Study of bagasse/tapioca starch film preparation and characterization

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Abstract. Bagasse/tapioca starch films (BT) were prepared with various contents of bagasse (10, 20, 30, 40 and 50 wt% based on tapioca starch), and the effect of bagasse concentration was studied by the performance of the BT films. Then, the BT films characteristics were analyzed using the instruments about ultraviolet spectrophotometer (US), SEM, TGA and XRD. The dispersion of the bagasse became better with bagasse concentration increasing, the transparency values of the films decreased.

1. Introduction

Biodegradable composite materials have attracted much attention in recent years due to growing environmental problems caused by petroleum synthetic plastics, and they can help alleviate the oil crisis resources and contribute to the development of low-carbon economy[1]. Currently, the natural biopolymers are applied to the manufacture of agricultural films such as cellulose, starch and protein. These environmental-friendly biopolymers are expected to become the main raw materials replacing petroleum in the future. However, inherent limitations of natural biopolymers are causing the main restriction for their application such as low mechanical properties, processing performance and interface compatibility. Various solutions are implemented to overcome the problems for the natural biopolymers, such as the addition of plasticizer, coupling agent and the modified treatment [2]. Consequently, natural biopolymer-based materials have a high potential for their application in agricultural film.

This paper researched a biocomposite film prepared with bagasse and tapioca starch, while the bagasse is processing waste with low value in the past. In recent years, it has attached more attention with rich in cellulose content. The bagasse cellulose has been widely used in the membrane preparation, if the bagasse prepare membrane directly without extraction of other materials, that can be gotten with the improvement of processing waste and the significance of environmental governance.
2. Experimental

2.1 Materials
Sugarcane bagasse was provided from Country Harvest of Guangdong province. Tapioca starch was purchased from Rikewei Material of Guangdong province. All the other chemicals were of analysis grade.

2.2 Preparation of bagasse/tapioca starch composite film
A certain amount of tapioca starch and water were heated at 80°C, then added the sieving of bagasse powder mixed, and increased its uniform dispersion with ultrasonic processing, the plasticizer glycerin and thickener sodium alginate were finally added. Mixing the mixture, a certain amount of tiles were put into the template, and dried forming under 50°C.

2.3 Light Transmittance Characterization
The transparency of the films was determined by visible light range at 400-800 nm respectively, using a UV-VIS spectrophotometer (UV-1780, Shimadzu, Japan).

2.4 SEM Analysis
The surface and cross section morphology of bagasse and tapioca starch biocomposite films were observed using a Scanning Electron Microscope (SEM, S-4800, Hitachi Co., Ltd., Matsuda, Japan). The composite material samples were rapidly cooled in liquid nitrogen, and the brittle cross section morphology was observed under scanning electron microscope after spraying gold.

2.5 FT-IR Analysis
FTIR spectra of bagasse and tapioca starch films were obtained using an Fourier transform infrared spectrometer (Spectrum GX-1, Shimadzu, Japan) in the range of 4000-500 cm\(^{-1}\).

2.6 DTG Analysis
The DTG of films was tested using a thermogravimetric analyzer (STA449C/4/G type, Netzsch, Germany). The temperature was set from -50°C to 250°C with increasing rate being 10 °C/min, and the 50 mL/min N2 was selected as the protection gas.

2.7 XRD Analysis
The crystal film samples were tested by X-ray diffractometer (DLMAX-2550, Japan), testing voltage was 40 KV, Cu target Ka radiation was k = 1.4056 Å, 20 testing ranges were 10°to 80°, the scanning speed of 6 °/min.

3. Result and discuss

3.1 Transmittance
The light transmission characteristic of the bagasse/tapioca starch biocomposite films was measured in the range of 400-800 nm (Table 1). The content of 10 wt% BT film reached the maximum value compared with the other BT films at same wavelength. It was obvious that the increasing bagasse led to a decrease in transparency of the composite BT films. The transmittance values at 400 nm of 10 wt% BT film and 50 wt% BT film were 22.7% and 12.7% respectively, which might be due to the UV light absorbing tendency of lignin in bagasse [5]. Therefore, controlling the bagasse concentration in manufacturing agricultural film was necessary.
Table 1 The transparency of bagasse/tapioca starch films at various wavelength

| Bagasse Content of Film | T<sub>400nm</sub> (%) | T<sub>500nm</sub> (%) | T<sub>600nm</sub> (%) | T<sub>700nm</sub> (%) | T<sub>800nm</sub> (%) |
|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| 10%                     | 22.7                    | 20.6                    | 23.8                    | 23.0                    | 25.0                    |
| 20%                     | 16.6                    | 10.0                    | 11.0                    | 9.9                     | 10.0                    |
| 30%                     | 15.0                    | 8.4                     | 9.0                     | 8.6                     | 9.5                     |
| 40%                     | 13.3                    | 5.3                     | 6.1                     | 4.7                     | 5.7                     |
| 50%                     | 12.7                    | 3.6                     | 4.5                     | 3.1                     | 4.3                     |

3.2 SEM Analysis

The SEM analysis of composite films was performed to observe the dispersion of bagasse through the microstructure surface (Fig. 1) and cross (Fig. 2) of the films. Fig. 1 showed that the distribution of bagasse was more uniform throughout the film containing the least and most bagasse. From Fig. 2, it could be observed that bagasse was evenly dispersed more with the bagasse content increasing, which was consistent with the surface image.

3.3 FT-IR Analysis

FT-IR spectroscopy was carried out to characterize the molecular groups of BT films with different content of bagasse. From Fig. 3, all BT films showed the absorption band at 3400 cm<sup>-1</sup> which was associated with O-H stretching of tapioca starch. It could be observed that the peak intensities at 3400 and 1100 cm<sup>-1</sup> significantly decreased with increasing bagasse content. This might be due to the strong intermolecular hydrogen bonding between the hydroxyl groups of bagasse and tapioca starch [5].

Figure 1. SEM graph of BT films surface

(a) 10 wt% bagasse/tapioca starch
(b) 50 wt% bagasse/tapioca starch

Figure 2. SEM graph of BT films cross section

(a) 10 wt% bagasse/tapioca starch
(b) 50 wt% bagasse/tapioca starch
3.4 DTG Analysis
The effect of bagasse content on thermal stability was studied by TGA which were presented in Fig.3. Increasing content of bagasse improved thermal stability of the films due to the high thermal stability of bagasse, which could limit the movement of molecular chain and prevent the transmission of heat.

![Figure 3. FT-IR spectroscopy and DTG graph of BT films](image)

3.5 XRD Analysis
The XRD diffraction profile of BT films were shown in Fig.4. There was a sharp diffraction peak between 15° and 25° in each sample. The diffraction peak was the presence of crystalline, amorphous and crystalline imperfections. The increasing content of bagasse didn’t influence the position but the intensity of the diffraction peak in the film. The intensity increased while the content of bagasse increasing.

![Figure 4. XRD graph of BT films](image)

4. Conclusions
The effect of bagasse/tapioca starch features were studied with different bagasse concentration in this paper. BT film showed good dispersion with the high content of bagasse, which also had stronger intermolecular hydrogen bonding. However, BT film with high content would cause the transparency decreasing.

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References
[1] J Robey M, G Field, M Styzinsk. Material Forum, 13: 1, (1989).
[2] Min Liu, Zhanbin Huang, Yujiao Yang, et al. Chinese Agricultural Science Bulletin, 24 (9): 439-443, (2008).
[3] Tiaokun FU, Gang Chang, Qiong FU, et al. Journal of Tropical Crops, 37 (10): 2007-2013, (2016).
[4] Shankar S, Reddy J P, Rhim J W. International Journal of Biological Macromolecules, 81(1): 267-273, (2015).
[5] Alemdar A, Sain M. Composites Science & Technology, 68(2): 557-565, (2008).