INTI JOURNAL | eISSN:2600-7320
Vol.2020:19

Optimization Treatment of Palm Kernel Cake for the Production of Bioadhesive for Plywood

Cheng Wan Hee, Wong Ling Shing and Lee Xin Wei

Faculty of Health and Life Sciences, INTI International University Persiaran Perdana BBN, 71800 Nilai, Negeri Sembilan, Malaysia

Email: wanhee.cheng@newinti.edu.my

Abstract

The expansion of plywood composite as well as health issues from synthetic call for the search of an alternative economical and environmentally friendly wood adhesive. Currently, the most widely used wood adhesives are synthetic adhesives derived from petrochemical, which cause severe health problems and pollution. Bio-adhesives that derived from natural sources such as palm kernel cake might be one of the solutions to replace the synthetic adhesives. The objectives of this study is to determine the best ratio of palm kernel cake biomass to alkaline (NaOH) treatment. In this study, the palm kernel cake powder was hydrolysed using NaOH (20 %) and mixed with different ratios of biomass to volume of NaOH, which are 1:3, 1:4, 1:5, 1:6 and 1:7. The results showed that bio-adhesive treated with 20% NaOH in ratio 1:7 have the highest shearing strength ($p>0.05$) which is 0.32 ± 0.020 MPa. The mixture of NaOH. Therefore, the result suggested that PKC is a potential biomass for bio-glue production with 20% NaOH treatment in 1:7 ratio.

Keywords

Palm kernel cake, bio-adhesives, plywood adhesives

Introduction

Bioadhesion is a phenomenon where natural or synthetic substances adhere to a biological surface (Palacio & Bhushan, 2012). The adhesive material can be made of natural resources or synthetic materials and should possess qualities such as easily use, non-toxic, and strong adhesive strength. The most commonly used adhesive materials in the wood industry are formaldehyde-based synthetic adhesives, such as phenol-formaldehyde (PF) and melanine-urea-fromaldehyde (MUF). They possess great adhesive strength and mechanical strength, resistance against corrosion, provides protection to the product (Bono et al., 2013). However, there are studies, which showed that formaldehyde brings harmful impacts to human health and the environment (Zhang et al., 2018). Emission of formaldehyde gas from degradation of formaldehyde resin in particleboard are carcinogenic to human. Hence, there is continuous research has been conducted to develop an alternative adhesive that are safer and cheaper for particleboard production.

International Conference on Innovation and Technopreneurship 2020
Submission: 8 July 2020; Acceptance: 20 July 2020

Palm kernel cake (PKC) considered a potential solution to replace the formaldehyde agents as adhesives of particleboard. PKC is an agricultural by-product of oil palm industry. It contains high amount of proteins, essential amino acids and fibres like hemicellulose, cellulose and lignin (Abdeltawab & Khattab, 2018). Amino groups (-NH_2) in protein content can form hydrogen bonds while cellulose and lignin also enhance the bonding strength which contributes to the adhesive power of PKC adhesive (Bono et al., 2013).

In this study, PKC is tested for its applicability as a safer and environmental-friendly adhesive alternative in the wood industry. Malaysia is among the top palm oil supplier in palm oil market. As this industry grows up, a huge amount of oil palm wastes had been generated, a part of them have been utilizes as animal feed in poultry industry but the rest of them remain as waste. Therefore, uses PKC as adhesives might solve problems of excessive kernel waste and serve as alternative filler from formaldehyde in wood industry. (Awalludin et al., 2015).

The objectives of this study is to identify the best ratio of palm kernel cake biomass to NaOH (PKC:NaOH) to produce the biodhesive based on the shear strength of the adhesive mixture.

Methodology

Palm kernel cake (PKC) was obtained from Johore oil palm plantation. The PKC was grinded using pestle and mortal into powder form and filtered with a sieve with pore size of 250 micron to obtain fine powder of PKC. The PKC powder was then kept in an empty beaker until further treatment. NaOH with concentration of 20 % was prepared using NaOH pellets from (Friendemann Schmidt Chemical, Malaysia). The 20% concentration of NaOH is selected were based on pre-test that has been conducted. The NaOH was mixed with PKC powder at different ratio of PKC: NaOH, namely 1:3, 1:4, 1:5, 1:6 and 1:7 (volume (ml) to weight (g) basis). The mixture were stirred with a magnetic stirrer foe 3 minutes to allow reaction to happen. A control (PKC with only distilled water) was prepared.

The application of the mixture on plywood began by aligning two plywood (2cm X 5cm) side by side at the shorter edge. The bio-adhesive was applied onto a smaller sized plywood (2cm X 2cm) before putting in middle two plywood that were aligned together. A gentle press was applied to the stacked plywood while the excess bio-adehsive was wiped away with tissues. A peg was used to hold the stacked plywood and the sample was left to air dry overnight.

The XLW(B) auto tensile tester machine from PARAM® was used to test the shear strength of the bio-glue applied on the plywood. The stacked plywood was inserted in an upright position and locked tightly. The speed of pulling is set to 25mm/min. The test started after selecting shear strength and test button. All data were recorded in Newton (N). The calculation of shear strength were was carried out by applying the following formula:

$$\text{Pascal} = \frac{force\ (N)}{area\ of\ applied\ glue\ (m^2)}.$$

All data obtained were analysed using one-way ANOVA testing with a 95% confidence level to find the relationship between adhesive strength (shear strength) and ratio of biomass (palm kernel cake). IBM statistical packages for social sciences (SPSS version 22) were used to analyse the mean and standard deviation of the data obtained.

Results and Discussion

The shear strength of the bio-adhesive mixture prepared at different ratios of PKC to NaOH (Figure 1). Based on the ANOVA analysis, the shear strength of different ratios were in the increasing manner of 1:4 ≤ 1:3 ≤ 1:5 ≤ 1:6 < 1:7. The highest shearing strength ($P < 0.05$) was recorded at 0.32 ± 0.02 MPa, for the ratio of 1:7. The lowest shear strength ($P<0.05$) was recorded at 0.15 ± 0.01 MPa, for the ratio of 1:4.

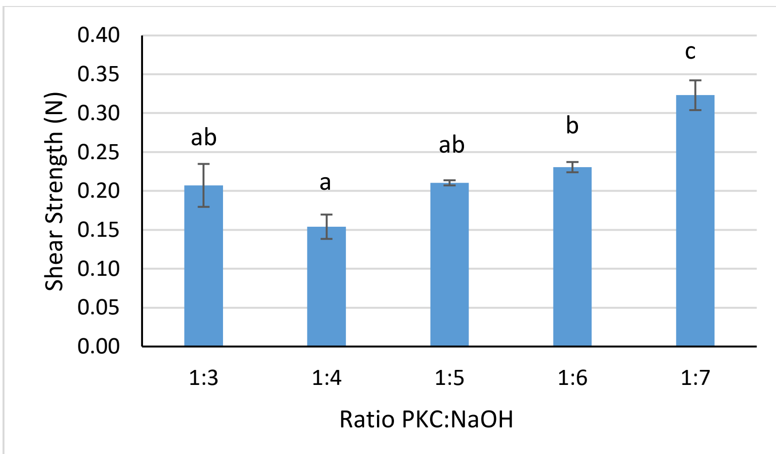

Figure 1. Shear strength (N) of bio-adhesive treated with 20% NaOH at different ratios of PKC:NaOH

The higher shear strength found in the ratio of 1:7 could be due to the higher portion of NaOH reacting to the protein content of PKC. Protein has four stages of structure, which are primary, secondary, tertiary and quaternary (Hemmilä, 2017). In the production of bio-adhesives, the protein content was hydrolysed by NaOH breaks open the structure allowing new bonds to form (Whitaker, 1983). The increased number of exposed hydrophilic functional group in the hydrolyzed proteins in 1:7 as compared to the rest of the ratios, due to increased portion of NaOH, formed bonds between the plywood, which held them together (Zhao et al., 2004).

Alkali hydrolysis usually happens by nucleophilic substitution, the strong hydroxide ion attacks nucleophile and substituted into the hydrolysed molecule (Theodorou et al., 2018). Therefore, if the amount of NaOH is lower than PKC biomass, some of the PKC might not be hydrolysed by the NaOH, hence the protein structure maintained and not available to form new bonds, not contributing to adhesive force of the bio-glue. Thus, the greater the amount of untreated PKC, the lower the adhesive strength of the bio-glue. This can be related to the lower NaOH proportion in ratio 1:3, 1:4, 1:5 and 1:6.

Conclusion

PKC biomass is found to be potential raw material for production of bio-glue. In this study, the highest shear strength of the bio-adhesive was achieved at a ratio of 1:7 (PKC:NaOH (20%)), which is 0.32 ± 0.02 MPa. However, further studies should be conducted in order to confirm the applicability of PKC treated with NaOH as bio-adhesives for plywood.

Acknowledgements

The authors wish to acknowledge the financial support provided through INTI International University's final year project student funding.

References

Abdeltawab, A. M., & Khattab, M. S. (2018). Utilization of Palm Kernel Cake as a Ruminant Feed for Animal: A Review. Asian Journal of Biological Sciences, 11(4), 157-164.

Awalludin, M. F., Sulaiman, O., Hashim, R., & Nadhari, W. N. (2015). An overview of the oil palm industry in Malaysia and its waste utilization through thermochemical conversion, specifically via liquefaction. Renewable and Sustainable Energy Reviews, 50, 1469-1484.

Bono, A., Anisuzzaman, A. M., Ismail, N. M. & Haziami, R. (2013). Performance of particle board with palm kernel cake as filler. Developments in Sustainable Chemical and Bioprocess Technology, 337-345.

Hemmilä, V., Trischler, J., & Sandberg, D. (2013). Lignin- an adhesive raw material of the future or waste of research energy? In C. Brischke & L. Meyer. Proceedings from the 9th Meeting of the Northern European Network for Wood Science and Engineering (WSE), (pp. 98-103). Hannover, Germany: S.n.

Palacio, M. L. B. & Bhushan, B. (2012). Bioadhesion : a review of concepts and applications. Philosophical Transactions of The Royal Society A Mathematical, Physical and Engineering Sciences, 370(1967), 2321-2347.

Theodorou, V., Alagiannis, M., Ntemou, N., Brentas, A., Voulgari, P., Polychronidou, V., Gogou, M., Giannelos, M., & Skobridis, K. (2018). Mild alkaline hydrolysis of hindered esters in non-aqueous solution. Arkivoc, 2018(7), 308-319.

Whitaker, J. R., Feeney, R. E., & Sternberg, M. M. (1983). Chemical and physical modification of proteins by the hydroxide ion. C R C Critical Reviews in Food Science and Nutrition, 19(3), 173-212.

Zhang, J. J., Song, F. F., Tao, J., Zhang, Z. F. & Shi, S. Q. (2018). Research progress on Formaldehyde emission of wood -based panel. International Journal of Polymer Science, 2018(5), 1-8.

Zhao, Y., Tu, Y., Li, J., Xu, M., Yang, Y., Nie, X., Yao, Y. & Du, H. (2014). Effects of alkaline concentration, temperature, and additives on the strength of alkaline-induced egg white gel. Poultry Science,93(10), 2628-2635.