Effects of Stone Powder on Water Absorption and Biodegradability of Low Density Polyethylene/Palm Pressed Fibre Composite Film

NOOR FATHEYAH Aris[1a,*], ROHAH A. Majid[2b], Wan Hasamudin Wan Hassan[3c], Mohd Faizal Abd Rahman[4d], Ng Yik Mun[5e]

[1]Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia
[2]Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 Skudai Johor, Malaysia
[3]Stesen Penyelidikan Usahasama MPOB/UKM, Bangi, 43000 Kajang, Selangor, Malaysia
[4]Malaysian Nuclear Agency (Nuclear Malaysia), Bangi, 43000 Kajang, Selangor, Malaysia
[5]Blapol Plastics Sdn Bhd., Kota Kemuning, 40460, Shah Alam, Selangor, Malaysia

[a]noorfatheyaharis@gmail.com, [b]rohah@cheme.utm.my, [c]wanhaswh@mpob.gov.my, [d]faizal@nuclearmalaysia.gov.my, [e]jacbiz@gmail.com

Keywords: Low density polyethylene, Palm pressed fibre, Stone powder, Composites

Abstract: This study was aimed to develop semi-biodegradable low density polyethylene (LDPE)/oil palm pressed fibre (PPF) composite film for agriculture applications such as nursery bag and plastic mulch. Biodegradability and water absorbency are among the properties need to be considered. Biocomposite plastic that rich with cellulose normally takes faster time to biodegrade as the fibres become the food source of microbes in soil. It also absorbs water easily due to hydrogen bonding formation between the cellulose and the water molecules. To have a balance between these properties is important to determine the service life of the film. Inorganic filler, stone powder with particle size of 37 micron was incorporated at 5, 10 and 15 phr into a mixture of LDPE/PPF, in order to improve both properties. The stone has undergone a catalytic transmuted process to produce fine powder using technology patented by Blapol Sdn Bhd. The mixture was compounded using twin screw extruder and palletized prior to blown into a sheet of film. The effects of stone powder onto water absorption and biodegradability were studied. The percentage of water absorption was decreased about 13 % with addition of 15 phr stone powder, which is thought due to the ability of stone powder to interfere the formation of hydrogen bonding between hydroxyl groups of cellulose and water molecules. Meanwhile, the weight loss in biodegradability test has been slow down, probably due to inorganic nature of stone powder that takes longer time to be digested by microbes in soil.

Introduction

Over 200 million tons of plastics are manufactured annually around the world which contributes to the heavy pile of plastic wastes in landfill. Plastic bags take 200 to 1000 years to decompose while foamed plastic cups take 50 years to degrade [1,2]. Plastics such as polyethylene, polypropylene and polystyrene are made from petroleum-based materials which are non-biodegradable. Due to awareness on environmental sustainability, many plastic manufacturers have showed their interests to produce semi or fully biodegradable plastic packaging. One popular approach is to incorporate natural fibre into polymer matrix since the fiber is cheap, readily available, low density and high specific performance [3]. Malaysia is one of the largest exporters of palm oil and its secondary products, leaving abundance of oil palm biomass at the backyard of factory. By proper design, this biomass can be turned into added-value products. In this project, palm press fiber (PPF), the second largest of biomass produced by the palm oil industry was used as filler. Biocomposite plastic that rich with cellulose normally takes faster time to biodegrade as the fibres become the food source of microbes in soil. It also absorbs water easily due to hydrogen bonding formation between the cellulose and the water molecules. To have a balance between the biodegradability and water absorption is important to determine the service life of the film Apart from using natural fibres, the introduction of low cost inorganic fillers such as calcium carbonate, talc or clay into polymer matrix is also a common practice to plastic industries [4]. In this research, stone powder with particle size of 37 micron was used as filler. The powder is produced from a catalytic transmuting process of rock stone patented by Blapol Sdn Bhd. Smaller particle size is thought can provide large surface area, which allows more interfacial contact between the filler and the polymer matrix. The hybrid fillers of PPF and stone powder were incorporated into low density polyethylene (LDPE) matrix. LDPE is one of commodity plastics that are commonly used in plastic packaging due to its good flexibility to undergo blown film extrusion [5].

Experiment

Materials

Low density polyethylene resin (blowing film grade, specific melt flow index of 5.05 g/10min and density of 0.8498 g/cm^3) was purchased from Titan Polyethylene Malaysia. Press palm fibre was from Malaysian Palm Oil Broad (MPOB). Stone powder was supplied by Blapol Sdn Bhd. Silane and natrium hydroxide were purchased from Fischer and used as received.

Preparation of PPF

Fibre treatment. The PPF was cleaned and soaked in 5% of NaOH solution for 8 hours. Later it was washed with water prior to dry in oven for 2 days at 60 ^{o}C. The dried PPF was ground using a hammer mill and sieved with a sieve shaker to obtain particle size of 63 µm.

Preparation of biocomposite film

Five samples were prepared with different formulations as shown in Table 1. The amounts of stone powder were varied at 5, 10 and 25 phr.

Table 1: Sample Formulation

Sample code	LDPE (wt%)	PPF (wt%)	Silane (wt%)	Stone powder (phr)
S0	100	0	0	0
S1	100	0	0	5
S2	95	0	5	5
S3	85	10	5	5
S4	85	10	5	10
S5	85	10	5	15

All ingredients were mixed using a high speed mixer. Later the mixture was compounded using twin screw extruder at screw speed of 250 rpm and temperature of 130-165^{0}C. The extrudate was palletized into a strand shape resin. Then, the resin was blown into a film by using extrusion blowing machine, operated at screw speed of 900 rpm and temperature of 130-160^{0}C.

Sample Testing and Characterization.

Water Absorption test. Samples were dried in oven for 24 hours at 60 ^{o}C. Then, the samples were weighed to get initial weight before immersed in distill water at room temperature. The results were taken for every two days until the weight became constant. The test was conducted for 20 days. The average of five samples was taken. The percentage of water absorbed was calculated by using Eq 2.

$$Percentages\ of\ water\ absorbed = \frac{final\ \ weight - initial\ \ weight}{initial\ \ weight} x100\% \quad (2)$$

Biodegradability Studies. The film strips were cut in same size, labeled and weighed. Then, the samples were buried at same time and location. After one week, the samples were carefully taken out from soil and washed to remove any dirt. Then, the samples were dried in oven for 24 hours at 60 ^{o}C before weighed. The test was conducted in four weeks. The average of five samples was taken. The percentage of weight loss was calculated by using Eq 3.

$$Percentages\ weight\ loss = \frac{final\ \ weight - initial\ \ weight}{initial\ \ weight} x\ 100\% \quad (3)$$

Result and Discussion

Water Absorption

Fig. 1 shows the percentages of water absorption for each sample. It can be seen that the addition of 10 wt% PPF has increased the percentage of water absorption as shown by sample S3. This can be related to the hydroxyl groups of cellulose that form hydrogen bonding with water molecules. Although the alkali treatment had improved the hydrophobicity character of PPF, there are some OH groups left in cellulose network. On the other hand, when 10 phr and 15 phr of stone powder were added, the amount of water absorbed decreased as clearly showed by sample S5. The stone powder has ability to interfere the formation hydrogen bonding between PPF and water, thus reducing the percentage of water uptake.

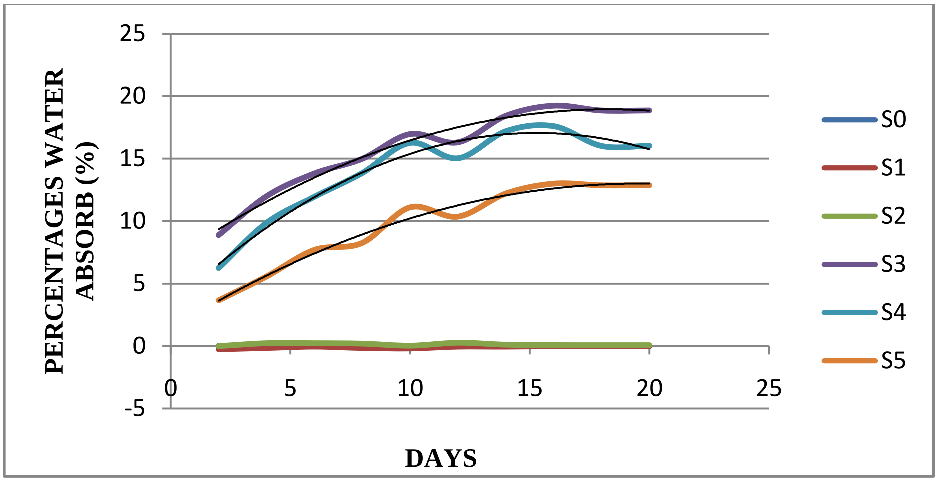

Figure 1 Percentages of water absorbed for each sample in 20 days

Biodegradability

The percentages weight loss for each samples are plotted in Figure 2. It can be seen that no significant changes on weight loss toward samples S0, S1 and S2. However, high percentage of weight loss was observed in sample S3 with addition 10wt% of PPF. The presence of fibres in the sample has become source of food for microbes in soil. This observation was in agreement with Silva et al. [4] that found materials that rich with cellulose, carbohydrate or natural substances are prefer to attack with microorganism and the biodegradation process started immediately. However, by increasing the amount of stone powder to 15 phr, the biodegradation process has been slow down. This could be due to inorganic nature of stone powder that takes longer time to be digested by the microbes.

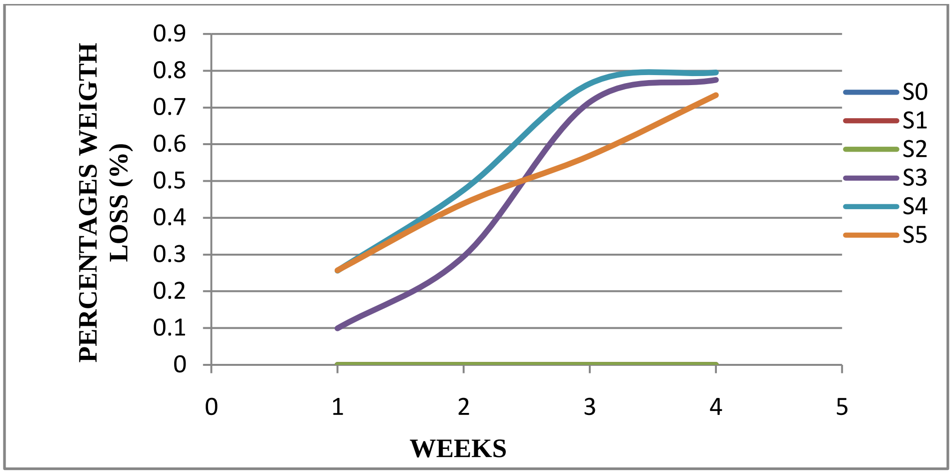

Figure 2 Percentages weight loss for each sample in four weeks

Conclusion

The addition of stone powder affects the flow property of samples. The percentage of water absorption was reduced with the addition of stone powder. This due to the ability of interfere the hydrogen bonding between the hydroxyl groups cellulose and water molecules. Meanwhile the inorganic nature of stone powder has slow down the biodegradation process compared with the sample with PPF only.

References

[1] Tokiwa Y., Calabia, B. P., Ugwu C. U. and Aiba S., Biodegradability of Plastics. International Journal of Molecular Sciences. 10 (2009) 3722-3742.

[2] Volke-Sepulveda, T., Favela-Torres, E., Manzur-Gonzales, M., Trejo-Quitero, G., Microbial Degradation of Thermo-oxidized Low Density Polyethylene. Journal of Applied Journal Sciences. 73(1999) 1435-1440

[3] J. P. Jog and D. Nabi Saheb, Natural Fiber Polymer Composites. Advanced in Polymer Technology, Vol 18, No. 4 (1999) 351-363.

[4] Silva M. C., Takahashi J. A., Chaussy D., Belgacem M.N. and Silva G. G., Composites of Rigid Polyurethane Foam and Cellulose Fiber Residue. Journal of Applied Polymer Science, Vol 117 (2010) 3665-3672.

[5] Abdel-Bary, E. M. (Ed.). Handbook of Plastic Films. United Kingdom: Rapra Technology Limited (2003).