ผลของตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่นที่มีต่อความทนทานต่อแรงกระแทกและการดูดซับน้ำของแผ่นไม้อัดจากผงต้นหญ้าแห้ง

Effect of Polyvinyl Acetate Emulsion Adhesives on the Impact Resistance and Water Absorption of Dry Grass Powder Plywood

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บทคัดย่อ

งานวิจัยนี้ศึกษาผลของตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่นที่มีต่อความทนทานต่อแรงกระแทกและการดูดซับน้ำของแผ่นไม้อัดจากผงต้นหญ้าแห้ง ซึ่งแผ่นไม้อัดเตรียมจากผงต้นหญ้าแห้งที่ผ่านการบดและผสมกับตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่นที่อัตราส่วนระหว่างผงต้นหญ้าแห้งต่อตัวเชื่อมประสาน คือ 1:0.2 1:0.4 1:0.6 1:0.8 1:1 และขึ้นรูปแผ่นไม้อัดด้วยเครื่องอัดไฮดรอลิกที่อุณหภูมิ 170 องศาเซลเซียส เวลา 10 นาที ความทนทานต่อแรงกระแทกทดสอบด้วยวิธีการที่สอดคล้องกับมาตรฐานการทดสอบ ISO 7765-1:1988 และการดูดซับน้ำทดสอบด้วยวิธีการที่สอดคล้องกับมาตรฐานการทดสอบ ASTM D570-98 จากการทดสอบความทนทานต่อแรงกระแทกและการดูดซับน้ำของแผ่นไม้อัดจากผงต้นหญ้าแห้งผสมตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่น พบว่า เมื่อปริมาณสัดส่วนของตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่นที่เพิ่มขึ้น ส่งผลให้ความทนทานต่อแรงกระแทกเพิ่มขึ้นและการดูดซับน้ำลดลง ซึ่งแผ่นไม้อัดจากผงต้นหญ้าแห้งผสมตัวเชื่อมประสานพอลิไวนิลอะซีเตตอิมัลชั่นที่อัตราส่วน 1:1 มีความทนทานต่อแรงกระแทกที่ดีที่สุดและการดูดซับน้ำน้อยที่สุด

คำสำคัญ: ผงต้นหญ้าแห้ง แผ่นไม้อัด พอลิไวนิลอะซีเตตอิมัลชั่น การดูดซับน้ำ ความทนทานต่อแรงกระแทก

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Abstract

This research studied the effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the impact resistance and water absorption of plywood from a dry grass powder (DGP). The plywood was prepared using dry grass powder mixed with polyvinyl acetate emulsion adhesives at 1:0.2, 1:0.4, 1:0.6, 1:0.8, 1:1 of DGP:PVAcEA ratio and formed a plywood with a hydraulic press machine at 170 ℃ of temperature for 10 minutes. The impact resistance was tested according to ISO 7765-1:1988, and water absorption was measured according to ASTM D570-98. It was found that the impact resistance increased, and water absorption decreased with the increase of polyvinyl acetate emulsion adhesives. The DGP: PVAcEA ratio at 1:1 showed the highest impact resistance and lowest water absorption.

Keywords: Dry grass powder, Plywood, Polyvinyl acetate emulsion, Water absorption, Impact resistance

Introduction

Plywood production uses natural wood as the main material. As a result, the number of trees in the forests of Thailand decreased. The increasing population resulted in the demand for wood materials in the construction industry design and various inventions. There is also an increase of plywood as a component. Moreover, the consumption of wood resources is insufficient to meet the needs of the population. For this reason, researchers studied how to use other materials to replace natural wood in plywood production such as cattail (Phonieum, 2016), sawdust (Klinpikul, 2014), oil palm biomass (Abdul Khalil et al., 2010), rice starch (Soubam et al., 2022), dioscorea alata stem fibers (Okafor et al., 2022), gmelina arborea trees (Tenorio et al., 2011). There is one important component in the plywood process is an adhesive. Many studies reported the adhesive development in plywood manufacturing. They used a soya-based

adhesive (Buddi et al., 2015; Muttil et al., 2014), Finely milled kenaf core as a binder (Okuda and Sato, 2007), formaldehyde-based adhesive (Sahoo et al., 2014), chitosan as bio-adhesive (Talaei et al., 2022), soya based phenolic resin (Mamatha et al., 2011), alternative castor oil-based polyurethane adhesive (Dias and Lahr, 2004), HDPE resins as adhesives (Chang et al., 2018), soy flour-polyepoxide adhesive (Huang et al., 2011), nanocellulose-reinforced phenol-formaldehyde resin (Lengowski et al., 2020), peanut meal as plywood adhesives (Chen et al., 2018), lignin-glyoxal resins as adhesives (Esfandiyari et al., 2019) in the processing of plywood. However, researchers are still studying other materials to replace natural materials and to develop an adhesive for plywood production to increase advantage and reduce costs.

Therefore, this research is interested in using dry grass (waste materials) and polyvinyl acetate emulsion adhesives (PVAcEA) in the processing of plywood. The effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the impact resistance and water absorption were studied.

Materials and methods

Materials

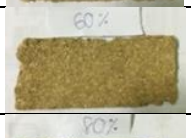
The dry grass was collected from various areas (faculty of science and technology, Princess of Naradhiwas university, Narathiwat, Thailand). Polyvinyl acetate emulsion adhesives (PVAcEA, 50 % of emulsion) were purchased from Penang trading company limited (Narathiwat, Thailand).

Plywood preparation

The plywood was prepared using dry grass powder (dry grass masticated using Retsch cutting mill (Germany) at 1,500 rpm, 0.25 mm x 0.30 mm of grid dimension) mixed with polyvinyl acetate emulsion adhesives as follow in Table 1 and formed a plywood with mold dimensions of 10 cm x 5 cm x 4 mm using a hydraulic press machine and a pressure of 0.05

MPa was applied at 170 ± 5 ℃ of temperature for 10 minutes. The dry grass powder plywood (Table 1) was placed for 24 hours at room temperature (23 ± 1 ℃).

Table 1 Formulation of dry grass powder (DGP) and polyvinyl acetate emulsion adhesives (PVAcEA)

Sample no.	DGP:PVAcEA		Dry grass powder plywood
	DGP (g)	PVAcEA (g)	
1	100	20	
2	100	40	
3	100	60	
4	100	80	
5	100	100	

Measurements

The impact resistance was tested according to ISO 7765-1:1988. The samples were prepared with dimensions of 10 cm x 5 cm x 4 mm and placed on the floor. The free-falling ball (a tennis ball is 170 g, Diameter is 6.35 - 6.67 cm, free-falling force is 1.66 N) was released from a 1 ± 0.2 m of height to fall on the center of the test sample with gravitational potential energy (Ep) is 1.66 ± 0.3 J and recorded the number of free-falling balls released until the test sample was fractured. This method was repeated three times.

The water absorption was measured according to ASTM D570-98. The test sample shall be in the form of 5 cm x 5 cm x 4 mm dimensions. The conditioned samples shall be placed in a container of water maintained at a room temperature of 23 ± 1 ℃ and shall be entirely

immersed. At the end of 24 h, the samples shall be removed from the water and wiped off with dry cotton on the surface samples and weighed immediately and recorded. This method was repeated three times. The percentage of water absorption is calculated using the following equation:

$$\text{Water Absorption, WAb}\,(\%) = \frac{W_{IM} - W_{OR}}{W_{OR}} \times 100$$

where WAb is the water absorption, W_{IM} is the weight samples after water immersion and W_{OR} is the weight samples before water immersion.

Results and Discussion

The effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the impact resistance of dry grass powder plywood was presented in Figure 1. It showed that the number of free-falling balls increased with the increase of polyvinyl acetate emulsion adhesive. It may be due to the crosslink of PVAcEA (Lu et al, 2011) was occurred and resulted in the adhesion between the dry grass powder and PVAcEA of plywood increased. It effected the impact resistance of plywood increased as presented in Figure 1 with the PVAcEA increased.

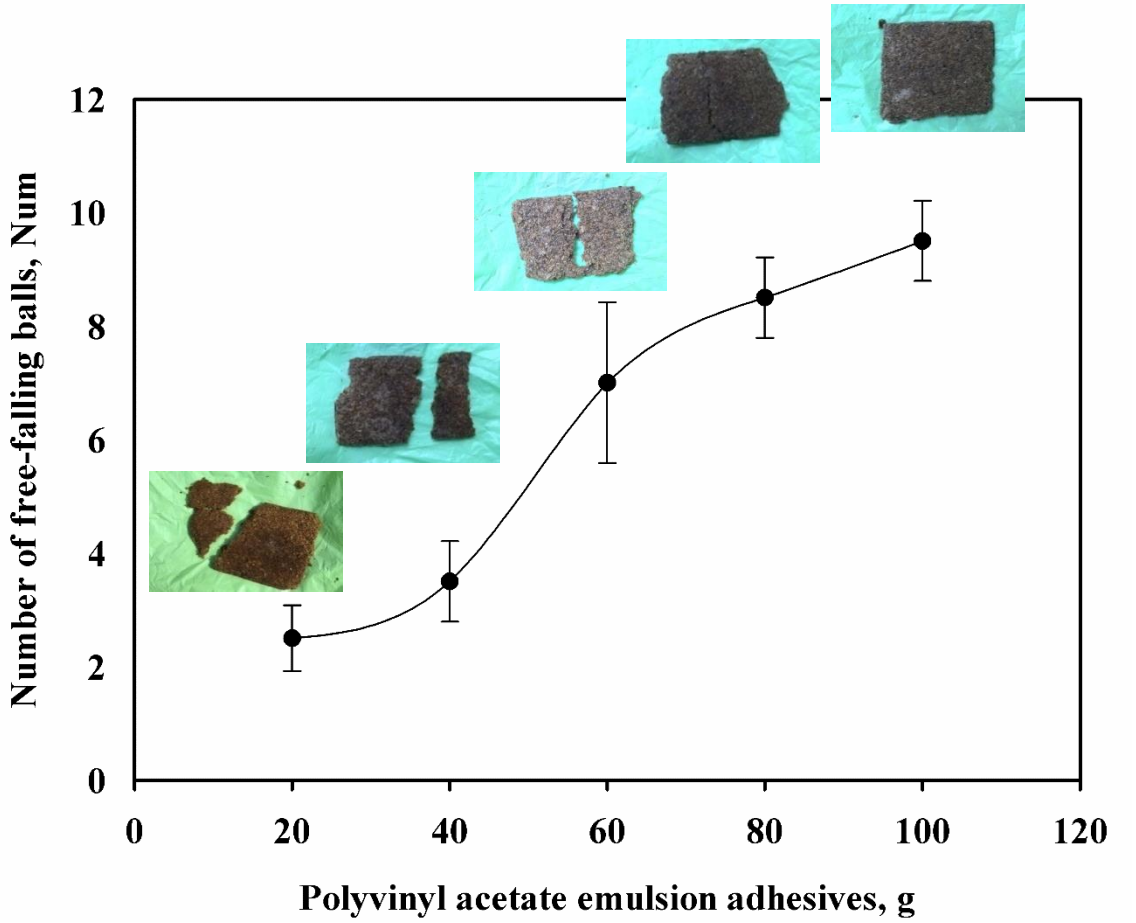


Figure 1 Number of free-falling balls (Num) and polyvinyl acetate emulsion adhesive (g) on the impact resistance of dry grass powder plywood

The effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the water absorption of dry grass powder plywood was shown in Figure 2. The PVAcEA at 20 g, the water absorption was undetected. It may be due to the emulsion state of the PVAcEA, which resulted in the efficiency of adhesion decreasing. It affected the plywood can easily swell and lose shape which leads to the plywood splitting apart and decomposing on water immersion for 24 h. Meanwhile, the water absorption decreased with the increase of the PVAcEA. Because the adhesion between the PVAcEA and dry grass powder of plywood increased and the crosslink of the PVAcEA (Lu et al., 2011) increased with the increase of the PVAcEA. It resulted in the

difficulty swelling of the plywood while immersed in water which in turn causes water absorption of the plywood decreased.

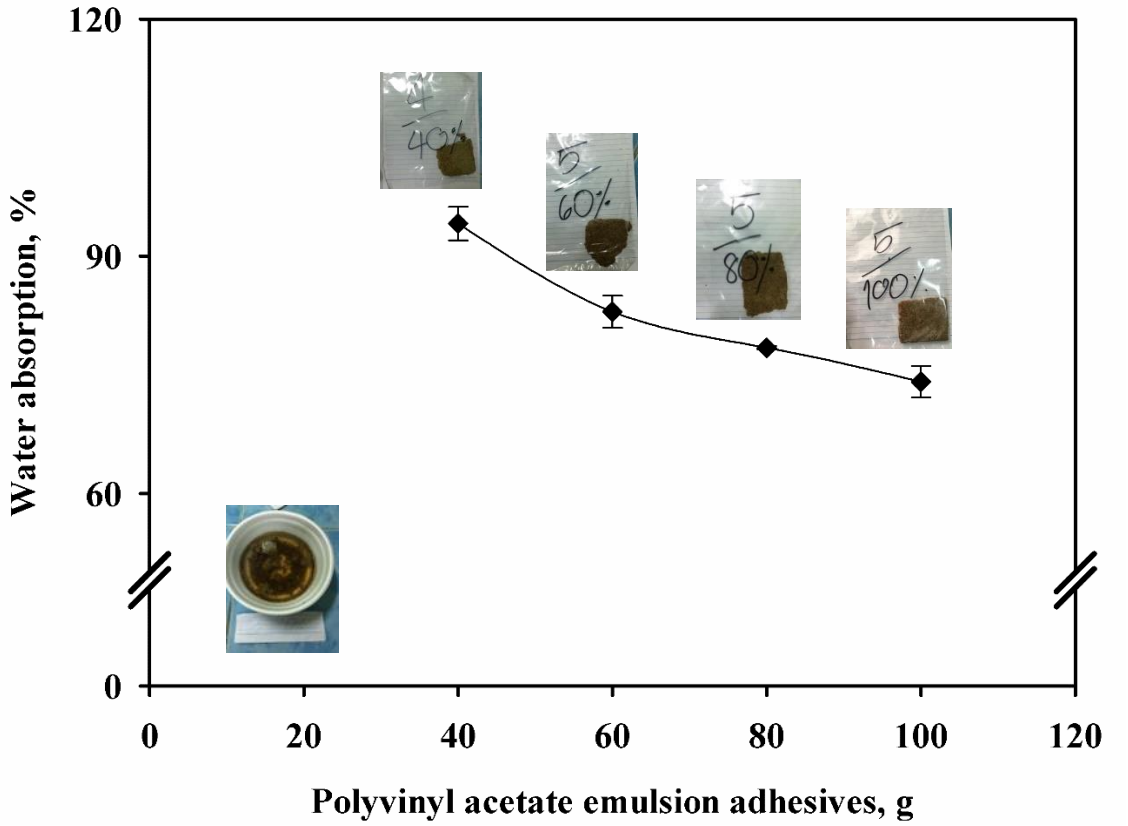


Figure 2 Water absorption (%) and polyvinyl acetate emulsion adhesive (g) of dry grass powder plywood

Conclusion

The plywood using dry grass (waste materials) as powder and polyvinyl acetate emulsion adhesives (PVAcEA) was prepared. Impact resistance and water absorption were studied in this work. The effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the impact resistance of dry grass powder plywood showed that the number of free-falling balls increased with the increase of polyvinyl acetate emulsion adhesive and the impact resistance of plywood increased. The effect of polyvinyl acetate emulsion adhesives (PVAcEA) on the water absorption

of dry grass powder plywood was found that the water absorption decreased with the increase of the PVAcEA. The DGP of 100 g and PVAcEA of 100 g showed the highest impact resistance and lowest water absorption.

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References

ASTM D 570-98 Standard Test Method for Water Absorption of Plastics. USA

Buddi, T., Muttil, N., Rao, B. N., & Singh, S. K. (2015). Development of a soya based adhesive in plywood manufacturing. *Materials Today: Proceedings*, 2(4-5), 3027-3031.

Chang, L., Tang, Q., Gao, L., Fang, L., Wang, Z., & Guo, W. (2018). Fabrication and characterization of HDPE resins as adhesives in plywood. *European Journal of Wood and Wood Products*, 76, 325-335.

Chen, Y., Shi, A., & Wang, Q. (2018). Peanut meal as plywood adhesives: preparation and characterization. *Journal of Adhesion Science and Technology*, 32(22), 2450-2463.

Dias, F. M., & Lahr, F. A. R. (2004). Alternative castor oil-based polyurethane adhesive used in the production of plywood. *Materials Research*, 7, 413-420.

Esfandiyari, M. R. T., TalaeiPour, M., Khademoleslam, H., Shokraei, S. A. M., & Bazyar, B. (2019). Investigating the possibility of making lignin-glyoxal resins as adhesives in the production of plywood. *BioResources*, 14(3), 7122-7133.

Huang, J., Li, C. & Li, K. (2012). A new soy flour-polyepoxide adhesive system for making interior plywood. *Holzforschung*, 66(4), 427-431.

ISO 7765-1:1988 Plastics film and sheeting — Determination of impact resistance by the free-falling dart method — Part 1: Staircase methods. Switzerland

Klinpikul, N. (2557). A study of fiberboard sheets made of sawdust with the use of lac as adhesive. The Research Project, Rajamangala University of Technology Krungthep. (in Thai)

Khalil, H. A., Fazita, M. N., Bhat, A. H., Jawaid, M., & Fuad, N. N. (2010). Development and material properties of new hybrid plywood from oil palm biomass. *Materials & Design*, 31(1), 417-424.

Lu, J., Easteal, A. J., & Edmonds, N. R. (2011). Crosslinkable poly (vinyl acetate) emulsions for wood adhesive. *Pigment & Resin Technology*, 40(3), 161-168.

Lengowski, E. C., Bonfatti Júnior, E. A., Dallo, R., Nisgoski, S., Mattos, J. L. M. D., & Prata, J. G. (2021). Nanocellulose-reinforced phenol-formaldehyde resin for plywood panel production. Maderas. *Ciencia y tecnología*, 23.

Mamatha, B. S., Sujatha, D., Nath, S. K., & Pandey, C. N. (2011). Soya based phenolic resin for plywood manufacture. *Journal of the Indian Academy of Wood Science*, 8, 112-115.

Muttil, N., Ravichandra, G., Bigger, S. W., Thorpe, G. R., Shailaja, D., & Singh, S. K. (2014). Comparative study of bond strength of formaldehyde and soya based adhesive in wood fibre plywood. *Procedia Materials Science*, 6, 2-9.

Okuda, N., & Sato, M. (2007). Finely milled kenaf core as a natural plywood binder. *Holzforschung*, 61(4), 439-444.

Okafor, C. E., Kebodi, L. C., Kandasamy, J., May, M., & Ekengwu, I. E. (2022). Properties and performance index of natural fiber reinforced cross-ply composites made from Dioscorea alata stem fibers. *Composites Part C: Open Access*, 7, 100213.

Phonieum, T. (2559). Production of Particle Board from Cattail and Application for Craft. A Dissertation Submitted in Partial Fulfillment of the Requirement for the Master's degree of Home Economics, Rajamangala University of Technology Thanyaburi. (in Thai)

Sahoo, S. C., Sill, A., & Pandey, C. N. (2014). A natural additive approaches to enhance the performance of formaldehyde based adhesive for plywood manufacturing. *International Journal of Innovative Science and Modern Engineering*, 3(1).

Soubam, T., Gupta, A., Sharma, S., & Jamari, S. S. (2022). Mechanical property study of plywood bonded with dimethylol dihydroxy ethylene urea crosslinked rice starch-natural rubber latex-based adhesive. *Materials Today: Proceedings*, 68, 756-759.

Tenorio, C., Moya, R., & Muñoz, F. (2011). Comparative study on physical and mechanical properties of laminated veneer lumber and plywood panels made of wood from fast-growing Gmelina arborea trees. *Journal of wood science*, 57, 134-139.

Talaei, A., Ashori, A., & Heydari, V. (2022). A Comparative Study on the Mechanical and Physical Properties of Plywood Panels Prepared by Chitosan as Bio-Adhesive. *Journal of Polymers and the Environment*, 30(10), 4263-4270.