Investigation on the Physical and Mechanical Properties of EIC Cellulose-Polyurethane Composite

Sri Wuryanti

Abstract: Composite is a mixture of two materials, one of which being named matrix, that is, a material serving as filler, and another fiber, or reinforcing material. In the present experiment, the matrix was polyurethane and fiber was cellulose. Polyurethane is a result of a reaction between diisocyanate and polyol and used among others for technical applications. Moreover, cellulose was obtained from a solid Extracting process from Imperata Cilyndrica reed (EIC Cellulose). The tests of stress and strain were conducted by using a UCT-5T Model UTP tensile test instrument. The highest stress value on the composite 2-3, was 14.2 ± 0.12 MN/m² and the lowest on the composite 1-1, was 9.1 ± 0.1 MN/m². The highest strain on the composite 1-1, was 1.9 ± 0.23 %GL and the lowest on the composite 2-3, was 1.9 ± 0.23 %GL. The highest Young’s Modulus value on the composite 2-3, was 7.47 MN/m² and the lowest on the composite 1-1, was 3.13 MN/m². The physical characteristics needed to know the occurrence of bond was tested by FTIR. In the test of the composite, a bond occurred as evidenced by the existence of peaks. The highest peak occurred on the Composite 2-2, was 3351.67 cm⁻¹. Meanwhile, the lowest occurred on the Composite 1-2, was 1230.01 cm⁻¹.

Keyword: Cold-press, EIC-cellulose, FTIR, Polyurethane A dan Polyurethane B, UCT-5T

1 Introduction

Polyurethane was obtained from a polyadiating reaction of a diisocyanate and polyol with a catalyst and other additional substance. Diisocyanate is a molecule with two functional isocyanates and polyol (a molecule with two or more hydroxil functional group). Its reaction product is a polymer with a urethane bond, -RNHCOOR'-. The dispersion of polyurethane occurs due to an isocyanate reaction, macroglycol, an internal emulsifier and extender chain. Cellulose was obtained from a solid extraction process of Imperata Cilyndrica reed [1]. Cellulose-based smart materials are very advantageous, particularly its smart behavior as a reaction to environmental stimulation and can be applied in various conditions [2]. Interaction process was conducted in two stages: pre-hydrolysis and delignification. The former was intended to remove extractive (solvable) material contained in the reed. The latter removed not only lignin but also hemicelluloses so as to obtain a content of cellulose.

2 Experimental

2.1 Material

Mixture 1 of EIC cellulosa, mixture 2 of EIC cseuflulosa, and mixture 3 of EIC cellulose [1], Polyurethane A dan Polyurethane B.
2.2 Composite Preparation

The same steps were conducted for the mixtures 1, 2, and 3 and placed on a cold-press at the pressure of 54022 N/m² in the pressuring time of 90 minutes. Result of these processes were Composite 2-1, Composite 2-2, and Composite 2-3.

3 Characterization

3.1 Mechanical testing

The tests of tensile strength and elastic modulus were conducted by using a UCT-5T Model UTP tensile test instrument. The dimensions of test material were in conformity with ASTM D882 by a specimen size of 6 cm x 1 cm x 0.02 cm. The conditions of operation were as follows: speed 1 mm/min, load range 10%RO, load full scale 10 kgf, temperature 23°C, and humidity 50% RH.

3.2 Fourier Transform Infra Red spectroscopy (FTIR)

Alpha Bruker was used for the Fourier Transform Infra Red spectroscopy (FTIR) analysis. Measurement of the number of reflectance began from 400 cm⁻¹ to 4000 cm⁻¹.

4 Result and Discussion

4.1 Mechanical Properties

Mechanical tests included Stress, Strain, and Young’s Modulus, as contained on Table 1.

<table>
<thead>
<tr>
<th>Pressure (N/m²)</th>
<th>Material</th>
<th>Stress (MN/m²)</th>
<th>Strain % GL</th>
<th>Young’s Modulus (MN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40517</td>
<td>Composite 1-1</td>
<td>9.1 ± 0.10</td>
<td>2.9 ± 0.32</td>
<td>3.13</td>
</tr>
<tr>
<td>40517</td>
<td>Composite 1-2</td>
<td>9.8 ± 0.44</td>
<td>2.3 ± 0.30</td>
<td>4.26</td>
</tr>
<tr>
<td>40517</td>
<td>Composite 1-3</td>
<td>10.0 ± 0.33</td>
<td>2.1 ± 0.30</td>
<td>4.76</td>
</tr>
<tr>
<td>54022</td>
<td>Composite 2-1</td>
<td>13.5 ± 0.36</td>
<td>2.4 ± 0.40</td>
<td>5.63</td>
</tr>
<tr>
<td>54022</td>
<td>Composite 2-2</td>
<td>13.9 ± 0.09</td>
<td>2.1 ± 0.23</td>
<td>6.62</td>
</tr>
<tr>
<td>54022</td>
<td>Composite 2-3</td>
<td>14.2 ± 0.20</td>
<td>1.9 ± 0.49</td>
<td>7.47</td>
</tr>
</tbody>
</table>
Table 1 showed that Stress and Young’s Modulus were the largest, i.e., 14.2 MN/m² and 7.47 MN/m², respectively, occurring in composite 2-3 at a pressure of 54022 N/m². The result obtained showed a good result because its value was above the value of widely used isolations, rockwool and polyurethane, but smaller than that of cellulose and calcium silicate [3-5].

4.2 Physical Properties
FTIR test was intended to analyze whether or not in the produced composite a bond between EIC-Cellulose and Polyurethane occur. The result obtained was described as a relation between wavenumber and transmittance. Fig.2 was a composite pressed by a pressure of 40517 N/m², and Fig. 3 was a composite pressed by a pressure of 54022 N/m². Measurement of the number of reflectance began from 400 cm⁻¹ to 4000 cm⁻¹.

![Figure 2: FTIR of EIC cellulose-polyurethane composite on a cold-press at the pressure of 40517 N/m².](image)

Peaks underwent a shift from the composite pressed by a pressure of 40517 to 54022 N/m², whereas the shift of polyurethane bond occurred around 1230 cm⁻¹ to 1598 cm⁻¹ [6]. Meanwhile, the shift of cellulose bond occurred around 2915 cm⁻¹ sampai 3352 cm⁻¹ [7]. Polyurethane is a NH stretch in wavenumber of 1509 cm⁻¹ and 3337 cm⁻¹, a CH alifatik in wavenumber 2915 cm⁻¹, a OC = O in wavenumber 1662 cm⁻¹, a CO - NH in wavenumber 1597cm⁻¹, a O-CO in wavenumber 1230 cm⁻¹ and a CO in wavenumber 1018
cm⁻¹. A nearly equal experimental result is that with a NH stretch in wavenumber of 1513 cm⁻¹ and 3310 cm⁻¹, a CH aliphatic in wavenumber 2932 cm⁻¹, a OC = O in wavenumber 1729 cm⁻¹, a CO-NH in wavenumber 1612 cm⁻¹, a O-CO in wavenumber 1227 cm⁻¹ and a CO in wavenumber 1079 cm⁻¹ [8].

![Graph showing FTIR of EIC cellulose-polyurethane composite on a cold-press at the pressure of 54022 N/m²]

Cellulose showed a peak at 3344 cm⁻¹ related to the peak stretch of OH in hydroxyl group-bonded hydrogen. There was a saturated CH aliphatic carbohydrate stretch in wavenumber of 2915 cm⁻¹, and cellulose stretch in CH₂ bond at 1311 cm⁻¹. A nearly equal experimental result was that of cellulose experiment that showed a peak at 3360 cm⁻¹, stretch of saturated CH aliphatic carbohydrate stretch at 2920 cm⁻¹, and cellulose stretch in CH₂ bond at 1319 cm⁻¹ [9]. The experimental results indicated that there were insignificant differences in peaks except for intensity. This was due to both reaction time and glycolysis temperature.

5 Conclusion
The best results for mechanical property was found in the composite 2-3 by average values of stress, and Young’s Modulus of 14.2 MN/m², and 7.47, respectively. Meanwhile, the highest peak occurred on the Composite 1-2, was 1230.01 cm⁻¹.

Reference


