Tensile Properties of Single Oil Palm Empty Fruit Bunch (OPEFB) Fibre
(Ciri Ketegangan Gentian Tandan Buah Kosong Kelapa Sawit Tunggal)

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ABSTRACT
The use of natural fibres obtained from plants and trees as reinforcing materials has attracted many researchers to widen their applications. Natural fibres are low cost, low density, have high specific properties, biodegradable and non-abrasive. Oil palm fibre (OPF) can be obtained directly from natural resource, it is cheap and also has advantages due to its renewable nature, low cost, and easy availability. In this study, the mechanical performances of single oil palm fibre are measured and evaluated. The diameter of OPF was in the range from 250 to 610 μm while moisture content was between 2.2 to 9.5%. The average tensile properties obtained were tensile strength, 71 MPa, Young’s modulus, 1703 MPa and elongation at break, 11%.

Keywords: Empty fruit bunch; natural fibre; tensile properties

ABSTRAK
Penggunaan gentian semulajadi daripada tumbuh-tumbuhan dan pokok sebagai bahan penguat telah menarik minat ramai penyelidik untuk digunakan secara meluas dalam pelbagai aplikasi. Gentian semulajadi mempunyai kos yang rendah, ketumpatan rendah, mempunyai ciri-ciri spesifik yang tinggi, mudah terurai dan tidak pelelas. Gentian kelapa sawit (GKS) boleh didapati secara terus daripada sumber semulajadi, murah dan mempunyai kelebihan berdasarkan sifatnya yang boleh diperbaharui, kos rendah dan mudah di perolehi. Dalam kajian ini, ciri mekanikal bagi gentian kelapa sawit tunggal telah diukur dan dinilai. Hasil cerapan diameter GKS adalah antara 250 hingga 610 μm dan kandungan lembapan adalah 2.2 hingga 9.5%. Ciri ketegangan yang diperolehi adalah kekuatan ketegangan, 71 MPa, modulus Young, 1703 MPa dan pemanjangan pada takat putus, 11%.

Kata kunci: Ciri ketegangan; gentian semulajadi; tandan buah kosong

INTRODUCTION
Over the last decade, polymers reinforced with natural fibres composites have attracted attention from the academic world and various industries. The rapid growth in the consumption of plastic products, persistence of plastics in the environment, the shortage of landfill space, the depletion of petroleum resources and entrapment by the ingestion of packaging plastic by marine and land animals have spurred efforts to look for better alternatives (Khalid et al. 2008). The advantages of using natural fibres compared to synthetic fibres includes low weight, recyclability, biodegradability and renewability. It has relatively high strength and stiffness and has no skin irritations effects (Oksman et al. 2003).

Oil palm empty fruit bunch (OPEFB) is one of the lignocellulosic materials, which has great relevance to Malaysia, as a large quantity of the biomass is generated by oil palm industries (Bakar et al. 2005; Tan et al. 2007). The fresh oil palm fruit bunch contains about 21% palm oil, 6-7% palm kernel, 14-15% fibre, 6-7% shell and 23% empty fruit bunch (Umikalsom et al. 1997). The incorporation of empty fruit bunch (EFB) into polymers to obtain cost reduction and reinforcement has been reported by various workers. Rozman et al. (2001) investigated the mechanical properties of polypropylene/EFB composites and found that EFB has high tensile modulus, but low tensile strength. Abdul et al. (2001) reported that modified EFB has improved the mechanical properties and water resistance of the polyester/EFB composites. Ishak et al. (1998) found that the tensile modulus of high density polyethylene (HDPE)/EFB showed an increase compared to neat HDPE, whereas tensile strength and impact strength decreased. Ridzuan et al. (2002) reported that EFB is possibly suitable for medium density fibreboard (MDF). Pre-treatment of the fibre to remove its residual oil significantly improved the MDF properties and eliminated the delamination during consolidation of the panels. For removing the oil, sodium hydroxide (NaOH) is more effective than water, but a poorer fibre was obtained with a higher bulk density which also reduced the mechanical and physical properties. Ismail et al. (1997) reported that the adhesion between oil palm fibre and rubber matrix is poor but it can be modified by a treatment at high temperatures and various bonding agents. According to Aznizam and Azman (2003), there were reductions of the impact strength from the incorporation of EFB into the unmodified and modified unplasticised...
In this study, the tensile properties of oil palm fibre are carried out to determine the tensile strength, Young’s modulus and elongation at break. It is hoped that data from this study would be used as inputs in the study of oil palm fibre reinforced polymer composites.

**MATERIALS & METHODS**

Oil palm empty fruit bunch was obtained from the Malaysian Palm Oil Board (MPOB), Bangi, Selangor, Malaysia. Figure 1 shows the bundle of OPEFB fibres. Oil palm fibre was extracted from palm oil vascular bundles in the empty fruit bunch (EFB). In the manufacturing process of palm fibre, EFB are shredded, separated, refined and dried.

The instron universal testing machine (model 5566) was used to determine the tensile strength, Young’s modulus and elongation at break of the specimen. The tensile properties of the OPF were tested on different diameters and test length of 50 mm tested at a cross speed of 2 mm/min. A fibre was glued to the paper, which was then carefully gripped by the testing machine, and cut with a scissor along the cutting line as indicated in Figure 2.

**RESULTS AND DISCUSSION**

**DIAMETER**

The diameter results for fibre is between 250 to 610 μm. Figure 3 shows the Zeiss optical microscopic image of the cross-section of a single EFB fibre. It is reported by Jacob et al. (2004) that the diameter of oil palm fibre is in the range of 150 to 500 μm. Khairiah & Khairul (2006) stated that the actual size of EFB fibre is 150 μm and 442 μm.

An optical microscope model Zeiss Axiovert 25 has been used to measure the diameter of the EFB fibre. At least 20 fibres were measured and the average diameter was calculated using equation;

\[
\text{Diameter of fiber} = \frac{D_1 + D_2 + \ldots + D_{20}}{20},
\]

where \(D\) is the fibre diameter.

Oil palm fibres were weighed and dried in an oven at the temperature of 103°C for 30 minutes, followed by cooling for 30 minutes and then weighed again. This step is repeated until the weight is constant. The moisture content of the test specimen was expressed as a percentage loss in weight of the final oven-dry weight using the equation;

\[
\text{Moisture content} = \frac{W_i - W_f}{W_i} \times 100\%
\]

where \(W_i\) is weight of fibre before dried in oven and \(W_f\) is weight of fibre after dried in oven.
μm obtained from the particle size analysis data using analyzer type Microtrax-X100 with 120 resolutions. Sreekala & Thomas (2003) have reported that OPEFB is in the range from 150 to 500 μm. The diameter is in the range of the previous studies but there are some diameters which are outside this range. Table 1 shows the diameter of other natural fibres. From the table, the diameter for oil palm fibre is higher than the sisal, banana and bundle of bamboo but lower than jute.

**MOISTURE CONTENT**

The moisture content of the sample is about 2.2% to 9.5%. According to Ismail et al. (1997), the moisture content of oil palm fibre was 10.4%. Our results is slightly lower than Ismail et al. (1997) and the reason is because of the temperature change during the drying process.

The higher the moisture content of the natural fibre the higher is the change in the mechanical and physical properties of composite can be affected and it leads to poor wettability with matrix which results in a weak interfacial bonding between the fibre and matrix (Biswas et al. 2001).

**TENSILE PROPERTIES**

For this study, the average tensile strength, Young’s Modulus and elongation at break is 71 MPa, 1703 MPa and 11% respectively. From the literature, the tensile strength, Young’s modulus and elongation of single fibre at break are 248 MPa, 6700 MPa and 14% respectively (Jacob et al. 2004; Sreekala et al. 2001) found the tensile strength, Young’s modulus and elongation of a single fibre were in the range of 100 to 400 MPa, 1000 to 9000 MPa and 8 to 18%. The results were different from Jacob et al. (2004) but for Young’s modulus and elongation at break it is in the range found by Sreekala et al. (2001). The different results may be due to the different pressures which hold the fibre during the tensile test from the upper and lower gripper. The inconsistent diameter of fibre also affected the result where some of the samples did not break in the middle of fibre. In Table 2, the tensile properties of single natural fibre reported by various researchers are presented.

The tensile stress-strain behavior of the single EFB fibre are shown in Figure 4. Stress at break and Young’s modulus of the fibre decreases when the fibre diameter increases and this can be seen in Figure 5. The same behavior is noticed for other fibres (Baley 2002; Bodros & Baley 2008). The fibres were considered as a perfect cylinder.

![Figure 4](image-url) Stress – strain behaviour of the single EFB fibre

**TABLE 1. Diameter of other natural fibres**

<table>
<thead>
<tr>
<th>Type of fibre</th>
<th>Diameter (μm)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sisal</td>
<td>205 ± 4</td>
<td>Idicula et al. (2005)</td>
</tr>
<tr>
<td>Banana</td>
<td>120 ± 6</td>
<td>Idicula et al. (2005)</td>
</tr>
<tr>
<td>Bundle of bamboo</td>
<td>88 - 125</td>
<td>Okubo et al. (2004)</td>
</tr>
<tr>
<td>Jute</td>
<td>30 - 50</td>
<td>Okubo et al. (2004)</td>
</tr>
</tbody>
</table>

**TABLE 2. Tensile properties of single natural fibre**

<table>
<thead>
<tr>
<th>Type of fibre</th>
<th>Tensile strength (MPa)</th>
<th>Young’s modulus (MPa)</th>
<th>Elongation at break</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sisal</td>
<td>350 ± 7</td>
<td>12800</td>
<td>6.0 – 7.0</td>
<td>Idicula et al. (2005)</td>
</tr>
<tr>
<td>Banana</td>
<td>550 ± 7</td>
<td>20000</td>
<td>5.0 – 6.0</td>
<td>Idicula et al. (2005)</td>
</tr>
<tr>
<td>Bundle of bamboo</td>
<td>441</td>
<td>35900</td>
<td>-</td>
<td>Okubo et al. (2004)</td>
</tr>
<tr>
<td>Jute 370</td>
<td>22700</td>
<td>-</td>
<td>-</td>
<td>Okubo et al. (2004)</td>
</tr>
<tr>
<td>Palm leaves</td>
<td>97 – 196</td>
<td>2500 - 4700</td>
<td>-</td>
<td>Al-Sulaiman 2002</td>
</tr>
<tr>
<td>Hemp</td>
<td>690</td>
<td>30000 - 60000</td>
<td>1.6</td>
<td>Dhakal et al. 2007</td>
</tr>
<tr>
<td>Pineapple leaf</td>
<td>126.60</td>
<td>4405</td>
<td>2.2</td>
<td>Arib et al. 2006</td>
</tr>
<tr>
<td>Oil palm</td>
<td>71</td>
<td>1703</td>
<td>11</td>
<td>present study</td>
</tr>
</tbody>
</table>
This paper reports the tensile properties of the oil palm fibre and other properties. The diameter, moisture content and tensile properties of the specimen were observed and analyzed. The diameter for OPEFB fibre was in the range from 250 to 550 μm and the moisture content was between 2.2 to 9.5%. The average tensile strength, Young’s modulus and elongation at break are 71 MPa, 1703 MPa and 11%, respectively. The diameter of the fibre can affect the tensile properties where the tensile strength will decrease when the diameter was increased.

ACKNOWLEDGEMENTS

The authors wish to thank the Mr. Mohd Kadri from Advanced Materials and Nanotechnology Laboratory, Institute of Advanced Technology (ITMA), Mr. Joha Muhsidi Department of Chemical and Environmental Engineering and Mr. Muhammad Badrushah from Department of Process and Food Engineering, Universiti Putra Malaysia for their support during testing. The authors also wish to thank Research Management Centre, Universiti Putra Malaysia and Mr. Muhammad Badrushah from Department of Chemical and Environmental Engineering and Mr. Muhammad Badrushah from Department of Process and Food Engineering, Universiti Putra Malaysia for the financial support under the Fundamental Research Grant Scheme (RUGS).

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Received: 26 June 2008
Accepted: 24 November 2008