

## **A Preliminary Study on Acoustical Performance of Oil Palm Mesocarp Natural Fiber**

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**Abstract.** As the population increases, the demand of a comfortable environmental such as sound pollution is getting higher. Sound pollutions also have become worsen and creating concerns for many peoples. Due to this problem, synthetic materials as acoustic absorbers still applied as commonly acoustical panels and this material may hazardous to human health and contribute significantly a pollution to the environments. However, researchers have interested in conducting their research on natural fiber to be an alternative sound absorber. This study investigated the potential of oil palm Mesocarp fiber for sound absorbing material. The Mesocarp fibers were mixed with polyurethane (PU) as binder with ratio of 70:30. The thickness was varied in 10mm, 20mm, 30mm, and 40mm. This study also investigated the air gap of 5mm and 10mm in the sound absorption performance. Impedance Tube Method was used to measure sound absorption coefficient ( $\alpha$ ). The measurement was done on accordance with ASTM E1050-98, which is the standard test method for impedance and absorption of acoustical materials using a tube. The results showed that the optimum value for Mesocarp fiber is 0.93. The optimum value obtained at 5000 Hz. The influence of air gap increases the sound absorption especially from 250 Hz to 4000 Hz. These results indicate that fiber from Mesocarp is promising to be used sound absorbing material.

### **Introduction**

Miscellaneous products of sound absorption panel have been created in market. Moreover, the common acoustical panels are made from glass wool, rock wool, slag wool and asbestos; which is harmful to human and sometime expensive. Some of synthetic material not only effect on human health but also contributes much higher Global Warming Potential (GWp) kg CO<sub>2</sub> [1]. Asbestos can cause asbestosis, lung cancer and mesothelioma [2]. Consequently, other natural fibers have been tested as alternative material such as coconut fiber [3], Kapok fiber [4], Arenga Pinnata [5], Paddy straw [6], Kenaf [7], Rice husk [8] and so on. Among these, oil palm Mesocarp is proving an interesting material because of low cost, low density, renewable, and saves for environment and human health.

At present, Malaysia is famous for the production of palm oil in the international market. Oil palm plantation showed a drastically increased in Malaysia. In 2011, about 5 million hectare of area oil palm has been planted [9]. Approximately 22% fiber produced from oil palm industry is a waste [10]. In addition, palm trees not only produce oil but provide a raw material such as oil palm (OPF), oil palm trunk (OPT), empty fruit bunch (EFB), palm kernel shell (PKS), palm kernel cake (PKC), palm kernel expeller (PKE), palm oil mill effluent (POME), dry decanter cake (DDC), ash and Mesocarp fiber [11]. Most of the oil palm fiber has been used widely in biomass media, mattress,

fiber board, cushion, rugs, carpets, and rope manufacturing. Mesocarp fibers consist of cellulose and can very easily be made into chip particles rather than other wood-based.

This research is carried out to investigate the potential of oil palm Mesocarp fiber for sound absorbing material. The Mesocarp fibers were mixed with polyurethane (PU) as binder with ratio of 70:30. The percentage of the polyurethane had been used in literature [12-13]. The thickness was varied in 10 mm, 20 mm, 30 mm, and 40 mm. This study also investigated the air gap of 5mm and 10mm in the sound absorption performance [14]. The most important parameters to determine acoustic characteristics are the sound absorption coefficient. The measurement was done on accordance with ASTM E1050-98, which is the standard test method for impedance and absorption of acoustical materials using a tube.

## Material and Methods

### A. Material Preparation

The material that used in this study is Mesocarp fiber that obtained from oil palm mill and known as press fiber. These fibers are taken after the press station, as shown in Fig. 1. These fibers also include cellulose, hemicelluloses, lignin and other unwanted dirt's. Thus, the fiber were treated with 10 % of alkaline treatment for 24 hours and dried at 70°C for 24 hours. The purpose of alkaline treatment is to remove unwanted dirt's, lignin and cellulose content and oil content. This treatment also will increase the surface roughness of the fibers, that will increase the sound absorption capability and also increase the adhesion capability between the binder and fibers [15-16]. The dried fiber is mixed with polyurethane with ratio 70:30 and prepared the samples in cylindrical shape with diameter of 28mm for high frequency measurements range from 125 Hz to 1600 Hz and 100 mm for low frequency measurements range from 1200 Hz to 6000 Hz, as shown in Fig. 2.



Fig. 1: Mesocarp fibers

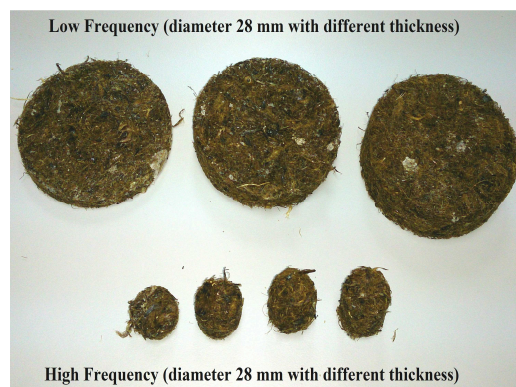


Fig. 2: Samples for Impedance Tube Method

### B. Sound Absorption Testing

Impedance Tube Method (ITM) was used to obtain the sound absorption coefficient ( $\alpha$ ) which is based with ASTM E1050-09 standard. This method places a loudspeaker at one end of an impedance tube and a small sample of the material under test at the other end. The loudspeaker generates broadband, stationary random sound waves. The sound wave propagate within the tube strike the sample and is reflected resulting in a standing wave interference pattern. The sound absorption measurement was done by varied the thickness of Mesocarp fiber, 10 mm, 20 mm, 30 mm, and 40 mm. The measurements are also performed with air gap of 5mm and 10mm at the back of the samples.

## Result and Discussion

### A. Sound Absorption Coefficient of Mesocarp Fiber

In Fig. 4, it shows that the Mesocarp fiber is a good absorber especially for sample made of 40 mm thickness. The optimum sound absorption for Mesocarp fiber is 0.93. The optimum values were obtained at frequency of 5000 Hz. The result clearly shows that the sound absorption increases as the thickness is increased especially frequency ranged from 100 to 2000 Hz. However, as the thickness increases, it will show insignificant effect on the results especially at higher frequencies. The result shows that the Mesocarp was a porous (fibrous) material: the demands for and significant thickness compared to sound wavelength make porous absorbers poor at low frequencies and they are good absorber at high frequencies [17]. Porous materials allow sound energy to easily enter and the low frequencies pass through material much easier than the high frequencies. Therefore, for the same material, thin material will not absorb as much low frequencies as will thicker material.

### B. Sound Absorption Coefficient of Mesocarp Fiber With Air Gap

Testing were performed with and without air gap of 5 mm and 10 mm between the rear of the sample and the backing of movable plunger of the impedance tube. From figure 5 to 8, introducing certain length of air gap increases the sound absorption performance especially frequencies at mid and high, despite decrease at certain range of frequencies. As the distance of air gap increases, the maximum peak value will also be different. It can be seen that as the distance of the air gap is increased, the maximum peak will move towards lower frequency. From the results, having an air gap will increase the sound absorption at certain frequency, where as the thickness increases, the peak point tend to move to lower frequencies for both samples. As seen in the figure, as the thickness is 10 mm and 20 mm, the sound absorption increased within frequencies from 250 Hz to 3150 Hz, while the thickness is 30 mm and 40 mm, the sound absorption tends to increase at lower frequencies, from 100 to 1600 Hz and at higher frequencies from 4000 Hz to 5000 Hz. Therefore, for the same amount of material, it is much better to have an air gap behind the layer, which has been confirm with the results and to improve sound absorption at mid and high frequencies.

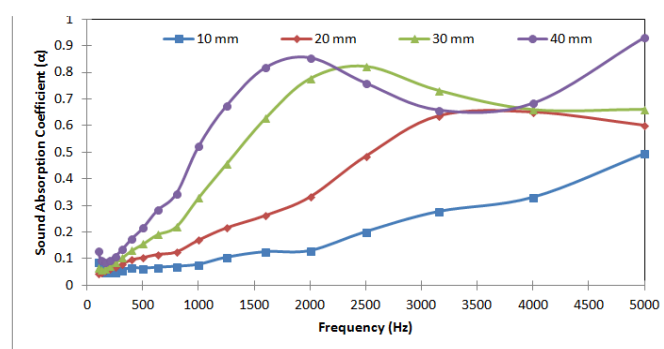


Fig. 4: Sound absorption of Mesocarp fiber with different thickness

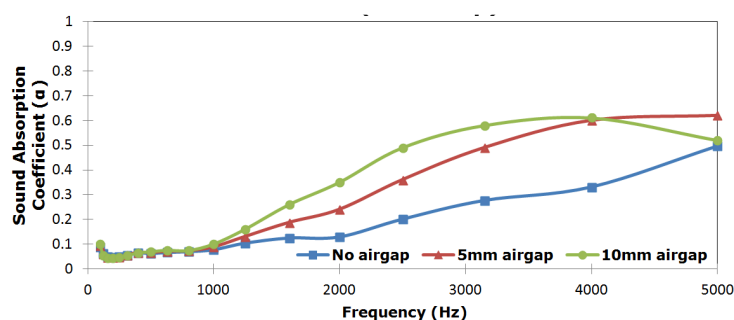


Fig. 5: Sound absorption of Mesocarp fiber with air gap of 5mm and 10mm at 10mm thickness

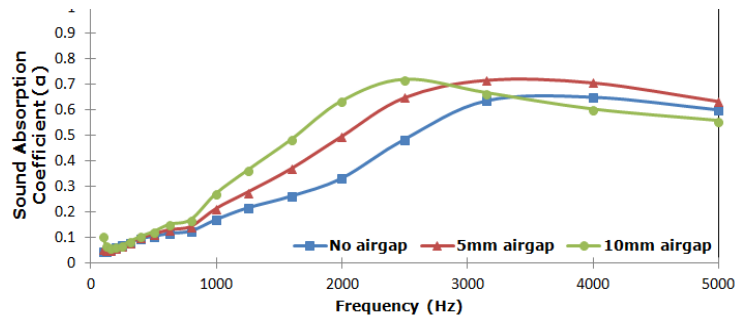


Fig. 6: Sound absorption of Mesocarp fiber with air gap of 5mm and 10mm at 20mm thickness

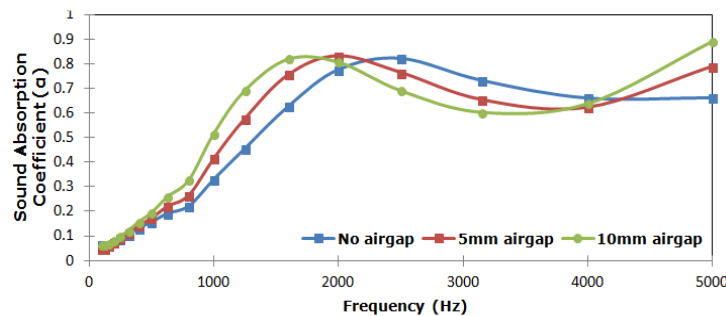


Fig. 7: Sound absorption of Mesocarp fiber with air gap of 5mm and 10mm at 30mm thickness

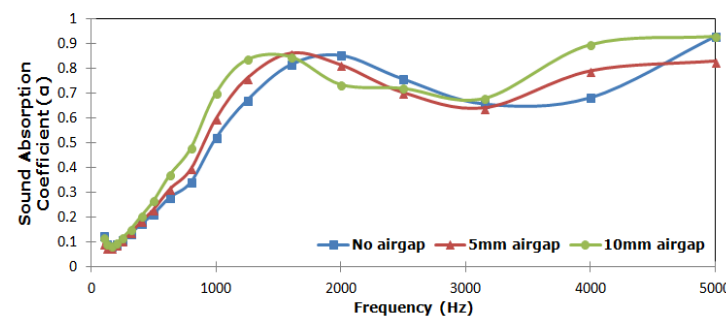


Fig. 8: Sound absorption of Mesocarp fiber with air gap of 5mm and 10mm at 40mm thickness

## Conclusion

The optimum sound absorption coefficient of Mesocarp fiber obtained at thickness of 40 mm. The sound absorption coefficients were good from the medium to high frequency from 1600 Hz to 5000 Hz within the range of 0.7 to 0.90. Air gap of 5 mm and 10 mm results in increasing of sound absorption especially at lower frequencies, from 250 to 3150 Hz. Overall, panel made from Mesocarp fiber has good sound absorption properties and adding a certain thickness of an air gap were improve better absorption at low frequency. These results show that fiber from Mesocarp is capable to be used as raw material for sound absorbing material.

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## References

- [1] S. N. Monteiro, F. P. D. Lopes, A. S. Ferreira and D. C. O. Nascimento, Natural-fiber polymer-matrix composites : cheaper, tougher, and environmental friendly (2009), *Jom* 61(1), pp. 17-22
- [2] E. Yano, Z. M. Wang, X. R. Wang, M. Z. Wang, Y. J. Lan, Cancer mortality among workers exposed to amphibole-free chrysotile asbestos, *American journal of epidemiology* 154.6 (2001), pp. 538-543.
- [3] M. J. M. Nor, N. Jamaludin, F. M Tamiri, A preliminary study of sound absorption using multi-layer coconut coir fibers. *Electronic Journal Technical Acoustics* (2004) 3, pp. 1-8.
- [4] A. Veerakumar and N. Selvakumara, A preliminary investigation on kapok/polypropylene nonwoven composite for sound absorption. *Indian Journal of Fibre & Textile Research* (2012) 37, pp. 385-388.
- [5] L. Ismail, M. I. Ghazali, S. Mahzan, and A. M. A. Zaidi, Sound absorption of Arenga Pinnata natural fiber. *World Academy of Science, Engineering and Technology* (2010) 67, pp. 804-806.
- [6] Y. Abdullah, A. Putra, H. Effendy, W. M. Farid, and M. R. Ayob, Dried Paddy Straw Fibers as an Acoustic Absorber: A Preliminary Study (2011), pp. 52-56.
- [7] M. J. Saad, and I. Kamal, Kenaf Core Particleboard and Its Sound Absorbing Properties. *Journal of Science and Technology* (2013), 4(2), pp. 23-33.
- [8] A. Zaidi, A. Mujahid, M. I. Ghazali, M. N. Yahya, and M. Ismail, Investigation on sound absorption of rice-husk reinforced composite. *MUCEET* (2009), pp. 19-22.
- [9] Malaysia Palm Oil Board. Oil Palm Planted Area : 1975 - 2011 (Hectares). Economics & Industry Development Division.
- [10] K. H Badri, Z. B. Othman, I. M. Razali, Mechanical properties of poyurethane composites from oil palm resources. *Iranian polymer journal* (2005) 14(5), pp. 441-448.
- [11] Cuah, C. K. (2009). *Hoog Chan Trading*. Retrieved May 6, 2014, from Product Provide: <http://www.hoongchan.com/>
- [12] S. Mahzan, A. M. Ahmad Zaidi, N. Arsat, N. M. Hatta, M. I. Ghazali and S. Rasool Mohidden, Study on sound absorption properties of coconut coir fiber reinforced composite with added recycled rubber. *International journal of integrated engineering* 2, no 1 (2010), pp. 29-34.

- [13] L. Ismail, Acoustic and durability performances of Arenga Pinnata panel. Doctoral dissertation Universiti Tun Hussein Onn Malaysia (2012).
- [14] H. S. Seddeq, Factors influencing acoustics performance of sound absorptive materials. Australian journal of basic and applied sciences, 3(4) (2009), pp. 4610-4617.
- [15] X. Li, L. G. Tabil, S. Panigrahi, Chemical treatments of natural fiber for use in natural fiber-reinforced composites: A review. Journal of polymers and the environment 15.1 (2007), pp. 25-33
- [16] M. S. Islam, K. L. Pickering ad N. J. Foreman, Influence of alkali fiber treatment and fiber processing on the mechanical properties of hemp/epoxy composites. Journal of applied polymer science 119.6 (2011), pp. 3696-3707.
- [17] D. A. Bies, C. H. Hansen, Engineering noise control : theory and practice. CRC Press (2009), pp. 302-308.