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Preparation and Characterization of Physical Properties of Durian Skin Fibers Biocomposite

Manshor, R.M.[1, a], Anuar, H.[1, b], Wan Nazri W.B.[2, c] and Ahmad Fitrie M.I.[1, d]

[1]Department of Manufacturing and Material Engineering, Faculty of Engineering, International Islamic University Malaysia, 53100 Gombak, Selangor, Malaysia.

[2]Food Technology Research Center, Malaysian Agricultural Research and Development Institute, 43400 Serdang, Selangor, Malaysia.

[a]romainor@gmail.com, [b]hazleen@iium.edu.my, [c]wannazri@mardi.gov.my, [d]ahmadfitrie88@gmail.com

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Abstract. Durian skin fibres (DSF) are cellulose-based fibres extracted from the durian peel. This paper present the physical behaviour, chemical structure and crystallinity of the fibres, as observed by environmental scanning electron microscope (ESEM), Fourier transform infrared (FTIR) and X-ray diffraction (XRD). The characteristic of the natural fibers produces from durian skins are similar with other types of natural fiber. The average diameter and density are 0.299 mm and 1.243 g/cm^3, respectively while the crystallinity index is slightly higher than the common fibers. The properties and charecteristic of durian skin fibers are within the propertise of lignocellulosic fiber which is suitable for development of biocomposite materials.

Introduction

Durio zibethinus Murray, commonly known as durian, is one of the most important seasonal fruit in tropical Asia. By nature, durian locally is called as the "King of fruits" is a dicotyledonous tropical seasonal plant species belonging to the members of family Bombacaceae and genus of *Durio* [1]. Durian skin fibers are the newly explored fiber as reinforcement for thermoset and thermoplastic to produce biocomposite products. It is important to understand their physical and thermal properties so that it be can used in appropiate and variety of applications [2]. The current management and utilization of waste from durian fruit are big problems to environment, therefore, the development of biodegradable composite using durian skin is one of the most promising methods for diversifying and value adding the usage of agricultural waste. Like any other, natural fiber such as kenaf and flax, DSF can be fabricated into biocomposite by using various techniques including resin transfer moulding, compression moulding, injection moulding, direct extrusion and vacuum infusion [3]. In order to optimize the properties of biocomposite, a comprehensive study on the physical characteristics of DSF is mandatory and are presented in this paper.

Materials and Method

Materials preparation

Durian skins were obtained from local market. The freshly skins were washed thoroughly with tap water to remove any adhering particles and dusk. After that, the skins were chopped and ground, and dried in an oven at 80ºC for 12 h. Next, dried durian skins were hammermilled and the dried skins were screened by sieve over a screen size of 1mm.

Characterization of DSF

For fiber aspect ratio, the dimension of fiber was determined with a Quanta 200 environmental scanning electron microscope (ESEM). ASTM D3800-09 standard was used to measured density of the fiber. Moisture content was determined according to ASTM D4442-92–for direct moisture content measurement of wood and wood based materials.

Fourier transform infrared (FTIR) analysis was performed using Spectrum 100 Perkin Elmer spectrometer Spectra were recorded in the wave number range from 4000 cm^{-1} to 380 cm^{-1} by co-added 8 scans of resolution. The crystallinity of fiber was obtained using a Shimadzu X-ray diffraction machine (XRD 6000) with CuK_{α} radiation (wavelength = 0.1542 nm, 2θ = 5º - 40º) at 50 kV and 40 mA.

Results and Discussion

Physical properties

The diameter for durian skin fibre is between 170.00 to 446.80 µm and the average is 298.54 µm. The length for durian skin fibre is between 0.839 to 2.379 mm and the average is 1.475 mm. Thus, the average aspect ratio (L/D) is 5.531 with range between 1.952 to 10.300. Compared to carbon nanofibre, the diameter of fibre is between 50–150 nm and lengths of 30–100 µm [4]. Fig. 1 shows the ESEM image of the durian fibre and Table 1 shows the data of diameter, length and aspect ratio of durian skin fibre (DSF).

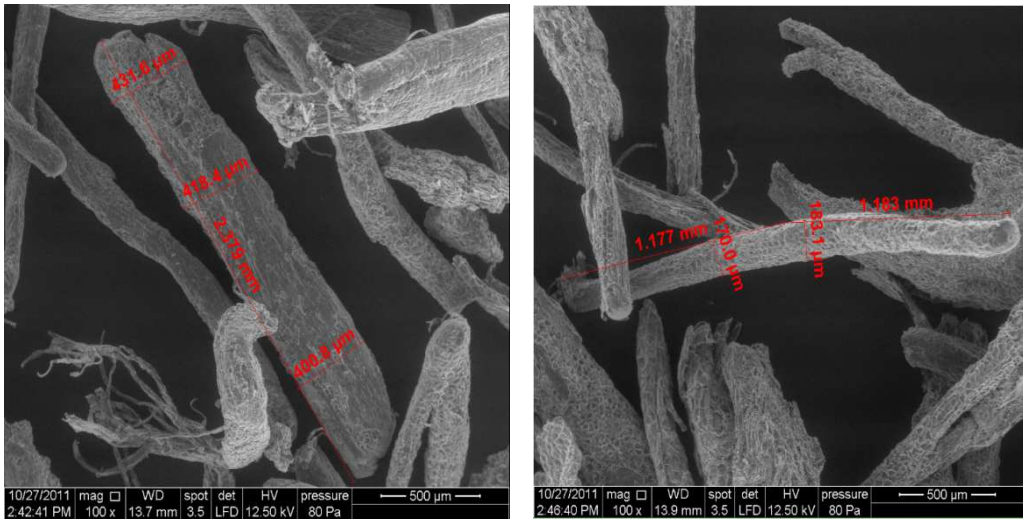

Fig. 1: ESEM image of DSF

Table 1: The measured length, diameter and aspect ratio

	Diameter, D (mm)	Length, L (mm)	Aspect Ratio, L/D
Min	0.170	0.839	1.952
Max	0.447	2.379	10.300
Average	0.299	1.475	5.531

Densitometer was used to determine the density of durian skin fibre. The density of the sample is about 1.152 g/cm^3 to 1.311 g/cm^3 and the average of density is 1.243 g/cm^3. Compared to hemp fibre with average 20 measurements of density, it was found to be 1.29 g/cm^3 [5]. Table 2 shows the details of density of durian skin fibre.

Table 2: Density and Moisture content (%) of durian skin fibre

	Density (g/cm^3)	Moisture Content (%)
Min	1.152	7.92
Max	1.311	9.10
Average	1.243	8.44

Table 2 also shows the data of moisture content (%) of durian skin fibre. The moisture content of the sample is about 7.92% to 9.10%. According to Zuhri et al. [6], the moisture content of oil palm fibre was 2.2% to 9.5%. Our result is slightly similar to them, and in the range of moisture content of natural fibres which are between 5% to 15% [7].

Increased in moisture will decreases their mechanical properties, provides the necessary condition for biodegradation, and changes their dimensions. Coupling agents, compatibilizers or other chemical modifications can be used to improve the moisture resistance of composites [8].

Chemical structure and crystallinity

The FTIR spectrum of durian fibre is shown in Fig. 2. It could be observed that five components present in the durian fibres. All these spectra reveal a broad and intense peak at 3293.92 cm^{-1} suggesting hydrogen-bonded (O-H) stretching vibration from the cellulose and hemicellulose structures (expected source) of the fiber. The band at 1240.34 cm^{-1} is related to the vibration (C=O) of esters, ethers and phenols groups attributed mainly to a presence of waxes in the epidermal tissue [9]. It also related to pectin and lignin structures [10].

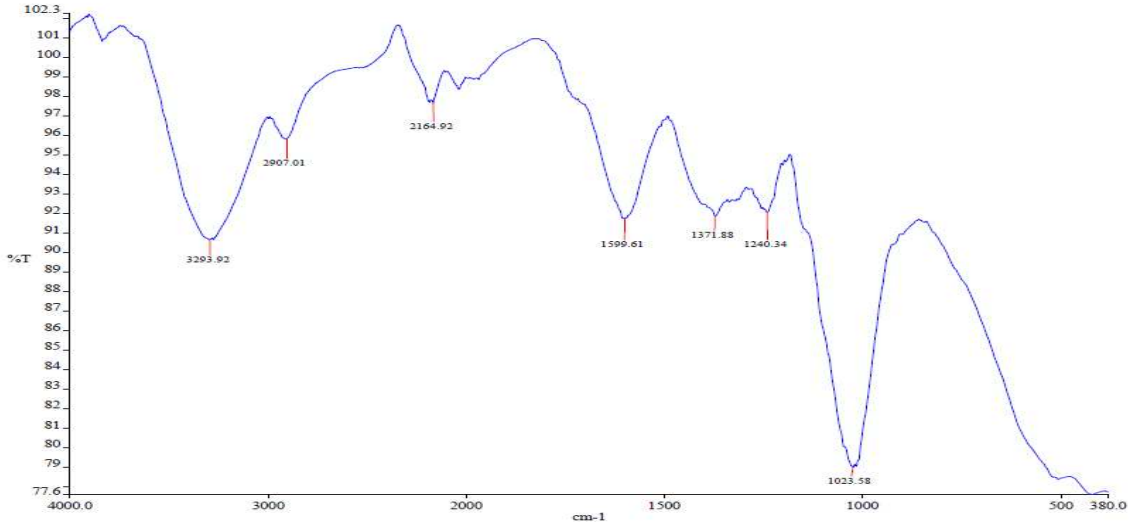

Fig. 2: FTIR spectra of durian skin fibres

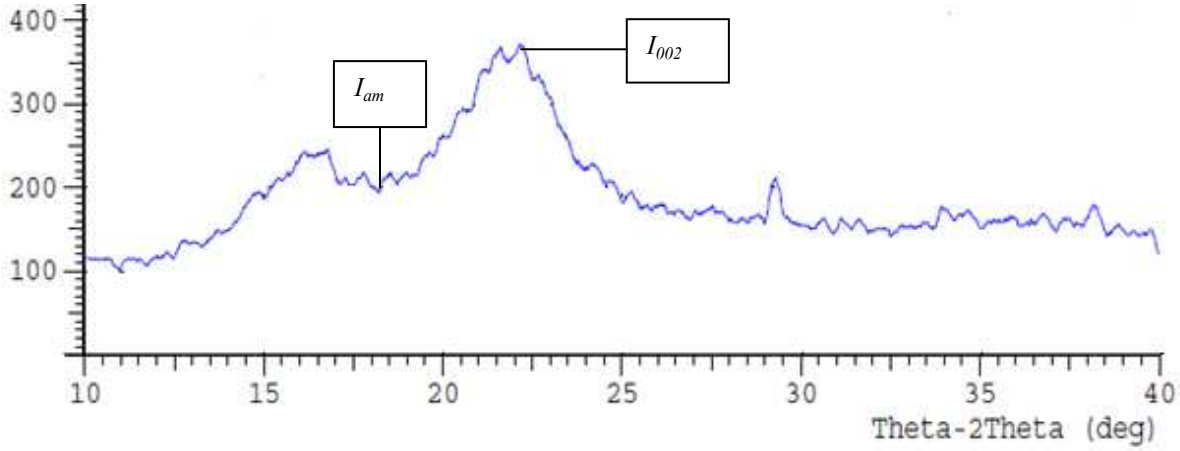

Fig. 3: X-ray diffractogram of durian skin fibre

X-ray crystallography was used to investigate the crystallinity of DSF. An example of X-ray diffraction photograph from durian skin fibres is given in Fig. 3. According to Roncero [11], the intensity peak at the maximum at 2θ angle, between 22° and 23° for the crystalline materials, while for amorphous materials is between 18° and 19°. It can be seen from Fig. 3 that the major crystalline peak of the durian skin fibres occurred at 2θ = 22.18°, which represents the cellulose crystallographic plane (002), Bragg's reflection. The minimum intensity between (002) and (110) peaks (I_{am}) is at 2θ = 18.26°. The crystallinity index (CI) of durian skin fibre is 58.33%. Similar observation have been reported by Alemdar and Mohini [12], where the crystallinity index for untreated fibers estimated was 57.5%.

Conclusion

Natural cellulose fibers obtained from durian skin have the structure and properties almost similar with other natural fibers, such as kenaf, oil palm fiber and flax. The length of DSF was in the range of 0.839 mm to 2.379 mm and diameter was between 170 μm to 447 μm. Their density was 1.243 g/cm^3, which is in the range of density of other natural fibres between 1.2 g/cm^3 to 1.5 g/cm^3. The percentage of moisture content investigated was between 7.92 to 9.10% and cystallinity index (CI) of durian skin fibers were 58.33%. Thus, through all the result obtained, it is expected that natural fibers from durian skin are suitable for blending and processing with other biopolymer to produce biocomposites material for various applications.

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