Characterization of Starch-Based Biodegradable Polymer

Oktay GONULTAS[1], Zeki CANDAN[1], Turgay AKBULUT[1], M. Hakki ALMA[2], Herman MOELIANA[3]

[1] Department of Forest Products Engineering, Istanbul University, Istanbul, TURKEY,

[2] Department of Forest Products Engineering, Kahramanmaras Sutcu Imam University, 46100, Kahramanmaras, TURKEY

[3] PT Inter Aneka Lestari Kimia, Jakarta, INDONESIA

Abstract

There is an increasing interest in utilization of renewable materials for packaging industry. Starch is one of the most important renewable natural polymers. Using starch-based biopolymers instead of oil-derived plastics are recently becoming popular. Because of its have abundant supply, low cost, renewability, biodegradability, and ease of chemical modifications. Characterization of the starch-based biopolymer can help to understand its material properties and to enhance its end-use performance. In this study, functional group of the biopolymer was investigated by Fourier transform infrared spectroscopy (FTIR). The water solubility properties were also determined at various temperatures. Thermogravimetric analysis (TGA) were carried out to determine thermal characteristics of the biodegradable polymer. The structural characteristics of the biofoam materials were evaluated by scanning electron microscopy (SEM) observation. The results of this study showed that the starch-based biodegradable polymer can be used in packaging industry for making shopping bags instead of oxo-biodegradable polymer. It could be also concluded that using the starch-based biodegradable polymer can help sustainable protection of nature.

Materials and Methods

The biodegradable polymer used in this study is EnviPlast® which is commercially available product. The experimental test specimens were supplied from PT Inter Aneka Lestari Kimia, Jakarta, Indonesia.

The biodegradable films were cut into 2.5 x 2.5 cm and placed in a beaker containing 25 ^{0}C distilled water. The temperature of water was raised at a rate of about 1 ^{0}C/min on a hot plate magnetic stirrer. Time and temperature were recorded until the film full dissolved.

Materials and Methods

Spectroscopic measurements were performed in a SHIMADZU FTIR 8400S spectrophotometer using the standard KBr method (100 mg KBr plus 1 mg biopolymer; resolution: 4 cm^{-1}; 64 scans).

Thermal stability of the biodegradable polymer was evaluated by thermogravimetric analysis (TGA). The biofoam samples were exposed to a heating rate of 10°C min-1 over a temperature range of 20°C to 800°C to carry out TGA. Nitrogen gas was used as the inert purge gas in order to avoid unwanted oxidation of the material.

Results

Figure 1. Water Sensitivity of biodegradable polymer

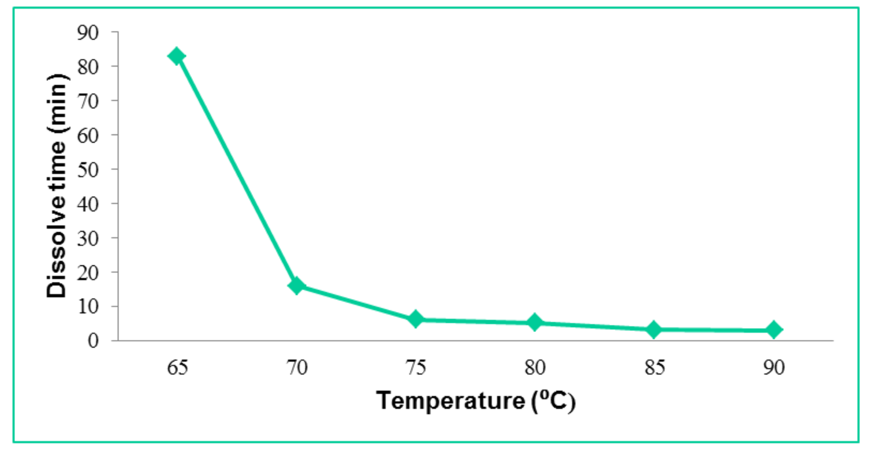
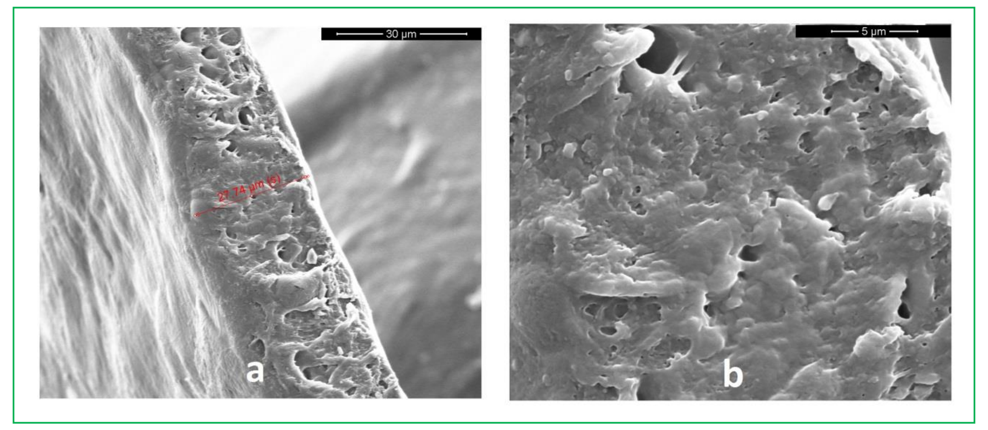


Figure 2 shows water sensitivity of biodegradable polymer. The film was dissolved at 65^{0}C water in 83 minutes, while at 70^{0}C water in 16 minutes. When the temperature increased up to 90^{0}C, dissolved time decreased to 3 minutes.

Figure 2. SEM micrographs of biodegradable polymer



Results

Figure 3. FTIR spectra of biodegredable polymer

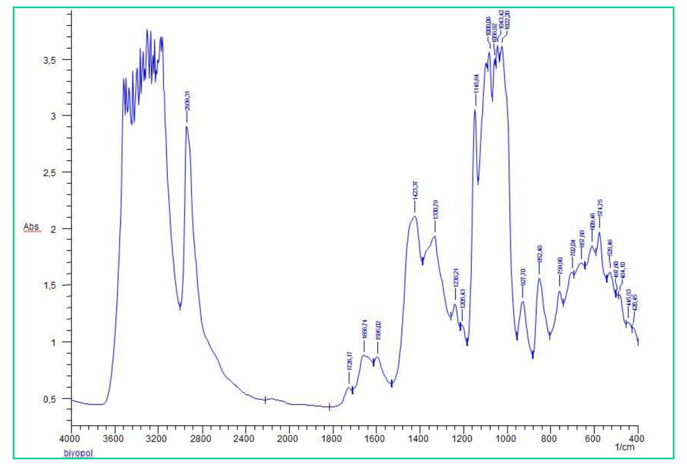


Table 1. Infrared Bands and Assignment of biodegradable polymer

Assignments	Band Position of Biopolymer (cm^{-1})	References
OH strech	3200	Pelissari et al. 2013; Bourtoom and Chiman, 2008
Characteristic peak of C-H stretch	2939	Demirgoz et al. 2000; Elvira et al. 2002; Aburto et al. 1997; Xu et al. 2005
Carbonyl stretching band of urethane groups	1726	Lu et al. 2005; Demirgoz et al. 2000; Elvira et al. 2002;
C=O stretching (amideI)	1656	Bourtoom and Chiman, 2008; Xu et al. 2005
Symmetric stretching of carboxyl group	1423	Pelissari et al. 2013; Kizil et al. 2002
C-C, C-O and C-O-H bonds of starch	1145-1080	Demirgoz et al. 2000; Xiong et al. 2008; Xu et al. 2005; Smits et al. 1998
Stretching vibration of C-O in C-O-C	1022	Elvira et al., 2002; Xiong et al. 2008; Smits et al. 1998
Glycosidic bonds of starch	927	Pelissari et al. 2013; Kizil et al. 2002
Characteristic absorption peak of starch	852	Lu et al. 2005; Xiong et al. 2008
Presence of aromatic structures	759-702	Pelissari et al. 2013; Xu et al. 2005

Table 2. TGA characteristics of biodegradable polymer

Weight (%)							
100 °C	200 °C	300 °C	400 °C	500 °C	600 °C	700 °C	800 °C
93.13	83.19	55.59	19.33	10.57	9.62	9.25	8.91

Conclusions

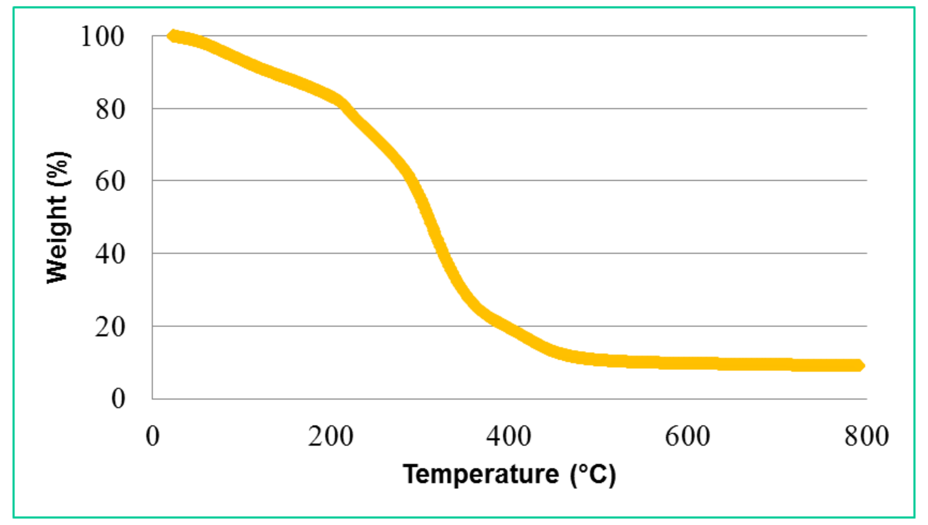


Figure 4 shows the TGA results generated on starch-based biodegradable polymer. The plot indicates the percent mass as a function of sample temperature for the polymer. Maximum weight change was observed between 200°C and 400°C. Beyond that point, weight change rate decreased. It was also determined that the biodegradable polymer leaved about 9 wt % of residue at 800°C in nitrogen atmosphere..

It can be seen from Figure 2, the starch-based biodegradable polymer had a homogenous structure. In addition, its thickness is allmostly same over the surface and was measured as 27µm.

Acknowledgements

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