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Mechanical and Physical Properties of Particleboard from Untreated and Treated Kenaf Particles

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ABSTRACT

Composite panels were manufactured from kenaf particles and treated with two different alkali treatments using 2% NaOH and 2% KOH with resin contents of 8% and 10% of phenol formaldehyde (PF) at medium density of 650kg/m^3. The objectives of this study were to determine the mechanical properties in terms of its modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond (IB), and physical properties namely thickness swelling (TS) and water absorption (WA) of treated kenaf board. The mechanical and physical tests were performed according to the Malaysian Standard (MS1787:2004). The minimum requirements value for MOE, MOR and IB were 2000 MPa, 14 MPa and 0.45 MPa respectively for furniture grade particleboards for use in humid conditions (PF2). According to Malaysian specifications for physical properties, the maximum requirement for thickness swell is 15%. Results indicated that both treated boards with NaOH and KOH showed an increase in strength properties compared to untreated particleboard. Particleboard treated with KOH exhibited the highest MOR and MOE values, while board with NaOH treatment gave the highest IB value. The boards with treated particles gave better performance in terms of physical properties. There were no significant differences in mechanical properties (MOR, MOE and IB) and physical properties for the different alkali treatment. The values of bending strength and IB strength increased with an increase in resin content, while TS and WA increased with a decrease in resin content. In conclusion, NaOH and KOH treated *kenaf particles improved board performance and could be considered as an alternative material for particleboard production.*

Keywords: *alkali treatment, chemical treatment, kenaf particleboard, potassium hydroxide, sodium hydroxide, exterior application*

INTRODUCTION

The increase in urbanisation has stimulated the rapid growth in the construction industry. The demand for particleboard is especially higher as it is widely used in housing construction and furniture manufacturing. Worldwide demand for particleboard has been steadily growing since then, at rate between two to five percent per annum [3,4, 28]. This situation demands continuous supply of raw materials to fulfil the demands. However, the depletion of forest has contributed to the decreasing of solid wood as the main raw materials.

Malaysia depends on rubberwood and hardwood species as the main source for wood-based panels such as particleboard and MDF for furniture industries. Rubberwood and other hardwood species are decreasing and becoming expensive to obtain due to deforestation and cultivation of oil palm trees [8]. Thus, researchers have been studying and exploring the growing species and non-woody plants that can be used as raw materials in particleboard manufacturing [18, 28].

Kenaf (*Hibiscus cannabinus L.*) has been considered as one of the potential plants to replace solid wood in particleboard manufacturing [8, 10, 27]. Kenaf has been introduced to the Malaysia bio-composite industry by National Kenaf and Tobacco Board (NKTB) in 2009. Kenaf is categorised as a fast growing species since it can be harvested between four to five months. Kenaf has a great potential as alternative materials to replace solid wood in particleboard industry as the chemical composition of kenaf stem is comparable to wood and rice straw [8, 24, 26].

Kenaf plant has a single, straight and branchless stalk with a height between three to five meters in four to five months [6, 10]. Kenaf stems are generally round with thorns ranging from small to large and its stem colour varies from pure green to deep burgundy. Kenaf flowers are large with 7.5 to 10 cm in sizes, bell-shaped and wide open with five petals. The colour of flowers ranges from light cream to dark purple, with shades between them. Many kenaf varieties have flowers with deep red or maroon in the centre of the flower [2]. The whole kenaf stem consists of two parts, which are bast fibre and woody inner core. Inner core fibres comprises for about 75% to 60% of kenaf stalk, while 25% to 40% of outer bast fibres based on oven dry weight. These two fibres have a huge difference in its morphology structure and chemical composition [1].

Although many studies have been conducted on kenaf plant, and it has been proven to have great potentials in the particleboard industry, the study on the use of kenaf plant for exterior purpose is still very limited. Thus, to improve the performance, this study used phenol formaldehyde (PF) resin as adhesive, since PF is well-known in the production of wood-based panel for exterior use products. Kenaf particles were also treated with alkali (2% of NaOH and 2% of KOH) to improve the adhesive bonding between particles.

MATERIALS

Wood Particles

Kenaf whole stem (bast and core) from variety V36 was used as wood particles in this study and was obtained from a kenaf plantation located in Chendor, Cherating, Pahang. Four-month-old kenaf plants with heights ranging between 2.0 m to 2.5 m were chosen.

Adhesive

Phenol formaldehyde adhesive was used as a binder which was obtained from Malayan Adhesive and Chemical (MAC) Sdn. Bhd., Shah Alam, Selangor. Different resin contents of 8% and 10% of phenol formaldehyde were used in this study.

Chemical Treatment

Sodium hydroxide (NaOH) and potassium hydroxide (KOH) were the chemicals that were used to treat kenaf stalk particles and were bought from *Syarikat Saintifik Jaya* in Glenmarie, Shah Alam. A total of 20 g of NaOH and KOH were diluted in 1000 ml distilled water to make 2% of NaOH and KOH solutions. The same steps were repeated for 2% KOH solutions.

Preparation of Raw Material

Preparation of raw material was mainly carried out at Bio-composite workshop, Universiti Teknologi MARA (UiTM) Shah Alam. However, for air drying process, it was carried out in a woodworking workshop at UiTM Jengka, Pahang. It took a month for the kenaf stalk to fully dry. Kenaf stalk were stacked vertically as shown in Figure 1. This is to ensure the air circulate uniformly between kenaf stalk and dried at the same rate. The dried kenaf stalks were cut into shorter length using a machete and were placed in a hammer mill machine to produce kenaf particles. The particles sizes ranging between 0.5 mm until 2.0 mm.

Figure 1: Air Drying Process
(Source by author)

Composite Preparation

Kenaf particles were soaked in 2% NaOH solution for 30 minutes. Then, the kenaf particles were oven dried to the desirable moisture content (MC). The treated and untreated kenaf particles were placed in the oven which was set at 60^{o}C for both treated and untreated particles until the particles reached an MC below 5%. This was to ensure that all the water inside the particles were dried up. The treated and untreated dried kenaf particles were poured into a mixer where the particles were mixed and blended well with the resin. The amount of resin was based on the board requirement and was calculated before blending it in the mixer machine. After blended with the resin, the particles were evenly spread in a mould to form a particleboard mat. The mould size was 400 mm × 400 mm. The mats were placed in a hot-pressing machine to cure the resin and to obtain the final thickness of 15 mm. The temperature and pressing time for the hot-pressing process were 170^{o}C and seven minutes, respectively. After cooling, the boards were cut based on Malaysian Standard for Wood-Based Panels – Part 2: Sampling and Cutting of Test Pieces (MS1787: Part 2: 2004) to obtain the desired length and width [13, 14].

Mechanical Properties Tests

Bending test

Bending test is basically used to measure modulus of elasticity (MOE) and modulus of rupture (MOR). MOE value is to measure the resistance to bending related to stiffness of a beam. MOR is the measurement of the rate of rupture of the particleboard specimen. Figure 2 shows an experimental set-up of a three-point bending test of a kenaf particleboard. The load was applied at the middle of the specimen until it deflected. The cross-head speed rate was 10 mm/min. This test is important to determine the strength of the particle. According to Malaysian Standard (MS 1036: 2006), the minimum requirements value for MOE and MOR are 2000 MPa and 14 MPa, respectively for furniture grade particleboards for use in humid conditions (PF2) [13, 14].

Figure 2: Three-Point Bending Test of Kenaf Particleboard
(Source by author)

Internal bond test

Internal bond test determines the tensile strength of the particles by determining the bonding between particles. A universal testing machine was used to test the internal bonding between particles. Figure 3 shows a set-up of the internal bond test. The machine gave a pull from upper and below sections of the board. The test was continued until the board cracked and a drop was shown in the graph. The minimum requirements value according to Malaysian Standard (MS 1036: 2006) for IB is 0.45 MPa [12].

Figure 3: Experimental Set-Up of Internal Bonding Test
(Source by author)

Physical Properties Tests

Water absorption and thickness swelling test

The dimensional stability of the board was determined by way of water absorption and thickness swelling test. The objectives of WA and TS test are to indicate how much the particleboard absorb water and to identify the durability of particleboard to water. All samples were submerged in tap water for two hours and 24 hours before measure the thickness and weight of the samples. According to Malaysian specifications (MS 1036: 2006) the maximum requirement for thickness swell is 15% and values that exceed the maximum value was considered not meeting the standard [15].

Figure 4: Water Absorption and Thickness Swelling Test
(Source by author)

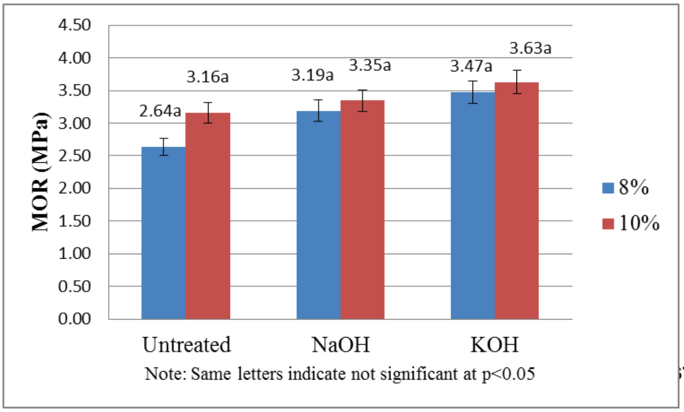
RESULTS AND DISCUSSION

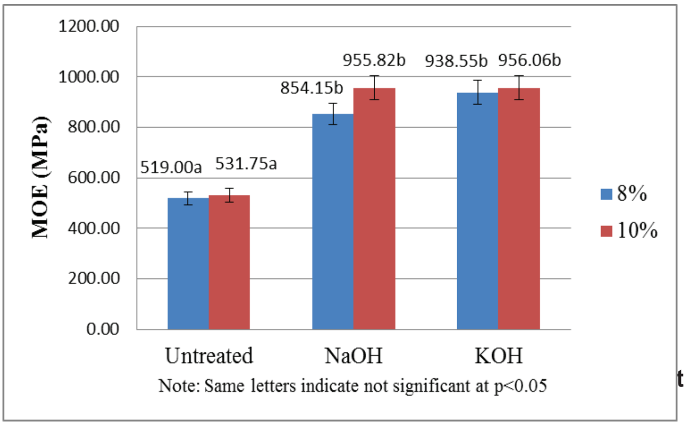
Effect of Chemical Treatment on Mechanical Properties

Two different chemical treatments were used in this study to evaluate the effect of chemical treatment on mechanical properties. Three tests that involved for determining the mechanical properties of boards are MOR, MOE and IB.

Bending Properties

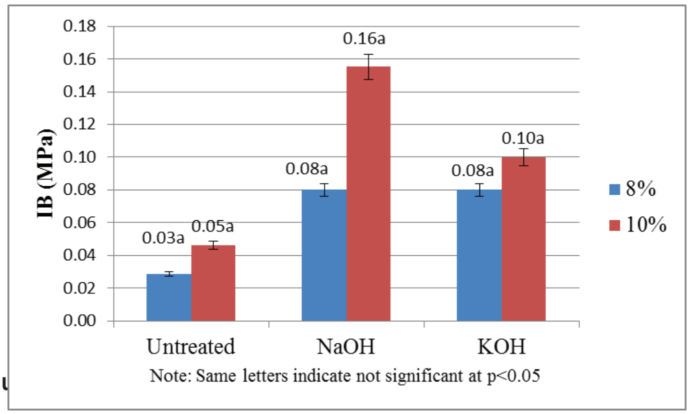
Figure 5 and Figure 6 show the values of MOR and MOE for each chemical treatment. There was no significant difference for all the values of MOR and MOE when treated with NaOH and KOH. However, there was a significant difference between the untreated and treated particleboards. Chemical treatment using 2% KOH had higher values for both MOR and MOE which were 3.47 MPa and 938.55 MPa at 8% resin loading and 3.63 MPa and 956.06 MPa at 10% resin loading, respectively. These results were similar to a previous study by [20] where, KOH treatment gave the best mechanical properties compared to other treatment. The study [22] also stated that KOH treatment was good in enhancing the mechanical properties of the composite. Meanwhile, kenaf particle that had been treated by NaOH showed the medium values of MOR and MOE between untreated and KOH treatment particles. The values of MOR and MOE from NaOH treatment were 3.19 MPa and 854.15 MPa at 8% resin content and 3.35 MPa and 955.82 MPa at 10% resin content, respectively. The values were higher than the untreated kenaf but lower than KOH treatment. This could be due to the different chemical characteristics of NaOH and KOH. Although both NaOH and KOH come from the same group elements, they have different chemical characteristic. Potassium hydroxide metal is heavier that NaOH metal [17]. Untreated kenaf particleboard which acted as a control gave the lowest values of MOR and MOE at both 8% and 10% resin content with, 2.64 MPa and 519.00 MPa and 3.16 MPa and 531.75 MPa, respectively. This proves that chemical treatment by using NaOH and KOH improve the mechanical strength of particleboard. Alkaline treatment causes the splitting of hemicellulose and lignin which, will make the fibre become more porous, thus, increasing the adhesion of fibre surface and the matrix [20]. However, at 10% resin content, all untreated and treated particles show an increase in bending strength and IB strength. This is because more resin is available to cover all the surfaces of particles [25].





Internal Bond

Figure 7 shows the effect of chemical treatment on IB. There was no significant difference between the two treatments. The result trend in IB strength was different than the MOR and MOE in the mechanical properties test. In this result, NaOH treatment gave the best values in IB strength than treatment by KOH with 10% resin loading, 0.16 MPa for NaOH and 0.10 MPa for KOH, respectively. However there was only a slight difference in IB values between NaOH and KOH treated particleboards, which was 0.06MPa at 10% resin content. This shows that NaOH and KOH treatment have similar effects on IB strength of kenaf particleboard. At 8% resin of loading, treated particle showed the same values for both treatment, with 0.08 MPa. Meanwhile, untreated kenaf particleboard had the lowest value of IB for both resin contents of 8% and 10%. This is because both alkali treatments remove lignin, hemicellulose and non-crystalline structure components inside the fibre cell wall. The chemical treatment gave fibre better ability to be wetted by resin, thus, resulted in improving the mechanical strength. The removal of lignin and hemicellulose from fibre structure also causing an improvement of fibre to blend well with adhesive resulted in better IB strength. This could be due to the bond inside the fibre loosening and cellulose structure changed after alkali treatment [5].



Figu

Effect of chemical treatment on physical properties

Physical properties tests which were thickness swelling and water absorption were carried-out to determine the dimensional stability of the boards. Figure 8 and Figure 9 show the values of thickness swelling and water absorption after 24 hours of immersion. There was no significant difference of the values for thickness swelling and water absorption from the chemical treatment. There was a significant difference for resin contents of 8% and 10% for water absorption. The untreated particleboard showed the highest amount of thickness swelling (109.81% and 86.39%) and water absorption (253.77% and 251.55%) with resin content of 8% and 10%, respectively. This is because untreated kenaf particles contain hemicellulose that has many hydroxyl groups, which attract water molecules [27]. Hydrophilic properties of hydroxyl groups in kenaf particles make it easy to form a hydrogen bonding when reacting with water [21]. These properties of untreated particle reduce the dimensional stability of the board. Treated particleboards using NaOH gave the best dimensional stability, with the lowest values of thickness swelling of 66.57% and 57.28%, and water absorption was 170.88% and 144.21% for both resin contents of 8% and 10% when compared to KOH treatment. This result was different with previous study by [23], where KOH treated fibre gave better water repellent properties than NaOH treated fibre. The values of thickness swelling of KOH treated particle were 75.90% at 8% resin content and 67.86% at 10% resin content, while water absorption values were 174.95% and 155.79% at resin content of 8% and 10%, respectively. However, both alkaline treatments gave better dimensional stability than the untreated fibre. Chemical treatment using NaOH and KOH make better fibre-resin interaction, thus, increase the polarity of the fibre to absorb resin which resulted in better physical properties [5]. At 8% resin contents, thickness swelling and water absorption increased for both untreated and treated kenaf boards. This could be due the low resin contents which fail to prevent the water from being absorbed into the board resulting in poor physical properties of kenaf board [21].

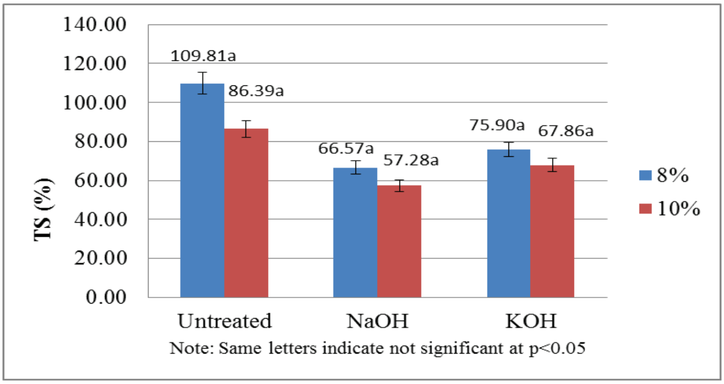


Figure 8: Effect of Chemical Treatment on Thickness Swelling

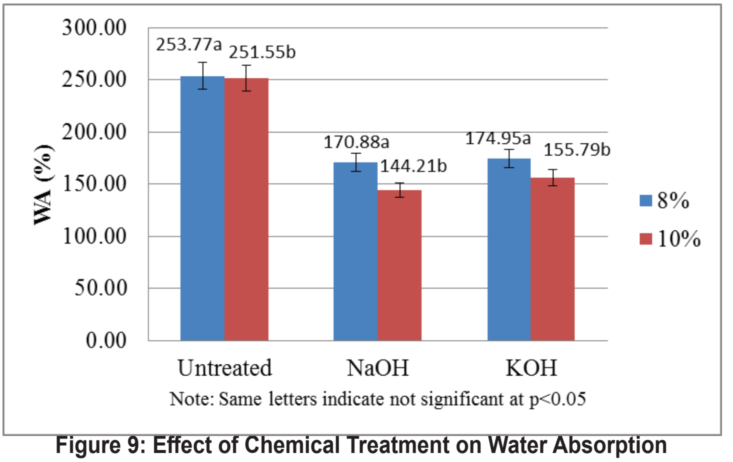


Figure 9: Effect of Chemical Treatment on Water Absorption

CONCLUSION

Mechanical properties and physical properties of kenaf particleboard showed improvement after alkali treatment using NaOH and KOH compared to untreated kenaf board. However, all the boards did not meet the minimum requirement based on the Malaysian standard for mechanical properties. This is due to all of the board properties did not achieve the standard values according to MS1036:2006, PF2 type for exterior application particleboard. Meanwhile for physical properties, the maximum requirement for thickness swell is 15% and values that exceed these values are considered not meeting the standard. It can be concluded that, the whole kenaf stem is suitable and possible to be used for particleboard production. However, further investigation and experiment with different parameters is needed in order to meet the standard requirement for exterior type particleboard and produce a better quality end product.

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REFERENCES

[1] H.P.S. Abdul Khalil, A.F. Ireana Yusra, A.H. Bhat and M. Jawaid, 2010. Cell wall ultrastructure, anatomy, lignin distribution, and chemical composition of Malaysian cultivated kenaf fibre, *Industrial Crops and Products, 31*(1), pp. 113-121. Doi: https://doi.org/10.1016/j.indcrop.2009.09.008.

[2] E. Alexopoulou, Y. Papatheohari, M, Christou, and A. Monti, 2013. Origin, description, importance and cultivation area of kenaf. In A. Monti and E. Alexopoulou (eds). *Kenaf: A Multi- Purpose Crop for Several Industrial Applications, Green Energy and Technology*, Springer, pp. 1-15. Doi: 10.1007/978-1-4471-5067-1_1.

[3] N. Ayrilmis, J.H. Kwon and T.H. Han, 2012. Effect of resin type and content on properties of composite particleboard made of a mixture of wood and rice husk, *International Journal of Adhesion & Adhesives, 38*, pp. 79-83. Doi: https://doi.org/10.1016/j.ijadhadh.2012.04.008.

[4] M. Baharoglu, G. Nemli, B. Sari, S. Bardak and N. Ayrilmis, 2012. The influence of moisture content of raw material on the physical and mechanical properties, surface roughness, wettability, and formaldehyde emission of particleboard composite, *Composites Part B: Engineering, 43*(5), pp. 2448-2451. Doi: https://doi.org/10.1016/j.compositesb.2011.10.020.

[5] A. Bogdan-Wlodek, M. Koziol, and J. Myalski, 2012. Influence of surface treatment on the wetting process of jute fibres with thermosetting polyester resin, *Polish Journal of Chemical Technology, 14*(1), pp. 21-27. Doi: 10.2478/v10026-012-0054-9.

[6] A.M.M. Edeerozey, H.M. Akil, A.B. Azhar and M.I.Z. Ariffin, 2007. Chemical modification of kenaf fibres, *Materials Letters, 61*(10), pp. 2023-2025. Doi: https://doi.org/10.1016/j.matlet.2006.08.006.

[7] A.H. Grigoriou, C. Passialis and E. Voulgaridis, 2000. Kenaf Core and Bast Fibre Chips as Raw Material in Production of One-Layer Experimental Particleboard, *Holz als Roh-und Werkstoff, 58*(4), pp. 290-291. Doi: 10.1007/s001070050429.

[8] A.H. Juliana, M.T. Paridah, S. Rahim, I. Nor Azowa and U.M.K. Anwar, 2012. Properties of particleboard made from kenaf (*Hibiscus Cannabinus L.*) as function of particle geometry, *Materials and Design, 34*, pp. 406-411. Doi: https://doi.org/10.1016/j.matdes.2011.08.019.

[9] Kalaycioglu, H., and G. Nemli, 2006. Producing composite particleboard from kenaf (*Hibiscus Cannabinus L.*) stalk, *Industrial Crops and Products, 24*(2), pp. 177-180. Doi: https://doi.org/10.1016/j.indcrop.2006.03.011.

[10] D. Li, and S. Huang, 2013. The breeding of kenaf. In A. Monti and E. Alexopoulou (eds). *Kenaf: A Multi- Purpose Crop for Several Industrial Applications, Green Energy and Technology*, Springer, pp. 45-58. Doi: 10.1007/978-1-4471-5067-1_3.

[11] Malaysian Standard, 2004. MS 1787: Part 10: 2004. Wood-based Panels - Part 10: Determination of Modulus Elasticity in Bending and of Bending Strength (ISO 16978:2003, MOD). Department of Standards Malaysia.

[12] Malaysian Standard, 2004. MS 1787: Part 11: 2004. Wood-based Panels - Part 11: Determination of Tensile Strength Perpendicular to the Plane of the Panel (ISO 16984:2003, MOD). Department of Standards Malaysia.

[13] Malaysian Standard, 2004. MS 1787: Part 2: 2004. Wood-based Panels - Part 2: Sampling and Cutting of Test Pieces (ISO 16999:2003, MOD). Department of Standards Malaysia.

[14] Malaysian Standard, 2004. MS 1787: Part 3: 2004. Wood-based Panels - Part 3: Determination of Dimensions of Test Pieces (ISO 9424:2003, MOD). Department of Standards Malaysia.

[15] Malaysian Standard, 2004. MS 1787: Part 6: 2004. Wood-based Panels - Part 6: Determination of Swelling in Thickness after Immersion in Water (ISO 16983:2003, MOD). Department of Standards Malaysia.

[16] Malaysian Standard, 2006. MS 1036: 2006. Wood Based Panels -Particleboards-Specification (First Revision). Department of Standards Malaysia.

[17] S. Morgan, 2017. Difference between Sodium and Potassium Hydroxide. Retrieved on 4th October 2018 from www.livestrong.com.

[18] G. Nemli and A. Aydın, 2007. Evaluation of the physical and mechanical properties of particleboard made from the needle litter of *Pinus pinaster* Ait, *Industrial Crops and Products, 26*(3), pp. 252-258. Doi: https://doi.org/10.1016/j.indcrop.2007.03.016.

[19] Y. R. Ng, S. N. A. M. Shahid and N. I. A. A. Nordin, 2018. The effect of alkali treatment on tensile properties of coir/polypropylene biocomposite, *The Wood and Biofibre International Conference (WOBIC 2017)*, *IOP Conf. Series: Materials Science and Engineering, 368*. Doi:10.1088/1757-899X/368/1/012048.

[20] I.G.N. Nitya Santhiarsa, 2016. Effects of alkaline treatment and fibre length towards the static and dynamic properties of ijuk fibre strengthened-epoxy composite. In Poppy Puspitasari, Heru Suryanto, Avita Ayu Permanasari, Andika Bagus Nur Rahma Putra, Fuad Indra, Duwi Leksono Adi and Ahmad Atiff Fikri (Eds). *AIP Conference Proceedings, 1778*. Doi: https://doi.org/10.1063/1.4965756.

[21] M.T. Nur Sakinah, K. Jamaludin, W. A. R. Wan Mohd Nazri, Y. Nur Farahin and A. Nurrohana, 2016. Impact of alkaline treatment on mechanical properties and thickness swelling of exterior particleboard made from kelempayan (*Neolamarckia cadamba*) wood. In Nor Azizah Yacob, Nur Asmaliza Mohd Noor, Nor Yuziah Mohd Yunus, Rahmah Lob Yussof, Shaikh Abdul Karim Yamani Zakaria (Eds). *Regional Conference on Science, Technology and Social Science (RCSTSS 2016)*, pp. 787-797. Doi: 10.1007/978-981-13-0074-5_76.

[22] I.O. Oladele, O.O. Daramola and S. Fasooto, 2014. Effect of chemical treatment on the mechanical properties of sisal fibre reinforced polyester composites, *Leonardo Electronic Journal of Practices and Technologies, 13*(24), pp.1-12.

[23] I. O. Oladele, O. G. Agbabiaka and P. T. Olorunleye, 2016. Impact of chemical treatments on the mechanical and water absorption properties of coconut fibre (*Cocos nucifera*) reinforced polypropylene composites, *Leonardo Electronic Journal of Practices and Technologies, 15*(28), pp. 1-8.

[24] M.T. Paridah, A.W. Nor Hafizah, A. Zaidon, I. Azmi, M.Y. Mohd Nor and M.Y. Nor Yuziah, 2009. Bonding properties and performance of multi-layered kenaf board, *Journal of Tropical Forest Science, 21*(2), pp. 113-122.

[25] B. Shahril Anuar, K.Y. Tengku Maliana, J. Gisip and J. Mohd Arif, 2008. Characterisation of strength behaviour of single-layer particleboard from Leucaena Leucocephala. In *National Conference on Forest Products 2008*, pp. 175-182.

[26] X. W. Xu, Q. L. Wu and D. G. Zhou, 2013. Influence of layered structure on physical and mechanical properties of kenaf core, *BioResources, 8*(4), pp. 5219-5234. Doi: 10.15376/biores.8.4.5219-5234

[27] L. Yusriah, S. M. Sapuan, S. Z. Edi, M. Mariati and M. Jawaid, 2014. Effect of alkali treatment on the physical, mechanical, and morphology properties of waste betel nut (*Areca catechu*) husk fibre, Peer-review article, *Bioresources, 9*(4), pp. 7721-7736. Doi: 10.15376/biores.9.4.7721-7736.

[28] Y. Zheng, Z. Pan, R.H. Zhang, B.M. Jenkins and S. Blunk, 2006. Properties of medium-density particleboard from saline Athel wood, *Industrial Crops and Products, 23*(3), pp. 318-326. Doi: https://doi.org/10.1016/j.indcrop.2005.09.003.

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