INTERNATIONAL JOURNAL OF SUSTAINABLE CONSTRUCTION ENGINEERING AND TECHNOLOGY
VOL. 13 NO. 3 (2022) 195-201

IJSCET

http://publisher.uthm.edu.my/ojs/index.php/ijscet

ISSN : 2180-3242 e-ISSN : 2600-7959

International Journal of Sustainable Construction Engineering and Technology

Preparation and Characterization of Oil Palm Tree for Insulation Material

Nur Amirah Elias[1], Siti Amira Othman[1*]

[1]Faculty of Applied Sciences and Technology,
Universiti Tun Hussein Onn Malaysia, Pagoh, 84600, JOHOR

*Corresponding Author

DOI: https://doi.org/10.30880/ijscet.2022.13.03.018
Received 30 March 2022; Accepted 20 August 2022; Available online 10 December 2022

Abstract: The most important commodity from Malaysia is the oil palm tree, which has helped to reshape the agricultural and economic landscape. Oil palm tree pieces are used to make cellulose biomass. However, the current state of oil palm waste has created a significant disposal issue. Waste management is based on the ideas of waste minimization and recycling. In order to achieve energy efficient and environmentally friendly, oil palm tree is the best choice. due to some problems occurring from previous studies which is fiberglass, cellulose has been made a new idea for insulation. The effectiveness of the insulation method is measured in R-value. R-value determines the ability of heat to pass through the insulator. If the fiberglass has been installed for a long period of time, the R-value will decrease as the insulation settles or compacts. The purpose of this study was to study the effect of ionizing radiation on cellulose using time-varying method, to identify the chemical and physical properties of oil palm tree and lastly, to identify the resistivity for cement and cellulose mixture. In view of the fact, cellulose contain no oxygen due to material's compactness. Considering, there is no oxygen in the materials, the amount of damage cause by fire can be reduced. In this research, it will undergo pre-treatment method to obtain the cellulose. After that, the sample will go through four-point probe method to earn the resistivity. Considering that the finding has been proven by the result of the resistivity. In summation, the cellulose from oil palm tree can be propose as the new insulating material in the building structure.

Keywords: Oil palm tree, insulation, cellulose, biomass, waste

1. Introduction

There has been an increasing interest in environmentally friendly and energy efficient systems in the construction sector in recent decades. As climate modifiers, buildings are usually designed to shelter occupants and achieve thermal comfort in the occupied space backed up by mechanical heating and air-conditioning systems as necessary (Ramli et al., 2002). Several operational phase aspects, such as the efficiency of the air conditioning system, window resistance, door thermal insulation losses of the thermal bridge and thermal performance, have accounted for most of the energy consumption in buildings. Nowadays, thermal insulation performance in the building sector has become a major interest to researchers concerned about energy consumption. Thermal insulation is a significant contributor and a practical measure for achieving energy efficiency, particularly in buildings located in places with harsh climatic conditions. As a result, several alternatives have been proposed to identify sustainable construction materials alternatives for ecologically friendly and energy-efficient structures. The best way to attain this aim is to employ green building materials and eco-products. Forecasting research predicted that in 2035, roughly 75 percent of total energy would be

*Corresponding author: sitiamira@uthm.edu.my

generated by fossil fuels, while numerous other studies indicated that commercial and residential structures utilize 48 percent of electrical energy.

In December 2012, Malaysia owned 5.08 million hectares of oil palm plantations and increased by 11.8% compared to 2008 and accounted for 39% of total world palm oil production and 44% of world exports (Aljuboori, 2013). An important concept of waste management is limiting and recycling waste while returning as much energy as possible. However, large amounts of oil palm trunk (OPT) production produce large amounts of biomass waste, posing a major disposal problem. The selection of construction materials with the environmental impact is critical to a country's growth. Researchers are now investigating recycled, low-cost and natural materials as building to optimize building performance efficiency. In general, palm oil trees are a material that should be employed to enhance the performance of a structure.

Past research has shown most thermal insulators used are fiberglass, but there were some issues with fiberglass and caused new ideas to emerge. Fiberglass insulation contains carcinogenic chemicals that cause cancer. Carcinogens are capable of producing cancer in live tissue and may provide a cancer risk to persons installing the insulation. The majority of fiberglass insulation materials are supplied with a warning that there may be health concerns. Fiberglass inhalation is a major issue. Inhaling tiny fibers can cause them to become lodged in the lungs, causing damage and impairing breathing. Next, the value of fiberglass insulation fluctuates with time. Thus, it severely reduces its efficacy. The effectiveness of the insulation method is measured in R-value. R-value determines the ability of heat to pass through the insulator. If the fiberglass has been installed for a long period of time, the R- value will decrease as the insulation settles or compacts. Finally, while fiberglass insulation may save energy once installed, the production process is not environmentally friendly. Fiberglass insulation consumes three times as much energy as cellulose insulation, which also has the advantage of being made primarily of recycled resources. Cellulose insulation is made of 75 percent recycled newspapers, while fiberglass insulation is made of new materials. As described above, the use of fiberglass has a detrimental effect on humans and the building. The use of thermal insulators from cellulose is preferable.

This research is to determine the thermal conductivity and effects of fibers after being irradiated at different times. This research is done to see the level of thermal conductivity of plum oil fibers. Generally, when the material's thermal conductivity is low, the potential for use as a high thermal insulator. Raw material samples are placed in containers and then tested using a thermal conductivity testing machine. Since the specimen volume is constant, the specimen's density is changed by adding or removing fibers from the specimen. In this way, the thermal conductivity of palm fibers at different densities can be determined. Next, put the sample under the scanning electron microscope (SEM). SEM is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals containing information about the sample's surface topography and composition. The intention for this part is to see the sample's characteristics. Afterwards, to see the radiation sample, it needs to go through several processes. First, the freezing process is to facilitate research. Next, the pre- treatment process. The purpose of this pre-treatment is to isolate cellulose, hemicellulose and lignin. This radiation is done to get the cellulose content in the oil palm fiber. Next, radiation in time-varying can be done by putting the sample in the GammaCell 220 exposure chamber to see the change occurring while the gamma-ray value is fixed at 25kGy.

2. Methodology

The oil palm fronds were cut into small pieces and cleaned using distilled. The purpose of the cleaning was to ensure that the material cleans from all unwanted materials. Afterwards, leave it overnight to ensure all the material is completely dry. Next, grind the material using ball mill until become powder before sieve the powder to avoid excess fiber from contamination.

In this research, the solution that should be used was 1.0 M NaOH. Firstly, fill the flask with halfway of distilled water. Then, add 40 gram NaOH pellets into the flask and add distilled water until 1 litre mark. Mix the solution until the pellet dissolves completely.

Fig. 1 - Palm oil fronds powder

Sample will undergo pre-treatment method. The purpose of pre-treatment was physically to remove most of the solute and to reduce the contamination load and protect all subsequent steps in the treatment plant. Pre-treatment was done to get the cellulosic material content in the sample. In this method, it is necessary to add 20 ml of sodium hydroxide solution into 5 grams sample. Stir the sample until the sample dissolves completely. After that, place the sample in the water bath for 90 minutes. Water bath is a preferred heat source for heating flammable chemicals instead of an open flame to prevent ignition. The other areas of its utilizations include warming of reagents, melting of substrates, or incubation of cell cultures. After the sample was removed from the water bath, add 10 ml of hydrogen peroxide (H_2O_2) to the sample. Hydrogen peroxide was used as an oxidizing and bleaching agent. After the sample is mixed, leave it at room temperature until the sample releases a large bubble. After the bubble occurs, place the sample in a water bath for 30 minutes and after that remove the sample and leave it for 5 minutes. Divide the sample into five parts with weight 5 grams each for irradiation purpose.

Fig. 2 - Sample ready to be irradiated

2.1 Insulation Material

The ratios for sand, cement and cellulose are 1.5: 1: 0.5. In this research cement is used as much as 15 grams while sand was used as much as 10 grams and cellulose is used as much as 5 grams. Three different samples will undergo a four-point probe method. Sample A is a mixture of cement with sand. Sample B is a mixture of cement, sand and cellulose. Finally, sample C is a mixture of cement and sand and cellulose placed on top of the cement. after the mixture was done leave the sample for 3 day to assure the sample completely dry.

The setting measurement for four-point probe machine was 4W for sense mood, function was Bias and the current level was 0.004A. To get a good result make sure used three different part.

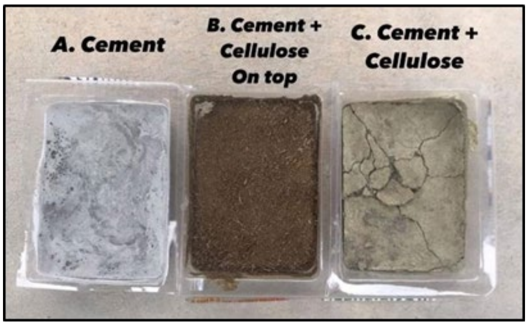

Fig. 3 - Sample insulation material

3. Results and Discussion

Surface morphology can be characterized using Scanning Electron Microscopy (SEM). SEM micrograph in Fig. 4, Fig. 5 and Fig. 6 illustrates the surface morphology for irradiated and non-irradiated cellulose powder. After irradiation, several changes on the surface were observed as shown on the figure below. As can be seen in Fig. 5. and Fig. 6 for the cellulose powder, the surface is more prominent compared to Fig. 4. When the radiation dose is increased, more dispersed particles and more space between cellulose surfaces appears, together with small voids. Drew on Fig 4, the surface on top of the fiber was a bit smooth compared to Fig 5. The principal impacts of gamma radiation, which were scission and cross-linking of molecular chains in cellulose, can be linked to such changes. Morphology is a product of the complicated thermo-mechanical history that the various constituents go through throughout material processing (Tassadit Aouat et al., 2019).

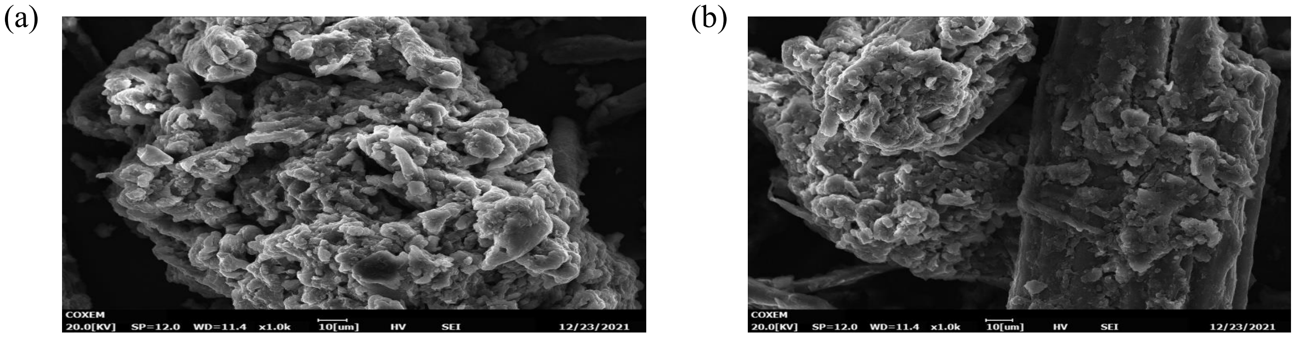

Fig. 4 - Non irradiated (a) cellulose powder (b) cellulose fiber

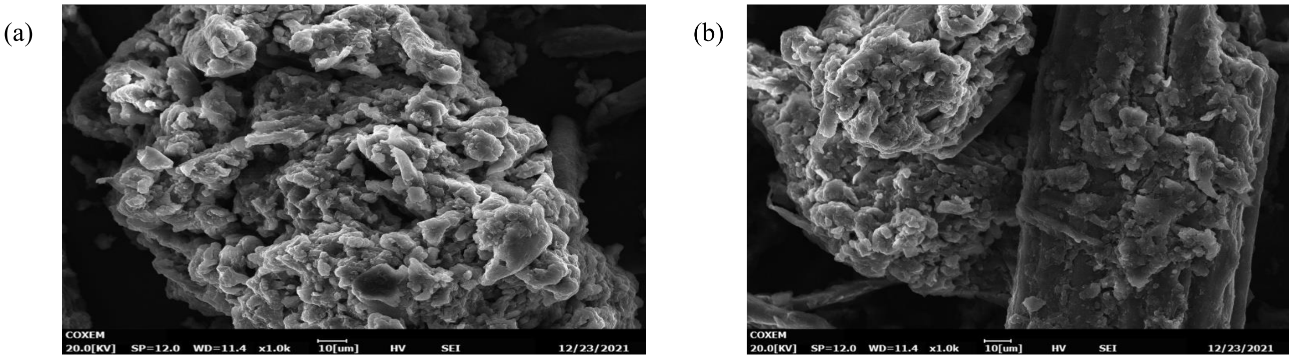

Fig. 5 - Irradiated at dose rate 0.5kGy (a) cellulose powder (b) cellulose fiber

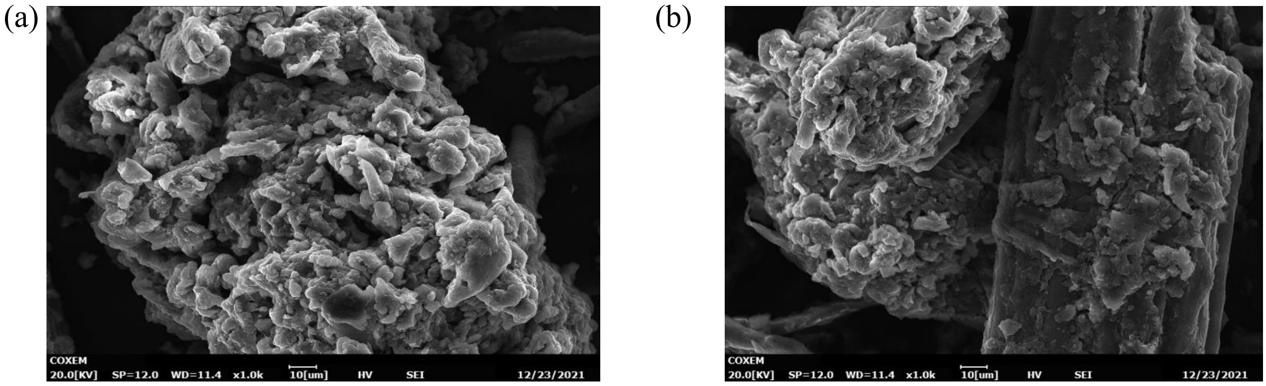

Fig. 6 - Irradiated at dose rate 2.5kGy (a) cellulose powder; (b) cellulose fiber

3.1 Chemical Bonding for Irradiated and Non-Irradiated Cellulose

Fourier Transform Infrared (FTIR) study was to carrier out the chemical bonding for irradiated and non-irradiated cellulose. According to figure 7, there is only a slight change in the intensity of the irradiated sample as compared to the non- irradiated sample. In the FTIR spectra of irradiated and non-irradiated cellulose for absorption band can be observed. Among all the irradiated cellulose, the irradiated cellulose at dose rate 05kGy, the intensity of the absorption was 2800cm^{-1}. With increased irradiation dose, the intensity of this absorption becomes weaker, indicating that the C-F bond has been scission. This is due to the cellulose sample's great resistance to ionic radiation. The shattering of one or two bonds in the structure may cause slight changes in the peaks of the irradiated sample, but this will not affect the polymer's overall structure. Cellulose undergoes random chain scission due to the effect of γ-irradiation (F. EL-Ashhab et al., 2013). Previous research has found that irradiating various cellulosic materials (cotton filters, softwood, cotton wool, microcrystalline cellulose) with various radiation sources (electron beam, -radiation) resulted in an increase in mid-chain scissions and a decrease in the degree of cellulose polymerization. (Badruddin et al., 2006)(Bassil et al., 2021). Above all, the change of the structure polymer result will come out different based on radiation source.

According to the table, there was a different between transmittance and absorbance for all the sample. The main difference between absorbance and transmittance is that absorbance measures how much of an incident light is absorbed when it travels in a material while transmittance measures how much of the light is transmitted. Based on the table below, the highest peak for the irradiated cellulose sample was at dose rate 2.5kGy and the lowest was at dose rate 0.5kGy. this have proven that the radiated have affected the chemical bonding between the cellulose content.

Table 1 - Data FTIR for irradiated and non-irradiated cellulose

Samples	Wavenumber (cm^{-1})	Transmittance (%T)
Non-irradiated cellulose	3333.63	65.61
Irradiated cellulose at 0.5kGy	3333.90	69.72
Irradiated cellulose at 1.5kGy	3333.71	67.49
Irradiated cellulose at 2.5kGy	3333.92	68.05

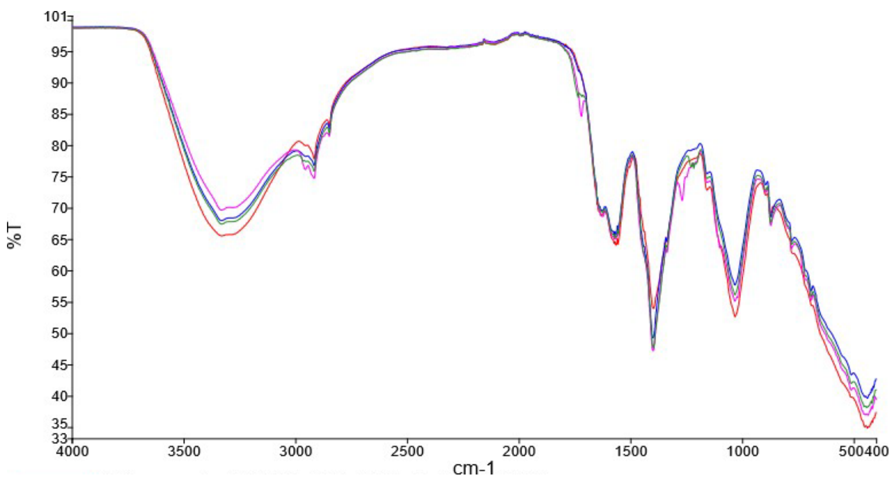

Fig. 7- Data FTIR for irradiated and non-irradiated cellulose

3.2 Volume for Cellulose Powder with Different Pressure

Volume can be calculated by using formula $V = \pi r^2 h$ by considering the pellet was cylinder. Where V is Volume, r is radius and h are height. The obtain the radius, divided the diameter into half and the thickness can be consider as height of cylinder. It has been proven that the volume is affected because of the radius and diameter of the material. Generally, a catalyst pellet or cylinder pellet with higher external specific surface area will have higher effectiveness factor because of better access for the reactants to diffuse into the interior zone of the catalyst pellet (Yiquan Zhao et al., 2021), and this can prove that effectiveness of the volume. The manipulate parameter can be seen based on the table below by using different pressure which is 2 tan, 3 tan and 4 tan. As been seen on the Table 2, the more the pressure the lesser the volume. Result for 4 tan was a bit lower than 2 tan and 3 tan. This was because the pellet was compressed and become compact. As the volume of the space containing air reduces, the pressure increases, if the temperature stays the same. That means that it can increase the pressure of air by forcing it into a smaller space. These parts undergo Boyle's Law. Boyle's Law has been used to calculate the air pressure from the measured volume changes tested in cyclically under unsaturated and undrained condition in triaxial tests (Salman, 2014)(Katherine and David, 2019).

Table 2 - Data for volume with different pressure

Pressure	Average Diameter (m)	Average Thickness (cm)	Volume (m) × 10^{-3}
2 tan	0.2019	0.0540	1.7288
3 tan	0.2016	0.0513	1.6375
4 tan	0.2013	0.0502	1.5976

3.3 Characterization Using Four Point Probe

A four-probe device is mounted on the surface of the concrete specimen, a voltage difference is supplied between the two medium probes, the quantity of current between the two exterior probes is measured, and the resistance (R) is calculated using the Ohm law, as described in a previous article (Heydar Dehghanpour and Kemalettin Yilmaz, 2020). The resistivity of the specimen is obtained by multiplication of coefficient $2\pi a$ (Ghosh and Tran, 2015, Amin Noushini and Arnaud Castel, 2016). Based on the result below, cement with cellulose have the highest resistivity compared to the cement and cement with cellulose on top. After all, the higher the resistance the better, because there is a greater resistance to heat transfer.

Table 3 - Data for four-point probe

Samples	Resistivity, ρ (m)
Cement	29685.755
Cement with cellulose	3116.302
Cement with cellulose on top	29685.755

4. Conclusion

The present study revealed that the surface morphology between irradiated and non- irradiated cellulose have been proven based on the roughness and the clumpers of the surface. accordance with the result above the non-irradiated cellulose is more clumpers rather than irradiated cellulose. Generally, the higher the dose rate the lesser the clumper. Next, the chemical bonding for the irradiated and non- irradiated can been proven by using FTIR. The higher the irradiation dose the lower the absorption. Lastly, the resistivity for the insulation for this research can be confirmed because the sample cement with cellulose have the higher resistivity. The higher the resistivity, the higher the resistance to heat transfer. In summation, the cellulose from oil palm tree can be propose as the new insulating material in the building structure.

Acknowledgement

The authors would like to thank the Universiti Tun Hussein Onn Malaysia for facilities provided that make the research possible.

References

Ramli, R., Jamaludin, M. A., & Bokhari, S. (2002). Thermal Conductivity of Oil Palm Fibre - Polyethylene Hybrid Composite metre. *Oil Palm Bulletin*, *45* (November), pp. 23–26.

Aljuboori, A. H. R. (2013). Oil Palm Biomass Residue in Malaysia: Availability and Sustainability. *International Journal of Biomass & Renewables*, *2*(June), pp. 13–18.

Tassadit Aouat, Mustapha Kaci, José-Marie Lopez-Cuesta, Eric Devaux, Mohamed Mahlous. (2019). The effect of gamma-irradiation on morphology and properties of melt-spun poly (lactic acid)/cellulose fibers, *Polymer Degradation and Stability, Elsevier*, 160, pp. 14-23. 10.1016/j.polymdegradstab.2018.11.014.

F. EL-Ashhab, L. Sheha, M. Abdalkhalek, Hussein A. Khalaf. (2013). The influence of gamma irradiation on the intrinsic properties of cellulose acetate polymers, *Journal of the Association of Arab Universities for Basic and Applied Sciences*,14 (1), pp 46-50, https://doi.org/10.1016/j.jaubas.2012.12.001.

Badruddin, I. A., Zainal, Z. A., Narayana, P. A. A., & Seetharamu, K. N. (2006). Heat transfer by radiation and natural convection through a vertical annulus embedded in porous medium. *International Communications in Heat and Mass Transfer*, 33(4), 500–507. https://doi.org/10.1016/j.icheatmasstransfer.2006.01.008

Bassil N. M., Joe S Small, Jonathan R Lloyd (2020). Enhanced microbial degradation of irradiated cellulose under hyperalkaline conditions, *FEMS Microbiology Ecology*, Volume 96 (7), fiaa102, https://doi.org/10.1093/femsec/fiaa102.

Yiquan Zhao, Yao Shi, Guanghua Ye, Jing Zhang, Xuezhi Duan, Gang Qian, Xinggui Zhou. (2021) Optimization of catalyst pellet structures and operation conditions for CO methanation, *Chinese Journal of Chemical Engineering*, 40, pp 106-113, https://doi.org/10.1016/j.cjche.2021.02.030.

Salman, J. M. (2014). Optimization of preparation conditions for activated carbon from palm oil fronds using response surface methodology on removal of pesticides from aqueous solution. *Arabian Journal of Chemistry*, *7*(1), 101–108. https://doi.org/10.1016/j.arabjc.2013.05.033

Katherine A. Kwa and David W. Airey. (2019). Investigating the use of Boyle's Law to relate pore air pressures and volume changes in unsaturated triaxial samples. *E3S Web of Conferences* 92, 1-6.

Heydar Dehghanpour, Kemalettin Yilmaz. (2020). Investigation of specimen size, geometry and temperature effects on resistivity of electrically conductive concretes, *Construction and Building Materials*, 250, 118864. https://doi.org/10.1016/j.conbuildmat.2020.118864

Ghosh, P. & Tran, Q. (2015). Correlation Between Bulk and Surface Resistivity of Concrete. *Int J Concr Struct Mater* 9**,** pp. 119–132. https://doi.org/10.1007/s40069-014-0094-z

Amin Noushini & Arnaud Castel. (2016). The effect of heat-curing on transport properties of low-calcium fly ash-based geopolymer concrete, *Construction and Building Materials*, 112, pp. 464-477, https://doi.org/10.1016/j.conbuildmat.2016.02.210.