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

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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/m^2 and the lowest on the composite 1-1 , was 9.1 ± 0.1 MN/m^2 . The highest strain on the composite 1-1, was 2.9 ± 0.32% 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/m^2 and the lowest on the composite 1-1, was 3.13 MN/m^2 .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

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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 csellulosa, and mixture 3 of EIC cellulose [1], Polyurethane A dan Polyurethane B.

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2.2 Composite Preparation

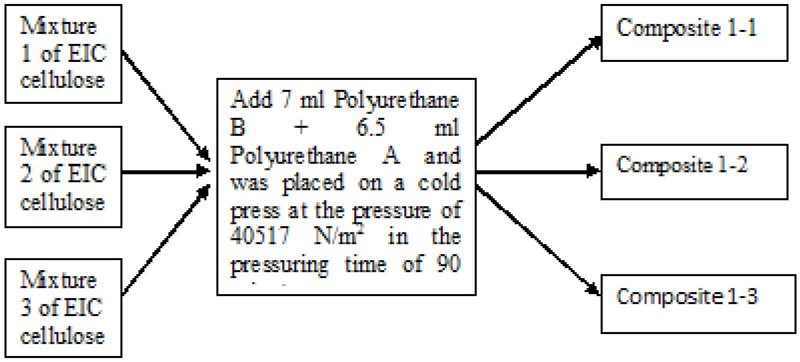

Figure 1: Schematic diagram of the composite of EIC-Cellulose with Polyurethane

The same steps was conducted for the mixtures 1, 2 and 3 was placed on a cold-press at the pressure of 54022 N/m^2 in the pressuring time of 90 minutes. Result of these process 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^{0}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 1. Mechanical properties of EIC cellulose-polyurethane composite

Pressure (N/m^2)	material	Stress (MN/m^2)	Strain % GL	Young's Modulus (MN/m^2)
40517	Composite 1-1	9.1 ± 0.10	2.9 ± 0.32	3.13
40517	Composite 1-2	9.8 ± 0.44	2.3 ± 0.30	4.26
40517	Composite 1-3	10.0 ± 0.33	2.1 ± 0.30	4.76
54022	Composite 2-1	13.5 ± 0.36	2.4 ± 0.40	5.63
54022	Composite 2-2	13.9 ± 0.09	2.1 ± 0.23	6.62
54022	Composite 2-3	14.2 ± 0.20	1.9 ± 0.49	7.47

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Table 1 showed that Stress and Young's Modulus were the largest, i.e., 14.2 MN/m^2 and 7.47 MN/m^2, respectively, occurring in composite 2-3 at a pressure of 54022 N/m^2. 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/m^2, and Fig. 3 was a composite pressed by a pressure of 54022 N/m^2. Measurement of the number of reflectance began from 400 cm^{-1} to 4000 cm^{-1}.

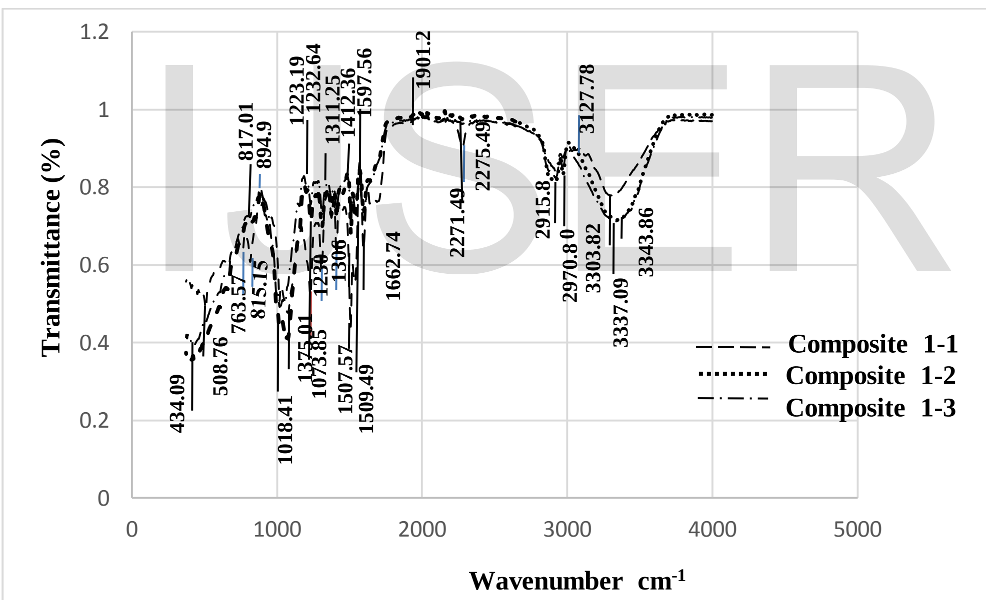

Figure 2: FTIR of EIC cellulose-polyurethane composite on a cold-press at the pressure of 40517 N/m^2.

Peaks underwent a shift from the composite pressed by a pressure of 40517 to 54022 N/m^2 , 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 alifatik in *wavenumber* 2932 cm^{-1}, a OC = O in *wavenumber* 1729 cm^{-1}, a CO-NH in *wavenumber* 1612cm^{-1}, a O-CO in *wavenumber* 1227 cm^{-1} and a CO in *wavenumber* 1079 cm^{-1} [8].

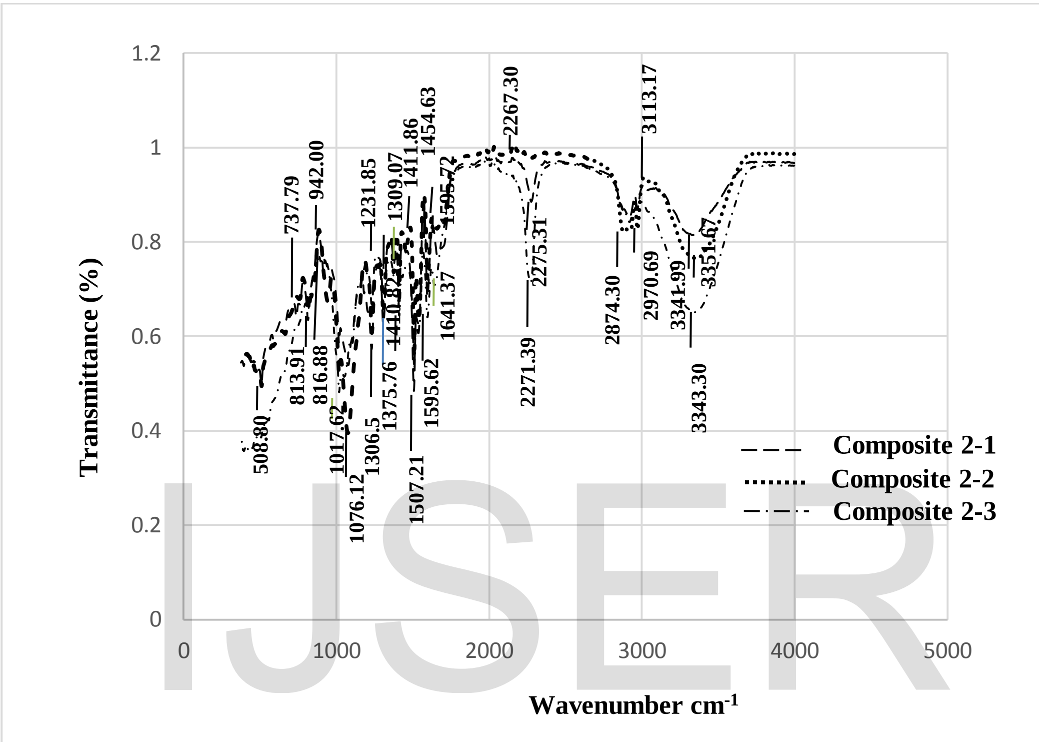

Figure 3: FTIR of EIC cellulose-polyurethane composite on a cold-press at the pressure of 54022 N/m^2

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 CH_2 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 CH_2 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 Conclussion

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/m^2, and 7.47, respectively. Meanwhile, the highest peak occurred on the Composite 1-2, was 1230,01 cm^{-1}.

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