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Weight Loss Degradation of Hybrid Blends LLDPE/Starch/PVA upon Exposure to UV Light and Soil Burial

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***Abstract*—**Poly bag and mulch films for agricultural field caused pose environmental problem due to the non-degradable plastics wastes upon disposal. Thus, a degradable poly bag was designed with hybrid sago starch (SS) and polyvinyl alcohol (PVA). Two Different blended compositions of SS and PVA hybrid have been compounded. Then, the hybrids blended are mixed with linear line density polyethylene (LLDPE) resin to fabricate poly bag film through conventional film blowing process. Samples of LLDPE, SS and PVA hybrid film were exposed to UV light and soil burial. The weight losses were determined during degradation process. Hybrid film by degradation of starch was found to hydrolyze and hydroxyl groups decrease on esterification upon exposure to soil burial and uv radiation. It was found out that, the hybrid film for 60% of SS composition showed greatest degradation in soil and UV radiation.

***Keywords*—**LLDPE, PVA, sago starch, degradation, soil burial, UV radiation.

I. Introduction

THE consumption of plastic in every time of life has been disputed over the past few decades due its non-renewability, non-recyclability and toxicity [1]. Degradable polymers are one of the economic advantages and superior properties to the commercial polymer. The developments of environmental friendly polymer materials can be overcome the significant environmental problem by using synthetic polymer.

Thousand years are needed to degrade the non-degradable plastic solid wastes made from synthetic polymers that caused environmental pollution. The possible solutions to increase the degradability rate of polymer by incorporating natural polymer such as sago starch (SS) into the plastic base. SS has a good raw material for degradation due to its properties, low cost and abundant [2]. The suitable plastic base incorporated with SS is PVA because it is hydrophilic in nature and water soluble polymer. SS possesses similar function as PVA due to consumable and biocompatible by microorganism.PVA widely use such as textile sizing agents, paper coating and water soluble packaging film due to its properties that high water absorption, emulsifying and adhesive properties.

Poly bag need to be suitable for humid environment especially tropical climate such as Malaysia. Polybags are fabricated using film blowing technique. Film of thickness of 0.06 mm and size 6x9 in were produced in industry due to suitability for plantation. The hybrid polybag have been tested and suitable product for degradation as a potential product.

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II. Methodology

A. Materials

Sago starch was supplied by Borgiap Industries SdnBhd who manufactured sago from its raw sago plant. It has average particle size of 20μm and decomposition temperature of 230ºC. LLDPE supplied by ETILINAS product code LL0209SA with a melting temperature of 130ºC and melt flow index of 2.0g/10min, manufactured by TITAN (M) Sdn. Bhd., Johor was used as a resin. Carbon black masterbatch was supplied by Plasma Color (KL) Sdn Bhd. Polyvinyl alcohol which is reagent grade chemical will acts as biodegradable plastic was supplied by Chemo Laboratory.

B. Samples Preparation

SS and LLDPE, along with the addition of PVA, and carbon black masterbatch were mixed until homogenized. The percentages of LLDPE, PVA and SS for hybrid blends were tabulated in Table I.

TABLE I
Composition of Hybrids

Materials (%)	Hybrid (a)	Hybrid (b)	Hybrid (c)	Hybrid (d)	Hybrid (e)
LLDPE	20	20	20	20	20
PVA	50	40	30	20	10
Sago Starch	20	30	40	50	60
Carbon Black	10	10	10	10	10

Different compositions of materials need variably duration of mixing process until homogeneity is achieved. Prior to the mixing process, it is important to dry the starch in oven for 24 hours at 60ºC to ensure all moisture entrapped inside was evaporated completely. Any moisture content can affect the process ability of compound during extrusion. Compound then was fed into Twin Screw Extruder with setting of rotor speed at 80rpm and the temperature for heating zone were set between 125ºC and 140ºC respectively. Minimal adjustments of setting were done due to changing types of compounds fed.

C. Film Characterization

Film of thickness of 0.06mm with 15 cm x 15 cm m of

compounded SS/PVOH was mixed with conventional LLDPE and carbon black master batch. Film were processed at 160ºC -180°C and rolled film. The pre-heating and cooling time were 5 minutes respectively. Blend films in average of 0.05mm-0.06mm, were trimmed and cut into strips for other testing.

For the UV radiation exposure, films degradation followed the ASTM D5071 standards. The testing required the characterization of the duration of exposure in term of solar radiation. It can caused serious product degradation such as fading, color change, cracking, peeling oxidation or loss of strength.

Soil exposure degradation has been standardized for testing plastic. Soil exposure degradation was performed with a slight modification. Weight loss of the sample over time was used to indicate the degradation rate of soil burial test. Soil burial test was used to give an indication of the duration of the test material in a given soil under given condition. The exposure conditions are not controlled such as temperature, rainfall, humidity and sunlight vary from day to day under Malaysian hot and humid weather [3].

III. Result and Discussion

A. Expose UV Radiation

Fig. 1 shows the weight loss of hybrid (e) with 60% content and hybrid (q) with 20% SS content after 60 days of UV radiation. Weight loss of films is one of the significant characters of UV degradation which indicates the breakage of polymeric bond in the system. The deterioration of films under UV radiation id called photo-degradation. The process occurred when the films have lost their mechanical strength depending on the sum of sun intensity and environment factors. The samples of poly bag with 20 % SS are only slightly decrease until 60 days which is only 15-20% upon UV exposure.

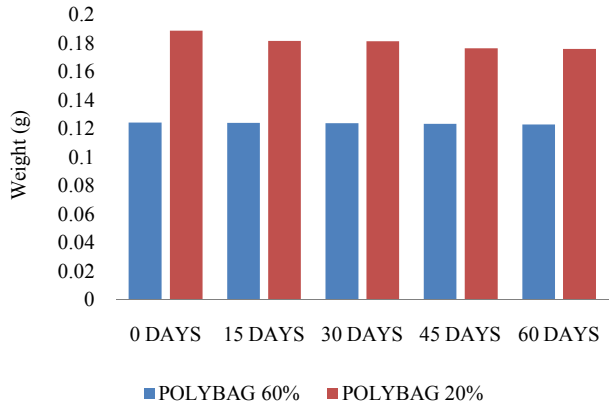

Fig. 1 Expose UV radiation of hybrid films LLDPE, SS and PVA

Another one polybag with 60% SS also decrease slightly which is about 12-15% up to 60 days exposure. The weight losses are found to be small as content of PVA/SS may have water and humidity being absorbed upon frequent rainfall and weathering. The PVA/SS is hydroscopic which can absorb water and may increase the weight of the hybrid film.

However, due to the incredibly strong bonds of PE, there were minor deterioration and weight loss of hybrid sample with less percentage of SS upon UV exposure which inhibit the films from being degraded. This shows that the degradation of LLDPE/PVA/SS hybrid film occurred from other forms of mechanism such as enzymatic; though only if it is in contact with soil rather than UV radiation. The degradation may proceed faster if photo degrading additive were incorporated into the blends. Addition of photo-degradant into non-degradable PE can initiate significant degradation upon UV exposure [4]. The hybrid film fabricated here does not have the photo-degradent additive which could assist in photodegradation. Photo degrading additive can assist deterioration and weight loss of film upon exposure to UV as it was found that in other studies, the oxygen uptake increase and the rate of alcohols can increase leading to the rapid increase in carbonyl group concentration [5] The effect of UV radiation mainly caused the chain reorientation in the form of shorter and more readily crystal sable [6].

B. Soil Degradation

The sample films were cut into 2cm x15cm dimension and place on the soil. The soil taken from oil palm plantation field in Ledang City, Johor which is a rich tropical top soil was place in a planting ceramic made pot and samples were put onto the soil surface for exposure under natural weather. In certain period the soil was kept moist by sprinkling water to maintain 50% humidity. Fig. 2 shows the soil degradation sample films along 60 days in various samples. The excess water was drained through a hole at the bottom of the pot.

Highest weight losses for blended films were exhibited by highest amount of sago starch content of 60% or hybrid (e). This implied that greater amount of SS had better hydrolysis capability to convert the hydroxyl for esterification.SS has better attraction for microbe to penetrate and initiate enzymatic attack and proceed the degradation process.

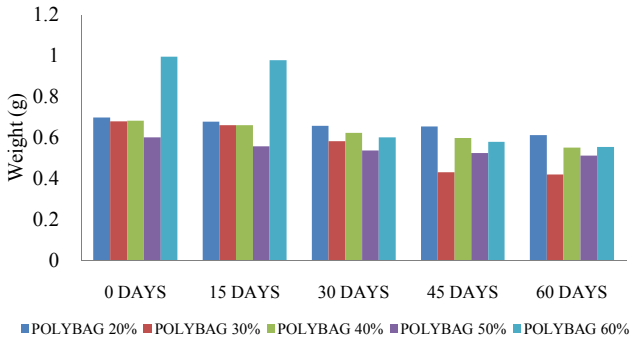

Fig. 2 Weight losses of five different hybrid films

It is shown in Fig. 2 that hybrid (e) which has 60% SS content film sample, the degradation is reduced significantly after 15 days to about 38% as the microorganisms started to attack and film deteriorate drastically. The lowest weight losses were depicted by hybrid film with SS content of 20%.

The enzymatic degradation was very much reduced as attacks from microorganisms are less due to fewer amounts of SS present. The films samples were cut into same dimension for homogeneity. The solubility of sago starch contributed agent for degradation of the samples. By microbial activities help the plastic films degrade and the structure into smaller fragments. The entire microbial act essential for degradation, not only for SS, it is also degrading PVA as a main composition for the film sample [7]. PVA enhance to degradation, however the rather rate slow. By addition of SS into the compounding has led increase the degradation film. Fig. 1 shows the visual changes of the blends films up to 60 days of soil burial degradation. All film samples were cut into same dimension for homogeneity. All blends showing high rate of degradation after 60 days of soil burial degradation. Defragmentation of film samples are obviously except for film polybag 30%. Blend film polybag 20%, polybag 40%, polybag 50% and polybag 60% where the texture of the samples is disintegrated. The solubility of SS contributed in promoting the degradation of the samples

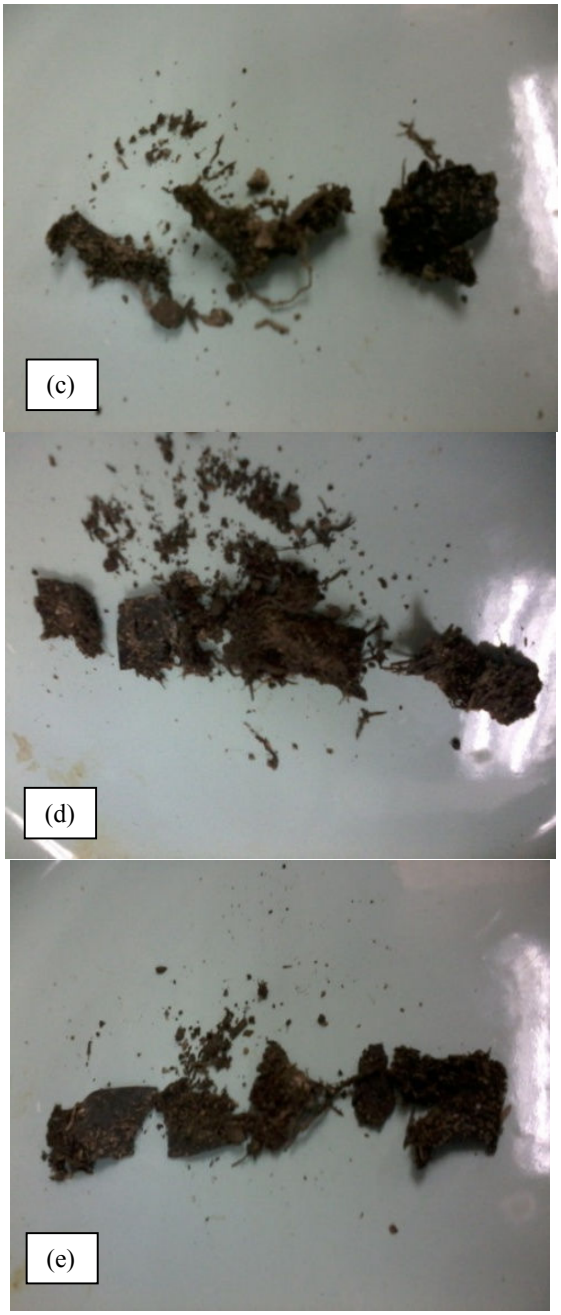

Fig. 3 Image of degraded hybrid films after 60 days of soil exposure (a) polybag 20%, (b) polybag 30%, (c) polybag 40%, (d) polybag 50%, (e) polybag 60%,

IV. Conclusion Composition of Hybrids

Hybrid films were prepared by extrusion LLDPE, SS, PVA along with plasticizer by varying the amount of PVA and SS in each formulation. As in agriculture, almost all used polymeric materials are discarded and often left unattended into soil or being disposed in the landfill. Thus, the interest of developing degradable polymer is becoming more important and crucial as to counter measure the problem of pollution and soil sterility caused by the polymer wastes. Research and development of degradable polymer is becoming more

important and crucial as to counter measure the problem of pollution and soil sterility caused by the polymer wastes.

These blended films have potential to use as degradable for low and moderate moisture product. Soil burial and exposure UV radiation of samples have been developed by producing the desired product for application in the agriculture, medical or even food packaging.

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