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Tensile Properties and FTIR Analysis of HDPE/ Soya Spent Powder in Oven Aging

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A B S T R A C T

This investigation involves pure HDPE and then HDPE with addition of soya spent powder with different weight percentagesbefore and after exposing in the oven aging. The characteristics of pure HDPE and HDPE/ soya spent powder blends were observed on the strength using tensile test and structural changes using fourier transform infrared (FTIR) analysis. The percentage of tensile strength and elongation at break increased inversely proportion with increasing soya spent powder content and number of day's heat exposure. While FTIR results, only HDPE/ 10% soya spent powder blends shows a significant changes between the functional group after exposed to the oven. The effect of SSP and heat energy shows that ratio 10% of SSP to HDPE shows a better indicator for degradation process

INTRODUCTION

High density polyethylene (HDPE) is one of the thermoplastic materials. This polymer is consists of many repeating monomers units in long chains. Commonly, the monomers are alkenes that reacts each other by addition of their unsaturated bonds. This polymer is a semi – crystalline polymer. This means that polyethylene is made up of crystalline and amorphous region. A polymer that has more crystalline region has a higher strength and greater density. So, this polyethylene combines the strength of crystalline polymers with the flexibility of amorphous. It can be tough with an ability to bend without breaking. Moreover, crystalline regions are highly ordered and its molecular chains arranged denser. This packed arrangement caused the polymer has less branch. Its chain can be around 500,000 to 1,000,000 carbon units long. Thus, their modulus material is high with a greater strength, hardness and chemical resistance [1].

HDPE has many uses as it has a greater strength and can resists for some reaction. HDPE is very popular in blow-molding applications. It can bend itself to blow molding to make bottles, containers, and fuel tanks for automobiles, toys and household goods. It is very useful for household goods and industrial chemicals because it can resist to chemical reaction [2]. Since it has a greater strength, HDPE can be used to make pipe fittings, wear plates, hinges and cutting boards [3].

While, soya spent powder (SSP) is byproduct of soya-bean oil. There are many products have been made up of soya-bean such as drinks, foods and many more. This is because soya-bean has a beneficial composition for healthy, material products and also to the environment [4].Therefore, the cooperation of SSP in HDPE can accelerate the degradation of polyethylene. They can bring larger surface for degradation activities [5]. Besides, oven aging also is used in order to investigate the period for degradation process under heat pressure. The properties of the blends that observed are the strength of the blends and its structural changes.

Experimental:

Sample Preparation:

The SSP was dried using a vacuum oven set at 60 °C for 24 hours. A table 2.1 shows that HDPE was blended with soya spent powder varies with different soya spent powder content. A twin screw extruder LTE 1416 was used to blend the both materials at speed 50 rpm at temperature 180 ºC. After that, HDPE/SSP blends were pelletized into resin form. About 25g of the blends was compression molded using a hot press. The hot press temperature was also maintained at 180 °C. Then, the molded samples were cut into dumbbell shapes using dumbbell specimen cutter before subjecting them to tensile testing. Two set of samples was made for all the process. One sample put into the oven aging before tested. Another sample was tested directly without expose to oven aging.

Table 2.1: Formulations of Materials

Materials	Formulations
HDPE	100% HDPE
HDPE/ 2% SSP	98% HDPE + 2% SSP
HDPE/ 5% SSP	95% HDPE + 5% SSP
HDPE/ 8% SSP	92% HDPE + 8% SSP
HDPE/ 10% SSP	90% HDPE + 10% SSP

Oven Aging Procedure:

Oven aging test was performed by putting the materials in the oven. Oven that used was based on temperature. This type of oven had same operation with forced-ventilation oven. So, it was recommended that specimens had a nominal thickness greater than 0.25 mm [7]. Therefore, the specimens used after the molding process finished. Then, they were put into the oven vertically so that whole surface of the materials exposed to the heat. Oven was set at 60ºC. Each formulation had put their samples for 1 day, 3 days, 7 days, 14 days and 21 days. Each formulation also prepared for control measurements. Therefore, each formulation prepared at least 12 sheets of materials. All materials must be exposed at the same time in the same device when using single temperature. The number of replicates of each material used must be sufficient for each exposure time so that results of tests used to characterize the material property can be compared by analysis of variance or similar statistical data analysis procedure [6].

Tensile Test:

Tensile test was carried out according to ASTM D638. At least 5 samples were testes and the average value is taken. The parameters obtained were tensile strength and elongation at break (E_b). The retention of these properties is calculated by using Equation 2.1.

$$\text{Retention (\%)} = \frac{\text{value after aging}}{\text{value before aging}} \text{ x } 100\% \quad (3.1)$$

Fourier Transform Infrared (FTIR) Analysis:

A Fourier transform infrared (FTIR) spectrometer (Perkin Elmer Version 10.002) is used to obtain the molecular changes of the blends after heat exposure. The equipment was operated at a 4 cm^{-1} resolution level, in the 4000-400 cm^{-1} scanning range. Thin sample sheets with a 1mm thickness were tested according to the attenuated reflection method.

RESULTS AND DISCUSSION

Tensile Properties:

Tensile strength decreased as weight of soya spent powder increased. According to [8], the increasing of filler leads the reduction of the flexural strength, tensile strength, elongation at break and impact strength of plastic composites. Soya spent powder is a natural polymer that can be leached from day to day. Therefore, the strength of the material decreased as its content decreased. Besides that, the tensile strength decreased as exposure period to the oven aging increased. When the materials are exposed to the heat, structure of material became weaken. Oven aging was given out heat that can break the bonds of the material. Thus, the longer the materials exposed to the heat, the weaken strength of the material.

Elongation at break (E_b) is the strain of the materials when it breaks. Elongation at break decreased when the addition of filler that increased the stiffness of the composites [9]. This is because deformability of a rigid interface between SSP and HDPE matrix decreased. The fillers harden the materials and reduced their ductility [8].

Figure 3.1 and 3.2 shows the tensile strength and elongation at break (E_b) of HDPE/ soya spent powder blends after exposing to the oven aging for 21 days, respectively. While, Table 3.1 and 3.2 show that retention of tensile strength and elongation at break decreased over period time of oven aging. This shows that oven aging is a good agent for degradation. It gives out heat energy to material that reduced surface area.

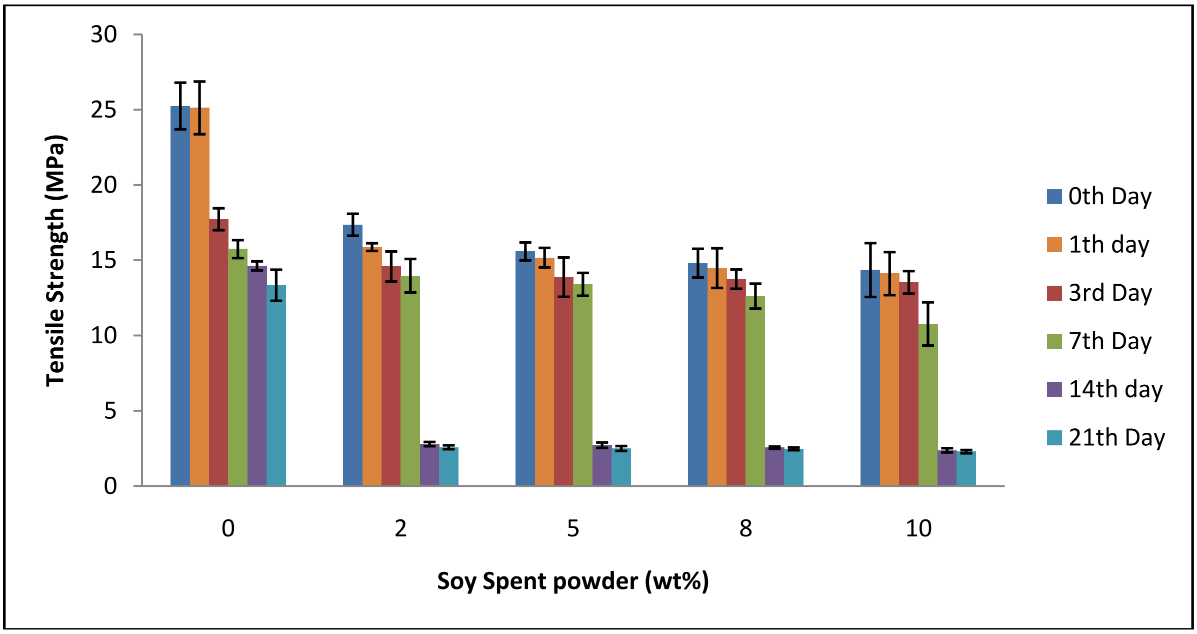

Fig. 3.1: Tensile Strength of HDPE/ SSP Blends with and without Exposing to the Oven Aging for 21 Days.

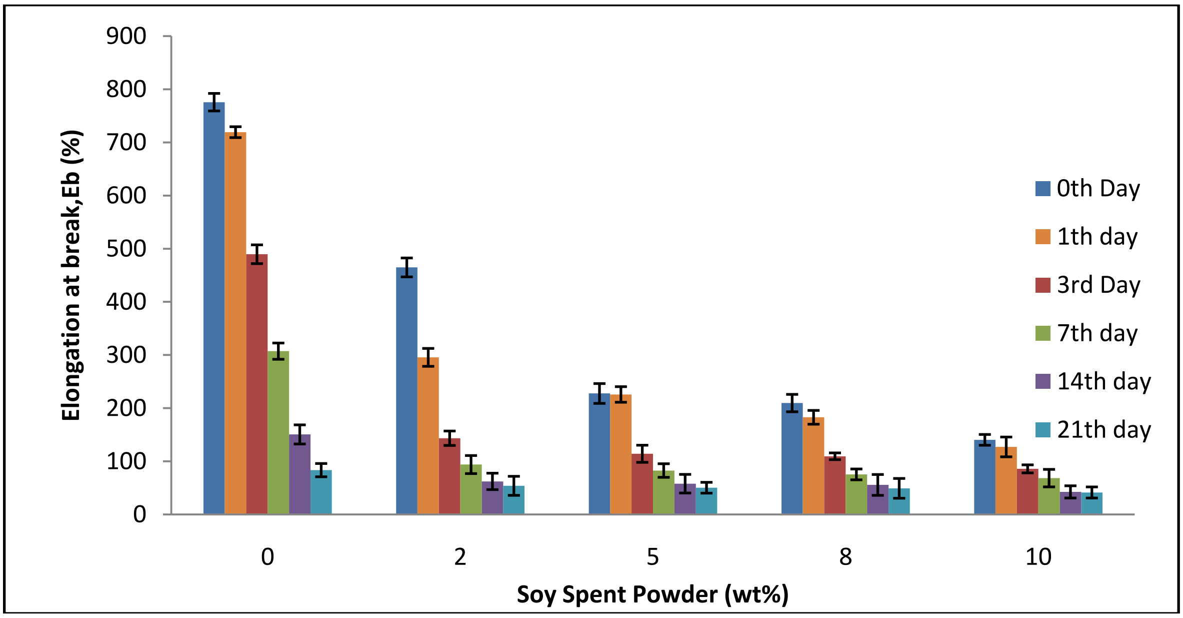

Fig. 3.2: Elongation at Break, (E_b) of HDPE/ SSP Blends with And without Exposing to The Oven Aging for 21 Days.

Table 3.1: Retention of Tensile Strength for HDPE/ SSP Blends After Different Periods of Oven Aging

	Tensile strength (%)				
Sample	1 day	3 days	7 days	14 days	21 days
HDPE	99.50	70.21	62.36	57.94	52.84
HDPE/ 2% soya spent powder	91.46	84.05	80.53	16.08	14.87
HDPE/ 5% soya spent powder	97.37	89.05	85.98	17.44	16.02
HDPE/ 8% soya spent powder	97.81	92.84	85.22	17.26	16.72
HDPE/ 10% soya spent powder	98.35	94.28	75.08	16.57	15.94

Fourier Transform Infrared Spectroscopy (FTIR) Analysis:

This analysis used to determine the structural changes that occurred after addition of soya spent powder and heat exposure. This analysis involved striking substances with progressive wavelength of infrared light and measuring the absorption. Different types of molecular bonds absorbed infrared light at different wavelength. From IR absorption spectra, the most important changes were in the carbonyl (1785-1700 cm^{-1}) and esters (1300-1000 cm^{-1}) regions. The mechanism of polyethylene degradation can be seen in Figure 3.3.

Table 3.2: Retention of Elongation at Break for HDPE/ SSP Blends After Different Periods of Oven Aging

	Elongation at break (%)				
Sample	1 day	3 days	7 days	14 days	21 days
HDPE	92.73	63.12	39.62	19.41	10.75
HDPE/ 2% soya spent powder	63.60	30.87	20.20	13.38	11.60
HDPE/ 5% soya spent powder	99.17	50.15	36.32	25.43	22.09
HDPE/ 8% soya spent powder	87.21	52.24	35.97	26.53	23.47
HDPE/ 10% soya spent powder	90.53	61.11	48.72	30.27	29.49

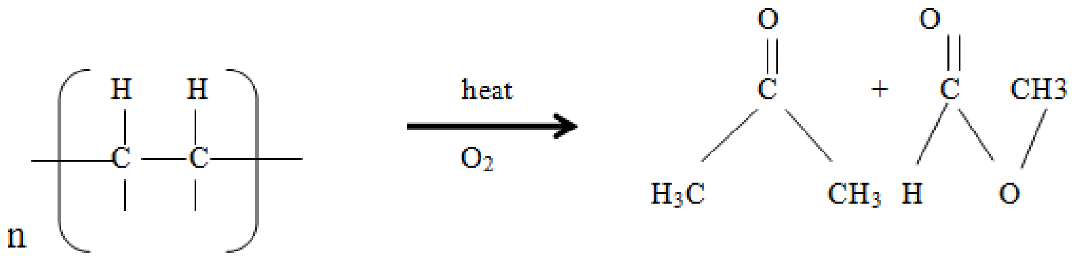

Fig. 3.3: Mechanism of Polyethylene Degradation with Addition of SSP with Heat Exposure.

HDPE/ 10% soya spent powder blends undergoing degradation when exposed to the heat and react with oxygen in surroundings. This generated of alkenes and ester groups. Other functional groups reacted with filler and light and temperature that produce these two functional groups for degradation process [10].

Conclusion:

For mechanical test, it was observed that tensile strength of pure HDPE decreased after heat exposure. Then, tensile strength of HDPE/10% soya spent powder blends showed the reduction from the pure HDPE. Meanwhile, elongation at break for pure HDPE was reduced after 21 days heat exposure. The value of elongation at break also was reduced after addition 10% soya spent powder. So, it can conclude that heat energy and filler can decrease mechanical properties of polymer. Therefore, it can increases degradation process.Besides that, there is a change in structural of pure HDPE after addition of SSP and heat exposure. This might be an initial step for the fragmentation of polyethylene into lower molecular mass.

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