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Biodegradable Bags Properties Evaluation for Nursery Application

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ABSTRACT

Background: In agriculture, biodegradable plastic films are desirable alternatives to black low density poly(ethylene) (LDPE) plastic for the usage of nursery applications. Therefore, an interest study of different types of potential biodegradable polymers used for nursery application has been carried out. **Objective:** To evaluate the durability and degradation of several alternatives of nursery polybag in rubber tree nursery application. **Results:** The samples are supplied from different companies were designated as control (LDPE), CF, SF and CO. Within the time period of three months, tensile properties for all the samples showed less changes except ductility for CO. Fourier Transform Infra-red (FTIR) revealed a characteristic absorbance of control sample, CF, SF and CO are associated with poly(ethylene), poly(butylene adipate-co-terephthalate) (PBAT), polyl(lactic acid), poly(vinyl alcohol) and starch molecular structure respectively. Thermal properties for degradation and decomposition temperature were carried out by thermogravimetry analyser (TGA). **Conclusion:** The tensile properties showed no significant changes during the three months period except for Nurbag CO. Absorbance peaks of FTIR characterization showed the nursery bags are associated with poly(ethylene), poly(butylene adipate-co-terepthalate), poly(lactic acid), poly(vinyl alcohol) and starch. Thermal properties revealed the Nurbag CO give low thermal stability compared to other nursery bags.

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INTRODUCTION

In the recent years, industries and agricultural sector were alarmed by the environmental consciousness. The extremely increase in production and use of plastics in daily life resulted in generation of massive plastic waste. In order to solve the problems, many attempts to search for alternative material that would have potential characteristic such renewability, biodegradability and walk away from harmful additives.

One of the most difficult wastes to recover or dispose in the agricultural sector is mulch film or other plastic film like nursery polybag. It was contaminated with various substances including soil, debris, and chemicals such as pesticides, insecticides and herbicides. Therefore, biodegradable material films have been introduced to mitigate this issue since they can biodegrade on the field after planting, thus eliminating film recovery and disposal (Kyrikou and Briassoulis, 2007; Kijchavengkul *et al.*, 2008).

Also in agricultural applications, nursery polybags are used for promoting an early establishment for the rubber tree before transplanting into the field. The seedling can be retained longer with nursery polybag when condition for field planting is not yet favorable. The objective of this research is to evaluate the durability and degradation of several alternatives of nursery polybag in rubber tree nursery application. The sole purpose for the evaluations is that polybags should withstand weather resistance for at least 9 months before actual rubber tree replanting to a target place.

MATERIALS AND METHOD

Materials:

Samples include 3 nursery bio-polybags (Nurbags) obtained from three different companies. Total of 4 samples including the control; Low density Polyethylene (LDPE) samples were then undergo various testing to investigate the contents and properties of the materials before replanting to a target place. The 4 samples are designated as Nurbag LDPE (polybag LDPE), Nurbag CF (polybag CF), Nurbag SF (polybag SF) and Nurbag CO (polybag

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CO) and the period testing of the nursery bag is from raw polybag and up to three months.

Tensile Test:

Tensile strength (TS) was evaluated for each film by using Shidmazu fully automated tensile test machine. Five dumbbell specimens (ASTM D638) were cut and then placed in the vacuum oven of 30°C for 8 hours before the test being carried out. The width of the specimens is 6.042 mm and length of 115 mm. The specimen's average thicknesses will be about 0.1 mm ± 0.07 mm. The crosshead speed used was 500 mm/min and the gauge length is 25mm. The tensile strength and elongation at break were then determined and analyzed.

Fourier-Transform Infrared (FTIR) Spectroscopy:

The infrared spectra of the biodegradable samples were obtained with an FTIR Nicolet-6700 spectrometer (Thermo Fisher Scientific Inc.) in attenuated total reflectance (ATR) mode with a diamond crystal collecting 32 scans. Each spectrum was acquired using OMNIC software at a wavelength resolution of 4 cm-1 within the range of 4000-500 cm^{-1}.

Thermal Analysis:

Thermogravimetric analysis (TGA) was carried out in nitrogen at a heating rate of 10°C/min using a Mettler-Toledo TG/SDTA 851 thermogravimetric analyzer. A sample size of approximately 7-11 mg was used, which was heated from room temperature to 800°C.

RESULTS AND DISCUSSIONS

Tensile Properties:

Tensile strength and elongation at break of different period of time for all the nursery bags are shown in Figure 1 and 2. Among the nursery bags, Nurbag CO exhibit the highest tensile strength value around 38 MPa while the lowest tensile strength value is Nurbag CF at around 13-17 MPa. Regardless the tensile strength value, a nursery bag would be strong and ductile enough to hold the weight of soil and the seedling itself. Thus, elongation at break also portrays an important property for a nursery bag. It is notice able, in term of elongation at break Nurbag CO appeared the lowest while Nurbag CF and Nurbag LDPE acquire high ductility characteristic.

Glycerol and sorbitol are example of plasticizer which has been widely used. The plasticizer reduced intra- and inter-molecular forcer of a polymer blends. Thus, plasticizer could lengthen, dilute and soften the blends effectively and consequently improves elongation at break (Wittaya, 2012). However, the plasticizing effect causes a reduction in tensile strength which reflected in the above results.

Since Nurbag CO is ascribed to be a PVA/starch blends, there is work reported the tensile strength, elongation and transparency of PVA/starch composites decreased rapidly with increased of starch content (Chen *et al*., 2008). Since starch and PVA blends molecules have a large of hydroxyl groups, PVA/starch blends display a hydrophilic nature. Mao *et al*. (2000) reported that the blends were very sensitive to relative humidity and tensile strength decreased significantly with increase of relative humidity.

Overall, tensile properties comparison for all nursery bags is showing fewer changes within the 3 months of usage, except Nurbag CO. This is because the nursery bags are made from hydrophilic materials, thus throughout the usage period hydrolysis may happened and affected properties of the bag.

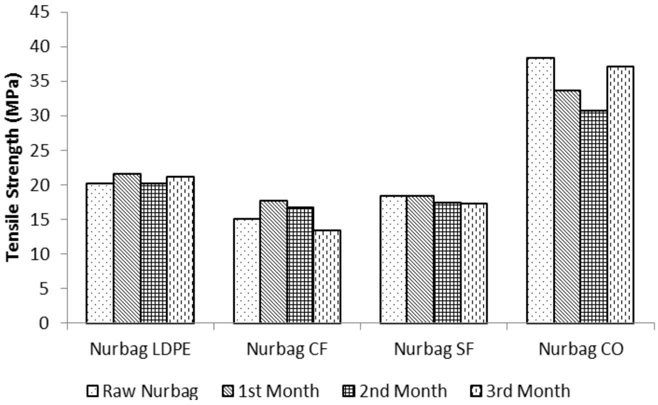


Fig. 1: Tensile strength value for all nursery bags.

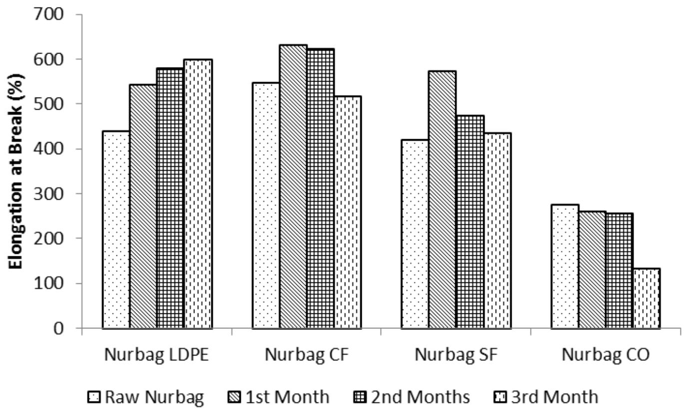
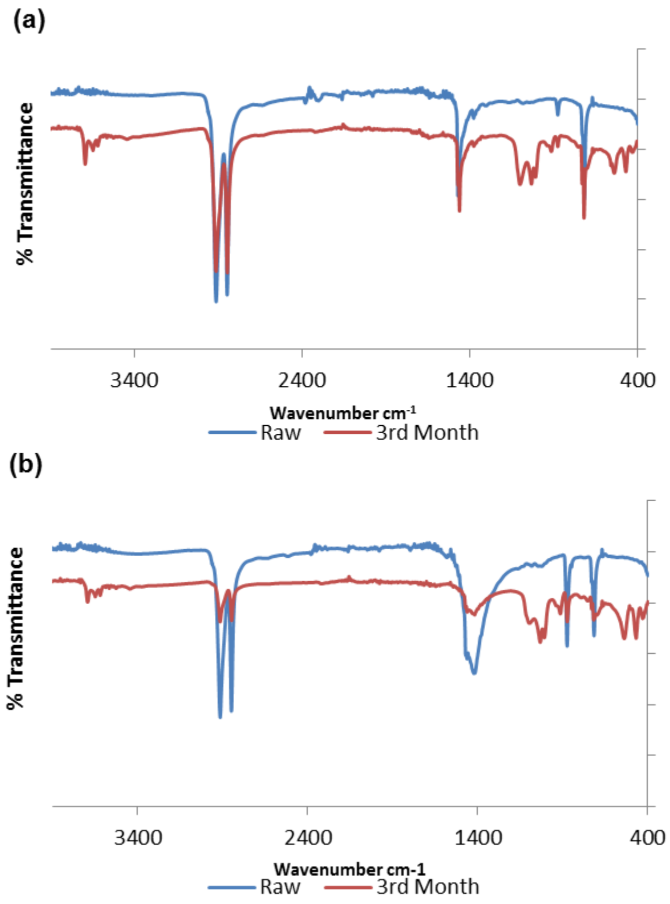


Fig. 2: Elongation at break value for all nursery bags.

Fourier Transform Infrared:

The IR spectra of the respective samples from raw nursery bags and after 3 month field usage are shown in Figure 3. As can be seen for the Nurbag LDPE (Figure 3(a)) main absorption band shows the following; 2913 cm^{-1} and 2847 cm^{-1} represent asymmetric –CH2 and symmetric stretching vibration, while 1470 cm-1 is due to the symmetric deformation of the methylene group and at the range of 710 cm^{-1} corresponding to bending and rocking vibration of crystalline and amorphous methylene group.

Figure 3(b) shows the IR spectra of Nurbag CF. The spectrum shows similar absorption band with Nurbag LDPE at some points which at 2193 cm^{-1} and 2847 cm^{-1} represent the –CH2 asymmetric and symmetric stretching vibration. Two absorption peaks are observed at 874 cm-1 and broad peak at the range of 1500 cm^{-1} and 1400 cm^{-1} which presumably indicates the presence of inorganic carbonates. The absorption phenomenon around 1266-1200cm-1 in the spectra refers to the bending frequency of C-H, O-H or CH2, while absorption around 1060-1050 cm^{-1} and 890 cm^{-1} refers to C-H stretching vibration of C-O and the structure of cellulose component (Alemdar and Sain, 2008).



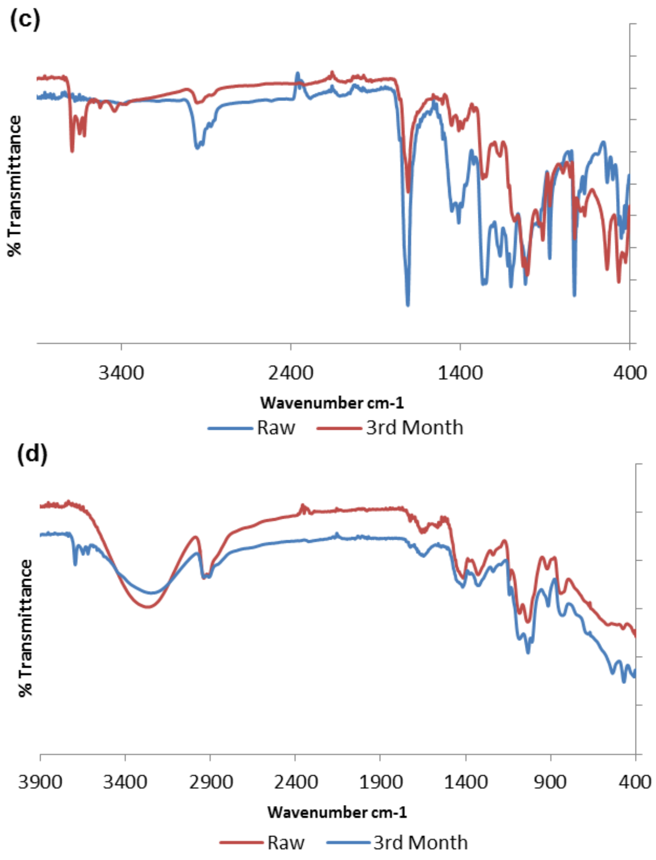


Fig. 3: FTIR spectra of nursery bags at raw and 3 month of usage. (a) Nurbag LDPE, (b) Nurbag CF, (c) Nurbag SF and (d) Nurbag CO.

Move on to IR spectra of Nurbag SF (Figure 3(c)) raw and after 3 months usage period. The absorption peaks are identical to main characteristic of PBAT/PLA (Weng *et al*., 2013). AS observed in the spectra the PBAT/PLA blends infrared spectral information shows as the following; 2952 cm^{-1} represent the –CH2 asymmetric vibration, 1708 cm^{-1} represent the stretching vibration of C-O, weak absorption band at 1505 cm^{-1} belongs to skeleton of the benzene ring. Further at 1409cm^{-1} represent the trans –CH2 plane bending vibration.

Figure 3(d) show the IR spectra of Nurbag CO. As shown in the spectra, a broad peak at 3267 cm^{-1} due to bonded OH groups. The absorption peak at 2938cm^{-1}, 1413 cm^{-1}, 1325 cm^{-1}, and 1032 cm^{-1} was due to –CH, C-C and C-O stretching respectively (Singha and Rana, 2012).

Thermogravimetry Analysis:

TGA was measured to access the thermal stability of both raw and after 3 months usage of the nursery bags. Figure 4 represent the raw nursery bags analysis curves while Figure 5 for the after 3 months analysis. Nurbag LDPE is showing only one stage decomposition temperature at 470°C and char yield at 5%). Moreover, Nurbag CF also showing similar maximum decomposition temperature at 475°C but it has another stage at 710-719°C and leaves a residue at 18%. Similar thermogram curve have been reported (Ndazi *et al*., 2007) which indicates that the Nurbag CF contained organic fibers related to the second stage temperature. The weight fraction of material that still existing after heating above 400°C is representative of the carbon content in the fibers (Hornsby *et al*., 1997). The increased residue amount at high temperature is due to the presence of ash as well as lignin in the fibers.

As for Nurbag CO, the initial stage of decomposition starts earlier at 97-140°C which ascribed to vaporization of water because the hydrophilic characteristic of PVA/starch blends. The later stages of the decomposition are at 365°C and 438°C with leaves low residue at 3%. The clear distinction at high temperature is similar curve of crosslinked PVA/starch blends reported by Yingmo *et al*., (2013) where crosslinked PVA/starch blend possessed better thermal stability compared to only PVA and starch films. The TG curve for Nurbag SF showing several stages of decomposition temperature which started at 250°C to 400°C (66% of material composition) followed by second stage at 587°C, third stages at 724°C then residue yield at 14% of the composition.

As can be seen from the TG curve of Nurbag SF, the former part presumably was PLA TG curve and the later was PBAT TG curve which reported by Weng *et al*. (2013). Furthermore the results show that decomposition process of various components but in this prospective Nurbag SF show the respective single polymers which likely to be PBAT/PLA blends. Generally, all the TG curves showed minor changes over the 3 months in term of degradation temperature except Nurbag CO.

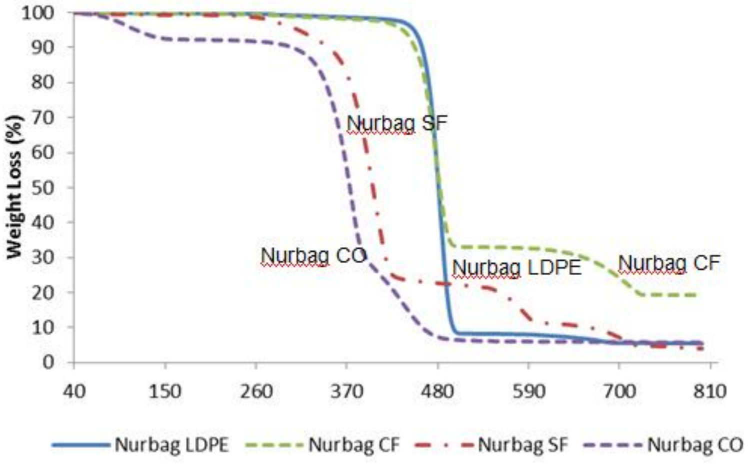


Fig. 4: Thermogram curves of nursery bags for raw plastics.

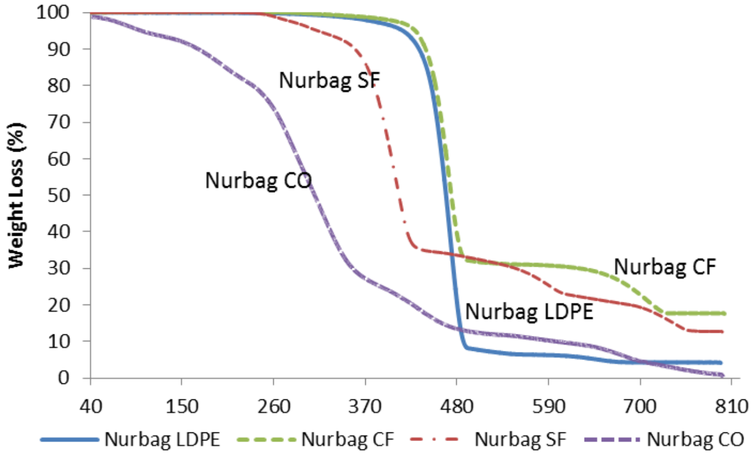


Fig. 5: Thermogram curves of nursery bags after three months period.

Conclusion:

The evaluation properties of biodegradable bags designated as Nurbag LDPE, Nurbag CF, Nurbag SF and Nurbag CO have been successfully conducted. The tensile properties showed no significant changes during the three months period except for Nurbag CO. Absorbance peaks of FTIR characterization showed the nursery bags are associated with poly(ethylene), poly(butylene adipate-co-terepthalate), poly (lactic acid), poly (vinyl alcohol) and starch. Thermal properties revealed the Nurbag CO give low thermal stability compared to other nursery bags.

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REFERENCES

Alemdar, A., M. Sain, 2008. Isolation and characterization of nanofibres from agricultural residue wheat straw and soy hulls. Bioresource Technology, 99: 1664-1671.

Chen, Y., X. Cao, P.R. Chang, M.A. Huneault, 2008. Comparative study in the films of poly(vinyl alcohol)/pea starch nanocrystal and poly(vinyl alcohol)/ native pea starch. Carbohydrate Polymers, 73: 8-17.

Hornsby, P.R., E. Hinrichsen, K. Tarverdi, 1997. Preparation and properties of polypropylene composites reinforced with wheat and flax straw fibers. Part I. Fiber characterization. Journal of Material Science, 32: 443–449.

Kijchavengkul, T., R. Auras, M. Rubino, M. Ngoujiao, R.T. Fernandez, 2008. Assessment of aliphatic-aromatic copolyester biodegradable mulch films. Part I: field study. Chemosphere, 71: 942-53.

Kyrikou, I., D. Briassoulis, 2007. Biodegradation of agricultural plastic films: a critical review. Journal Polymer Environment, 15: 125-50.

Mao, L.J., S. Imam, S. Gordon, P. Cinelli, E. Chiellini, 2000. Extruded corn starch-glycerol-polyvinyl alcohol blends: Mechanical properties, morphology and biodegradability. Journal of Polymers and Environment, 8(4): 205-211.

Ndazi, B.S., S. Karlsson, J.V. Tesha, C.W. Nyahumwa, 2007. Chemical and physical modifications of rice husks for use as composite panels. Journal of Material Science, 38: 925–935.

Singha, A.S., A.K. Rana, 2012. A comparative study on functionalization of cellulosic biofibres by graft copolymerization of acrylic acid in air and microwave radiation. Bioresource, 7: 2019-2037.

Weng, Y.X., YJ. Jin, QY. Meng, L. Wang, M. Zhang, YZ. Wang, 2013. Biodegradation behaviour of polybutylene adipate-co-therephthalate) (PBAT), poly(lactic acid) (PLA) and their blend under soil conditions. (2013) Polymer Testing, 32: 918-926.

Wittaya, T., 2012. In structure and function off Food Engineering, Chapter 5 (Eds: Yaman Amer Eissa), ISBN 978-953-51-0695-1, 414 pages Publisher: In Tech, Chapters., pp: 103-134.

Yingmo, H., W. Qingling, T. Mingru, 2013. Preparation and properties of Starch-g-PLA/poly (vinyl alcohol) composite film. Carbohydrate Polymers, 96: 384–388.