Mechanical and Morphological Properties of Cellulose and Polyol-Isocyanate Composites for Isolator

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Abstract: ***Polyol-isocyanate and cellulose are a material that are often used for insulation materials. The manufacture of composites polyol-isocyanate with cellulose is expected to produce a material that is stronger and more environmentally friendly. This study presents a insulation material of cellulose made from reeds imperata cylindrica type with the extraction process. The extraction of cellulose fibers to form a sheet by adding 3.5% Na-CMC (Sodium Cellulose Carboksil Metyl). The production of the composite was made by pouring some polyol-isocyanate to a cellulose sheet and then put it into a cold-press and pressured for 90 minutes by varied pressures of 40517 N/m^2 and 54022 N/m^2.The sheets were then tested for their mechanical properties and morphology. The mechanical properties tested were tensile strength, and specific tensile strength. Specific tensile strength is a ratio of tensile strength and density. Meanwhile, the morphology was tested for the surface of material. The test showed : minimal and maximal average tensile strengths were 9.1 MPa and 14.2 MPa, respectively; and minimal and maximal specific tensile strengths were 0.002 Mm and 0.013 Mm. Homogeneity composite occurred on 3rd mix with cold-press process at a pressure of 54022 N/m^2.***

Keywords: Cellulose; Isolation; Polyol-Isocyanate; Reed; Na-CMC.

1. Introduction

Cellulose is a polymer which is relatively stable, because the hydrogen bond can not be dissolved in a solvent of water [1]. Polyol-isocyanate is the materials that can be used as a heat insulator, because that has low heat conductivity than other materials ie 0.0127 W / m K [5].

The researcher here conducted a research with new raw material, i.e., cellulose extracted

from *imperata cylindrica* reed [6]. The current research also differs from earlier ones in test sampling. In earlier researchers, it had been produced by simply casting pulps and then sunrise dried, whereas in the current research the cellulose fibers were blended thoroughly and then 3.5% Na-CMC was added. The result of mixture between cellulose and Na-CMC were made in sheets by pouring it into a teflon tray and evaporated in a 40^{0}C oven for 36 hours. The sheets were then tested for their mechanical properties and morphology.

The mechanical properties tested were tensile strength, and specific tensile strength. Meanwhile, the morphology was tested for the surface of material. Specific tensile strength is a ratio of tensile strength and density.

2. Test Procedure

Material Preparation

Compositing the polyol-isocyanate with Cellulose by using this following method: 7 ml of polyol was poured into cellulose sheet of mixture 1 and then leveled to one side. Into the polyol added sheet was then added 6.5 ml of isocyanate rapidly, not longer than 100 seconds, because in 140 seconds the mixture of polyol and isocyanate would become foam. And after the cellulose sheet and polyol and isocyanate were mixed rapidly, the mixture was then placed in a cold-press device and pressed by the pressure of 40517 N/m^2 for 45 minutes.

Same steps was done to the other side, and thus a composite of cellulose and polyol - isocyanate for mixture 1 at the pressure of 40517 N/m^2 was obtained in the total pressuring time of 90 minutes.

The same steps was conducted for the mixtures 2 and 3 at the same pressure and with the same time. To determine the effect of pressure on thermal properties by the same method, the mixture was placed on a cold-press at the pressure of 54022 N/m^2 in the pressuring time of 90 minutes.

Mechanical Properties Test

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. The results of tensile strength test were in a form of a graphic (Figs. 1). The testing results of elastic modulus were shown in Table 1. The value of specific tensile strength was found by using the following formula:

$$\sigma_s = \frac{\sigma}{\rho_w} \quad (1)$$

where ρ_s is specific gravity in kg/m^{2}s^2 (density × g), σ is tensile strength in MN/m^2 , σ_s is specific tensile strength in Mm. The Measurement results of specific tensile strength were shown in Table 2. The density values were found from an experiment of *Imperata Cylindrica* Cellulose Thermal properties form the material of isolation.

Morphological Test
The morphological test was conducted by *Scanning Electron Microscopy* (SEM), experiments were carried out with an acceleration voltage of 20 kV and a magnification of 100 × and samples coated with gold palladium. The results of test were shown in figs. 3.

3. Results and Discussion

The research was conducted to determine the effect of material crumbling duration on both mechanic properties and material surfaces. The results were shown in the figures and tables below.

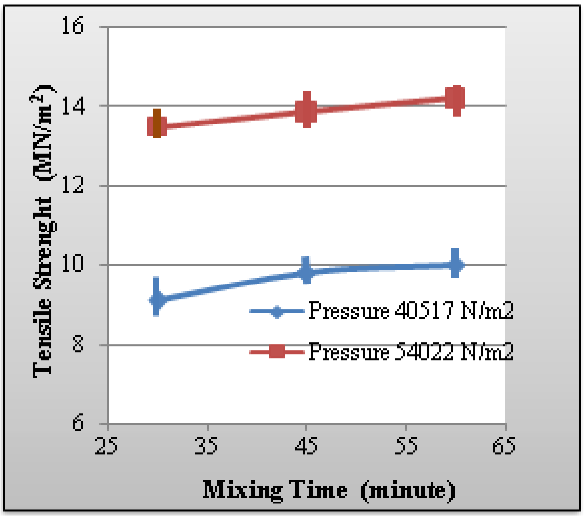


Figure 1: Relationship the mixing time and the tensile strength in pressure 40521 N/m^2 and 54022 N/m^2

Results of tensile strength largest average is 14.2 MN/m^2 which occurs in the composite 3 with pressure 54022 N/m^2. The pictures shows the increase of pressure, adds to the tensile strength. So also with the addition of a blender provides a higher aspect that increases the tensile strength. This result was very good in that it was above the most widely used isolation value, i.e., rockwool 3.8 MN/m^2 [2] and polyurethane 0.8 MPa [7] isolations. Relationship specific tensile strength values versus time at various pressure is shown in Figure (2).

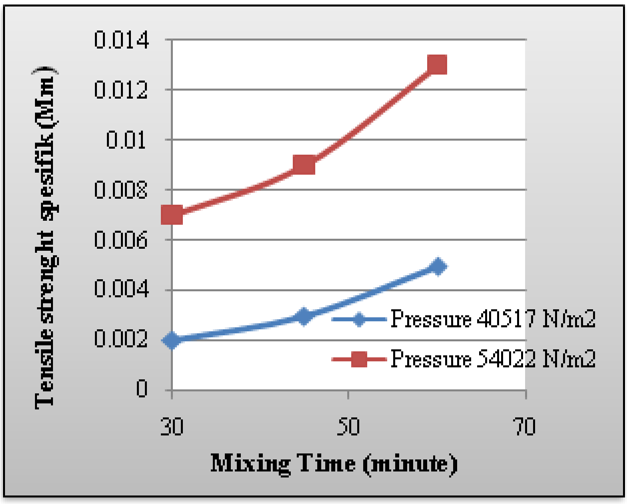
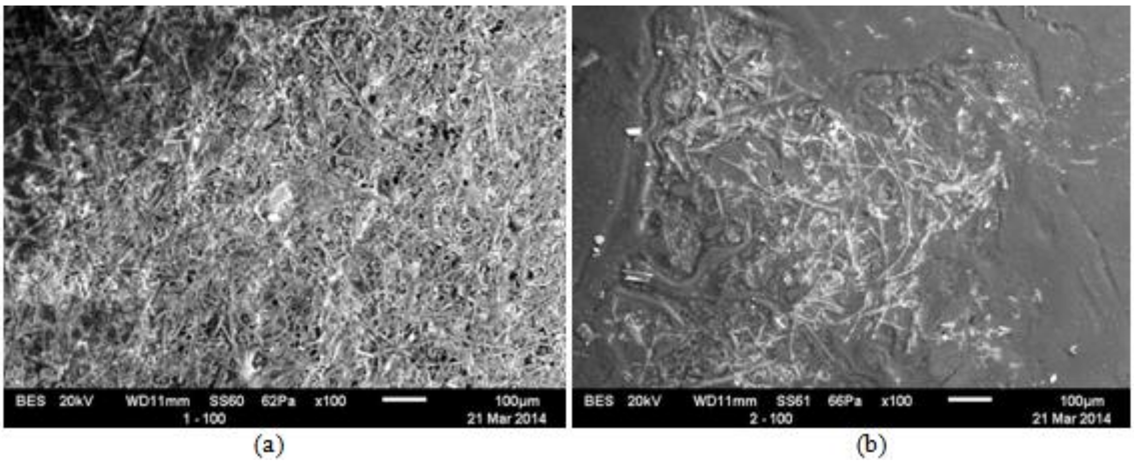


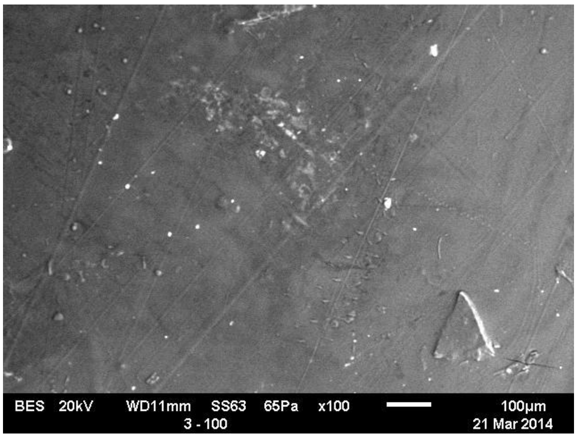
Figure 2: Relationship the mixing time and the specific tensile strength in pressure 40521 N/m^2 and 54022 N/m^2

Specific tensile strength values calculated using equation (1) and obtained the optimum price to the composite as shown in Table 1, ie 0.013 Mm.

Table 1: The results of the calculation of specific tensile strength of Composites

Pressure	40517 N/m^2	54022 N/m^2	40517 N/m^2	54022 N/m^2	40517 N/m^2	54022 N/m^2
Composites	1	1	2	2	3	3
Tensile Strength [MN/m^2]	9.1	13.47	9.55	13.57	9.83	14.2
Density (kg/m^3)	455.5	426	217.4	205.6	113.9	109
Specific Gravity (kg/m^2 s^2)	4459	4174.8	2130.5	2014.9	1116.2	1068.2
Specific tensile strength (Mm)	0.002	0.003	0.005	0.007	0.009	0.013





(c)

Figure 3: Microstructure (M - 100x) with a cold-press process at a pressure of 54022 N/m^2 Composite 1 (b) Composite 2 (c) Composite 3

The picture shows that the composite cellulose with polyol - isocyanate in composite 3 with a cold-press process at a pressure of 54022 N/m^2, look more homogeneous than the other mixtures and particles appear more evenly distributed across the surface of the material. By modifying the increase in mixing time and increased pressure, reduce the size of the cell.

4. Conclusions

The best results for mechanical property was found in the mixture 3 by average values of tensile strength, and specific tensile strength of 14.2 MN/m^2, and 0.013 Mm, respectively. Based on the SEM test, the longer the mixing duration was, the more homogenous the mixture would be.

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