Jurnal
Teknologi

Full Paper

POTENTIAL OF RHIZOPHORA SPP PARTICLEBOARD TREATED WITH SOY FLOUR AS WATER EQUIVALENT MATERIAL

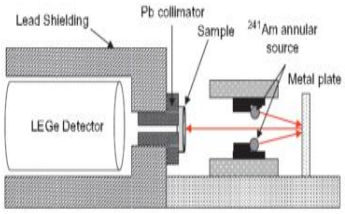
Nor Ain Rabaiee[a*], Mohd Zahri Abdul Aziz[a], Rukiah Hashim[b], Abdul Aziz Tajuddin[a], Muhammad Fadhirul Izwan Abdul Malik[c]

[a]Cluster Oncological and Radiological Science, Advanced Medical and Dental Institute, Universiti Sains Malaysia Bertam.
[b]School of Industrial Technology, Universiti Sains Malaysia Pulau Pinang.
[c]Science and Engineering Research Center, Universiti Sains Malaysia Engineering Campus, Nibong Tebal.

Article history
Received
19 June 2015
Received in revised form
26 June 2015
Accepted
10 July 2015

*Corresponding author
norainrabaiee@gmail.com

Graphical abstract



Abstract

Water is a recognized tissue equivalent material. Due to some reason, water is not a suitable material to use as the daily routine in Quality Assurance assessment. In this paper, Rhizophora spp was treated with soy flour were applied to fabricate solid water equivalent material. Nine samples of three different particle sizes of Rhizophora spp as well as their treatment level were prepared. An innovative approach, x-ray fluorescence was used to measure the unknown attenuation coefficient while field emission scanning electron microscopy was presented to evaluate the microscopy structure of desired samples. Effective energy range between 15.7 to 26.7 keV was used to measure the mass attenuation coefficient of the fabricated particleboard. All the results were compared with the water value in XCOM database. This study showed that there was no significant difference ($p>0.05$) between mass attenuation coefficient of sample with the water value from XCOM. In addition, the morphology images were improved for post-treated compared to untreated Rhizophora spp particleboard. Based on these results, Rhizophora spp particleboard is amenable as an alternative window of purported water equivalent material.

Keywords: Rhizophora spp; soy flour; particleboard, water equivalent material

Abstrak

Air adalah terkenal sebagai bahan seantara tisu. Disebabkan beberapa faktor, air tidak sesuai digunakan sebagai rutin harian dalam penilaian Jaminan Kualiti. Di dalam kajian ini, Rhizophora spp dirawat dengan tepung soya digunakan untuk menghasilkan bahan pepejal seantara air. 9 sampel dari tiga saiz zarah Rhizophora spp yang berbeza, serta tahap rawatan telah disediakan. Pendekatan inovatif, x-ray pendarflour digunakan untuk mengukur pekali pengecilan yang tidak diketahui sementara mikroskop pelepasan bidang imbasan elektron digunakan untuk menilai struktur mikroskopi sampel yang diingini. Julat tenaga berkesan diantara 15.7 hingga 26.7 keV digunakan untuk mengukur jisim pekali pengecilan partikel. Hasil kajian dibandingkan dengan nilai air dalam pangakalan data XCOM. Kajian ini mendapati tiada perbezaan yang nyata ($p>0.05$) diantara jisim pekali pengecilan bahan dengan nilai air daripada XCOM. Sementara, imej marfologi menunjukan teknik selepas rawatan adalah lebih baik daripada papan partikel Rhizophora spp yang tidak dirawat. Berdasarkan kajian ini, papan partikel Rhizophora spp telah membuka tingkap altenatif untuk bahan seantara air.

Kata kunci: Rhizophora spp; tepung soya; papan partikel; bahan seantara air

1.0 INTRODUCTION

Water is vastly used in quality assurance in radiotherapy department. It is accepted as gold standard because it is an ideal match with human soft tissue. Because it is not always practical to use a large quantity of water in busy working department, solid phantom was introduced. Solid phantom such as solid water, polystyrene and acrylic are used as an alternative. However, they failed to provide a good agreement to the mass attenuation coefficient of water at low and high energies[1][2][3].

The effort by Bradley and his team to conduct a study on range of tropical hardwood as water equivalent opens a new window for this field [4]. Their contribution increased the value of one species of the tropical hardwood; *Rhizophora* spp. It is proven that *Rhizophora* spp has mass attenuation coefficient with water at photon energy range. Since then, a number of researches started to develop phantom by using this hardwood as main material[5][6].

Rhizophora spp can be found widely in tropical and subtropical coastal region [7]. They are mainly harvested to be used for several purposes such as charcoal, firewood and building materials. *Rhizophora* spp in the form of particleboard is said to have better properties than the raw wood in the purpose of phantom fabrication. Good properties such as uniform density, homogenous slab and easy to mould depending on the desire size made the fabricated *Rhizophora* spp have much significant value.

Marashdeh fabricate the particleboard using *Rhizophora* spp and shown a good agreement with water but lack of durability[5].Because of this concern, soy flour was introduced in this study as an adhesive to increase the performance of Rhizophora particleboard. Soy flour is proven as an excellent adhesive by several researchers [8][9]. In addition, soy flour is inexpensive, high accessibility and also environmental friendly made these adhesive as an attractive options. The aim of this study is to assess the possibility of *Rhizophora* spp particleboard treated with soy flour as purported tissue equivalent material and their morphology.

2.0 METHODOLOGY

2.1 Samples Preparation

Rhizophora spp trunk was harvested from Forest Department of Mangrove Reserve Forests, located in Kuala Sepetang, Perak. The tree trunks were cut into smaller size and completed into chip using surface planner machine. Grinder machine was further used to reduce the chip into smaller particle size. Next, the particles were classified into three different sizes (50,104 and 210 µm).

Dimension for the fabrication of *Rhizophora* soy flour particleboard is 21 x 21 x 0.5 cm^3. Particleboards with three adhesive levels (0, 8% and 16%) were prepared for each particle sizes. Each particleboard has target density 1 g/cm^2. After 20 min, the pressure was reduced slowly to avoid any unexpected changes and crack. Samples were then marked with A0, A8, A16, B0, B8, B16, C0, C8 and C16. The detail for fabricated particleboard for this study is shown in Table 1.

Table 1 Details of *Rhizophora*- soy flour particleboard

Sample	Particle size	Moisture content (%)	Percentage of Adhesive (%)
A_0	104-210 µm	7.83	0
A_8			8
A_{16}			16
B_0	50-104 µm	5.17	0
B_8			8
B_{16}			16
C_0	<50 µm	6.62	0
C_8			8
C_{16}			16

2.2 Determination of Linear and Mass Attenuation Coefficient

The mass attenuation coefficient of samples was determined using x-ray fluorescent (XRF) method. The XRF technique was based on photoelectric effect concept. Experimental set up is shown in Figure 1.

Samples with size 5x5 cm^2 were prepared and irradiated with 100 mCi Am-241 to produce XRF photons. Zirconium (Zr), Molybdenum (Mo), Argentum (Ag) and Tin (Sn) were used as a metal target to produce energy of 15.7 keV, 17.4 keV, 22.1 keV and 25.3 keV respectively.

The x-ray fluorescent photon was passed through the sample before it is detected by high purity germanium. As x-ray beams passes through, the intensity will attenuates according to Beer-Lambert law as in equation 1. The incident and transmitted intensity was determined by net counts under Ka peak of the energy spectrum.

The Beer-Lambert law declared that the beam is attenuated exponentially as it passes through the materials [3][9]

$$I_t = I_o\, e^{(-\mu x)} \quad (1)$$

Where I_t is the intensity of photon transmitted, I_o is the incident intensity, x is the thickness of the sample and μ is the attenuation coefficient.

By rearranging the equation above, attenuation coefficient can be find as

$$\mu = \ln(I_o/I_t) / x \quad (2)$$

In order to determine the mass attenuation coefficient, linear attenuation coefficient μ is divided with density of the materials, ρ.

$$\mu/\rho = \ln I_0/I_t / x\rho \quad (3)$$

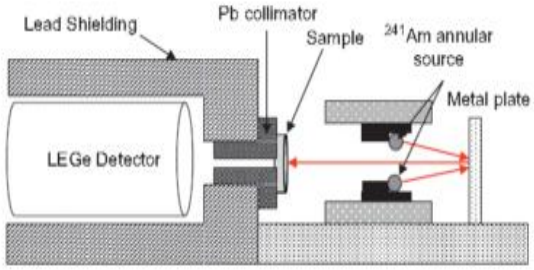


Figure 1 Experimental set up for measurement of linear attenuation coefficient of *Rhizophora* spp particleboard.

2.3 Marphology Study

Microscopy images of *Rhizophora* spp particleboard without treatment as well as one treated with soy flour was analyzed using field emission scanning electron microscope (FESEM) Model FEI VERIOS 460L. Field emission scanning electron microscopy enables to reveal the morphology changes by using the electron to form an image rather than light.

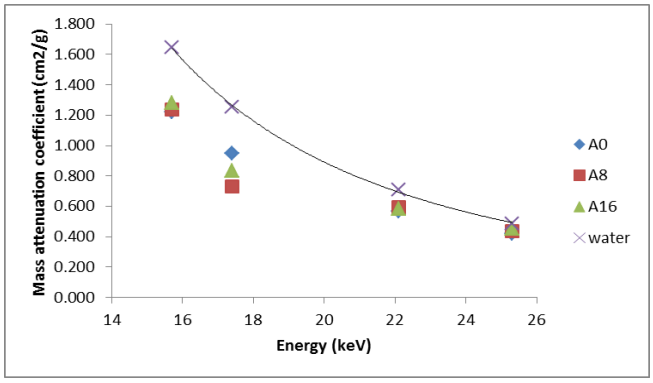
Samples of dimension 0.5x0.5 cm^2 with different particle sizes and treatment level were firstly coated using platinum layer to enhance the conductivity. Then the samples were fixed onto specific specimen holder before it was placed accordingly. Analyses were performed under vacuum condition.

Image captures was then analyzed using Image J software to determine their homogeneity between the *Rhizophora* spp and soy flour.

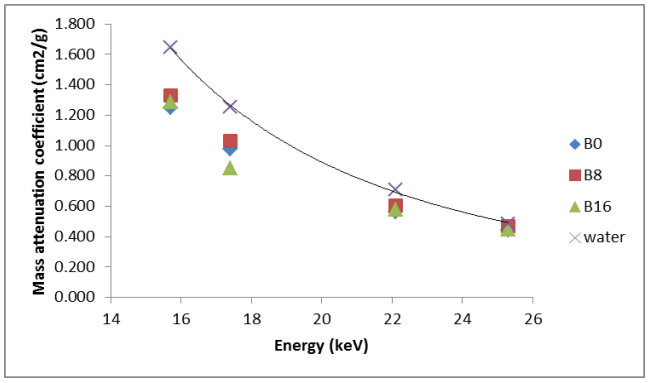
3.0 RESULTS AND DISCUSSIONS

3.1 Mass Attenuation Coefficient

Water is acknowledged as a gold standard of Quality Assurance (QA) because the density is almost similar to a soft tissue. Materials should have similar dosimetric properties as water in order to be considered as water equivalent [10]. Thus, it is necessary that the attenuation coefficient of fabricated *Rhizophora* spp particleboard to be compared to water from XCOM database for it to be qualified as a viable alternative.



(a)



(b)

(c)

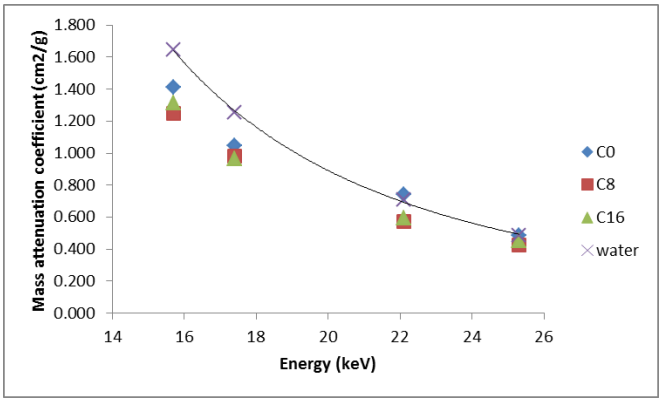


Figure 2 Mass attenuation coefficient of particle sizes a) 104-210 μm, b) 50-104 μm, c) <50 μm with different treatment level at energy range between 15.7 to 25.3 keV compared with water (XCOM)

The linear and mass attenuation coefficients of *Rhizophora* spp particleboard were studied by the attenuation of XRF photon from a few metal plates; Zr, Mo, Ag and Sn for energy range between 15.7 to 25.3 keV. The incident and transmitted intensity was determined by net counts under Ka peak of the energy spectrum.

The results obtained were compared to water from XCOM database that was provided by National Institute of Standard and Technology (NIST) as shown in Table 1. XCOM is a photon cross sections database that was developed by Berger and Hubber on 1987 [11]. It provides a method to calculate the photon cross sections at energy range between 1 keV to 100 GeV

It is apparent from Figure 2, mass attenuation coefficient of the samples are close to water (XCOM) for the energy range between 15.7 to 25.3 keV. Sample C0 and B8 was perfect match to water compared to the other sample. Furthermore, statistical test performed by using paired sample T–test revealed that the entire sample have no significant difference with water, $p>0.05$ at different energy range.

3.2 Microscopy Images

Microscopy images of *Rhizophora* particleboard at different treatment level are illustrated in Figure 2. By magnification of 800x (Figure 3a-c), it is obvious that wood was coated by adhesion for the entire sample. *Rhizophora* spp particleboard treated with soy flour at 8% and 16 % treatment level have less void space compared to sample with 0 % soy flour. It was also revealed that *Rhizophora* spp with soy flour particleboard has better contact with each other at 8 % and 16 % treatment level.

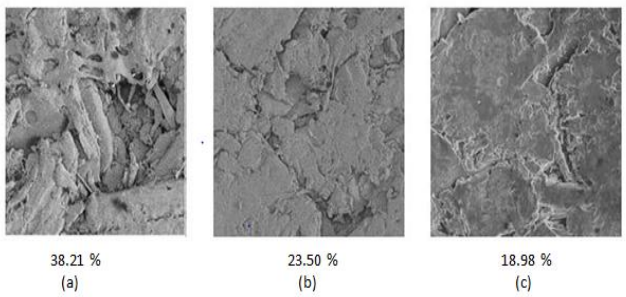


Figure 3 Morphology images of *Rhizophora* spp (50-104 µm) at three different adhesive treatments a) 0 %, b) 8 %, c) 16 % of soy flour at 800 x magnifications with standard deviation (SD) obtained from Image J software.

Results obtained from Image J software shows that *Rhizophora* spp particleboard treated with soy flour has improved the uniformity. Better uniformity was provided by having less standard deviation (SD). Only 18.98 and 23.50 of 8 % and 16 % adhesive respectively at the same particle size compared to 38.21 for 0 % of adhesive.

The increasing percentage of adhesion cause better penetration through porous wood. This was due to the melted soy flour adhesive when it was applied at the temperature and filled void space. Soy flour acts as an adhesive that improve the physical and mechanical properties, as well as surface of *Rhizophora* spp particleboard. The ability of soy flour as an adhesive to coat and penetrate into wood also been discussed [12].

The presence of soy flour also resulted in a uniform homogenous blend of the compressed cell walls, fibers, and ground parenchymatous tissues. Adhesive penetration on porous wood surface improves the strength and produce smooth surface [13].

4.0 CONCLUSION

In these present studies, mass attenuation coefficient of *Rhizophora* spp treated with soy flour is still up to standard and has no significant difference with water (XCOM database). The morphology results of treated *Rhizophora* spp also improved and have homogenous surface compare to *Rhizophora* spp with untreated soy flour. Eventually, *Rhizophora* spp treated with soy flour have potentials to represent tissue equivalent material in the near future.

Acknowledgement

The author would like to give special acknowledge to Department of Higher Education (Malaysia), for providing grant under Fundamental Research Grants Scheme (FRGS) 203/CIPPT/6711341. This appreciation also goes to staff of Advanced Medical and Dental Institute, School of Physics USM, School of Industrial Technology USM as well as Science and Research Engineering Center USM.

References

[1] S. B, Z, Shakhreet ; S, Bauk; A, A, Tajuddin; A. 2009. Mass Attenuation Coefficients Of Fabricated Rhizophora Spp Particleboard For The 15.77-25.27 Kev Range. *American Journal of Scientific and Industrial Research.* 4: 89-94

[2] O. S. Muhammad Wasef Marashdeh, Rokiah Hashim, Abdul Aziz Tajuddin, Sabar Bauk.2011.Effect Of Particle Size On The Characterization Of Bindelss Particleboard Made From Rhizophora Spp Mangrove Wood For Use As Phantom Material.*Bioreserach.com.* 6: 4028–4044.

[3] A. Abuarra, S. Bauk, R. Hashim, S. Kandaiya, and E. T. Tousi.2014.XRF Technique for the Evaluation of Gum Arabic Bonded Rhizophora spp . *Particleboards as Tissue Equivalent Material.* 4(3): 201–204.

[4] D. A. Bradley, A. A. Tajuddin, Che Wan Ahmad Che Wan Sudin, and S. Bauk. 1991. Photon Attenuation Studies On Tropical Hardwoods. *International Journal Of Radiation Applications And Instrumentation. Part A. Applied Radiation and Isotopes*. 42(8): 771–773.

[5] M. W. Marashdeh, S. Bauk, A A Tajuddin, and R. Hashim. 2012. Measurement Of Mass Attenuation Coefficients Of Rhizophora Spp. Binderless Particleboards In The 16.59-25.26 Kev Photon Energy Range And Their Density Profile Using X-

Ray Computed Tomography.," *Appl. Radiat. Isot.* 70(4): 656–62.

[6] B. Shakhreet, S. Bauk, and A. Shukri.2013.Mass Attenuation Coefficients Of Fabricated Rhizophora Spp. Particleboard For The 15.77 – 25.27 kev Range. *Am. J. Sci. Ind. Res*. 4(1): 89–94.

[7] A. Abuarra, R. Hashim, S. Bauk, S. Kandaiya, and E. T. Tousi. 2014. Fabrication And Characterization Of Gum Arabic Bonded Rhizophora spp. Particleboards. *Material Dosimetry*. 60: 108–115.

[8] E. T. Tousi, R. Hashim, S. Bauk, M. S. Jaafar, A. M. H. Abuarra, and B. Ababneh. 2014. Some Properties Of Particleboards Produced From Rhizophora Spp. As A Tissue-Equivalent Phantom Material Bonded With Eremurus Spp.," *Measurement*. 54: 14–21.

[9] E. T. Tousi, S. Bauk, R. Hashim, M. S. Jaafar, A. Abuarra, K. S. A. Aldroobi, and A. M. Al-Jarrah. 2014. Measurement Of Mass Attenuation Coefficients Of Eremurus–Rhizophora Spp. Particleboards For X-Ray In The 16.63–25.30kev Energy Range. *Radiat. Phys. Chem.* 103: 119–125

[10] A. Montaseri, M. Alinaghizadeh, and S. R. Mahdavi. 2012. Physical Properties Of Ethyl Methacrylate As A Bolus In Radiotherapy. *Iran. J. Med. Phys*. 9(2): 127–134.

[11] S. Bauk and A. A. Tajuddin. 2008. Attenuation coefficient of Rhizophora spp in the 11.22 to 28.43 keV Photon Energy Range. *J. Nucl. Relat. Technol*. 5(1): 11–19.

[12] C. R. Frihart and H. Satori. 2013. Soy Flour Dispersibility And Performance As Wood Adhesive. *J. Adhes. Sci. Techno*l. 27(18–19): 2043–2052.

[13] R. Kumar, V. Choudhary, S. Mishra, I. K. Varma, and B. Mattiason. 2002. Adhesives And Plastics Based On Soy Protein Products. *Ind. Crops Prod.* 16(3): 155–172. Nov. 2002