Physical and mechanical properties of insulation from rubber leave

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Abstract. This research aims to study the insulation sheet of rubber leaves. By testing physical properties and mechanical property at the ratio of rubber leave : rubber latex were 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20. Use rubber latex as a binder to allow the material to be bonded. The insulating sheets produced are smooth 16×16×2 cm3. From the results showed that the moisture content of the sample were 6.722 - 14.747%. The tensile strength were 0.0002 – 0.0288 MPa. The fire spread rate were run of 0 - 6.640 mm/min and the ratio of 70:30 and 80:20 were no fire spread rate. Then finally, the heat conductivity coefficient were 0.0283 - 0.0442 W/m·K. Moreover, samples of ratio 80:20 have a better conductivity coefficient than commercial insulation and confirmed with the SEM-EDX analysis.

Keywords: physical properties, mechanical properties, insulation, rubber leave

1. Introduction

In Thailand which is an agriculture country and there are many agriculture wast. Normally those wastes will be used as animal feed and fuel. Many researchers have used processed waste to produce new materials. Which one of them is Bring materials to produce as insulation with natural fiber. There are many fiber widely used today such as rice husk, banana fiber, cotton, hemp, flax, jute, kenaf, and coconut [1,2,3]. These material are better mechanical properties such as low density, high porosity. And low thermal conductivity compared to several conventional material such as steel, plastic and ceramic [4]. In addition, the insulation from natural materials is also an environmentally friendly material and not sending pollution to humans. For this study, in the three southern of Thailand, is the area that is suitable for rubber cultivation in the early season, the plat tires [5] there will be a lot of rubber leaves. Besides the rubber leaves can be a good fertilizer from natural degradation. With increase the potential of rubber leaves by the production of insulation to reduce the cost of energy use and another to use natural materials to reduce global warming. By using the principles and theories of the research process which is extremely important for product development since it is the use of natural materials to study and develop to add value to local materials [6].

Have conducted research on Energy-efficient of insulation produced from rubber leaf using the difference of degree hours as the variable foe comparing the conclusion is shown as follows: all thermal insulations has effect if heat gain reduction. But those made from rubber leaf are the most capable for heat reduction and it also has a same effectiveness of heat decreasing as fiber goes [5]. Have conducted research on a comparison of banana fiber insulation with biodegradable fibrous thermal insulation. Comparison of the thermal conductivity at 25 °C and at the optimum density of coconut fiber, sugar cane fiber and oil palm fiber with banana fiber indicated that they were all within the range of 0.02 W/m.K to 0.06 W/m.K for use as building thermal insulation. Of the four
lignocellulose materials considered, banana fiber showed the lowest thermal conductivity value of 0.04415 W/m.K at a density of 70.4 kg/m³ compared to 0.0488 W/m.K at a density of 69.57 kg/m³ for coconut fiber, 0.0483 W/m.K at a density of 95.94 kg/m³ for sugarcane fiber and 0.0572 W/m.K at a density of 100.30 kg/m³ for oil palm fiber [7]. Finally, in this study, the variation of thermal conductivity with bulk density of rubber fibers for use as insulation and compare with commercial thermal insulation.

2. Experimental Method

![Figure 1. Rubber leaves.](image1)

![Figure 2. Mix rubber leaves para leaves with sodium hydroxide.](image2)

![Figure 3. Boil rubber leaves 3 hours.](image3)

![Figure 4. Pour the latex on the fibers.](image4)

![Figure 5. Pour the fiber into the wood block.](image5)

![Figure 6. Wood block up, press with the C-clamp.](image6)

![Figure 7. Fibers that are shaped in sheets.](image7)

First of all, clean the rubber leaves (see figure 1) by soaking and drying for about 3 hours. Then put rubber leaves with a concentration of sodium hydroxide 10% (see figure 2), mixed with prepared rubber leaves and then soaked for 1 day, then washed with rubber leaves again. Bring the rubber to boil for 4 hours to get the rubber fibers and bake for 3 hours. After that, bring the rubber fibers to stir in the BORAX compound at 10% concentration for 30 minutes. Then, wash the rubber leaves and dried for 3 hours (see figure 3). The rubber fiber and rubber latex were preparing of 7 ratio, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20 (see figure 4). Then put ratio of fiber with each condition of the wood block. Bring the fiber into the block size 16×16×2 cm³ (see figure 5). Use the c-clamp as a press to keep the insulator tightened up to expel the air from the insulation (see figure 6). Bake sample at 100 °C for 3 hours for the latex to remain perfectly shaped (see figure 7). Finally have insulation from rubber fiber in each condition (see figure 8).
Figure 8. Insulation from rubber leaf for Sample (A) 20:80, (B) 30:70, (C) 40:60, (D) 50:50, (E) 60:40, (F) 70:30 and (G) 80:20.

For Density, Thermal conductivity, Tensile strength, Flammability Moisture Content were tested following equations:

2.1. Density
The mass of the rubber leaf was measured the volume (v) was measured directly from the geometry of the material. The density of the material than calculated from equation 1 [8].

\[ \rho = \frac{m}{v} \]  

(1)

Where \( \rho \) is the density of the object (kg/m3), m is the total mass of the object (kg), and v is the total volume of the object (m3).

2.2. Thermal conductivity
The smart Q heat flow sensor meter was used for measuring the thermal conductivity. The sample size used for measurement was 15 x 15 x 2 cm3. In this test, the sample was placed in between two sample room. The first room was the day situation (outside room) and the temperature was kept at room temperature to 80 °C for 12 h. The second room was the night situation (inside room) and the temperature was kept at 80 °C for 12 h. The coefficient of thermal conductivity of the sample was calculated by equation 2.

\[ k = -\frac{Q}{A \Delta T} \]  

(2)

Where k is the thermal conductivity (W/m·K), Q is Heat flowing through the sample surface area (W), A is Areas where heat flows through (m2), L is test piece thickness (m), and \( \Delta T \) is the temperature difference between the material surface, high temperature and low temperature (k).

2.3. Tensile strength
Tensile strength test was conducted to investigate the maximum force (tensile stress) that the bio-board can withstand on before it broke (reach a fracture point) and over the elasticity limit.
After data recorded data was calculated by following equation 3 [9].

\[ \sigma = \frac{F}{A} \]  

(3)

Where \( \sigma \) is modulus of rupture (MPa), and \( F \) is the maximum tensile force that causes the test piece to be broken (N) and \( A \) is area of the test piece (mm²).

2.4. Flammability

The fire spread occurs when the rate of decomposition of the Thermal insulation is accelerated. By the heat generated by the combustion process causing the amount of combustible fuel to increase. Leading fire spread at the surface of the thermal insulation material such events are controlled by the amount of heat in the combustion of the thermal insulation. The higher the amount of heat, the higher the value. The heat that is sent back causes a continuous burning that will increase. Can be calculated as equation 4 [10].

\[ V = \frac{S}{(t-t_1)} \]  

(4)

Where \( V \) is a fire spread rate (mm/min), \( S \) is fire spread (mm), \( t \) is time of burning 0-75 mm, and \( t_1 \) is time of burning at a distance 0-25 mm.

2.5. Moisture Content

The weight of the rubber does not include any water. It is the weight of the piece after it is oven-dry and all water has been removed. The weight of the water is the difference in the weight of the piece before and after drying. Therefore, when the test is done, we use the following formula to calculate moisture content [11].

\[ \text{Moisture content (\%)} = \left( \frac{W_1 - W_2}{W_2} \right) \times 100 \]  

(5)

Where \( W_1 \) is the weight before soaking (g), and \( W_2 \) is weight after immersion (g).
3. Results and discussion

3.1. Density

Figure 9. Thermal insulation density of rubber leaves mixed with latex at a ratio of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20.

The density of the sample is presented in figure 9. Their density of all samples were close at 990.3 – 995.3 kg/m³. The values obtained from the experiment are close to the thermal insulation from natural waste materials. The density is 800 kg/m³ [12].

3.2. Tensile strength

Figure 10. Tensile strength of thermal insulation from rubber leaves mixed with latex at 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20.

The tensile strength of the sample is presented in figure 10. There tensile strength of all samples were close at 0.0002 – 0.028 MPa. At the ratio of 20:80 and 30:70, this tensile strength from this research were nearly of the insulation from corn and of 0.024 MPa [13].
3.3. Thermal conductivity

![Figure 11](image1.png)

**Figure 11.** The relationship between room temperature (The difference in sample contact temperature) and the time of insulation from rubber leaves mixed with latex at a ratio of 80:20.

The coefficient of thermal conductivity of each sample was measured by a thermal conductivity test. The data on the experimental of temperature at first room and second room (Figure 11) was found that the temperature of the first room and second room were equal thermal equilibrium due to the both rooms has gaps where the air can flow between them. The all heat flow sensor probes measured the temperature of both rooms started at 30 °C, which confirmed the accuracy of the probe. When the insulation sheet blocked the gap between the both rooms and take the heat in, turn on the lamp in the first room. At the time 0 - 64,000 s (12h), the temperature of the first room increased from 30 °C to 80 °C while the temperature of the second room increased from 30 °C to 33 °C (depend on the ratio of rubber leave: natural rubber latex). After the time 64,000 s, the temperature of the both rooms was decreased until to thermal equilibrium at 33 °C.

![Figure 12](image2.png)

**Figure 12.** Thermal conductivity coefficient of thermal insulation from rubber leaves mixed with latex.
It was found that the initial coefficient of thermal conductivity (figure 12) increased rapidly and gradually increased slightly. Will see that the thermal conductivity coefficient at the ratio of 60:40 is the most valuable and at the ratio of 80:20 is the smallest which in the production of good thermal insulation must have a low thermal conductivity coefficient.

**Figure 13.** Thermal conductivity coefficient of thermal insulation from rubber leaves mixed with latex at a ratio of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20.

The thermal conductivity of the sample is presented in figure 13. Thermal conductivity of all samples were close at 0.0283 – 0.0431 W/m·K. Which is closely of another research of natural insulation from plant of corn cobs to 0.066 W/m·K [9] the banana fiber is within the 0.02 W/m.K to 0.06 W/m.K [3] the oil palm fiber the values of k obtained were found to be 0.2 W/m.K to 0.069 W/m.K [14] insulation material from rice husk granule the lowest thermal conductivity (0.0746 W/m.K) [1] production of thermal insulator from water hyacinth fiber and natural rubber latex the thermal conductivity values ranging from 0.0246-0.0305 W/m.K [15]. And when comparing with commercial insulation, the value is 0.032 W/m·K, found that the ratio of 80:20 has a better thermal conductivity coefficient than the commercial thermal insulation.

### 3.4. Moisture Content

**Figure 14.** The moisture content of thermal insulation from rubber leaves mixed with latex at a ratio of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20.

The moisture content of the sample is presented in figure 14. There moisture content of all samples were close at 6.722 – 14.748 %. The results are in the standard criteria, not more than 10%. Except the ratio of 20:80, 30:70, 40:60 and 50:50 exceeding the standard and the ratio of 80:20 which is consistent with the development of thermal insulation to buildings from corn cobs and natural rubber latex is equal to 5.93% [13].
3.5. Flammability

![Flammability graph]

**Figure 15.** Flammability of thermal insulation from rubber leaves mixed with latex at a ratio of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20.

The flammability of the sample is presented in figure 15. There flammability of all samples were closely at 6.640, 5.827, 6.022 mm / min. At the ratio of 50:50 and 60:40 can burnt by itself and at the ratio of 70:30 and 80:20 no burning. Which the experimental values are close to the properties of fiberboard from coconut fiber and flame retardant polystyrene foam is equal to 1.84 mm / min [10] and when compared commercial flammability. That the ratio at 70:30 and 80:20 does not cause a flammability which corresponds to the rate of commercial flammability.

3.6. Surface condition analysis with scanning electron microscope (SEM)

![SEM-EDX analysis images]

**Figure 16.** SEM-EDX analysis for Sample (A) 20:80, (B) 30:70, (C) 40:60, (D) 50:50, (E) 60:40, (F) 70:30 and (G) 80:20.
The rubber latex content of the rubber leaves fiber is expected to affect the insulation property. The characteristics of rubber leaves with different composition of rubber latex were evaluated by the SEM-EDX. Based on figure 16, the morphology the ratio sample of 80:20 has a higher surface area and micro holes-pore structure than other sample [1]. Insulation surface conditions from rubber fibers than sample 80:20, with a very porous surface which can allow air to transplant and flow easily, therefore resulting in a low thermal coefficient compared to other fibers.

4. Conclusion

This research is a study of thermal insulation from rubber leaves mixed with rubber latex as a co-ordinator which uses a rubber leaf ratio: latex at a ratio of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20 by weight and testing coefficient of thermal conductivity, moisture content, density value fire spread rate and tensile strength values.

From the test results, it was found that the thermal conductivity coefficient was in the range of 0.0283 - 0.0442 W/m·K Thermal insulation from this rubber sheet has physical properties, i.e. moisture content 6.722 - 14.748%. The density is in the range of 990.3 - 995.3 kg/m3 and the rate of fire spread is in the range 0 - 6.640 mm /min. Mechanical properties are Tensile strength is in the range of 0.0002 - 0.0288 MPa. It can be seen that the insulation produced from rubber leaves has good thermal insulation properties. Especially when comparing with commercial thermal insulation, the value is 0.032 W/m·K. It is found that the ratio of 80:20 is equal to 0.0283 W/m·K which is better insulated from the rubber sheet commercial and in this research, at a ratio of 80:20 that is appropriate to be used as a thermal insulation because it has the lowest coefficient of heat and moisture.

5. References

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