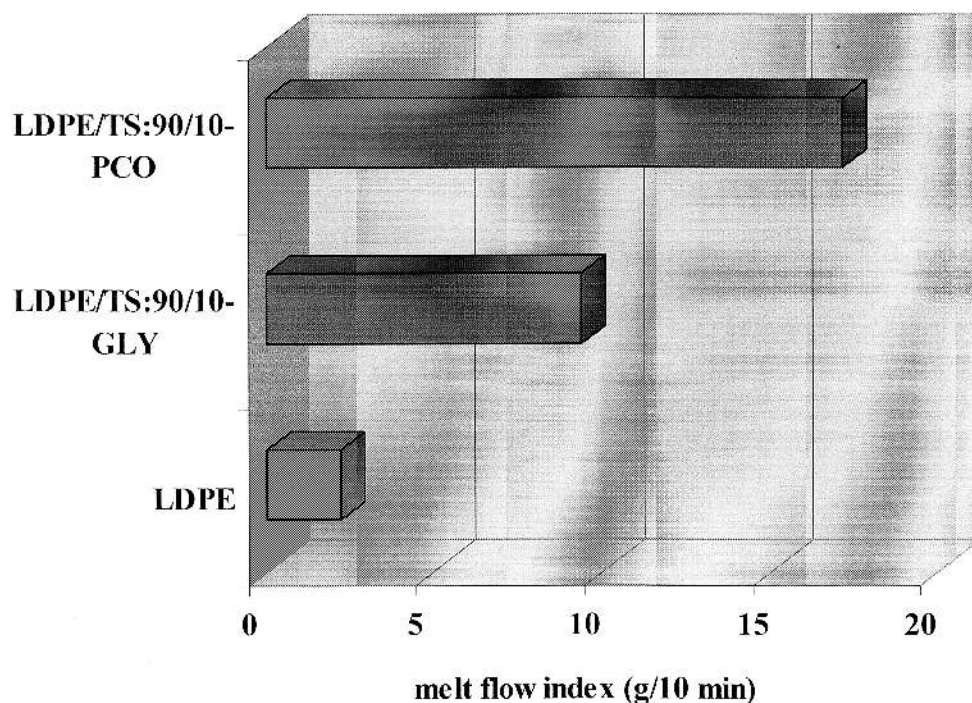


Figure 1 Melt flow index (MFI) values of LDPE and blends of LDPE/TS blends with the addition of glycerol and palm cooking oil as processing aids.

3.2 Thermogravimetry Analysis

Figure 2 presents the TGA thermograms of LDPE and blends of LDPE and tapioca starch with the addition of glycerol and palm cooking oil as processing aids. When starch granules are heated, they are thermally stable up to 280 – 300°C, thermal degradation takes place, depending mainly on the water content of starch. However, LDPE is thermally stable up to 470 – 500°C. Starch is fully biodegradable polymer; however it has low thermal stability. Blending of starch and LDPE will produce biodegradable polymers with acceptable thermal stability. As observed, LDPE/tapioca starch films have two weight loss stages corresponding to two different materials in the blends. The first stage weight loss of LDPE/tapioca starch film is due to degradation of starch. The first stages of LDPE/TS:90/10 film accounts for 92 – 94% of the weight loss, which is attributing to 10 wt% of starch content in the blends and water content of the starch. The second stage of weight loss is due to LDPE, thermally stable up to 450 to 520°C. Addition of palm cooking oil as processing aid in the blend increased thermal stability of the film. The first stage weight loss of LDPE/TS:90/10-PCO film started at 320°C, whereby LDPE/TS:90/10-GLY film started to degrade at 250°C.

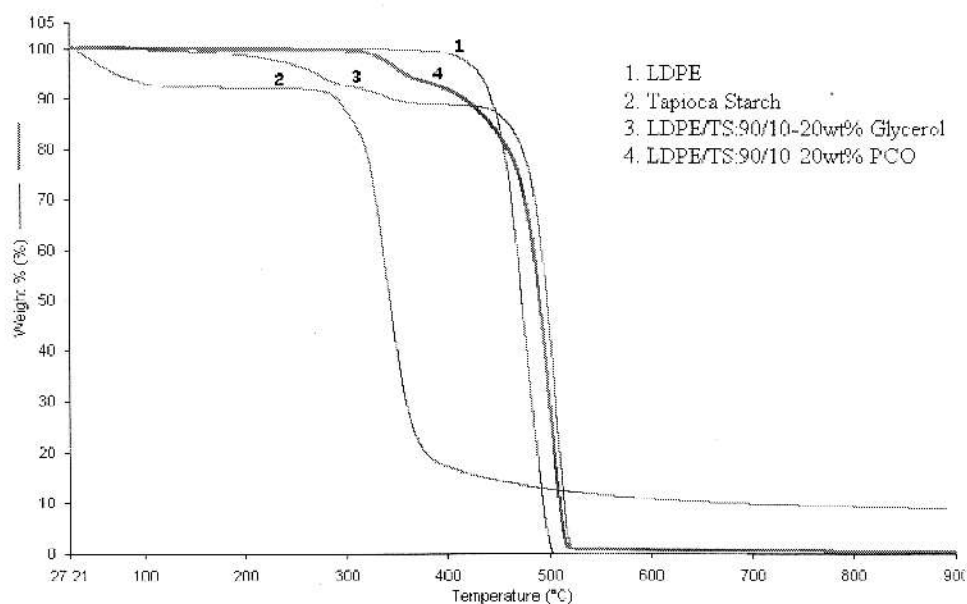


Figure 2 TGA thermograms of LDPE and blends of LDPE/TS with the addition of glycerol and palm cooking oil as processing aids.

4.0 Conclusion

Melt flow index of LDPE/TS:90/10 with addition of palm cooking oil as processing aid increased compared to neat LDPE. The addition of processing aid to the blends increased the melt flow index of the polymers. As the viscosity of the blends decreases the process ability is expected to be improved. Addition of palm cooking oil to the blends also improved thermal stability of the polymer.

5.0 Acknowledgement

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