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Effects of Percentage Fibre with Treated and Untreated on Sound Absorption Properties in Rubber Wood Fibre Composite

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Abstract – Current developments on natural fibre as sound absorption purpose have attracted researcher's attention since sound pollution has been a threat to peoples. Hence, in this study, a fibrous acoustic material, which is rubber wood fibre, was used to determine acoustical properties. To achieve higher sound absorption coefficient (SAC) especially at low frequency, pre-treatment of the fibre is needed where in this study alkaline treatment was implemented. Three different percentages of fibre, namely 20%, 25% and 30% for non-treated and treated fibre were used to study the acoustical characteristic. Impedance tube method (ITM) was used to determine SAC. From the result, it has been found that SAC for fibre treated with alkaline was better than untreated fibre at low frequency. Alkaline treatment of the rubber wood fibre reduced the fibre diameter. More tortuous path and higher airflow resistance occurred since more fibre needed to reach the volume density of the sample. This work confirms by increasing rubber wood fibre content in the sample would also increase the acoustic performance and this has been proved where 30% of fibre sample mostly demonstrated better SAC compared to other fibre content for untreated and treated fibre and can be considered as sound absorption application.

Keywords: Sound Absorption Coefficient, Rubber Wood Fibre, Epoxy, Alkaline Treatment

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1. Introduction

These days noise pollution has become a huge problem to committee from various developing nations and has turned into the third pollution resource that has extraordinary adverse effects on the earth, human health and economy. Here lies the significance of noise control, which tries to decrease the direct contact of noise to human [1]. Majority of these pollution sources occur outside of home such as transportation systems, including vehicle noise, aircraft noise, and railroad noise.

Various techniques have been execute to decrease noise pollution such as wearing hearing protection, installation of sound barrier and executing sound absorption panel. This paper focused about sound absorption panel instead of any other techniques that can reduce noise pollution. Sound absorption is one of the major needs for human solace today, as noise pollution has become a huge problem to community [2]. Sound absorption process refers to the process by which a material, structure, or object absorbs sound energy when sound waves are experienced, rather than reflecting the energy.

Granular, cellular and fibrous applied in outdoor and indoor applications as the available commercial sound absorption material. Fibrous materials can be classified in form of natural or synthetic. Sound absorption material that made from natural fibres are less dangerous to human health and more eco-friendly compared to those made from synthetic fibres [3]. Therefore, due to human health problem and safety issues, engineers and manufactures take these problems seriously by find another alternative that is implement natural fibres to be potential replacement for synthetic fibres as sound absorption material [1] .

The ability and capability of natural fibres, which classes as green material are found with a few works and can be selected as sound absorption material. Common industrial plywood and rice straw-wood particleboard were tested for their sound absorption properties and the result show, with lower specific gravity, rice straw-wood particle could be good sound absorption compared to the plywood [4].

For sound absorbing purpose, porous materials are often used because the material has much voids and contains connected solid matrix that can resist shear stress and within has tiny pores that filled by a compressible fluid [5]. Flow resistivity and porosity are the fundamental material characteristics in the porous absorbents as the both characteristics are the most necessary parameters to determine properties of material [6].

In this study, rubber wood fibre reinforced with epoxy was used to study its sound absorption properties in order to determine whether the composite is a good sound absorption material or not. The effect of alkaline treatment and influence of fibre percentage are investigated as the potential replacement of synthetic and minerals fibres as sound absorption material.

2. Methodology

In this paper, method to determine sound absorption properties is by using impedance tube, which is followed by ASTM E1050, two-microphone method. Before performing the sound absorption test, physical properties of the sample such as density and porosity are also investigated.

2.1. Preparation of Samples

This study used rubber wood fibre as the raw material and epoxy as the binder. Before being used, rubber wood fibre was soaked into Sodium Hydroxide (NaOH) solution for at least 3 hours. In this process, the ratio of water and Sodium Hydroxide is 95:5 and the reason of this treatment is to remove other unwanted substances and separated linen from the fibre. Then, the fibre dried under sun for 3 days before put into the oven for 24 hours to get fully dried fibre.

Both untreated and treated Rubber wood fibre was mixed together using epoxy as the binder, prescribed as in Table 1. 100 mm diameter for low frequency and 28 mm diameter for high frequency of round shape mould were prepared to fabricate samples with 10 mm thickness were prepared as shown in Figure 1.

Table 1
Composition of untreated and treated rubber wood fibre, epoxy resin for 28 mm and 100 mm sample diameter

Sample	Rubbber Wood Fibre (%)	Epoxy (%)
1	20	80
2	25	75
3	30	70

Figure 1. Composite sample

2.2. Physical Measurement

Density kit was used to determine the density of the samples. While to determine porosity, equation 1 is used. There are several data must be obtain before completing the equation, which are, weight dry (W_d), weight float (W_f) and weight wet (W_w). Using density kit same as to measure the density, these data can be determined. With the obtained data, porosity can be calculated by using the Eq.(1) as derived from [7].

$$\varepsilon = \left(\frac{W_w - W_d}{W_w - W_f}\right) \times 100 \qquad (1)$$

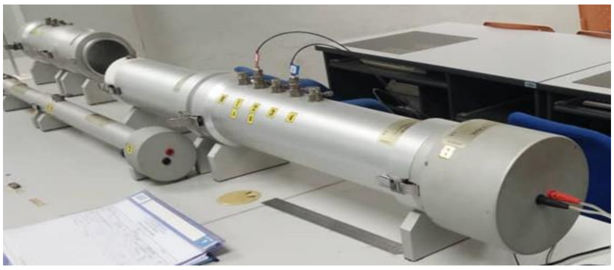

Figure 2. Impedance tube (low frequency)

Figure 3. Impedance tube (high frequency)

2.3. Acoustical Measurement

The ratio between the energy of acoustic that is not reflected by the surface to the sound energy in incident wave called sound absorption [6]. Sound absorption also can be defined as a sound incident on a material and can be reflected, absorbed and transmitted. . Generally, sound absorption coefficient vary from zero which is no absorption of sound until one which is for complete absorption of sound. Sound absorption properties of a material is determined by the sound absorption coefficient, which indicates how much sound can absorb by the material [7].

The procedure of this test was done according to ASTM E1050-98 and experimental procedures divided into two parts, which are 28 mm for high frequency and 100 mm for low frequency. 70 Hz to 2000 Hz is the value for low frequency range while 2000 Hz to 6920 Hz for high frequency range. Figure 2 and Figure 3 show the impedance tube that were used to determine the sound absorption coefficient for low and high frequency

3. Results and Discussion

3.1. Physical Properties Analysis

Figure 4 shows the density when the rubber wood fibre content increase from 20% to 30% for treated fibre in the composite.

The increase of density influenced by rubber wood fibre content. As desired, the untreated 30% of fibre sample has the highest density, which is, 1.0926 g/cm^3 and the second highest of density is 1.0780 g/cm^3 which is for sample with 25% of treated fibre. From literature [8], the researcher reported that the increase of sample density will enhance the sound absorption value in the middle and higher frequency. As density of sample affected by fibre percentage, the surface friction increase when fibre content increase then improve the sound absorption due to energy loss.

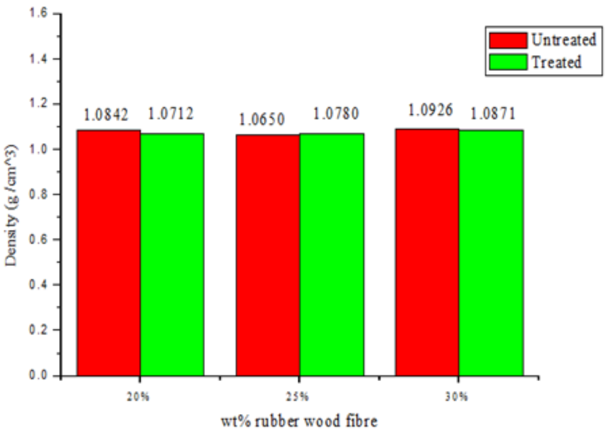

Figure 4. Values of density for various percentages of untreated and treated rubber wood fibre

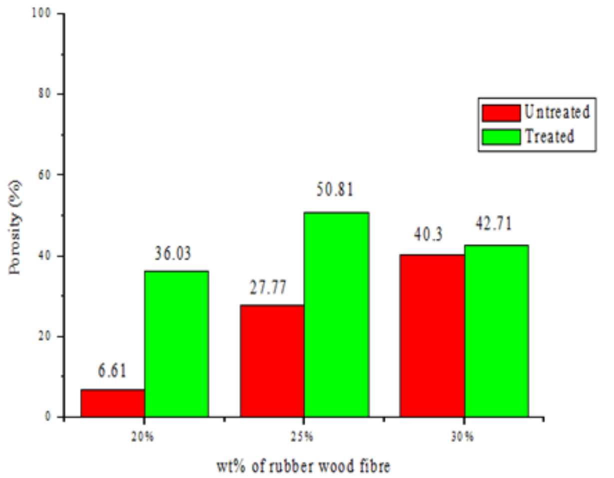

Figure 5. Values of porosity for various percentages of untreated and treated rubber wood fibre

From Figure 5, sample, which contains 25% of treated rubber wood fibre has the highest porosity, which is 50.81% and lowest porosity 6.61% for 20% of untreated fibre sample. For untreated rubber wood fibre, there is a strong relationship between percentage of rubber and porosity. Sample with 20% of fibre has the lowest porosity and this result are due to the binder hold the rubber tightly and reduce the pores in the sample. When the percentage of fibre increased, more hollow space produced within sample. More open pore and voids created when the sample fill up with higher content of fibre [1]. However, porosity for 25% of treated fibre sample is higher than sample with 30% of treated fibre. This is due several factors such as problem in mixing the sample composition properly that causing the rubber wood fibre and epoxy not distributed homogenously through the whole sample.

3.2. Acoustical Properties Analysis

Figure 6 and Figure 7 depict influence of percentage of untreated and treated rubber wood fibre. It shows that the SAC for all samples initially increase from beginning until 1900 Hz but within 1900 to 2100 Hz range, SAC decrease for all. However, SAC proportionally increase again with the frequency value until 6700 Hz.

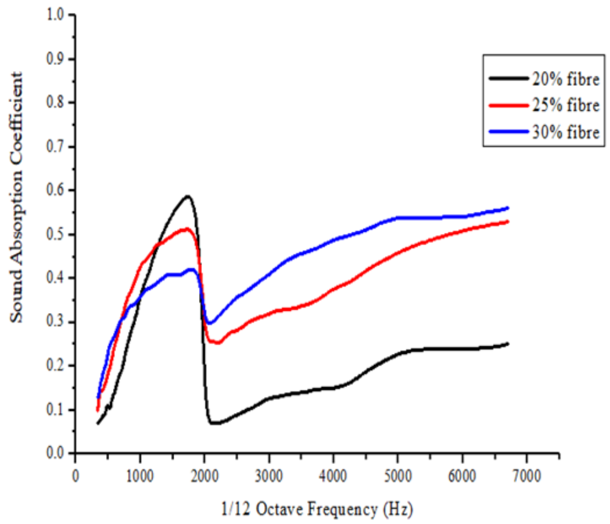

Figure 6. Influence of percentage of untreated rubber wood fibre

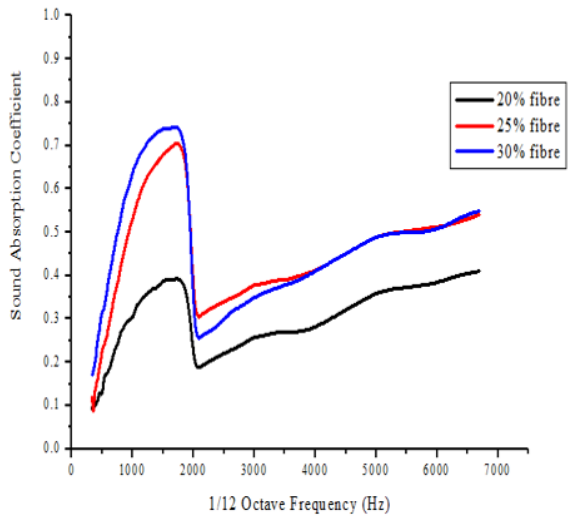

Figure 7. Influence of percentage of treated rubber wood fibre

Essentially, on the graph of porous absorbent material, this is the standard pattern [9]. Although 30% of fibre sample has the highest value of SAC from beginning until 670 Hz, 20% of fibre sample shows the best sound absorber at low frequency because of the high value of SAC, which is 0.61.

The results also demonstrated that when the percentage of epoxy increased, it will improve the SAC value at low frequency range. Thus, damping can remove the cavity resonances. Sound are not easy to through the partitions when the resonant frequency, and so, low frequency were being better [6].

At high frequency range, it is clearly shown that the sample with 25% and 30% of rubber wood fibre are the good sound absorption sample, which are their SAC are above 0.5. This result also indicated samples added with 25% and 30% of fibre give poor of SAC values at low frequency range compared to sample with 20% of fibre and this condition may cause the samples not suitable to use as sound absorption material.

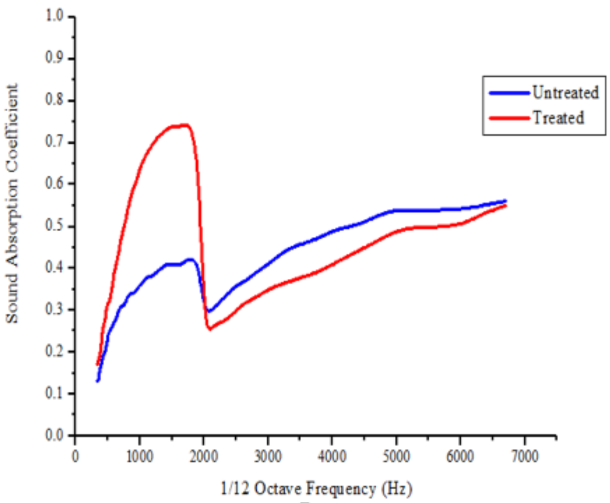

Figure 8. Comparison between two optimum results of untreated and treated fibre samples

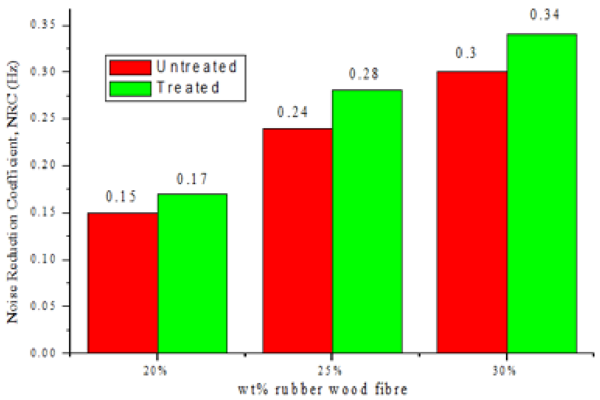

Figure 9. Noise reduction coefficient for different composition of composite

Figure 7 shows the sample with 30% of fibre has better result of sound absorption coefficient at low frequency compared to other two samples. At high frequency, 25% of fibre sample demonstrated the best value of SAC at frequency 2000 Hz to 3750 Hz and then the SAC value of the sample does not much different with 30% of fibre sample after range of frequency 3750 Hz to 6700 Hz. The result also certainly shown that sample with 25% and 30% of rubber wood fibre have better SAC than 20% of fibre sample at both range of frequency. When the percentage of binder increased, it will be causing the pores in the sample become closed or clogged and avoid sound wave to pass through the sample.

Principally, in the material have two main mechanisms that sound waves are absorbed which are direct dissipation to thermal energy and conversion to mechanical friction at sample boundaries. In this situation, the presence of epoxy as binder known to have a strong effect on dissipation of mechanical energy, which is the dissipation, occurred between epoxy and fibre. Therefore, the damping obtained in the samples with less amount of epoxy actually very less.

Considering the acoustical performance for both types of samples, the optimum composition were was obtained for sample with 30% of fibre added with 70% of epoxy resin.

Figure. 8 shows the both optimum compositions were plotted together to make comparison between them. Based on the figure, 30% fibre that treated with alkaline demonstrated good results at low frequency compared to non-alkaline 30% of fibre. However, SAC for the untreated fibre sample perform better after 2000 Hz and this clearly shows the sample is good at high frequency compared to treated sample.

Alkaline treatment process on fibre can reduce the diameter of fibre. To enhance the sound absorption performance of any fibrous material, diameter of fibre is the most necessary physical geometrical parameter [3]. Decreasing diameter of fibre leads to the increase of fibre content in sample with high viscous friction of air molecules with a larger surface area. This is because to get the same volume density at the same thickness of sample material, more fibres are needed. More tortuous path and greater airflow resistance occurred and as a result, due to the viscous friction through air vibration, the sample can have good acoustical performance at low frequency [3]. Table 2 shows the sound absorption coefficient for all samples at 500 Hz.

Based on Fig. 9, it can see that composite sample with 30% of rubber wood fibre and 70% of epoxy show the higher NRC that is 0.34 Hz. High percent of fibre means that sample is denser. The samples per unit area increased by the content of fibre because density of sample is high as the fibre will act as fillers and fill the void in the composite sample [8]. The result also demonstrates NRC values obtained for treated rubber wood fibre samples always produced higher NRC values compared to untreated rubber wood fibre samples. NRC values produced were within 0.17 to 0.34 while NRC values calculated for untreated rubber wood fibre samples yield the values from 0.15 and 0.3. This is clearly shown that samples with treated rubber wood fibre provide better sound absorption coefficient compared to untreated fibre samples. Tipical of similar results in composite can be found in [10].

Table 2
List of the sound absorption coefficients for all samples at low frequency

Treatment	Sample	SAC at f = 500 Hz
Untreated	20% of fibre	0.11
	25% of fibre	0.19
	30% of fibre	0.24
Treated	20% of fibre	0.12
	25% of fibre	0.23
	30% of fibre	0.32

4. Conclusion

As a conclusion, the acoustical and physical characteristic of rubber wood fibre for sound absorption material has been identified. This study was undergo to know the influence of percentage of fibre on physical and acoustical characteristics and effect of alkaline treatment on sound absorption coefficient. Six samples of fibre mixture has been fabricated as the sound absorption material where the rubber wood fibre is not treated and treated with alkaline were mixed with three different percentages of epoxy as binder which are 20%, 25% and 30%. The results from the experiment show the composite has good sound acoustic at different range of frequency and can be considered as an alternative to replace synthetic based commercial product. The composite with 30% of treated fibre has the highest sound absorption performance in the range of low frequency compared to other samples while sample with 30% of untreated fibre was excellent at high frequency. From the result, it demonstrates that sample with alkaline treatment shows better acoustical characteristic at low frequency compared to untreated fibre sample as other percentage of fibre also show the same pattern in low frequency range and this study has achieved the first objective.

Results from sound absorption test indicated that percentages content of fibre influencing the acoustical properties. Although 20% of fibre sample shows the best acoustic performance in low frequency for untreated sample, sample with 25% and 30% of fibre shows better acoustical properties at high frequency for untreated fibre sample and in both frequency range for sample with treated fibre. Sample with 30% of treated fibre has the highest noise reduction coefficient (NRC) that is 0.34 Hz and this shows that the sample is the best sound absorption material compared to other samples. Hence, the sample is applicable for sound absorption panel since this material also had a good potential to be an environmentally friendly product. For result of physical properties test, which are density and porosity, mostly results show the increasing of fibre content increase the density and porosity value because it will decreases the pores in the sample. All of these clearly showed that increasing of fibre percentage influencing the acoustical and physical properties and the second objective was answered by the results.

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